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# Biodiversity, macroeconomics and sovereign risk

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# Biodiversity, macroeconomics and sovereign risk

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**Summary**: This study explores the links between biodiversity, macroeconomics and sovereign risk, with a focus on emerging and developing countries (EDCs). As a starting point, it details the channels identified in the literature through which biodiversity can affect the macroeconomy and sovereign risk. Despite the inherent difficulties in analyzing biodiversity risks, and an evolving scientific backdrop, research has served to highlight the strong and manifold links between our economic activities and biodiversity. The increasing pressure that these activities exert on our natural capital results in an erosion of the ecosystem services on which they depend. There are thus tangible macroeconomic risks related to biodiversity loss (physical risk) and the introduction of conservation policies (transition risk). In terms of sovereign risk, these effects can have a material impact on the "traditional" risk pillars (for example, the economy, public finances and external accounts).

The study uses the methodology of Maurin, Calas and Godin (2025) to examine the exposure of the socio-economic aggregates of 158 countries to biodiversity-related physical and transition risks, and the disparities between countries faced with these risks. The results suggest that EDCs are the most exposed countries to the direct physical risks related to biodiversity, especially through their exports and tax revenue. Their economic activities have stronger dependencies on ecosystem services, although the risk is often mitigated by the fact that they have more substantial and better conserved natural resources. Advanced economies would generally appear to be less exposed, especially because they outsource their environmental footprint. In terms of transition risk, low-income countries also have the most exposed socio-economic indicators, insofar as their economic activities are particularly erosive for biodiversity.

The study also highlights the importance of economic diversification as a vehicle for the resilience of economies. Indeed, the degree of development of the service sector and dependence on raw materials largely account for the disparities in terms of direct exposure to biodiversity risks. The more economies are diversified and service-oriented, the more the socio-economic exposure to biodiversity risks appears to be contained. Conversely, concentrated economies that are dependent on the production and export of raw materials (agricultural, mining, energy) appear to be especially at risk.

In addition, it analyzes the extent to which some of the countries identified as being highly exposed to biodiversity risks also have macro-financial vulnerabilities which place them in a situation of double vulnerability, while others have more leeway to address these risks. Here again, EDCs appear to be particularly exposed, as the vast majority of them are in a situation of double biodiversity and macro-financial vulnerability.

Finally, we illustrate the analysis through the case of Morocco, with an assessment of its biodiversity and the associated risks, and the connection with its sovereign risk profile. Despite levels of exposure to the physical and transition risks related to biodiversity that are consistent with international averages, we identify several sources of vulnerability that may adversely affect the country's sovereign profile. They include a downturn in its labor market, a weakening of its debt trajectory, and an erosion of its external accounts.

**Keywords:** Biodiversity, nature, macroeconomics, sovereign risk, development

**JEL Classifications:** C67, H41, H87, H63, O11, Q01, Q57

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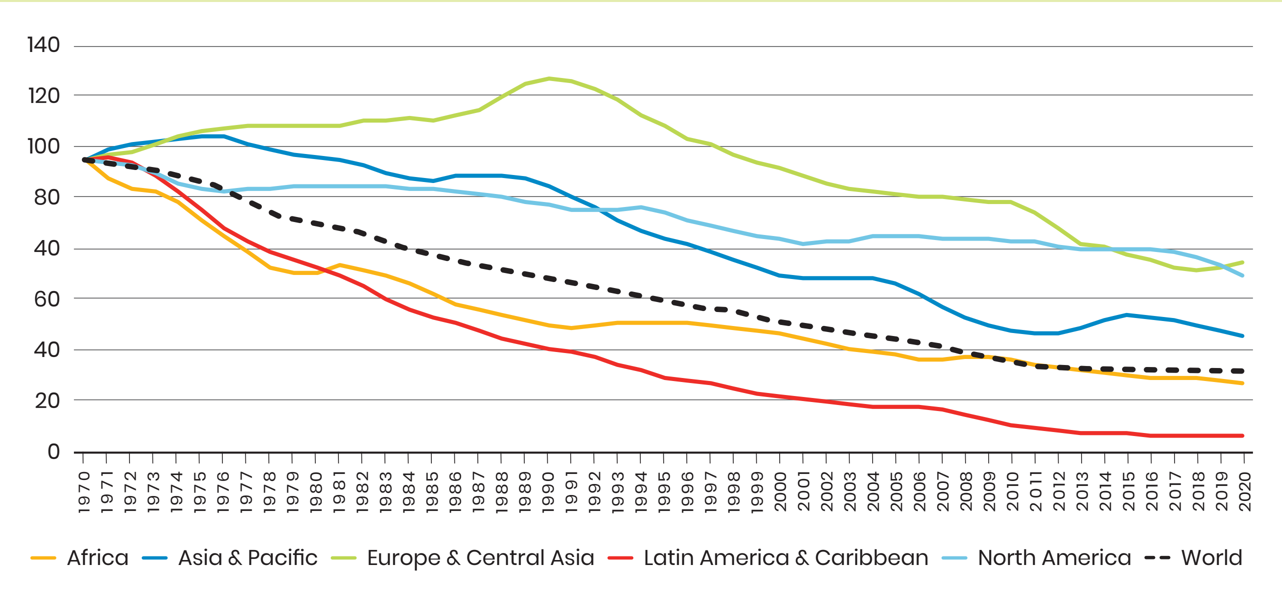
# Contents

# 1. Introduction

The organization of the Biosphere Conference in Paris in 1968 marked the first international recognition of the importance of preserving the natural wealth of the world. Since its origin, humanity has relied on biodiversity – understood as the variety of species, genes, ecosystems and networks that connect the living world – for its survival, development and prosperity. It feeds us, provides us with essential resources, protects us from diseases and climate hazards, enriches soils, purifies air and water, and inspires our cultures (Daily, 1997, Duarte *et al.*, 2009, Keesing and Ostfeld, 2021, Galindo *et al.*, 2022). Nature thus plays a central role in our societies and has multidimensional links with our economies.

However, this natural capital is deteriorating at an alarming rate. According to the Living Planet Index, the world has lost an average of 73% of wildlife populations since 1970 and developing regions appear to be the most affected, with Latin America experiencing an average decline of 95% (**Graph 1**). This global rate of degradation is unprecedented in the history of humanity and is due to human activities that place increasing pressures on nature (IPBES, 2019). Biodiversity experts estimate that about 30% of species have been threatened or driven to extinction globally since 1500 (Isbell, 2022), and there are growing fears of a massive collapse of ecosystems (Huang *et al.*, 2023, Blake *et al.*, 2024). If this trend continues, it would have disastrous consequences for our societies and economies, threatening approximately $44 trillion (more than half of world GDP) of economic wealth generated by nature (World Economic Forum, 2020).

Graph 1: Living Planet Index (1970 = 100)




Source: World Wildlife Fund and Zoological Society of London.

In response to this major challenge, the international community and policymakers are rallying to slow and ultimately reverse the ongoing loss of biodiversity. In 2022, the adoption of the Kunming-Montreal Global Biodiversity Framework defined a path to achieve this through a set of 4 objectives for 2050 and 23 targets for 2030. In connection with these measures, in particular target 15 of the agreement, economic actors (including financial institutions) are seeking to gain a better understanding of the financial risks related to biodiversity loss (physical risk) and to the measures taken to reduce pressure on biodiversity (transition risk). The regulation is at a preliminary stage at the global level, and the approaches differ considerably depending on the jurisdictions and institutions. However, a number of authorities in advanced and emerging countries have already launched initiatives (Financial Stability Board, 2024). While the analysis of biodiversity-related risks is complex, the emergence of a rich and multidisciplinary literature in recent decades has provided us with new modeling techniques and promising analytical frameworks.

This study explores the links between biodiversity risks, macroeconomics and sovereign risk, with a focus on emerging and developing countries (EDCs). As a starting point, it details the channels through which biodiversity can affect the macroeconomy and sovereign risk based on a literature review. It subsequently uses the methodological framework developed Maurin, Calas and Godin (2025) to assess the disparity in the exposure of countries to biodiversity-related macroeconomic risks. Finally, it provides an illustration of the interconnection between biodiversity risk and macrofinancial vulnerabilities through the case of Morocco.

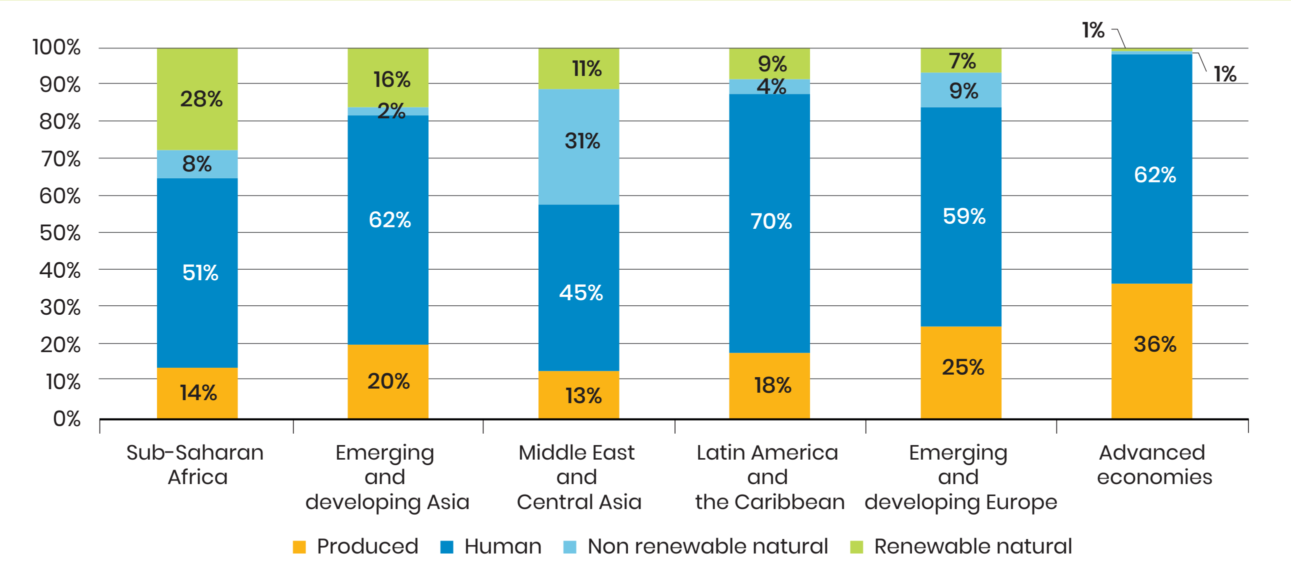
## 2. The links between nature, macroeconomics and sovereign risk

Far from being an abstract notion delinked from human activities, biodiversity plays a crucial role in these activities. Economic activities are thus intertwined with – and dependent on – nature. Economists for a long time failed to consider this, but the multiplication of research at the intersection of economic and ecological sciences in recent decades has allowed a better understanding of the role that nature plays in the economy and development. We provide a concise review of this research here.

### Nature as capital (which is eroding)

The assessment of a nation's economic performance cannot be confined to an analysis of its gross domestic product, which only provides a partial interpretation of socio-economic progress. Economists have thus sought to complement this measurement of economic flows with a measurement of national capital. While the former measures wealth creation, the latter measures its accumulation (or erosion). As we gained a deeper understanding of the enablers of prosperity, the definition of capital was broadened, initially encompassing, among others, physical capital, then financial and intangible capital and, finally, human capital (Roy Trivedi, 2009). For Dasgupta (2021), a sustainable economic development trajectory would be one that increases wealth in the broad sense. Dasgupta's proposal is to include natural capital in this conception of national wealth.

Graph 2: Composition of wealth by region, 2020 (%)




Source: World Bank, authors' calculations.

The World Bank's "The Changing Wealth of Nations[2]" program, launched in 2006, provides the most comprehensive database on national wealth currently available and can give indications on the sustainability of economic trajectories, as a complement to GDP. It differentiates between the following different forms of capital: produced capital, human capital and nonrenewable and renewable natural capital (**Box 1**). Regional disparities in terms of composition are striking: while the share of renewable natural capital in the wealth of advanced economies is negligible (1%), it is much higher for EDCs and even reaches 28% in Sub-Saharan Africa (**Graph 2**).

[2] https://www.worldbank.org/en/publication/the-changing-wealth-of-nations#data

Box 1: The notions of capital in "The Changing Wealth of Nations" data and their limitations

The data presented in **Graphs 2 to 4** are from the World Bank's "The Changing Wealth of Nations" database, which proposes an inclusive measurement at national level, including:

- **Produced capital:** Machinery and equipment, buildings, intangible assets, such as intellectual property, and urban land. The estimates take account, *inter alia*, of investment data and information on asset lives and depreciation models

- **Human capital:** The value of skills, experience and the efforts made by the working population over their lifetime. Human capital is estimated as the current value of the future labor income that could be generated over the lifetime of people currently living in the country

- **Nonrenewable natural capital:** Fossil fuels, minerals and metals. The value of reserves of fossil fuels, minerals and metals is calculated as the present value of the expected rents until the resource is depleted

- **Renewable natural capital:** Agricultural land, forests, mangroves, fisheries and renewable energy potential (in particular hydropower). The capital is equal to the present value of expected rents from natural endowments with a 100-year life assumption. The rents are not only related to the provision of biomass (fish and forest products, for example), but also the provision of services (cultural, coastal protection and water-related services, for example)

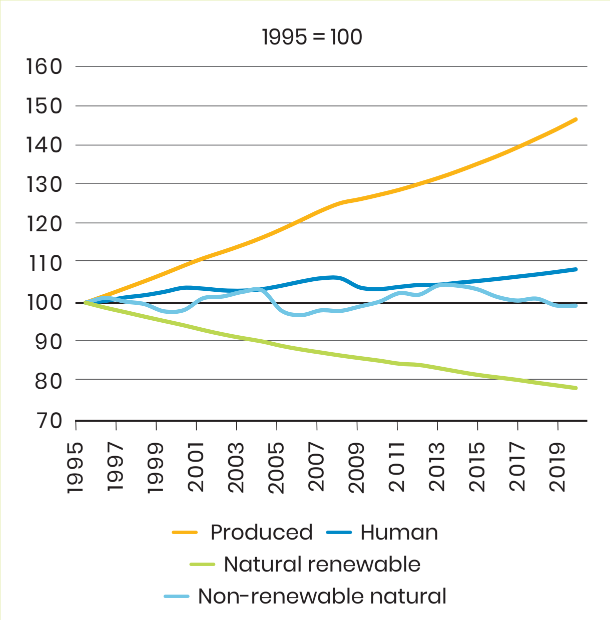
Broadly speaking, this approach poses many methodological challenges, especially in terms of the assumptions on discount rates and asset lives, as well as the inherent difficulty in valuing certain types of assets (human and natural capital, for example). Similarly, the World Bank's inclusive wealth is not exhaustive, as a certain amount of capital is not taken into account (social capital and some natural capital, for example).

These challenges are greater when it comes to natural capital, where the principle of valuation is itself debatable and based on strong assumptions, some of which are called into question by empirical studies (Godin, David, Lecuyer & Leyronas, 2022). In particular, the substitutability of natural capital by other types of capital is in reality highly restricted, as a large number of the functions performed by nature cannot be replaced.

Source: World Bank (2024).

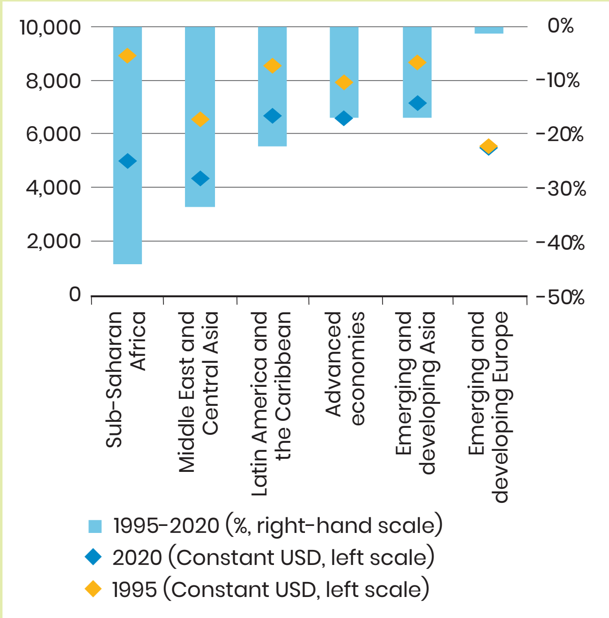
However, it is the long-term trends that raise questions. Produced capital and human capital have grown globally (by 47% and 8% between 1995 and 2020, respectively), while renewable natural capital, which would be able to regenerate if it was managed sustainably, has declined by more than 22% per capita since 1995 (**Graph 3**). Nonrenewable natural capital (mining resources) has remained broadly stable, despite a depletion of the stock, as a result of innovations, price fluctuations and discoveries of new deposits (World Bank, 2024). Here again, there are marked regional disparities, with a sharp decline in per capita renewable natural capital in Sub-Saharan Africa (-44% between 1995 and 2020), while it has remained virtually unchanged in emerging and developing Europe (-1%, **Graph 4**). Strong demographic pressure in certain regions partly accounts for these disparities.

