



# Integrating Nature into Debt Sustainability Analysis



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Centre for  
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# Integrating Nature into Debt Sustainability Analysis

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The views expressed in this paper are those of the authors alone. Any errors are our own.



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SOAS University of London

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For more information, visit <https://www.soas.ac.uk/centre-for-sustainable-finance/>

# Executive Summary

Awareness of nature and biodiversity risks to the global economy is on the rise among investors and policy-makers alike. Financial authorities and financial markets are deepening their scrutiny of the link between environmental risks and economic and financial outcomes. It is now critical that nature risks are properly integrated into macro-financial risk analysis in general, and debt sustainability analysis in particular.

While the International Monetary Fund (IMF) has started to incorporate climate risks into its key surveillance and monitoring exercises, including its frameworks for Debt Sustainability Analysis (DSA), it has not yet started to address nature-related risks. By omitting them, the IMF's DSAs miss significant economic and financial risk.

This report highlights the importance of integrating nature-related risks into DSAs and shows how it can be done.

It does not only demonstrate that including nature is possible, but also provides compelling quantitative evidence that the inclusion of nature collapse scenarios is necessary to provide a full picture of debt sustainability risks to sovereigns.

To stay as close as possible to the practice applied by the relevant multilateral institutions, the report proposes a four-step process for integrating nature-related risks into the debt sustainability framework for market access countries used by the IMF. This methodology is subsequently applied to six countries – Bangladesh, Brazil, Canada, Indonesia, Nigeria and Vietnam – using novel World Bank estimates of the macroeconomic cost of a partial collapse of ecosystem services. These collapse scenarios relate to the production of forestry and fisheries products, pollination and other services directly provided by nature.

The results show that nature loss matters for debt sustainability. For Bangladesh and Vietnam, the partial collapse of ecosystem services would eclipse all other stress scenarios in severity. This includes the IMF's combined macro-fiscal stress scenario, in which the IMF lumps together individual macro shocks. For Indonesia and Nigeria, nature is the second-largest shock, only behind the combined IMF shock.

For Bangladesh, the country in the sample most affected by the partial nature collapse scenario, the debt-to-GDP ratio would rise by 15 percentage points to 56% within a year after the shock, compared to the baseline scenario without shock. In comparison, Bangladesh's debt ratio increased by merely 4 percentage points between 2019 and 2021 (from 36% to 40% of GDP). In other words, the nature collapse shock would be between three and four times as damaging to Bangladesh's debt sustainability than even the pandemic has been. Similarly, gross financing needs would rise sharply when ecosystem services collapse as deficits rise, and GDP shrinks.

For Indonesia, a partial nature collapse would increase debt-to-GDP ratio by over 11 percentage points to exceed 63%. GDP would shrink by 11%, which is almost 4 percentage points more than the COVID pandemic caused. Brazil would see an increase in the debt-to-GDP ratio of 7 percentage points while its GDP would fall by over 4% in the case of a partial nature collapse. Nigeria's debt-to-GDP ratio would grow by over 13 percentage points and GDP decrease by 9.5%.

Without considering nature-related risks, the IMF's DSAs will for many countries misdiagnose the true risks to debt sustainability, leading to erroneous policy recommendations and increasing the risk of avoidable debt crises.

The debt sustainability assessment resulting from the Fund's DSAs has important consequences. The DSA-classification may have repercussions on governments' market access or the need to outright restructure public sector obligations. It powerfully drives the macro-conditionality of IMF-sponsored economic programmes.

**It is therefore imperative that the IMF and World Bank introduce biodiversity and natural capital risks into their DSAs and other analytical frameworks for macroeconomic and financial risk analysis.**

By developing a global macroeconomic model that is linked to a suite of science-driven environmental economic models of ecosystem service provision, the World Bank has laid the groundwork for incorporating scenarios for the macroeconomic consequences of nature loss into DSAs. Given the significance of nature-related risks for economic prosperity and development, failing to integrate nature-related risks into DSAs and other macroeconomic and financial risk assessments would be a grave omission.

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## 1

# Introduction

Nature and biodiversity loss are progressing at the fastest rate in human history and constitute a major threat to economic development and debt sustainability. Sustaining the organisms, ecosystems, and processes that underpin human well-being is necessary to achieve sustainable development and, by extension, sustainable debt.

Yet nature keeps disappearing at a rapid and accelerating pace. Current extinction rates are 100 to 1,000 times higher than the long-term baseline rate (Pimm et al. 1995). As pointed out by the Dasgupta report – an independent review on the economics of biodiversity for the UK Treasury – many ecosystems have already been degraded beyond repair or are at imminent risk of ‘tipping points’ (Dasgupta 2021). The stock of natural capital per person has declined by nearly 40% in just over twenty years through 2014. Biodiversity-related tipping points and the resulting loss of ecosystem services could have disastrous economic consequences. The ubiquitous retreat of nature is not just a problem for insects, polar bears, and orangutans. Irrefutable evidence has been mounting for years that loss of biodiversity can also pose a serious threat to societies and economies. Nature and biodiversity are not “nice-to-haves”. Biodiversity affords natural systems with productivity, resilience and adaptability.

Awareness of biodiversity risks to economies is on the rise among investors and policy-makers alike. Financial authorities and financial markets are deepening their scrutiny of the link between environmental risks and economic and financial outcomes. Research that has been confirmed by the International Monetary Fund (IMF) has shown how climate change can amplify sovereign risk, worsen sovereign credit ratings, and undermine debt sustainability.<sup>1</sup> While the focus to date has been on climate risks, nature and biodiversity risks are increasingly recognised as potentially material risks to financial and macroeconomic stability<sup>2</sup>, particularly in many developing countries where natural capital makes up a higher share of total wealth. Agarwala et al. (2022) show that many countries would face significant downgrades of their sovereign credit ratings under partial ecosystem services collapse scenarios.

Mirroring steps taken to analyse and address climate risks, central banks are starting to assess biodiversity risk for finance (van Toor et al. 2020, Svartzman et al. 2021), while a Task Force for Nature-related Financial Disclosures (TNFD) was launched in June 2021 (TNFD 2021). The Network for Greening the Financial System (NGFS), a global group of more than 100 central banks and supervisors, has also begun to take a keen interest in the impact of biodiversity on financial stability, having launched a dedicated study group on this topic in June 2021. Building on the findings of this study group,<sup>3</sup> the NGFS (2022: 2) has asserted “that nature-related risks, including those associated with biodiversity loss, could have significant macroeconomic implications, and that failure to account for, mitigate, and adapt to these implications is a source of risks for individual financial institutions as well as for financial stability”.

It is now critical that nature risks are properly integrated into macro-financial risk analysis in general, and debt sustainability frameworks in particular. While the IMF has started to incorporate climate risks into its key surveillance and monitoring exercises, including Article IV consultations, Financial Sector Assessment Programs, and its frameworks for Debt Sustainability Analysis (DSA),<sup>4</sup> it has so far stopped short of attempting to introduce biodiversity and natural capital risks into its analytical frameworks. By omitting nature risks, DSAs miss a significant economic and financial risk. Such partial DSAs will therefore in many countries misdiagnose the true state of debt sustainability, leading to erroneous policy recommendations and increasing the risk of avoidable debt crises.

The debt sustainability assessment resulting from the Fund's DSAs have important consequences. The DSA-classification may have repercussions on governments' market access or the need to outright restructure public sector obligations. It powerfully drives the macro-conditionality of IMF-sponsored economic programmes. The Fund is currently working on an enhancement of its DSA framework and plans to include more explicitly the repercussions of climate change on debt sustainability. Yet, the IMF has so far stopped short of attempting to introduce biodiversity and natural capital risks into its DSA frameworks. This omission needs fixing. Nature risks should be included in the Fund's DSA framework.