Graph 3: Trends in global wealth per capita




Source: World Bank, authors' calculations.

Graph 4: Trends in renewable natural capital per capita




Source: World Bank, authors' calculations.

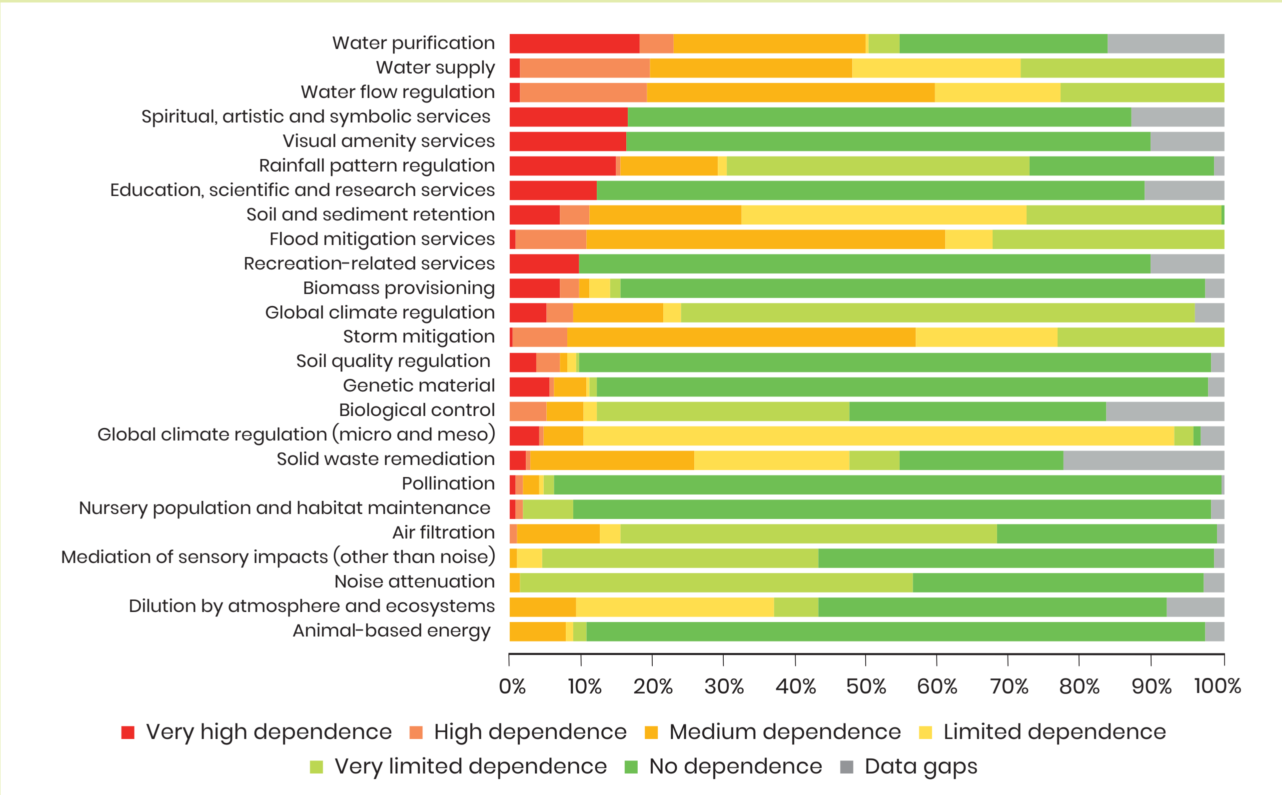
As with any form of capital, natural capital can serve as an essential input for the production of goods and services. This understanding of nature has thus contributed to developing the concept of ecosystem services, defined as the benefits that humanity derives from ecosystems. There are three main categories: i) resource provisioning services (food, water, wood and genetic resources, for example); ii) regulation and maintenance services (climate regulation, water purification and waste management, for example), and iii) cultural and non-material services (spiritual, aesthetic and recreational values, for example). These services, some of which would be difficult to substitute in production processes if they were reduced (Ekins *et al.*, 2003), can play a central role in our economic activities.

The Exploring Natural Capital Opportunities, Risks and Exposure (ENCORE) database [3] allows for a better understanding of the links and levels of dependence between economic activities and ecosystem services. The level of dependence is understood as the extent to which a disruption in nature's capacity to provide ecosystem services would have a significant impact on economic activities and their profitability. Some production processes can be highly dependent on ecosystem services, meaning that they have limited capacities to compensate for the deterioration of a service without it significantly disrupting the activity (interruption or need for substantial investments in offsetting solutions).

[3] https://encorenature.org/en

**Graph 5** shows the level of dependence of economic activities on each service, expressed as the share of activities (271 in total) based on the level of dependence estimated by ENCORE. The services that appear to contribute to the largest number of economic activities are those related to water (purification, supply and flow control), with about 20% of the 271 activities depending heavily or very heavily on them. Looking at all existing links between economic activities and ecosystem services, we find that, while a substantial share of economic activities are not heavily dependent on individual ecosystem services, about one activity in two is at least highly dependent on an ecosystem service. The economic activities that are highly dependent on multiple ecosystem services include primary activities such as agriculture, fishing and forestry (Natural Capital Finance Alliance and UNEP-WCMC, 2018).

Graph 5: Dependence of economic activities on ecosystem services



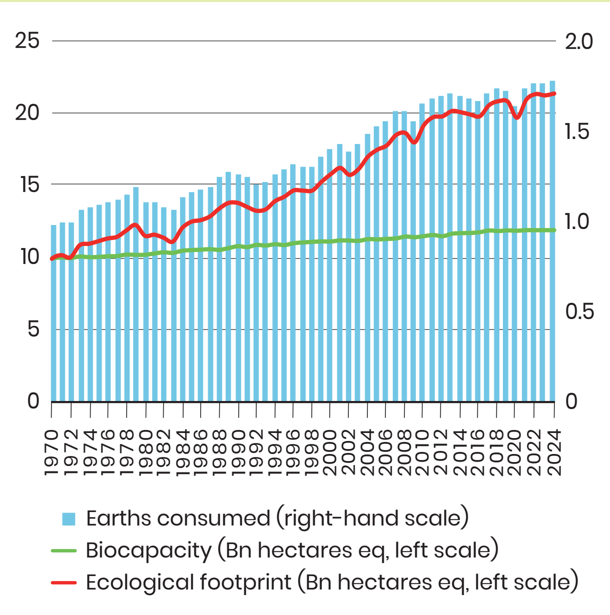

Source: ENCORE, authors' calculations.

### Nature as a global public good (which needs to be preserved)

If we want to ensure its conservation, biodiversity, through its universal nature and the overall magnitude of its externalities, needs to be understood and managed as a global public good (Rands *et al.*, 2010). Reducing the damage related to biodiversity loss thus amounts to producing public goods (Dasgupta, 2021). This would involve drastically reducing pressures on biodiversity, the main ones being changes in land and sea use, the overexploitation of species, pollution, invasive species, and climate change (IPBES, 2019). Yet the world remains on an unsustainable trajectory, characterized by an upward trend in these pressures. According to the Global Footprint Network, humans use almost twice the ecological resources (goods and services provided by flora and fauna and their habitats) than the planet is able to provide (**Graph 6**).

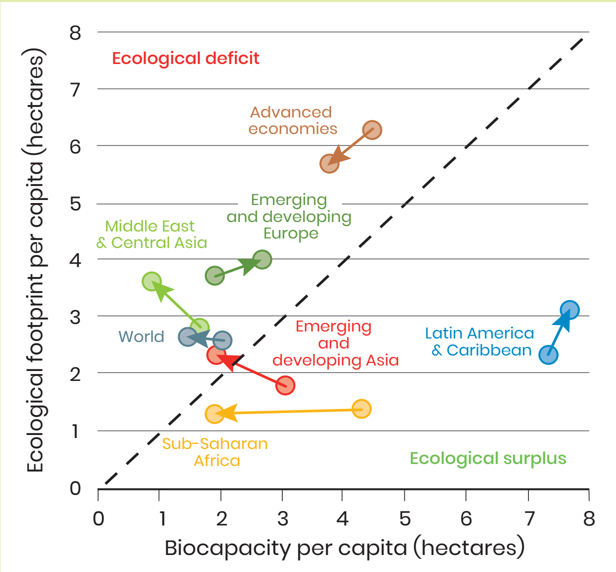
The majority of advanced economies have had continuous ecological deficits (the difference between the biocapacity of their country and the ecological footprint of their population) for decades. The first consequence is the loss of their domestic biodiversity due to an overexploitation of their ecological capital, which predates the overexploitation in many developing economies. The second consequence is the outsourcing of their ecological footprint, as advanced economies need to exploit the biocapacity of other countries (primarily EDCs) to meet their demand (Lenzen *et al.*, 2012). Indeed, Irwin *et al.* (2022) find that the consumption of advanced economies is the main factor contributing to the risk of extinction for species in other countries, primarily in Africa. While this problem of ecological deficits mainly concerns advanced economies, the ecological balances of developing regions are also deteriorating (**Graph 7**). Only Latin America and, to a lesser extent, Sub-Saharan Africa, on average maintain ecological surpluses, reflecting their vast natural capital and their low levels of production.

Graph 6: Biocapacity and global ecological footprint



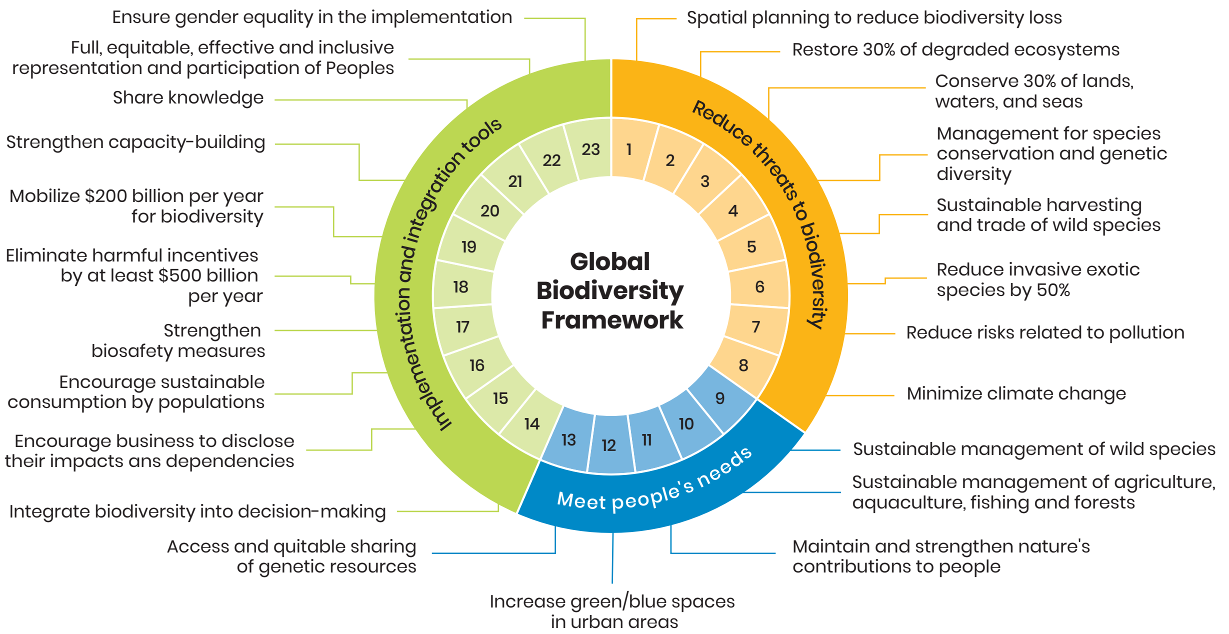

Source: Global Footprint Network, authors' calculations.

Graph 7:
Average ecological balances, 1990-2024




*N.B.:* The ecological balance is equivalent to the distance to the 45-degree line.
Source: Global Footprint Network, authors' calculations.

Graph 8: Overview of the Kunming-Montreal Framework targets



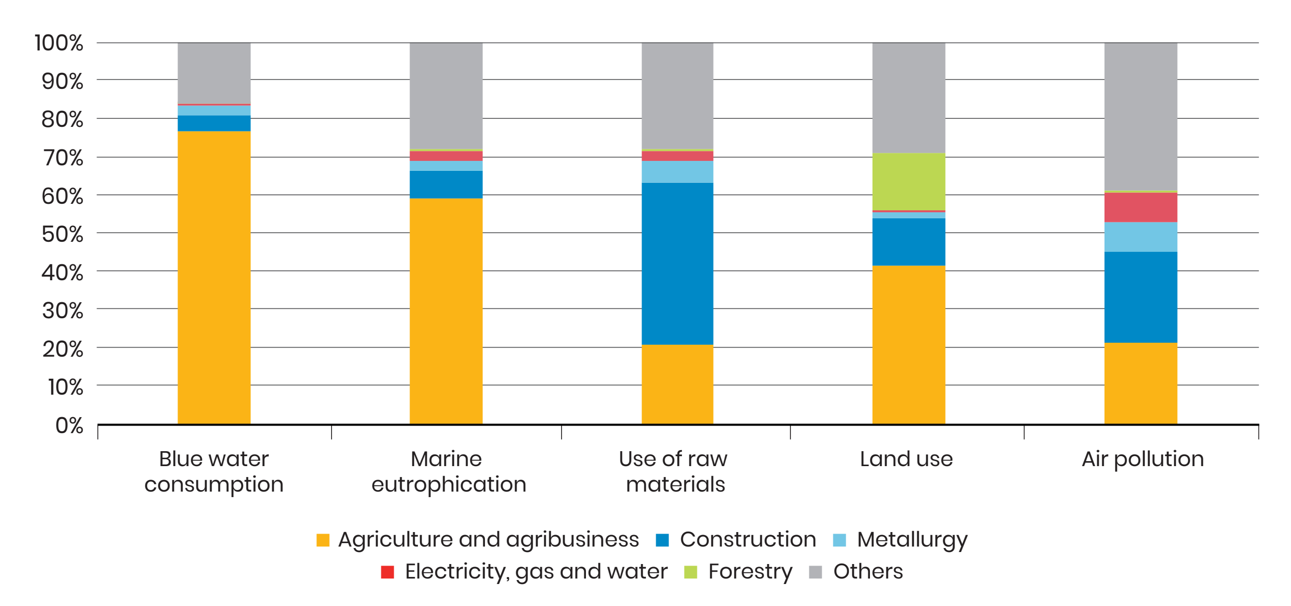

Source: Authors' illustration adapted from Wildlife Conservation Society Canada.

To reverse this trajectory, national and international public policies are required to organize collective action, change behavior and encourage technological innovation. International biodiversity conservation efforts emerged in the early post-war period, but the establishment of multilateral governance really took shape with the signing of the Convention on Biological Diversity in Rio de Janeiro in 1992. To raise global ambitions and address national implementation gaps – none of the 20 Aichi Biodiversity Targets of the Strategic Plan for Biodiversity 2011-2020 have been fully achieved, with 6 partially achieved (Secretariat of the Convention on Biological Diversity, 2020) – the international community adopted the Kunming-Montreal Framework in 2022, which defines a series of 23 targets[4] to create a society living in "harmony with nature" by 2030 (**Graph 8**).

The most cited include the restoration of 30% of degraded ecosystems (Target 2), the conservation of 30% of terrestrial, inland water and of coastal and marine areas (Target 3), the reduction of subsidies harmful for biodiversity by at least $500 billion per year (Target 18), and the mobilization of $200 billion per year for biodiversity (Target 19). The framework also calls on businesses and financial institutions to regularly assess and disclose their risks, dependencies and impacts on biodiversity along their operations, supply and value chains, and portfolios (Target 15). Finally, signatory countries committed to mitigate the direct drivers of biodiversity loss, notably through the sustainable management of agriculture, aquaculture, fisheries and forestry (Target 10), as well as indirect drivers, by encouraging sustainable consumption (Target 16).

[4] https://www.cbd.int/gbf/targets

Graph 9: Top 5 sectors contributing to a range of pressures on biodiversity, 2024
(% of global pressures)




Source: SCP-HAT, authors' calculations.

To be effective, measures to halt biodiversity loss need to address the direct and indirect drivers that fuel it (IPBES, 2019). According to the Convention of 1992, this would require integrating "the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programs, and policies". The activities and sectors that contribute the most to these pressures would thus be exposed to risks related to changes in public policies, consumer behavior and technologies (transition risk). According to data from the Hotspot Analysis Tool for Sustainable Consumption and Production,[5] a large proportion of global pressures are related to a limited number of sectors, notably the agri-food sector which is estimated to account for 77% of blue water consumption (*i.e.*, freshwater found in rivers, lakes and underground aquifers), 59% of marine eutrophication (*i.e.*, the process of the over-enrichment of marine waters with nutrients, mainly nitrogen and phosphorus, often originating from human activities) and 42% of land-use change (**Graph 9**).[6] Indeed, our agri-food systems – the entire process of food production, processing, transport and consumption – are estimated to be responsible for the largest share of terrestrial biodiversity loss (UNCCD, 2022).

It should be noted that biodiversity transitions do not inherently involve replacing sectors with a high ecological footprint with others that have a more moderate footprint. For example, the substitution of agricultural activities, which are particularly exposed to the transition risk given their significant contributions to pressures, by other activities more benign for biodiversity is not credible, given their criticality for sustaining human societies. For these activities that are difficult to substitute, the priority would be above all to promote more sustainable prac-tices and drive their adoption within value chains (agroecology, agroforestry, Nature-based

[5] https://scp-hat.org/

[6] Here we refer to pressures from a consumption perspective, which means taking into account the supply chains that contribute to countries' environmental footprints. For example, if an agricultural product is produced in country A, but is then used by an industrial sector in country B, the pressure will be attributed to the industrial sector of country B. See the technical documentation of the SCP-HAT for more information.

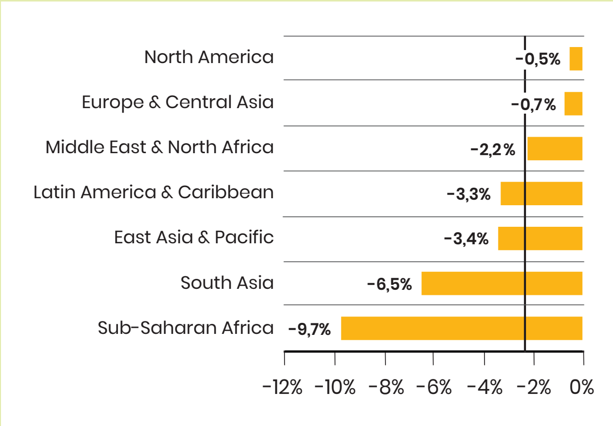
Solutions and efficiency gains in resource utilization, for example). Furthermore, the implementation of local public policies on conservation will affect production processes that exert pressures on biodiversity (materialization of transition risk), but could have direct beneficial effects for local biodiversity, thus reducing the physical risk.

### Nature as a component of sovereign risk (which needs to be integrated)

Sovereign risk, defined here as the risk that a State will default on its debt, involves a complex interaction of many factors. However, empirical studies and an increasingly extensive record of sovereign defaults have made it possible to identify a set of economic, fiscal, financial and institutional fundamentals that determine or influence sovereign risk. Looking at the sovereign risk assessment methodologies of the three main rating agencies (Fitch, Moody's and S&P), we can group them into five main "traditional" risk pillars: i) economic risk; ii) fiscal risk; iii) external risk; iv) financial stability risk; and v) political and institutional risk. While the rating agencies recognize the importance of taking environmental factors into account in their analyses, the explicit and systematic integration into their methodologies remains very incomplete (Gratcheva *et al.*, 2022) and focuses almost exclusively on climate risks. Similarly, several articles have focused primarily on the effect of climate risks on fiscal vulnerabilities, the cost of sovereign borrowing and default risk (Mallucci, 2022, Beirne *et al.*, 2021).

However, economic activities are highly dependent on biodiversity and ecosystem services and their degradation would constitute a significant threat (biodiversity-related physical risk). Johnson *et al.* (2021) conservatively estimate that a collapse of ecosystem services for pollination, food provision by fisheries and timber from indigenous forests could lead to a decline in world GDP of around $3 trillion (2.3% of world GDP) annually by 2030, with the most significant impacts in EDCs and especially in Sub-Saharan Africa, where the decline in GDP could exceed 20% for certain countries (**Graph 10**). The risks are especially serious and difficult to measure because ecosystems are facing tipping points that occur when environmental thresholds are crossed, with potentially disastrous consequences (Marsden *et al.* 2024). Ranger *et al.* (2023) analyze more than 60 past environmental shocks, caused by the erosion of natural capital. They highlight their broad nature, as they can occur in any country, as well as the fact that they often combine climate and natural components and have a complex interaction with social and political factors.

Graph 10: Real GDP losses due to a partial collapse of ecosystems, 2030

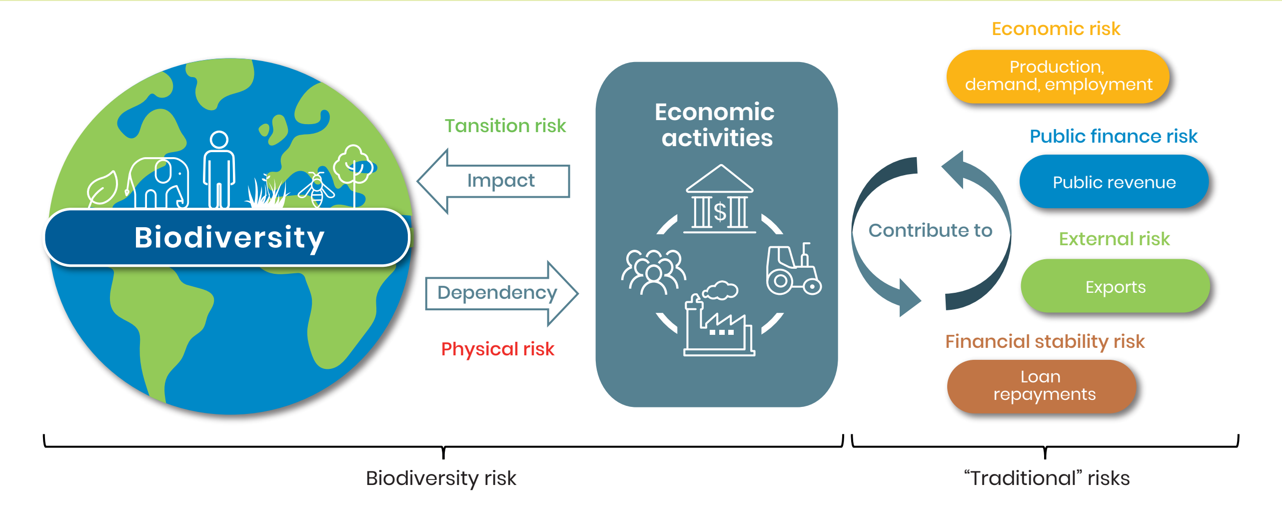



Source: Johnson *et al.* (2021).

Similarly, the expected changes in behaviors, public policies and technologies as a result of concerted efforts to reduce the impact of economic activities on biodiversity involve various risks (which can be grouped under biodiversity transition risk). For example, the implementation of the targets for restoring and conserving 30% of degraded ecosystems by 2030 could lead to adverse macro-financial effects due to a reduced availability of productive land and the disruption, cessation or relocation of economic activities outside of conservation zones (Kedward & Poupard, 2024). These effects would be particularly marked in low- and middle-income countries. Several studies show that biodiversity transition risk has begun to be integrated into company share prices, with investors beginning to demand a risk premium from firms with high biodiversity footprints due to the impacts that future conservation policies could have on their business (Garel *et al.*, 2024, Giglio *et al.*, 2023).

Our economic activities can thus be disrupted by the ongoing degradation of natural capital if they are highly dependent on ecosystem services. They are also exposed to biodiversity transition risks if they contribute significantly to the pressures and threats facing biodiversity. These economic activities can play a central role in countries' macro-financial performance, stability and sustainability by contributing to their macroeconomic indicators, including exports, public revenues, wages, employment, as well as demand and national production (**Graph 11**). Biodiversity risks can thereby affect sovereign risk through the traditional pillars of economic, fiscal and external risks (Pinzón *et al.*, 2020). The effects on financial stability and institutional and political dynamics would be more indirect. Biodiversity losses would be a source of financial risk due to the loss of value they would cause on assets that depend on ecosystem services. Svartzman *et al.* (2021) thus estimate that in France, 42% of securities held by financial institutions come from issuers that are highly dependent on ecosystem services, and Calice *et al.* (2021) find that in Brazil, 46% of bank loans are concentrated in sectors highly dependent on these services. Furthermore, globally, nearly 38% of bank loans from the 100 largest banks are allocated to economic sectors dependent on subsidies harmful for biodiversity and are therefore exposed to the transition risk (Gardes- Landolfini *et al.*, 2024). These effects could be particularly severe for the most exposed countries. Using a model based on machine learning techniques, Agarwala *et al.* (2024) find that a partial collapse of a selection of ecosystem services would lead to downgrades in the sovereign ratings of more than half of their sample (26 countries), with a drop of more than three notches for more than a third of affected countries.

Graph 11: Interaction between biodiversity and the "traditional" pillars of sovereign risk




Source: Authors' illustration, based on Svartzman *et al.* (2021).

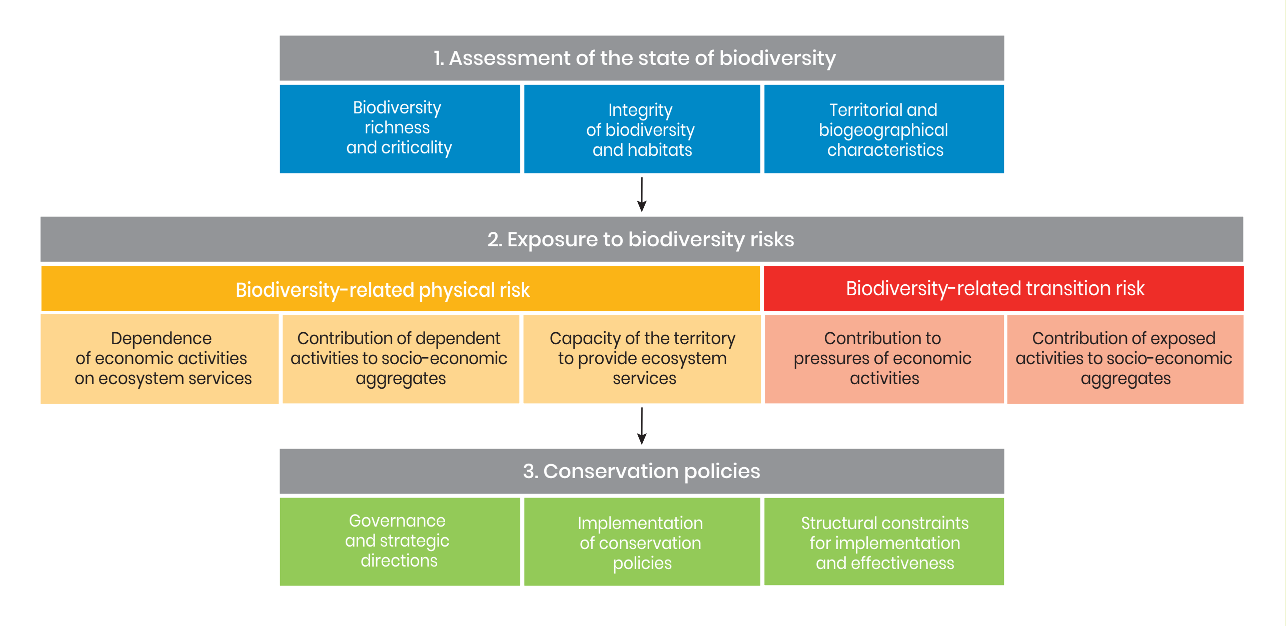
It should be noted that the effects of implementing public policies and investments aimed at biodiversity conservation are likely to reduce the risk of ecosystem service degradation and can generate economic gains (Expert Review on Debt, 2025). Johnson *et al.* (2021) thus model the adoption of various nature protection measures that would avoid up to 50% of land conversion compared to a "business as usual" scenario and would generate economic gains (an increase in real GDP by 2030 of between $50 billion and $150 billion depending on the scenarios). Similarly, a proactive and orderly ecological transition reduces long-term transition risks, as it avoids the need for a sudden and disorderly transition in the future.

# 3. Analytical framework for biodiversity risks at the country level

As mentioned above, biodiversity risks for a sovereign[7] primarily stem from the links that its economy has with nature. These links may vary depending on the different activities that make up its economy, implying a differentiated exposure to biodiversity risks. Maurin, Calas and Godin (2025) propose an innovative sectoral approach that allows for the analysis of the links of dependence and impact between economic activities and biodiversity, and for the measurement of the resulting socio-economic exposure at the national level.

Beyond exposure, the level of risk also depends on the probability of the hazard occurring. For physical risk, this can be partially approximated by the state of biodiversity and what it implies for the capacity to provide ecosystem services. For transition risk, the probability of occurrence is linked to the prospects for implementing conservation policies depending on the strategies in place in the country and in third-party countries. Indeed, biodiversity risks can be mitigated by the proactive and orderly implementation of public policies on conservation, though not without short-term costs. The analytical framework used in this study is based on three key steps (**Graph 12**): i) assessment of the richness, state and evolution of the country's biodiversity; ii) analysis of socio-economic exposure to biodiversity risks (Maurin, Calas & Godin, 2025); and iii) consideration of public policies on conservation.

Graph 12: Overview of the biodiversity risk analysis framework




Source: Authors' illustration.

[7] A sovereign, a term commonly used in credit risk assessments, is the highest level of government in a country.

### Assessment of the state of biodiversity

The first step of the analysis involves an overview of the state of a country's biodiversity, quantitatively and qualitatively assessing the richness and diversity of species and ecosystems, as well as their state of conservation. The country's territorial characteristics, such as the diversity of its biomes, its biogeographical regions and its climates, are also taken into account. In doing so, we take into account three key dimensions of biodiversity: i) the extent of ecosystems; ii) the condition or integrity of ecosystems; and iii) the significance of ecosystems for global biodiversity. To support our analysis, we use national assessments and data on land cover composition and its evolution, biodiversity richness indicators (Species Richness Index, for example), biodiversity integrity indicators (Biodiversity Intactness Index, for example), and extinction risk indicators for endangered species (Red List Index, for example). The more the biodiversity integrity of a country is degraded, the more its ecosystem services will be at risk and the more urgent the need to implement conservation policies will be. Conversely, a country with an extensive and intact natural capital will generally be better protected against biodiversity risks.

### Analysis of exposure to biodiversity risks

The analysis of exposure to biodiversity risks is based on an assessment of the interdependencies between biodiversity and economic activities. It involves identifying the economic activities that are exposed to biodiversity risks and measuring their socio-economic contribution within a national economy.

#### *Biodiversity-related physical risk*

In terms of biodiversity-related physical risk, the assumption is as follows: if an economic activity is highly dependent on at least one ecosystem service and if this service is not provided in sufficient quantity by ecosystems, the activity will be threatened. Yet some of these dependent activities can make a significant contribution to the main socio-economic indicators of a country, thus directly exposing this country to biodiversity-related physical risk.

The methodology developed by Maurin, Calas and Godin (2025) can be broken down into three steps:

1. Identification, in each country, of a set of activties exposed to biodiversity related physical risk, based on their level of dependence on 17 ecosystem services, assessed using the ENCORE database (see Appendix I for an overview of the main databases used by the authors). For example, the agriculture sector is highly exposed to physical risk because it relies on production processes that are heavily (or even very heavily) reliant on virtually all ecosystem services. Extractive industries are also exposed to a multitude of physical shocks from biodiversity loss. Conversely, activities in the service sector, such as professional services and financial activities, generally have lower levels of dependence.

2. Calculation of the share of key socio-economic indicators generated by these exposed activities to assess countries' exposure to physical shocks from biodiversity loss. These variables include exports (net of imported inputs), tax revenue (net of subsidies), wages, employment, production and final consumption. The data comes from the Global Resource Input-Output Assessment (GLORIA)[8] database.

3. In addition to these first two steps, and to assess the probability of a shock occurring (degradation or collapse of the ecosystem service), the analytical framework also provides an initial quantitative approximation of the capacity of national ecosystems to provide ecosystem services at the country level. This method takes into account land cover (wooded areas, crops and arid areas, for example) and the general state of ecosystems to determine a score per country and per ecosystem service ranging from 0 (degraded capacity) to 5 (preserved capacity).

[8] https://ielab.info/labs/ielab-gloria

### *Biodiversity-related transition risk*

Economic activities that contribute significantly to nature/biodiversity degradation are considered as being exposed to transition risk. The more an economic activity contributes to pressures on biodiversity at the country level, the more exposed it could be to a concerted effort to reduce its impact, notably through sectoral policies. However, the literature currently does not propose a taxonomy of activities exposed to biodiversity transition risk.

The approach proposed by Maurin, Calas and Godin (2025) has two steps:

1. Identification, in each country, of activities exposed to transition risk through their contributions to the pressures exerted on biodiversity and to the risk of species extinction. This is done by applying two complementary filters. The first uses the environmental satellite accounts of GLORIA EE-MRIO to measure the contribution of economic activities to greenhouse gas emissions, water resource utilization, agricultural land use, and NOX (nitrogen oxide), NH3 (ammonia) and SO2 (sulfur dioxide) pollution. The second uses the Species Threat Abatement Restoration (STAR)[9] metric, based on the Red List of Threatened Species of the International Union for Conservation of Nature (IUCN), to measure the contribution of activities to the threats facing these species. The identification of exposed activities through these two filters ensures complementarity, with the aim of overcoming the limitations associated with each individual filter, and enables a better identification of the economic activities with the greatest impact on biodiversity.