Against this backdrop, this report highlights the importance of integrating nature risks into DSAs and shows how it can be done. To stay as close as possible to the practice applied by the relevant multilateral institutions, we propose a four-step process for integrating nature risks into the debt sustainability framework for market access countries used by the IMF. To test our approach, we apply this methodology to six countries – Bangladesh, Brazil, Canada, Indonesia, Nigeria and Vietnam – using novel World Bank estimates of the macroeconomic cost of a partial collapse of ecosystem services (Johnson et al. 2021). These ecosystem services collapse scenarios relate to the production of forestry and fisheries products, pollination and other services directly provided by nature.

Our results show that nature loss matters for debt sustainability. For Bangladesh and Vietnam, the collapse of biodiversity would eclipse all other stress scenarios in severity, including the IMF's combined macro-fiscal stress scenario, in which the IMF lumps together individual macro shocks. For two further countries (Indonesia and Nigeria), nature is the second-largest shock, only behind the combined IMF shock. Although the estimated GDP effects in the nature shock scenario are relatively small for Brazil, the debt-to-GDP ratio would still rise by 7 percentage points. For Canada, the only advanced economy in the sample, the nature shock is almost immaterial.

For Bangladesh, the country in the sample most affected by the partial nature collapse scenario, the debt-to-GDP ratio would rise by 15 percentage points to 56% within a year after the shock, compared to the baseline scenario. In comparison, Bangladesh's debt ratio increased by merely 4 percentage points between 2019 and 2021 (from 36% to 40% of GDP). In other words, the nature collapse shock would be between three and four times as damaging to Bangladesh's debt sustainability as the Covid-19 pandemic has been. Similarly, Bangladesh's gross financing needs would rise sharply when ecosystem services collapse as deficits rise, and GDP shrinks.

In this report, we do not only demonstrate that including nature-related risks into DSAs is possible. We also provide compelling quantitative evidence that its inclusion is necessary to provide a full picture of debt sustainability risks to sovereigns. The IMF and the World Bank ought to introduce biodiversity and natural capital risks into their analytical frameworks for macroeconomic and financial risk analysis, including DSAs. By developing a global macroeconomic model that is linked to a suite of science-driven environmental economic models of ecosystem service provision (Johnson et al. 2021), the World Bank has laid the groundwork for incorporating scenarios for the macroeconomic consequences of nature loss into DSAs. Given the significance of nature-related services for economic prosperity and development, failing to integrate nature-related risks into DSAs and other macroeconomic and financial risk assessments would be a grave omission.

The remainder of this report is structured as follows. Section 2 highlights why biodiversity- and nature-related risks matter for debt sustainability. Section 3 makes the case for incorporating nature-related risks into DSAs. Section 4 presents our methodological approach for doing so. Section 5 subsequently presents and discusses our empirical results. Section 6 concludes with policy recommendations.