2. Calculation of the share of the key socio-economic indicators generated by these exposed activities to assess countries' exposure to transition shocks. These variables, from the GLORIA database, include exports (net of imported inputs), tax revenue (net of subsidies), wages, employment, production, and final consumption.

### Consideration of public conservation policies

Public conservation policies, if implemented in a reasoned and effective manner, can mitigate biodiversity risks, especially by better preserving natural capital nationally and globally. It is important to note that if no conservation policies are implemented, this does not eliminate transition risk. On the contrary, the absence of proactive policies enabling a gradual and orderly transition today increases the risk of a late, sudden and disorderly implementation of policies in the future.

The analysis of public policies on conservation firstly includes an assessment of the country's strategic directions (national strategies and action plans,[10] sectoral strategies and investment programs, for example) and the governance and institutional framework (stakeholders, drivers for action and laws, for example). This provides an overall vision of the country's commitment, ambition and institutional capacity to assess and manage its biodiversity risks. The effective implementation of public policies to reduce pressures on biodiversity is then evaluated, supported by quantitative indicators, such as the territorial coverage of protected areas, the share of forests covered by a long-term management plan, and public environmental protection expenditures. Finally, the analysis takes into account structural factors that may constrain the implementation and effectiveness of conservation policies (limited financial resources, governance gaps and security risks, for example).

[9] https://www.iucnredlist.org/assessment/star

[10] At COP10 in 2010, the signatory countries of the Convention on Biological Diversity pledged to develop National Biodiversity Strategies and Action Plans (NBSAPs) by 2015 and update them by 2025.

## The limitations of the proposed framework

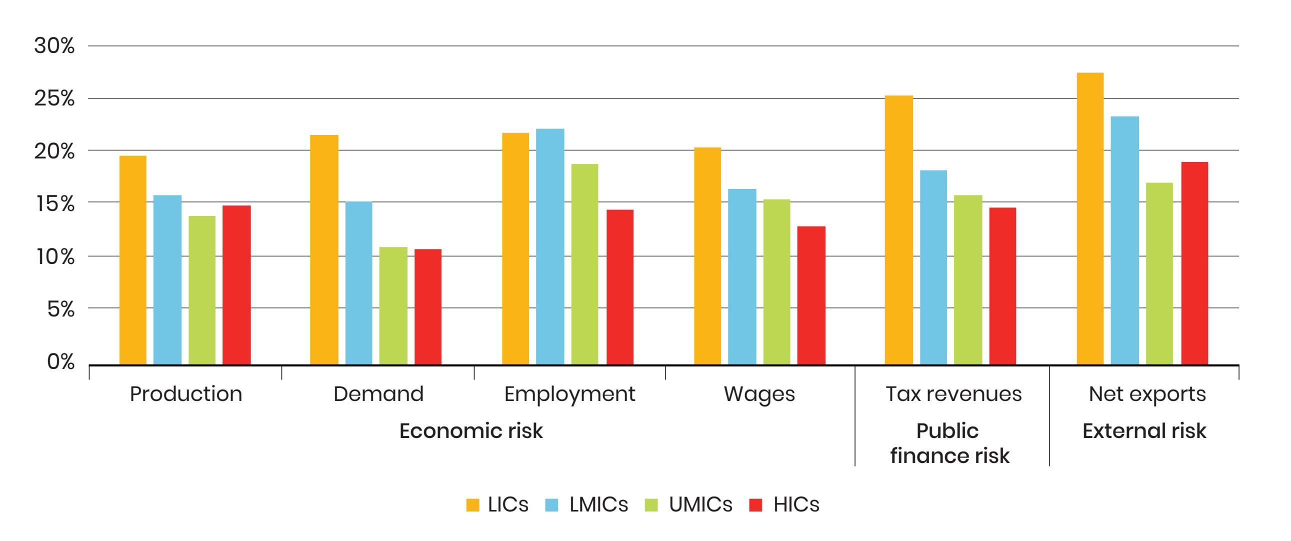
The methodological framework described above offers tools for analyzing and quantifying biodiversity risks at a country level, but it remains experimental and has several limitations that should be noted. Firstly, our capacity to take account of the complexity of natural processes and their interactions, as well as the intertwining of our societies in nature, is improving but remains very limited. The data used are thus incomplete and are often based on estimations and approximations (sometimes using global data rather than national or, even less so, local data) which can limit their precision. Secondly, the proposed approach does not yet enable an exhaustive analysis of biodiversity risks, as a certain number of pressures and ecosystem services are not analyzed, including cultural services (recreational, aesthetic, spiritual and knowledge). Similarly, not all ecosystems (marine ecosystems, for example) are subject to detailed analysis. Thirdly, the modeling of socio-economic exposure to biodiversity risks focuses on direct risks. It does not take account of the indirect effects that can materialize throughout the value chain. For some countries, especially those whose ecological footprint is largely outsourced, biodiversity risks may thus be underestimated. Finally, the analysis is static and does not factor in the various possible scenarios of ecological transition. Yet, such scenarios can have a strong impact on the degradation of natural capital, or even reverse it.

# 4. Exposure to biodiversity risks of emerging and developing countries

### Disparities depending on the level of development

Out of the 158 countries analyzed (See **Appendix II** for the list of countries included in the sample), low-income countries (LICs) appear, on average, to be more directly exposed to biodiversity-related physical risk than the other categories of countries (**Graph 13**).

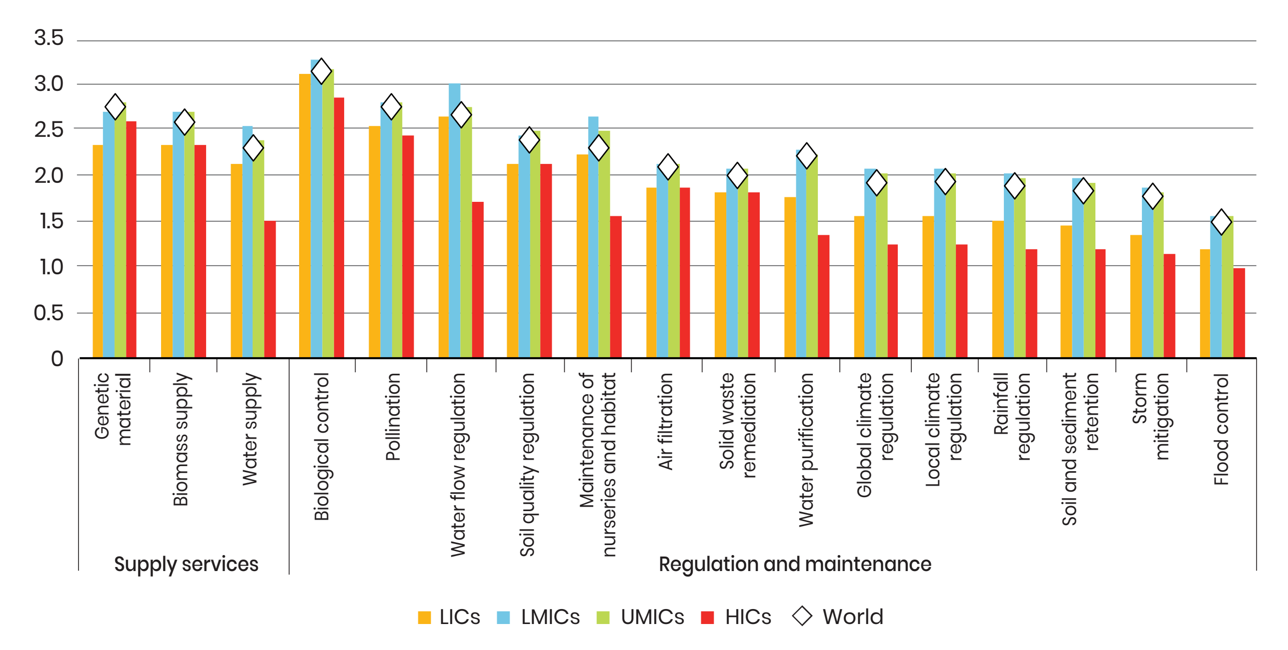
Graph 13: Average exposure to biodiversity-related physical risk (% of the total socio-economic indicator)




Source: Authors' calculations.

In LICs, over 50% of production, 70% of tax revenue and 65% of exports come from economic sectors that are highly dependent on at least one ecosystem service. The other socio-economic indicators, such as employment and wages, also show significant exposure, with over 40%, on average, of the indicators from economic sectors highly dependent on at least one ecosystem service. These levels of direct exposure are lower for middle-income countries (MICs), and high-income countries (HICs) appear to be the least exposed. However, HICs remain highly exposed, with over 30% of production, demand, employment, wages and tax revenue and over 40% of exports generated by economic activities highly dependent on one or several ecosystem services. The interruption or alteration of one of these ecosystem services could thus affect these activities and, consequently, the economic situation of the country.

Graph 14: Average score on the condition of ecosystem services (0 = degraded; 5 = preserved)

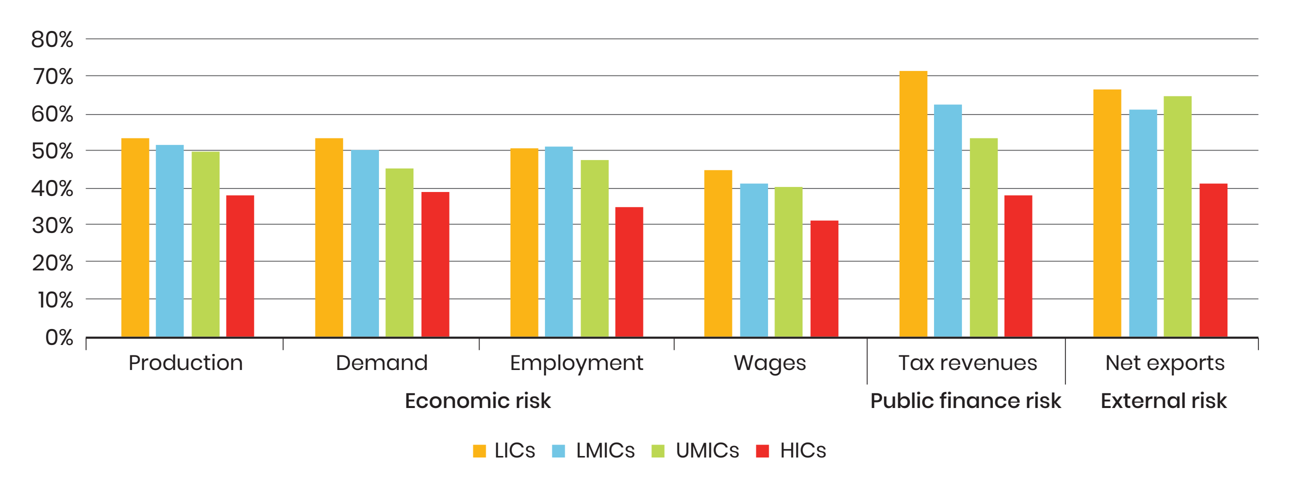



Source: Authors' calculations.

However, the preliminary results presented above could be further refined or nuanced by taking into account the capacity of ecosystems to provide these services. The ecosystem service condition scores of Maurin, Calas and Godin (2025) provide a first approximation of the capacity of the national territory (through land cover composition) and ecosystems (through integrity indicators) to provide these services. **Graph 14** presents the average condition scores by income category and ecosystem service. The averages scores for lower-middle-income countries (LMICs) and upper-middle-income countries (UMICs) are relatively high and systematically above the world average, while the averages for LICs are relatively close to the world average. Ecosystem services appear to be the most degraded in HICs, in particular due to greater land artificialization and less intact ecosystems. The share of HICs with at least four "degraded" ecosystem services, meaning their condition score is below the world average, stands at 59%, while it stands at 33%, 28% and 24% for LICs, LMICs and UMICs, respectively. Despite a lower exposure of their economic indicators to biodiversity risk, there would thus appear to be a greater probability of a physical biodiversity shocks occurring in HICs.

In terms of biodiversity-related transition risk (**Graph 15**), LICs are once again more exposed than others. Nearly 20% of their production is generated by activities exerting considerable pressures on biodiversity (water resource utilization, land use, greenhouse gas emissions, pollution and threats to species), while this level is around 15% in MICs and HICs. Due to the pressures they exert on biodiversity, these sectors are subject to transition risk since public policies, such as the creation of protected areas, the reduction of public subsidies to sectors affecting biodiversity and the imposition of more stringent standards, could affect their activity.

Graph 15: Average exposure to biodiversity transition risk
(% of the total socio-economic indicator)

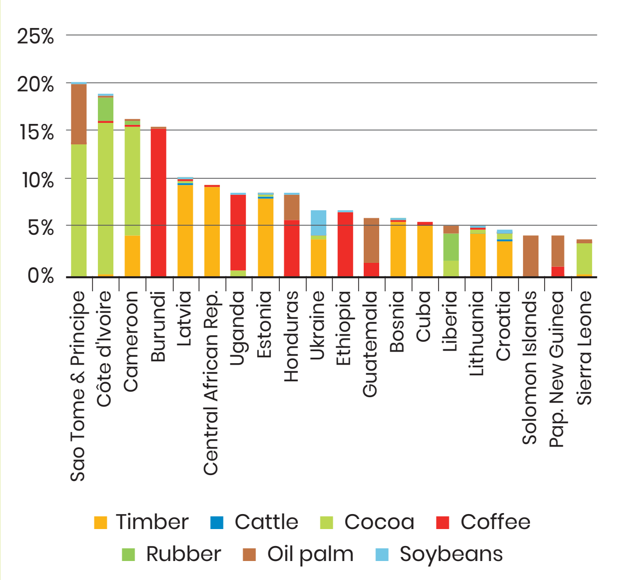



Source: Authors' calculations.

These are direct biodiversity risks, meaning those linked to the dependencies (pressures) of local economic activities on local biodiversity. However, for many countries, mainly HICs, biodiversity risks would appear to be more indirect in nature, notably due to the outsourcing of their ecological footprint and their dependence on raw materials sourced from EDCs. They can materialize through trade by affecting the entire value chain.

A striking example is the EU Deforestation Regulation (EUDR). Adopted in 2023, it aims to reduce the pressures (deforestation in this case) induced by European consumption on biodiversity around the world by imposing restrictions on the sale, import and export of several agricultural commodities (cattle, cocoa, coffee, palm oil, rubber, soya and wood), as well as their derivatives (European Parliament, 2023). This regulation could entail tangible compliance costs for European importers as well as non-EU exporters (European Commission, 2021). For some countries, the share of exports of sensitive agricultural products (because they are potential sources of deforestation) to the EU can reach over 15% (Burundi, Cameroon, Côte d'Ivoire), or even 20% for São Tomé and Príncipe (**Graph 16**).

Graph 16: Top 20 countries exposed to the EUDR through their exports
(% of total exports)




Source: CEPII, authors' calculations.

Trichet and Faivre-Dupaigre (2026) have conducted a detailed analysis of the macro-economic impacts of the regulation for exporting countries. They find that, apart from the case of an adverse (and unlikely) scenario where exporting countries fail to comply with the regulation and lose access to the European market, the economic consequences would be limited for the producer countries. However, the regulation can provide an incentive for these countries to implement measures to combat deforestation and reorganize the sectors concerned.

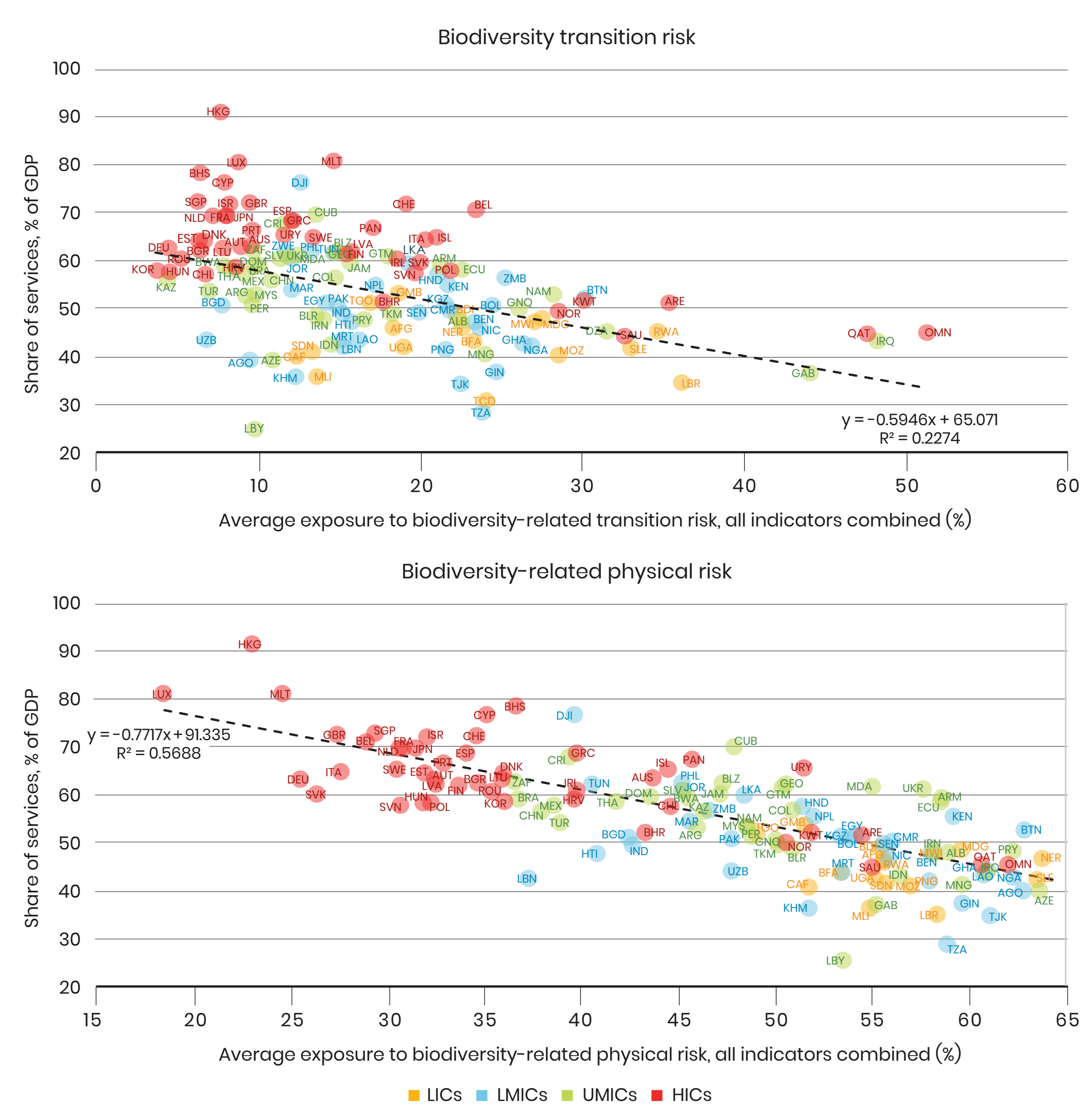
### Disparities depending on the level of economic diversification

The disparities in exposure to biodiversity risk show a strong correlation with the level of economic diversification. **Graph 17** shows the average exposure to biodiversity risk of socio-economic indicators (a simple average for each country of the exposure of exports, production, revenue, demand, employment and wages), as well as the share of services in countries' GDP. Economies where the service sector has a larger share have, on average, socio-economic indicators that are less directly exposed to both physical and transition biodiversity risks. Indeed, the service sector's share in the economy alone accounts for 23% of the variance between countries' levels of exposure to transition risk. The relationship is particularly striking for exposures to physical risk, where 57% of the variability is associated with the weight of service activities in the economy.

In terms of physical risk, service sector activities are characterized by less dependence on ecosystem provisioning and regulating services[11] than secondary or primary sector activities. Among low- and middle-income countries, several countries with an economy where the service sector is underdeveloped (Angola, Azerbaijan, Chad, Liberia, Niger, Sierra Leone, Tanzania) are thus among the countries whose socio-economic indicators are the most exposed to physical risk. For transition risk, service activities on average exert less pressure on biodiversity (lower greenhouse gas emissions, water resource utilization, agricultural land use and pollution). There is thus a negative correlation between the level of the service sector and the degree of direct economic exposure to transition risk. For instance, certain countries with largely service-based economies (Hong Kong, Luxembourg, Malta) are among the countries whose socio-economic indicators depend the least on activities that exert pressure on biodiversity.

[11] It should be noted that service activities, particularly the tourism sector, can depend heavily on "cultural" ecosystem services. However, due to methodological limitations, they are not included by Maurin *et al.* (2025) in the scope of the methodology.

Graph 17: Average level of exposure and size of service sector in the economy




*N.B.:* The average exposure to biodiversity risks is calculated as a simple average of the exposures across the six socioeconomic indicators considered.

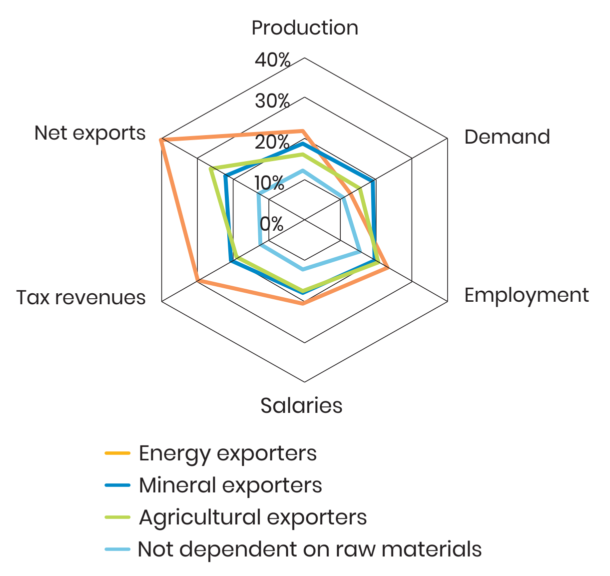
Source: Authors' calculations.

Similarly, when examining levels of exposure based on whether or not there is dependence on several raw materials,[12] the disparities are once again telling. Indeed, countries that produce and export raw materials (agricultural products, minerals and energy) are, on average, more exposed to biodiversity-related physical and transition risks than more diversified countries. More than 50% of the produc-

[12] We use the UNCTAD list, which classifies countries as dependent on raw materials (agricultural, energy and minerals) when they account for more than 60% of their exports: https://unctad.org/topic/commodities/state-of-commodity-dependence.

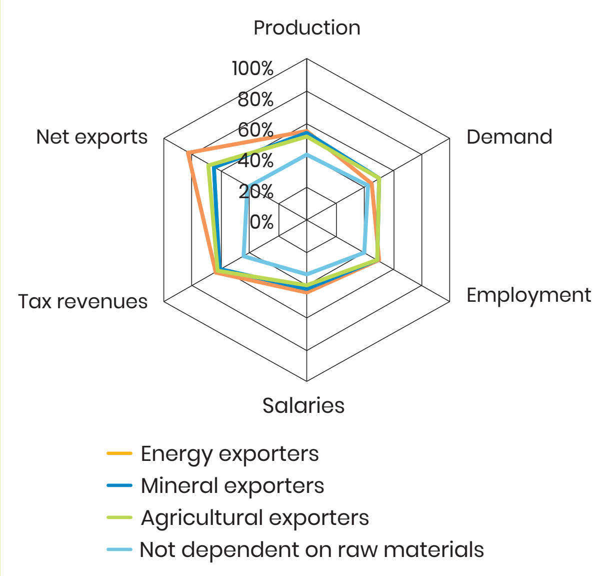
tion of exporting countries for energy, agricultural products and minerals is generated by activities highly dependent on ecosystem services, while on average, only 40% of the production of countries not dependent on raw materials is exposed to ecosystem services (**Graph 18**). It should be noted that agricultural activities are highly dependent on a multitude of ecosystem services, whereas extractive sectors depend heavily on a more limited number of services. Due to the strong pressures they exert on biodiversity, these extractive (energy, minerals) and agricultural sectors are also more exposed to transition risk, placing the countries producing these raw materials among those with the most exposed macroeconomic indicators (**Graph 19**). The difference is particularly significant for the exports and tax revenue of energy exporting countries: 40% of the exports of oil-producing countries are exposed to transition risk compared to 13% for other countries not dependent on raw materials and, in terms of physical risk, 80% of the exports of oil-producing countries compared to 20%.

Graph 18: Average exposure to physical risk by country category




Source: Authors' calculations.

Graph 19: Average exposure to transition risk by country category



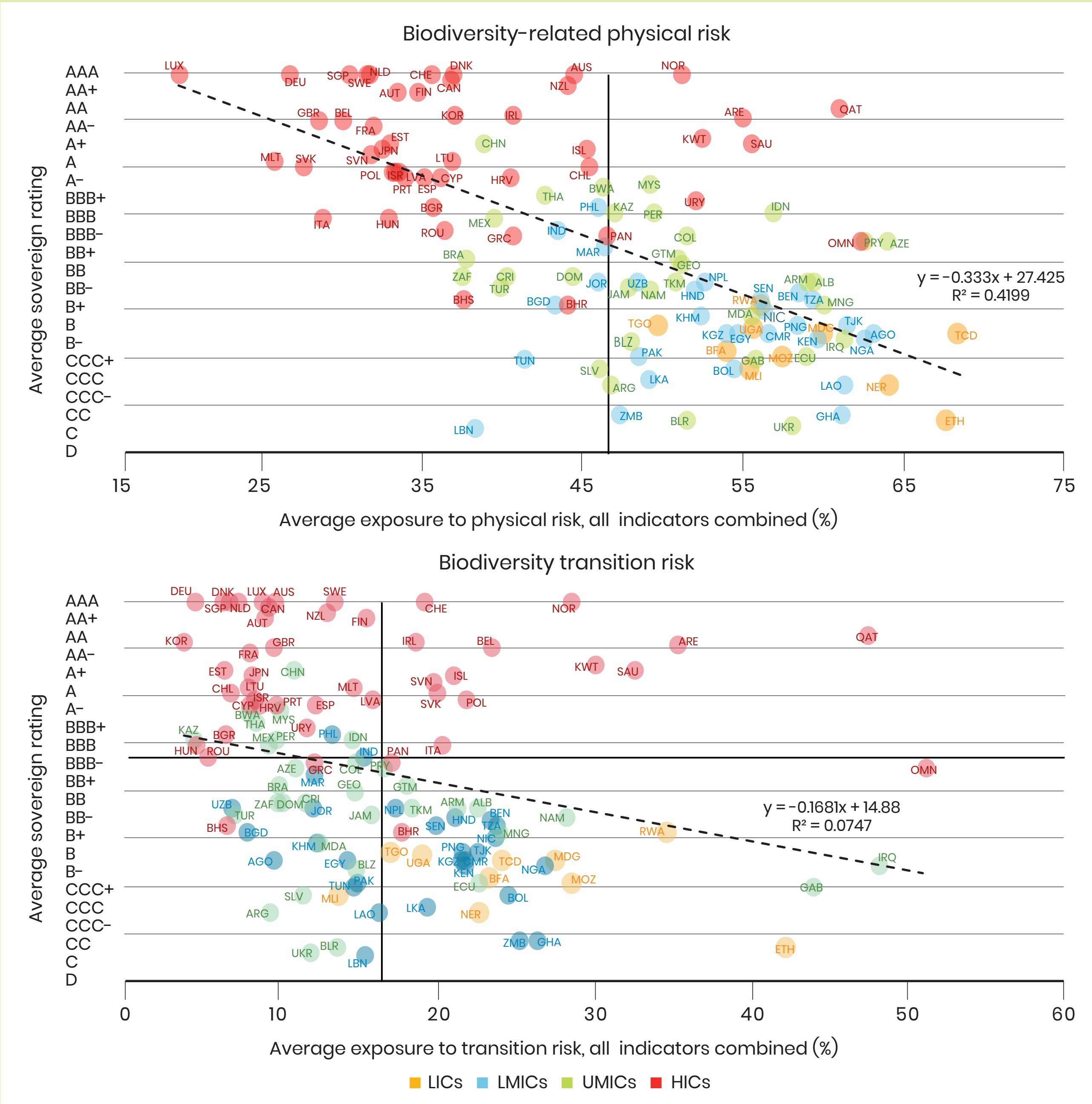

Source: Authors' calculations.

Countries whose economy is more concentrated and focused on the exploitation of raw materials would thus be particularly exposed to biodiversity risks. Beyond the increased exposure to biodiversity risks, a high economic concentration can lead to chronic macroeconomic volatility, exacerbate vulnerability to shocks, and hinder the country's development trajectory (World Trade Organization, 2021). Furthermore, as economies concentrated on raw materials have few alternative growth drivers, they would have limited room for maneuver to mitigate the consequences of a materialization of biodiversity risks. These factors underscore the importance of diversification, particularly towards the service sectors, as a means of mitigating biodiversity risks.

### Sovereign risk and nature risk: the problem of double vulnerability

As we have seen, biodiversity risks are multidimensional from a macroeconomic point of view, affecting a plurality of indicators. The materialization of these risks can thus lead to significant macroeconomic imbalances with negative repercussions on sovereign risk. It could hinder growth, erode tax revenue, and degrade export performance, threatening debt trajectories and the ability of countries to repay their foreign currency-denominated debt. Similarly, job losses and price pressures can exacerbate social tensions and disrupt the political-institutional system of countries. While biodiversity risks are not yet systematically and explicitly integrated in the rating agencies' methodologies, their damaging effects are likely to worsen as the erosion of natural capital intensifies and/or as measures to reduce ecological pressures are ramped up. This raises the issue of double nature macro-financial vulnerability where countries with a fragile macroeconomic position are also be highly exposed to biodiversity risks.

Graph 20: Exposure to biodiversity risk and sovereign risk

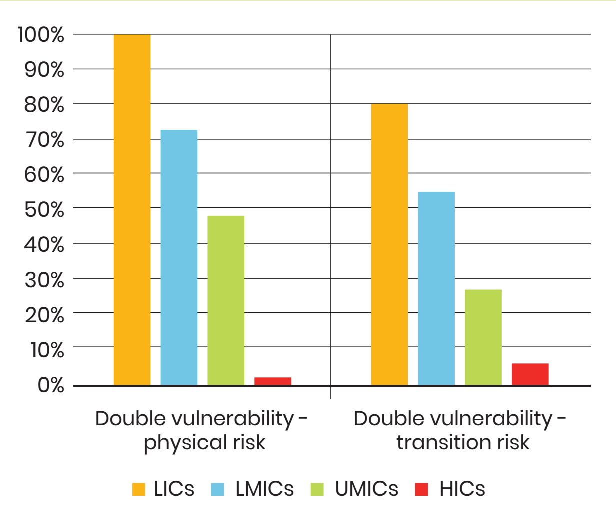



*N.B.:* The average exposure to biodiversity risks is calculated as a simple average of the exposure by indicator.

Source: Fitch, Moody's, S&P, authors' calculations.

To identify countries in a situation of double vulnerability, we adapt the climate approach of Bedossa (2023) and compare the average level of countries' exposure to biodiversity risk with their sovereign rating at the end of 2024 (**Graph 20**).[13] For sovereign ratings, we calculate a simple average of the ratings of the Big Three agencies (Fitch, Moody's, S&P) by converting the ratings on a scale ranging from 22 (AAA/Aaa) to 1 (D/SD). Firstly, we note a strong correlation between the exposure to biodiversity-related physical risk and the degree of countries' macro-financial vulnerability, approximated by their sovereign ratings: countries with the weakest sovereign ratings typically have high levels of exposure and vice versa. This relationship is less significant between the biodiversity-related transition risk and sovereign risk, with more heterogeneous levels of exposure across the rating scale.

Graph 21: Share of countries with a double vulnerability (% of countries in the income category)




Source: Authors' calculations.

To assess the share of countries in a situation of double vulnerability, we subsequently define two thresholds. Firstly, an absolute threshold for sovereign ratings at the boundary between the ratings BBB-/BB+, the threshold between "investment grade" (issuers with good credit quality) and "speculative grade" (issuers with a high sovereign risk). For the level of biodiversity risk exposure, we use a relative threshold equivalent to the sample average. In total, among the 119 countries rated by the Big Three in our sample, 51 are in a situation of double vulnerability (including 10 LICs, 22 LMICs, 16 UMICs, and 3 HICs), with biodiversity-related physical and/or transition risks higher than the world average and an unfavorable macro-financial situation. Here again, the disparities by income level are very pronounced. While 100% of LICs and 72% of LMICs have a double vulnerability to biodiversity-related physical risk, only 48% of UMICs and 2% of HICs are among the countries with a double vulnerability (**Graph 21**). Similarly, 80% of LICs, 55% of LMICs, 27% of UMICs and 6% of HICs have a double vulnerability to biodiversity-related transition risk-sovereign risk. However, these disparities largely reflect the good overeign ratings that HICs benefit from, with only six HICs having "speculative grade" ratings. It is worth noting that some of the HICs highly exposed to biodiversity risk (Kuwait, Norway, Qatar, Saudi Arabia, United Arab Emirates) benefit from favorable sovereign ratings. They would thus a priori appear to have healthier macroeconomic fundamentals and more financial room for maneuver for implementing biodiversity conservation policies and supporting the transition to mitigate the risks.

Beyond these findings concerning the differentiated exposure to biodiversity risks for certain groups of countries, the next section of this report focuses on the detailed analysis of the physical and transition risk of Morocco, which has a medium exposure to these risks, but with potential implications for its sovereign risk nonetheless in view of several macro-financial vulnerabilities.