## 2

# Why biodiversity and nature-related risks matter for debt sustainability

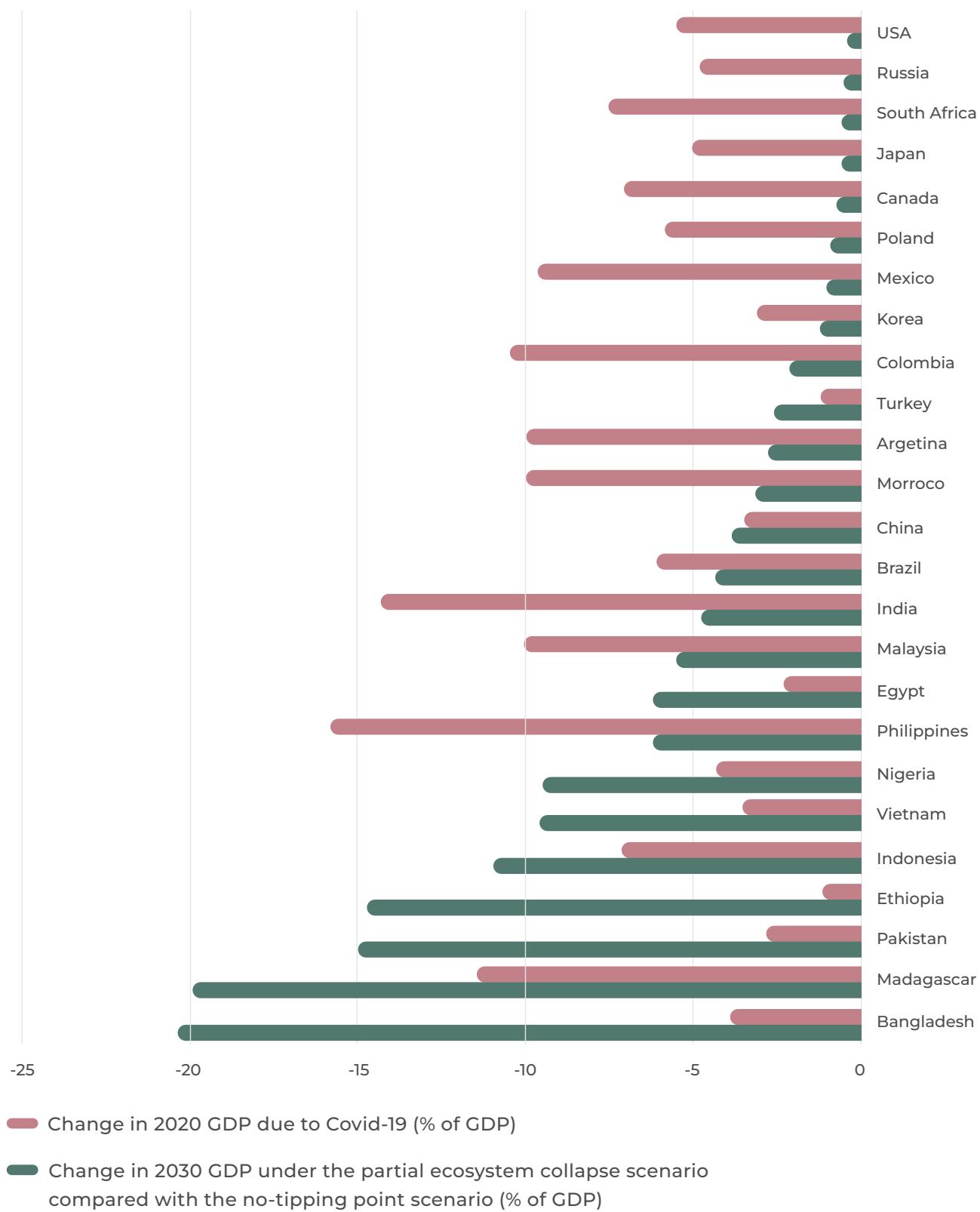
Overuse of renewable natural resources can affect a country's economy in multiple ways, ultimately impacting its ability to manage its public debt. Overwhelming nature's reproductive capacity is equivalent to overusing physical infrastructure, allowing it to be run down year after year, with only partial replacement through new investments. Such a negligent strategy to roads, rails and power lines would hurt economic development and hence debt sustainability over the longer term. The same applies to the depletion of our natural capital, with the difference that certain ecosystems, once lost, cannot be restored. Excess demand beyond nature's ability to reproduce or reinvest in its bio-stock will also lead to economic reverberations, the size of which will depend on the structure of an economy. It will also depend on the prosperity of a country. The macroeconomic impact of a collapse of ecosystem services will in turn affect public finances and therefore the government's debt sustainability.