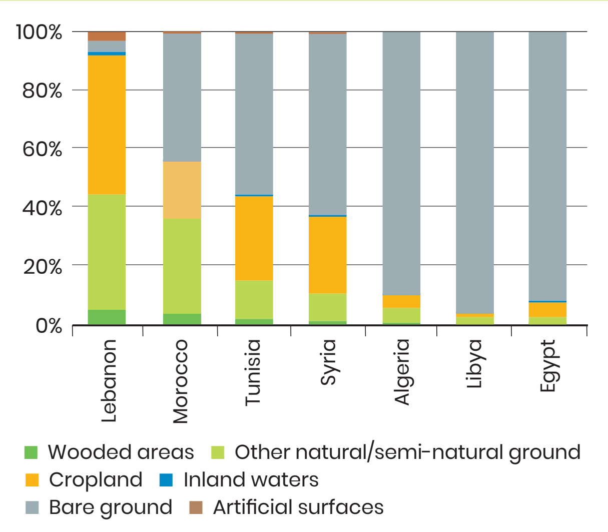
[13] Sovereign ratings are directly available on the websites of the three agencies.

## 5. Case study: Morocco

### Biodiversity assessment

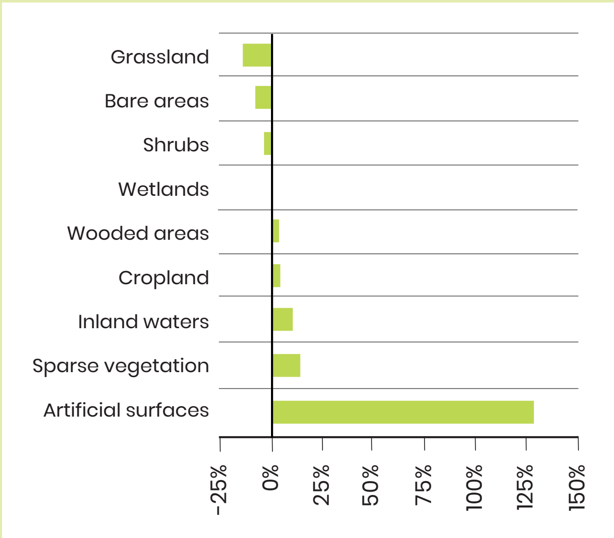
Morocco covers five biogeographical regions (Atlantic, Atlas, Continental, Mediterranean and Saharan), making it one of the most diversified countries in the Mediterranean basin. The territory has a highly heterogeneous and complex mosaic of ecosystems and habitats, ranging from the forest-covered and snow-capped mountains of the High Atlas to the arid desert region, and including vast alluvial plains, rivers, lakes, marine waters and steppic regions. The country has rich forest and marine ecosystems, more than 24,000 animal species and 8,300 plant species, mainly concentrated in the northern half of the country. It also has particularly high rates of endemism. As part of the Mediterranean basin, it is among the 36 Biodiversity Hotspot regions, characterized by an exceptional concentration of endemic species and a significant risk of degradation.

Graph 22: Land cover: Morocco vs peer countries




Source: Food and Agriculture Organization of the United Nations (FAO), authors' calculations.

Graph 23: Evolution of land cover in Morocco since 1992



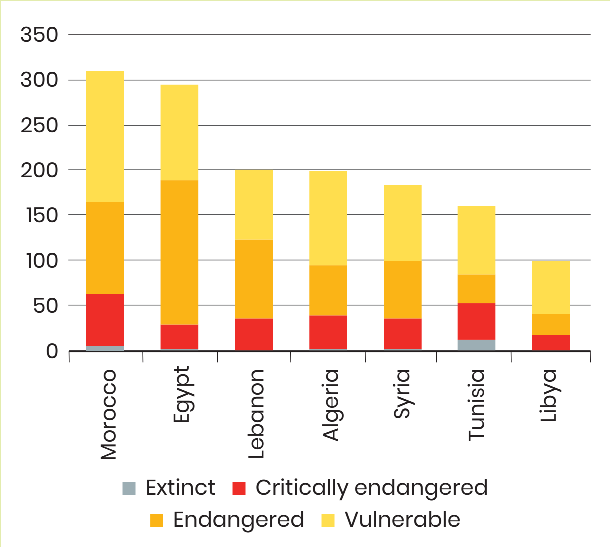

Source: Authors' calculations.

According to data from the European Space Agency's Climate Change Initiative, forested areas and other natural or semi-natural areas cover more than a third of the territory, while bare areas cover 44%. Artificial areas account for a minute fraction of the territory (<1%) and are concentrated on the country's north coast.[14] Among peer countries in the Mediterranean basin,[15] Morocco is one of those with the highest share of natural or semi-natural land cover[16] (**Graph 22**). While the surface area of forested and sparsely vegetated areas is increasing (by 4% and 14% since 1992, respectively), there is also substantial land take (**Graph 23**). Indeed, artificial surfaces have more than doubled since 1992, primarily on the north coast of the country.

[14] FAO data on Moroccan land cover do not include the Western Sahara.
[15] Algeria, Egypt, Lebanon, Libya, Syria, Tunisia.
[16] Including: forested areas, shrub-covered land, sparsely vegetated areas, vegetated wetlands and grasslands.

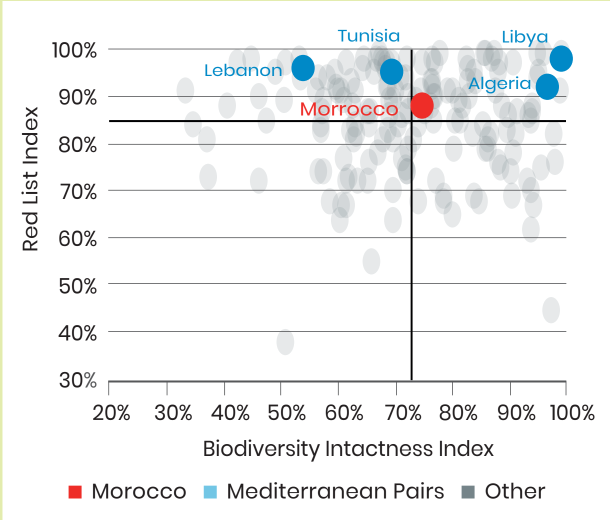
The general trend for biodiversity is towards degradation. Among the 2,630 species identified in Morocco on the International Union for Conservation of Nature (IUCN) Red List, 9 are extinct and 300 are endangered. This is the highest number of endangered species among peer countries in the Mediterranean basin (**Graph 24**). The risk to endangered species is reflected by a score of 88% on the Red List Index,[17] one of the lowest in the region. The rate of degradation is considered irreversible for certain species, particularly for those located around cities and in the Rif region. Marine ecosystems are also suffering from the effects of overexploitation linked to fishing activities. Morocco is the leading fish producer in Africa, as well as the world's leading producer of sardines and small pelagic species, whose populations are declining at an alarming rate while accounting for 80% of the country's fishing potential. Finally, soil degradation is intensifying, characterized by water and wind erosion, as well as an increase in salinization and pollution. However, the country's position remains generally under control for two biodiversity integrity measurements: the Biodiversity Intactness Index and the Red List Index, both of which are slightly above the global average (**Graph 25**).

Graph 24: Number of endangered species referenced on the IUCN Red List




Source: IUCN.

Graph 25: Morocco's position on the biodiversity integrity indicators




*N.B.:* The axes intersect at the global averages
Source: Philipps *et al.* (2021), IUCN.

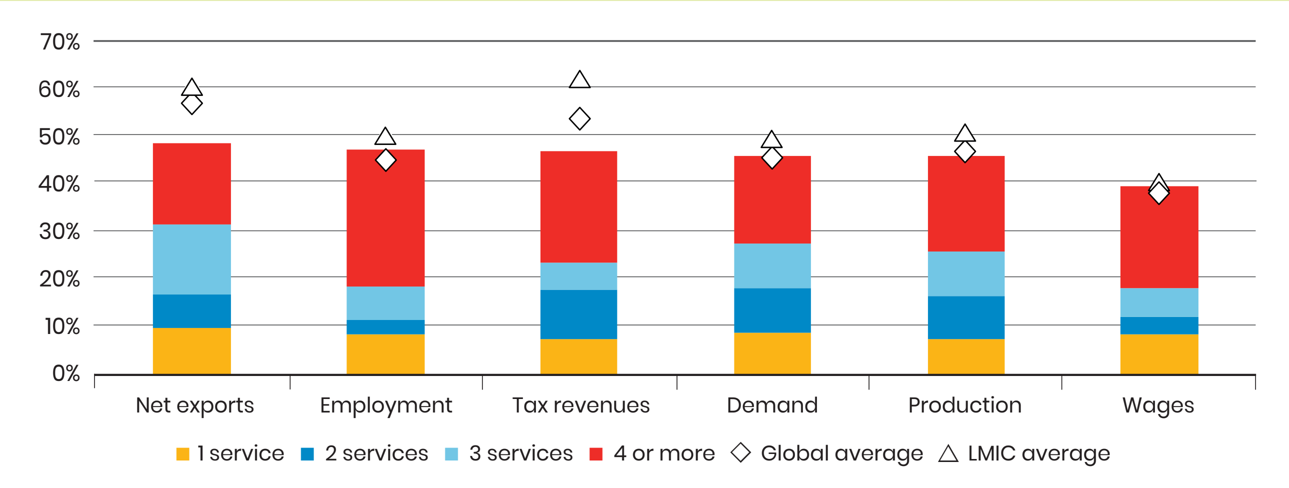
[17] The Red List Index shows trends in the overall extinction risk for groups of species. A value of 100% indicates that there is currently no extinction risk for any of the species included. A value of 0% means that all the species included are extinct.

The main causes of biodiversity loss are, in particular, habitat fragmentation, degradation and loss, pollution, water management, invasive species, overexploitation and climate change (Kingdom of Morocco, 2016). These pressures primarily stem from human activities and the country's increasing urbanization, but also from natural threats including desertification and climate change. The consequences are multiple, the main ones being a reduction in the availability of natural resources, increased risks for water resources and soil impoverishment, which especially threaten the country's agricultural activity.

### Socio-economic exposure to biodiversity risks

#### *Biodiversity-related physical risk*

Graph 26: Morocco's exposure to biodiversity-related physical risk by socio-economic indicator (% of total)

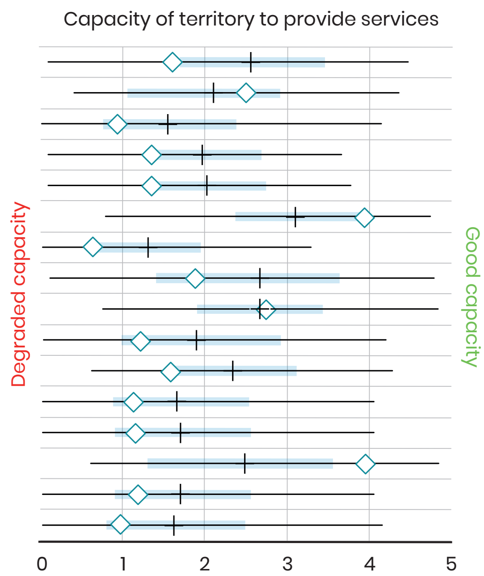



Source: Authors' calculations.

We measure the contribution of economic activities exposed to a biodiversity-related physical shock by examining these activities' dependencies on ecosystem services. The contribution of these "exposed" economic activities to the degradation of ecosystem services is high. The external accounts appear to be the most exposed, with nearly 50% of exports (net of intermediate imports) heavily dependent on at least one ecosystem service (**Graph 26**). Similarly, around 45% of employment, tax revenue, demand and production, as well as 40% of wages, are generated by activities dependent or highly dependent on at least one ecosystem service. While they are high in absolute terms, these levels generally remain below world averages and those for LMICs, which on average have less diversified economies than Morocco.

Graph 27: Dependence of the Moroccan economy on ecosystem services

| Ecosystem service | Exp. | Tax rev. | Sal. | Empl. | Dem. | Prod. |
|---|---|---|---|---|---|---|
| Biomass provisioning | 12% | 13% | 13% | 20% | 10% | 11% |
| Water supply | 38% | 25% | 23% | 31% | 23% | 27% |
| Storm mitigation | 13% | 19% | 18% | 26% | 17% | 16% |
| Solid waste remediation | 1% | 1% | 1% | 2% | 1% | 1% |
| Air filtration | 0% | 0% | 0% | 0% | 0% | 0% |
| Biological control | 12% | 12% | 12% | 19% | 9% | 9% |
| Flood control | 16% | 22% | 21% | 27% | 17% | 19% |
| Genetic material | 12% | 13% | 13% | 20% | 10% | 11% |
| Pollination | 10% | 11% | 11% | 18% | 8% | 8% |
| Water purification | 38% | 28% | 29% | 36% | 28% | 29% |
| Soil quality regulation | 11% | 11% | 11% | 19% | 8% | 10% |
| Rainfall pattern regulation | 18% | 28% | 22% | 29% | 23% | 23% |
| Global climate regulation | 16% | 14% | 15% | 21% | 9% | 11% |
| Water flow regulation | 38% | 25% | 23% | 31% | 23% | 27% |
| Local climate regulation | 11% | 11% | 12% | 19% | 8% | 9% |
| Soil and sediment retention | 14% | 27% | 20% | 27% | 23% | 22% |

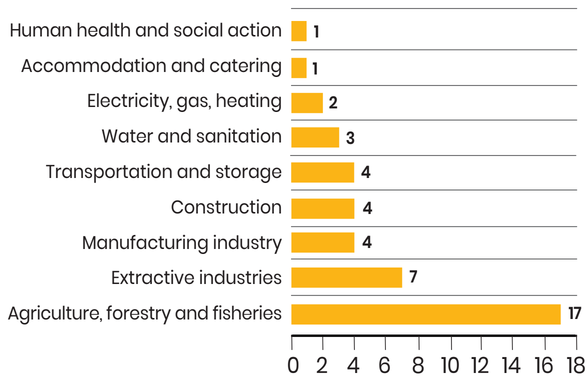



Interquartile range ◇ Morocco + World average — Min-Max

Source: Authors' calculations.

Three sectors dominate among the activities exposed to a shock to ecosystem services and play a key role in the Moroccan economy: manufacturing industries[18] (15% of GDP in 2019), agriculture, forestry and fisheries (12% of GDP), and construction (6% of GDP). Depending on the indicator, the exposed activities of these three sectors represent between two-thirds and three-quarters of the country's total exposure. There are multiple dependencies, with between 18 and 36% of employment depending on a large number of ecosystem services (**Graph 27, left side**). Water-related services (supply and regulation) are particularly important, contributing to a significant share of economic activity. The Moroccan agriculture sector is a specific issue given the multitude of ecosystem services on which it relies, 17 in total (**Graph 28**).

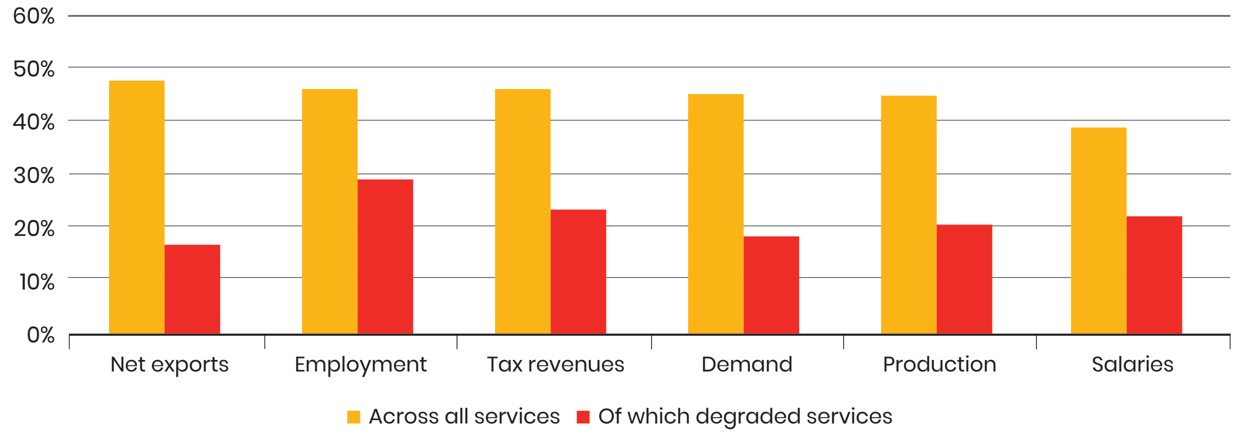
Graph 28: Number of essential ecosystem services by sector




Source: Authors' calculations.

[18] Manufacturing industries are typically major water consumers and therefore depend on water supply, purification and flow regulation services.

Graph 29: Morocco's exposure to biodiversity-related physical risk depending on the state of ecosystem services (% of total)



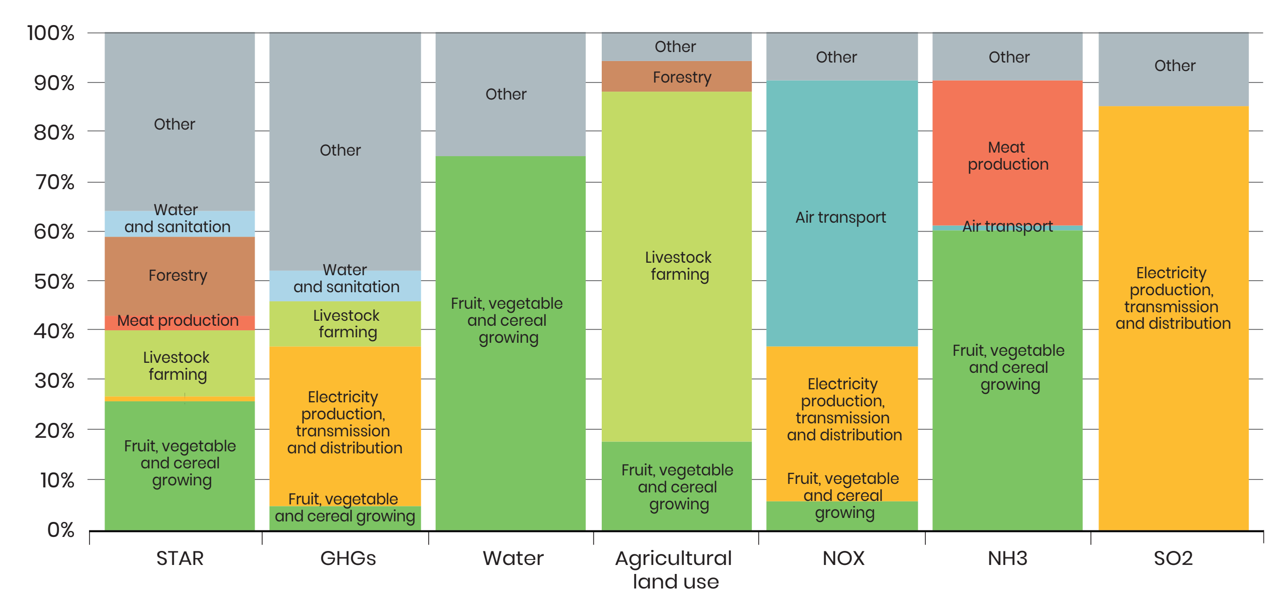

Source: Authors' calculations.

A preliminary analysis of Morocco's land cover suggests that several ecosystem services may be degraded (**Graph 27, right side**). Indeed, the scores for the provisioning capacity of four ecosystem services (biomass supply, solid waste remediation, air filtration and flood control) are below the first quartile of the country sample. Economic activities that depend heavily on these degraded ecosystem services would thus be especially threatened. They account for 17% of exports, 18% of demand, 21% of production, 22% of wages, 24% of tax revenue and 30% of employment (**Graph 29, red bars**). At first glance, ecosystem services for water supply and water flow regulation appear to be largely preserved, but face considerable pressure, in particular due to climate change. A significant degradation of these services would undermine between a quarter and two-fifths of socio-economic indicators and would also exacerbate the effects of the chronic drought in the country.

***Biodiversity transition risk***

To identify economic activities that would be potentially exposed to a biodiversity transition shock, we analyze their contributions to the pressures exerted on biodiversity at the national level (**Graph 30**). In total, these pressures are primarily attributable to seven economic activities that account for between 52% (greenhouse gas emissions, GHGs) and 94% (agricultural land use) of Morocco's pressures. The contributions of these economic activities vary by type of pressure. While the electricity sector is the primary source of GHGs and nitrogen oxide and sulfur dioxide pollution, fruit, vegetable and cereal growing plays a major role in water consumption and ammonia pollution, as well as in direct threats to endangered species (as measured by the STAR score). In view of their significant contributions to the pressures on Morocco's biodiversity, these activities are potentially exposed to a ramping up of public conservation policies.

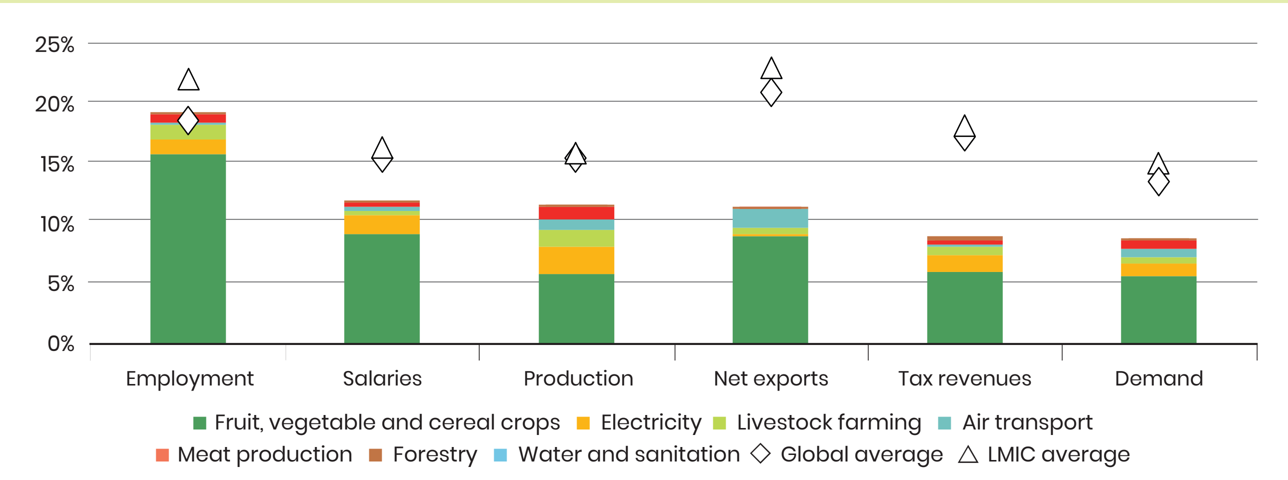
Graph 30: Contributions of Morocco's economic activities to a selection of pressures on biodiversity (% of total)




Source: Authors' calculations.

The contribution of these "exposed" activities to Morocco's socio-economic indicators is relatively moderate by international comparison. In total, they account for 9% of tax revenue and demand, 11% of net exports and 12% of wages and production (**Graph 31**). Employment is most at risk, with an exposure at 19%. These levels remain well below the average levels for all countries globally and for LMICs, with the exception of employment. The exposure is highly concentrated in the agriculture sector, particularly for fruit, vegetable and cereal growing, which accounts for between half and four-fifths of the country's socio-economic exposure depending on the indicator.

Graph 31: Morocco's exposure to the biodiversity transition risk by socio-economic indicator (% of total indicator)




Source: Authors' calculations.

While the levels of exposure are moderate, the probability of a transition shock, particularly concerning water consumption, is relatively high. Indeed, the droughts in the country and the growing tensions on traditional sources (dams and groundwater, for example) could prompt the authorities to implement an increase in water tariffs, rationing measures, or a tightening of regulations to limit water-intensive crops.

### Public policies on conservation

#### *Ambitions, objectives, strategic directions*

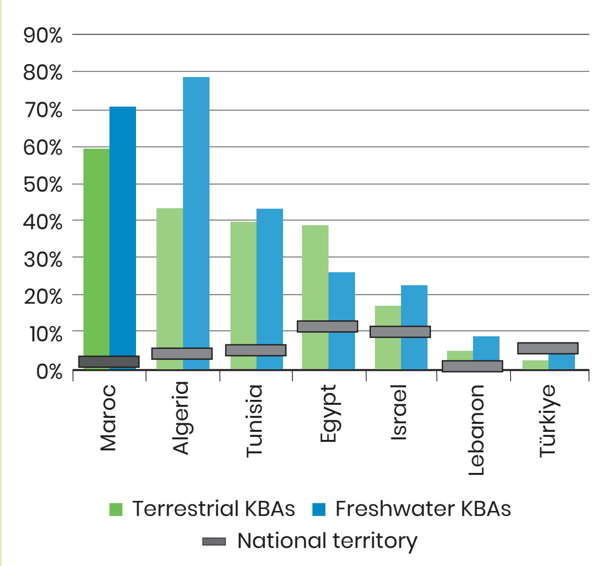
Approved in 2016, the National Biodiversity Strategy and Action Plan (NBSAP) 2016-2020 sets six strategic priorities and 26 operational objectives that aim primarily to: A) reinforce the conservation of species and ecosystems; B) ensure the sustainable use of biodiversity; C) contribute to improving the living conditions of people by strengthening natural capital; D) strengthen biodiversity governance; E) improve and develop knowledge of biodiversity; and F) catalyze changes in citizen behavior towards biodiversity (Kingdom of Morocco, 2016). The National Sustainable Development Strategy, adopted in 2017, incorporates the Sustainable Development Goals, as well as the Nationally Determined Contributions (NDCs) for the climate. Natural resources and biodiversity are among the priority issues, with a focus on water supply for user sectors, soil quality and conservation policies.

#### *Implementation and capacity for action*

The Sixth National Report on the Implementation of the Convention on Biological Diversity of 2019 makes a positive assessment of the measures and actions associated with Morocco's NBSAP (Kingdom of Morocco, 2019). As of early 2019, almost half of the 26 operational objectives were on track, 11 showed tangible but insufficient progress, and only three showed no significant change. Similarly, the majority of the measures implemented have been effective (23%) or partially effective (58%), while only 5% have been evaluated as being ineffective. The most effective measures taken by the State appear to be for the strategic priorities A, C, E and F.

The expansion of protected areas was launched in 1996 with the National Strategy for Protected Areas, which identified critical ecosystems and led to the creation of protected areas. This was reinforced by the 2010 Law on Protected Areas, which required the development of management plans for these areas. The share of key biodiversity areas (KBAs) thus increased from 20% in 2000 to approximately 60% in 2022, positioning Morocco first among peer countries in the Mediterranean basin (**Graph 32**). Similarly, a review of the 1995 Master Plan for Protected Areas is due to be presented at the end of 2025 and will testify to the modification of zoning and the creation or extension of new protected areas.

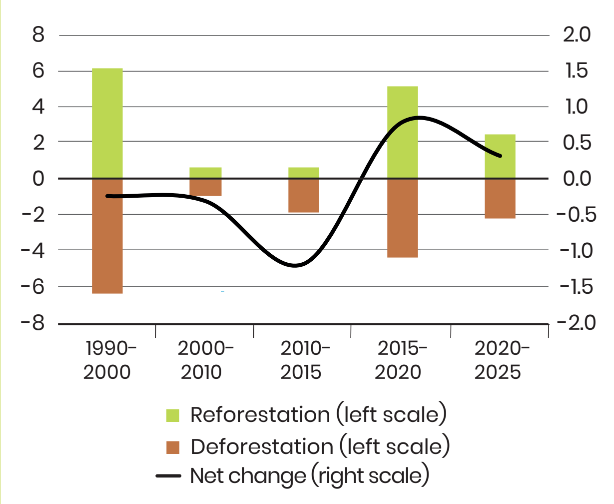
Graph 32: Territorial coverage of protected areas (% of total surface area)




Source: World Bank, FAO.

At the same time, the country has conducted a relatively effective policy for the restoration of forest cover, firstly through the National Forestry Program launched in 2005 and supported by laws to combat desertification and protect the environment, as well as revisions to the Forestry Code in the early 2000s. The Forests of Morocco Strategy 2020-2030 now sets the objectives for reforestation and reversing forest cover loss and is to be implemented by the newly created National Agency for Water and Forests. These efforts are reflected in the increase in the share of forests covered by a long-term management plan (which rose from 20% to 60% between 2000 and 2020) and, especially, a reversal of the deforestation trend as of 2015, which is estimated to have resulted in a net expansion of forest cover of 5,500 hectares according to data from the FAO Global Forest Resources Assessment (**Graph 33**).

Graph 33: Estimated average changes in Morocco's forests (1,000 hectares)




Source: FAO.

While these are positive developments, conservation efforts are still insufficient to reduce the substantial and persistent pressures on Morocco's constantly declining biodiversity. Water scarcity and the erosion of soil biodiversity are major challenges that will put pressure on biodiversity and for which public policy responses are likely to materially affect the agriculture sector. The National Water Plan focuses on a diversification of resources, including non-conventional water (graywater reuse, for example) and efficiency gains, in particular through irrigation. The authorities could also implement measures to curb demand and balance trade-offs in uses to prevent the total depletion of resources, which would have detrimental effects on agricultural productivity.

## Interactions between Morocco's biodiversity risk and sovereign risk

### *Overview of Morocco's sovereign risk*

Graph 34: Overview of the strengths and weaknesses of Morocco's sovereign profile

| Factors of resilience | Factors of fragility |
|---|---|
| • Sound macroeconomic policies<br>• Strong support from official creditors<br>• Favorable debt profile<br>• Comfortable foreign exchange reserves | • Low level of development and per capita GDP<br>• Governance gaps<br>• High public debt<br>• Contingent liability risks<br>• Exposure of the economy to climate risks |

Source: Fitch, Moody's, S&P.

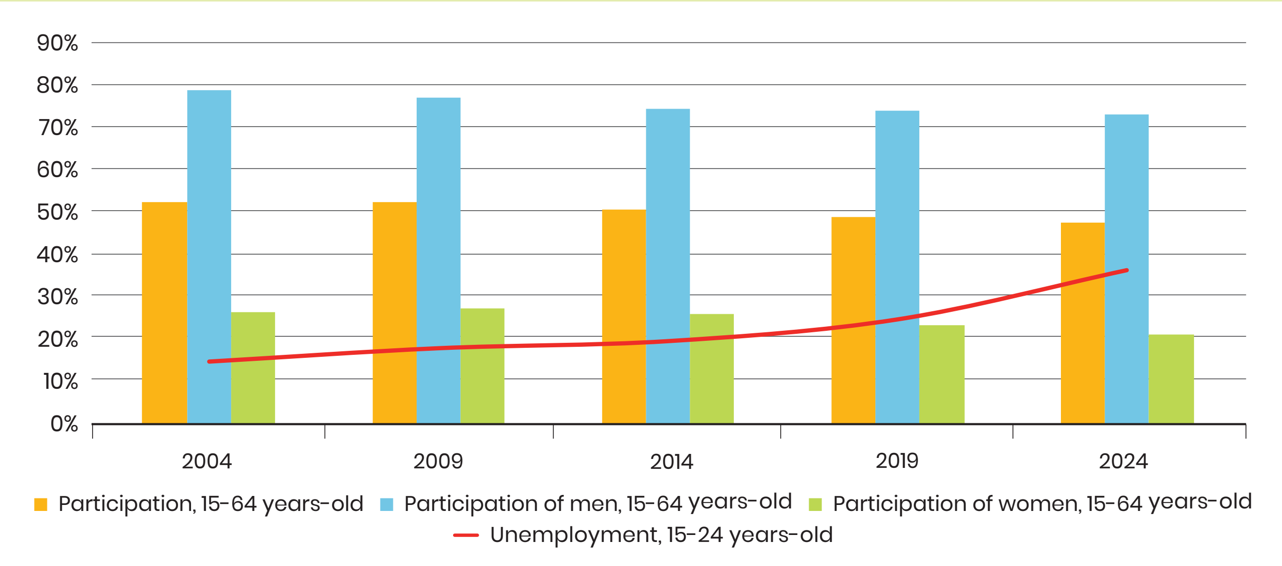
Morocco's sovereign risk, as measured by the sovereign ratings of the Big Three, is relatively high. While the country was one of the few African countries to benefit from an "investment grade" rating between 2007 and 2021, the economic and budgetary impact of the Covid-19 crisis led the rating agencies to downgrade it to "speculative grade". In September 2025, S&P upgraded Morocco's rating to BBB-, while Fitch and Moody's assigned a BB+ rating, implying a still relatively high credit risk. Among the country's structural weaknesses, the rating agencies mention its low level of human development, gaps in its governance indicators, its relatively high public debt, the risks associated with its high contingent liabilities, and its high exposure to climate risks (**Graph 34**).

Morocco is not among the countries with a double vulnerability to biodiversity risk-sovereign risk, as its exposure is below the world average in terms of both physical risk and transition risk. This contrasts with other LMICs whose rates of double vulnerability are relatively high: 76% of LMICs have at least one double vulnerability to biodiversity risk (physical or transition) and sovereign risk. Beyond the drivers of vulnerability mentioned below, other authors have highlighted the materiality of biodiversity risks for Moroccan credit quality. In their study, Agarwala *et al.* (2024) estimate that Morocco's sovereign rating could lose up to three notches[19] in a scenario of partial collapse of a selection of ecosystem services, meaning an increase in the probability of default of more than 10%.

***Driver of vulnerability 1: The labor market***

Among the drivers of vulnerability, the significant exposure of jobs to the country's biodiversity risks (~20% exposed to transition risk, ~75% exposed to physical risk) is a major challenge. Indeed, the Moroccan labor market has several chronic vulnerabilities (**Graph 35**): the labor force participation rate (44%) is one of the lowest in the world, has been declining since the early 2000s, and especially affects women (participation rate of 19%). Similarly, unemployment is very high and primarily affects young people (37% for 15-24 yearolds). This is a major obstacle to the country's economic and human development. It is also one of the structural weaknesses highlighted by the rating agencies. Yet the materialization of biodiversity risks could affect job creation and lead to a rise in unemployment, especially in the agriculture sector. The sector is already seeing job losses, with 137,000 job losses in 2024 after 202,000 job losses in 2023 (Haut Commissariat au Plan, 2025).

Graph 35: The growing challenges of Morocco's labor market



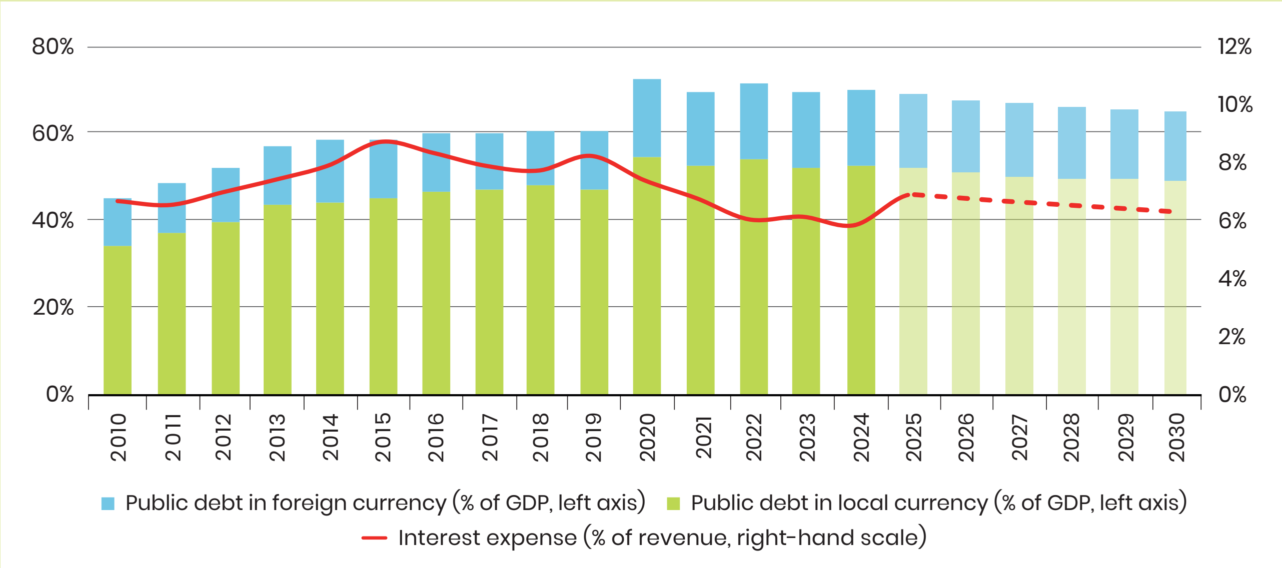

Source: Haut Commissariat au Plan, World Bank.

[19] On a 20-notch scale ranging from AAA (20) to CC/C/D (1).

***Driver of vulnerability 2: The debt trajectory***

The materialization of biodiversity risks could also undermine the public debt trajectory. At 70% of GDP in 2024, public debt is high for an LMIC country in relation to its public revenue (29% of GDP) and increased significantly during the Covid-19 crisis. For now, and after years of increases, it is on a downward trajectory, bolstered by relatively favorable growth and the reduction of the public deficit from 4.1% in 2024 to 3.1% by 2030 (**Graph 36**). While the government plans to increase public revenue, 75% is exposed to biodiversity-related physical risk (exposure to transition risk is more contained, at 9%). An erosion of public revenue would have adverse effects on several public finance metrics. At first, it would automatically lead to an increase in the deficit and interest burden (expressed as a percentage of revenue). It could subsequently also threaten the downward trajectory of public debt. The positive public finance dynamics would thus be undermined and one of the country's structural weaknesses – high public debt – would not be addressed and could be further compounded.

Graph 36: Trajectory of public debt and interest burden

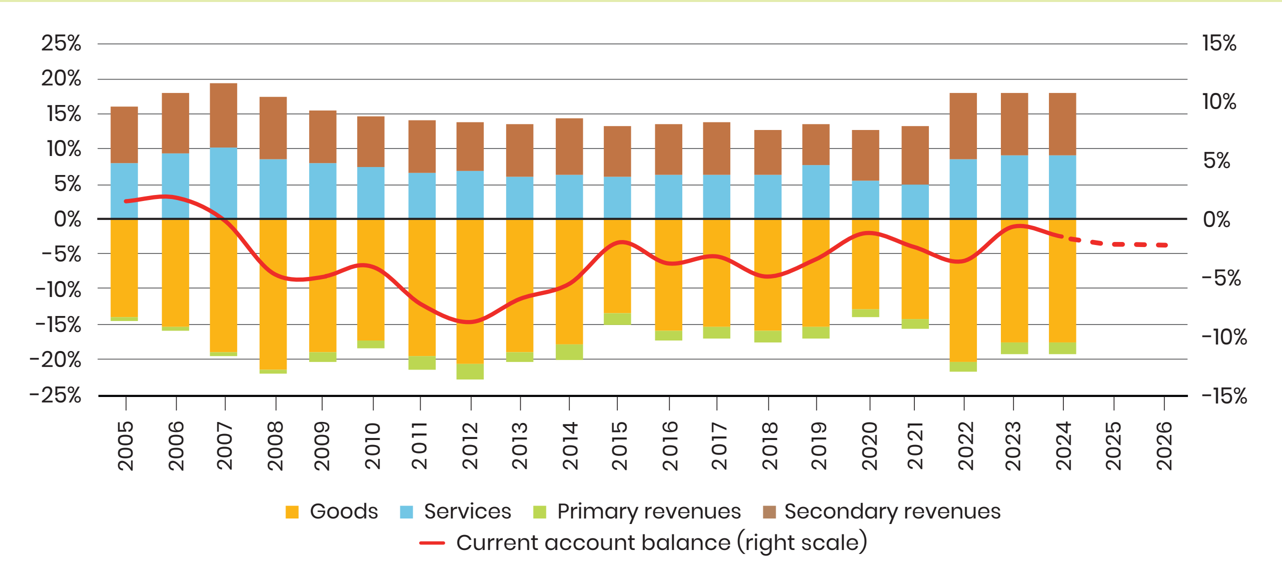



Source: IMF, authors' calculations.

***Driver of vulnerability 3: External accounts***

Finally, the external accounts and the level of foreign exchange reserves are also at risk. While Morocco's current account has improved significantly since the early 2010s, it continues to be characterized by structural deficits, in particular due to significant deficits in the balance of goods (~16% of GDP on average over the past decade, **Graph 37**), which are only partially offset by its surpluses in services (6.9% of GDP) and migrant remittances (categorized as secondary revenue in the graph: 7.7% of GDP). The partial reduction of these deficits has allowed the country to rebuild its reserves. They now stand at around $40 billion, or 5.6 months of imports, which are considered comfortable levels. However, the current account deficit is expected to widen again, notably as a result of an anticipated increase in imports. This represents a limited risk for the country, which also benefits from substantial external financing. However, a decline in exports linked to activities exposed to biodiversity risks (71% for physical risk, 11% for transition risk) could further widen the current account deficit. Without external financial flows to offset this, the level of reserves would drop, thus undermining one of the strengths of the country's sovereign profile.

Graph 37: Current account (% of GDP)




Source: IMF, authors' calculations.

## 6. Conclusion

While the analysis of biodiversity-related risks is complex and can be further improved, the emergence of a rich and multidisciplinary literature over recent decades has provided a better understanding of the interrelation between nature and the economy. It has also provided new modeling techniques and analytical frameworks. The methodology of Maurin, Calas and Godin (2025) offers new perspectives for comparable analyses of the exposure of socio-economic indicators to biodiversity-related physical and transition risks for a large sample of countries.

The comparison of the results highlights significant disparities between countries faced with these risks. Firstly, direct exposure to biodiversity risks differs depending on the level of development. Indeed, LICs on average appear to be among the most exposed to direct biodiversity-related physical risk, as their economic activities are highly dependent on ecosystem services provided by their domestic natural capital. In terms of transition risk, the socio-economic indicators of LICs also seem to be the most exposed, as their economic activities seemingly exert more pressures on local biodiversity. In contrast, HICs appear to be less directly exposed to biodiversity risks.

The economic structure of countries appears to be a determining factor in the levels of exposure. Indeed, the level of development of the service sector in countries accounts for much of the disparities in terms of exposure, as service activities are less dependent on ecosystem services and exert less pressure on biodiversity. Similarly, countries that export raw materials (agricultural, mining and energy) appear to have an economic structure especially prone to biodiversity risk. This highlights the importance of economic diversification as a potential avenue to build resilience to biodiversity risks.

While HICs, economies that are more diversified, more service-oriented and have a low level of raw material production, appear to be less directly exposed to biodiversity risks, this primarily reflects their integration into international trade. Indeed, a large share of their consumption is based on products that depend on raw materials exported by EDCs. The pressures exerted on biodiversity and dependencies on ecosystem services are thus largely outsourced. For these countries, the nature of the biodiversity risk appears to be more indirect. It is therefore essential to estimate these indirect effects, taking all the value chains into account, to fully appreciate biodiversity risks globally.

Given the magnitude of biodiversity risks for countries' macro-fiscal and socio-economic trajectories, the implications for sovereign risk can be material. Here again, there are marked disparities depending on the level of development. All the LICs analyzed have a double biodiversity and macro-financial vulnerability, while HICs appear to have more room for maneuver in addressing these risks. However, the sovereign risk of all countries is subject to biodiversity risks, as shown by the case of Morocco. Although the country is not one of the most exposed to biodiversity risks, their materialization could exacerbate several structural weaknesses or undermine its resilience factors. This underscores the importance of integrating more systematically nature-related factor in financial risk analyses such as credit ratings.

The analysis and measurement of biodiversity risk and their potential implications for a country's socioeconomic indicators can inform the implementation of public policies on conservation and support the transitions of the most exposed sectors. In this respect, progress towards achieving Target 15 of the Kunming-Montreal Global Biodiversity Framework, on the documentation by businesses and financial institutions of their dependencies and impacts on biodiversity, would help gain a better understanding of the risks and define the measures to address them.

For decision-makers, the public policy response needs to reflect the nature of the risks their countries face. All countries need to take steps to reduce pressures on biodiversity at the national level.

Moreover, advanced economies should also take into account the ecological footprint that their demand exerts on the rest of the world, especially in EDCs exporting raw materials. If well-designed, trade policies, such as the EU Deforestation Regulation, can be powerful tools to reduce the domestic consumption of products with a high ecological footprint and promote the adoption of more virtuous practices for biodiversity internationally.

The robustness and accuracy of these analyses of biodiversity risk could be improved in the future through methodological developments and a greater granularity of databases. The results at national level can thus be supplemented by more detailed analyses through the spatialization of risks and their economic consequences within a country (see Hadji-Lazaro *et al.*, 2025, for South Africa), the decomposition within economic sectors of the diversity of practices with different ecological footprints and, finally, the identification, beyond the risks, of the opportunities offered by the implementation of conservation and transition policies.

## 7. List of acronyms and abbreviations

| | |
|---|---|
| **DC** | Developing country |
| **EUDR** | European Union Deforestation Regulation |
| **FAO** | Food and Agriculture Organization of the United Nations |
| **GHG** | Greenhouse gase |
| **HIC** | High-income country |
| **IUCN** | International Union for Conservation of Nature |
| **KBA** | Key biodiversity area |
| **LIC** | Low-income country |
| **LMIC** | Lower-middle-income country |
| **NBSAP** | National Biodiversity Strategy and Action Plan (Morocco) |
| **NDC** | Nationally Determined Contribution |
| **UMIC** | Upper-middle-income country |

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# 9. Appendix

## Appendix I — The main databases used in the analysis [20]

### ENCORE

The Exploring Natural Capital Opportunities, Risks and Exposure database was developed by Global Canopy, the United Nations Environment Programme Finance Initiative (UNEP FI) and the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC). It provides a series of datasets designed to help financial institutions and companies assess both their dependence on nature and their impact on the environment. In terms of dependencies, the links between economic sectors and ecosystem services have been established through an extensive literature review of each ecosystem service and the relevant production processes, supplemented by interviews with sector experts.

ENCORE assigns five levels of importance to the potential dependencies (materiality ratings) of 615 NACE sectors with regard to 25 ecosystem services, which help assess the extent to which production processes could be disrupted by the degradation of these services. It is the only comprehensive data sourcencurrently available covering dependencies across all economic sectors. However, the list of ecosystem services is not exhaustive and the tool is not geographically specific, meaning it applies uniform dependency assessments globally, despite variations in production processes and dependence on ecosystems across regions.

This database is used to establish the dependencies between economic activities and ecosystem services in order to estimate exposure to biodiversity-related physical risk.

### GLORIA EE-MRIO

The GLORIA (Global Resource Input-Output Assessment) database is a multi-regional input-output (MRIO) database created by the University of Sydney for the United Nations International Resource Panel (UN IRP) for the update of the material footprint accounts that are part of the UN IRP material flow database. To exploit synergies between different UNEP initiatives, it was decided to also use GLORIA as the underlying MRIO model for the Sustainable Consumption and Production Hotspot Analysis Tool (SCP-HAT).

The database makes it possible to track trade activities between countries (more than 160 in total) by economic activity (more than 120 in total). It traces how the goods and services from one sector are used as inputs for the activities of others. Beyond economic data throughout the value chain, the GLORIA database contains satellite accounts on the social and environmental impacts of economic activities. Environmental impacts include energy and water consumption, land use, greenhouse gas emissions and pollutants.

This database is used to estimate the contributions of economic activities to the pressures on biodiversity in the assessment of transition risks. It is also used to estimate the share of socio-economic indicators exposed to biodiversity-related physical and transition risks.

[20] A more detailed presentation of how these data are used for exposure modeling is provided in Maurin, Calas and Godin (2025), on which this content is based.

**IUCN Red List**

Established in 1964, the International Union for Conservation of Nature Red List of Threatened Species has become the world's most comprehensive source of information on the extinction risk of animal, fungi and plant species worldwide. It lists more than 170,000 species, including more than 48,000 endangered species, assessing their extinction risk based on scientific data, field surveys and expert evaluations.

This database is used in conjunction with GLORIA data to estimate the contributions of economic activities to the threats to endangered species, meaning the calculation of the STAR metric.

# Appendix II — List of countries in the sample analyzed

| Low-income countries | Lower-middle-income countries | Upper-middle-income countries | High-income countries |
|---|---|---|---|
| Afghanistan | Angola | Albania | Australia |
| Burkina Faso | Bangladesh | Algeria | Austria |
| Burundi | Benin | Argentina | Bahamas |
| Central African Republic | Bhutan | Armenia | Bahrain |
| Chad | Bolivia | Azerbaijan | Belgium |
| DR Congo | Cambodia | Belarus | Brunei Darussalam |
| Eritrea | Cameroon | Belize | Bulgaria |
| Ethiopia | Congo | Bosnia and Herzegovina | Canada |
| Gambia | Côte d'Ivoire | Botswana | Chile |
| Liberia | Djibouti | Brazil | Croatia |
| Madagascar | Egypt | China | Cyprus |
| Malawi | Ghana | Colombia | Czech Republic |
| Mali | Guinea | Costa Rica | Denmark |
| Mozambique | Haiti | Cuba | Estonia |
| Niger | Honduras | Dominican Republic | Finland |
| Rwanda | India | Ecuador | France |
| Sierra Leone | Jordan | El Salvador | Germany |
| Somalia | Kenya | Equatorial Guinea | Greece |
| South Sudan | Kyrgyzstan | Gabon | Hungary |
| Sudan | Laos | Georgia | Iceland |
| Syria | Lebanon | Guatemala | Ireland |
| Togo | Mauritania | Indonesia | Israel |
| Uganda | Morocco | Iran | Italy |
| Yemen | Myanmar | Iraq | Japan |
| | Nepal | Jamaica | Kuwait |
| | Nicaragua | Kazakhstan | Latvia |
| | Nigeria | Libya | Lithuania |
| | Pakistan | Macedonia | Luxembourg |
| | Palestine | Malaysia | Malta |
| | Papua New Guinea | Mexico | Netherlands |
| | Philippines | Moldova | New Zealand |
| | Senegal | Mongolia | Norway |
| | Sri Lanka | Namibia | Oman |
| | Tajikistan | Paraguay | Panama |
| | Tanzania | Peru | Poland |
| | Tunisia | Serbia | Portugal |
| | Uzbekistan | South Africa | Qatar |
| | Vietnam | Thailand | Romania |
| | Zambia | Türkiye | Russia |
| | Zimbabwe | Turkmenistan | Saudi Arabia |
| | | Ukraine | Singapore |
| | | | Slovakia |
| | | | Slovenia |
| | | | South Korea |
| | | | Spain |
| | | | Sweden |
| | | | Switzerland |
| | | | United Arab Emirates |
| | | | United Kingdom |
| | | | United States of America |
| | | | Uruguay |

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