A collapse of nature will have more adverse economic effects than the Covid-19 pandemic for many countries. There is now a compelling body of research pointing to the critical role played by nature driving economic productivity and growth. Nature is increasingly recognised as a central precondition for our sustained subsistence and prosperity. The World Economic Forum estimates that more than half of the world's annual GDP depends at least to a meaningful extent on nature (World Economic Forum 2020). That share can be significantly higher for some countries, especially for less developed ones, which are often particularly dependent on natural capital.

In a new landmark report, the World Bank estimates that, in a conservative scenario, a collapse in select nature services could result in a decline in global GDP amounting to \$2.7 trillion in 2030 (Johnson et al. 2021), equivalent to over 3% of current world GDP. In 40% of the countries covered, the impact of a nature collapse on the economy would be more severe than that of the Covid-19 contraction in 2020 (Figure 1). The estimated GDP losses from ecosystem services collapse are the largest for low and lower-middle-income countries (Figure 2). It is indisputable that such orders of magnitude are shocks that will severely impact a government's debt sustainability.

**Figure 1**

GDP loss following major shocks (in %)



**Note:** GDP loss due to Covid 19 (depicted in the red bars) is calculated as the difference between the IMF's GDP growth forecast for 2020 in its October 2019 World Economic Outlook and the actual recorded GDP growth for 2020.

**Source:** Compiled with data from Johnson et al. (2021) and the IMF's Historical World Economic Outlook Forecasts Database, October 2021 (IMF 2021a).

**Figure 2**

Change in 2030 real GDP under the partial ecosystem collapse scenario compared to the no-tipping point scenario by geographic region and income group (in %)



**Source:** Compiled with data from Johnson et al. (2021).

The impact of degrading biodiversity will depend on the structure of an economy. Economies that depend to a larger extent directly on the productivity of natural resources (e.g. agriculture, fisheries, forestry) will be most impacted as their productive capacity declines. But this is not the only transmission channel:

Economic sectors depending on intact nature and biodiversity will see their output potential decline (e.g. ecotourism or the incipient global carbon offset market).

Many advanced and developing countries depend critically on the export of primary commodities, many of which will require an intact habitat to be sustainable.

Countries running down their biodiversity (e.g. to expand the intensive cultivation of cash crops) will run risks of trade restrictions by importing countries as sustainable supply chain legislations become more binding. For similar considerations, investors may begin to charge a risk premium for debt issued by sovereigns reducing their natural endowment. A higher interest burden will increase credit risk and raise interest further, potentially setting off a vicious circle.

As a nation's natural endowment declines, the need for additional food imports adds to the risks to the sustainability of the balance of payments and external debt.

The macroeconomic impact of a collapse of ecosystem services will in turn affect public finances and therefore the government's debt sustainability.

Government debt has already reached dangerous levels in much of the biodiversity-rich economies; nature risks amplify macro-financial risks and threaten debt sustainability. Debt sustainability has come under mounting pressure in emerging and developing economies (EMDEs), many of which are heavily dependent on nature. Public debt as a share of GDP has been on the rise for that country group every single year since 2010 and will surpass 70% in 2024, according to IMF staff estimates (IMF 2021b), almost twice the level from a decade ago. Similarly, debt service now accounts for 43% (2021) of EMDE's exports, from an average of 28% during 2006-2010. A debt crisis is simmering in many parts of the developing world. The risk of biodiversity collapse multiplies debt sustainability risks.

## 3

# Including climate change into DSA is only the first step. Nature must follow!

The IMF has begun to include climate risks in its standard DSA tools. Since 2018, the DSA module for low-income countries (LIC) includes a climate stress test, focusing primarily on physical risk, such as climate-induced natural disasters. The IMF's recent Review of the Debt Sustainability Framework for Market Access Countries marked an important milestone as it recommended: "to incorporate long-term macroeconomic implications of climate change" for "[c]ountries with existential or high vulnerability to climate change per exposure, susceptibility and adaptive capacity" (IMF 2021d). The review recommends that DSAs include projections for growth impacts and additional climate change spending and their impact on debt ratios over 30 years. Importantly, it recommended the inclusion of the cost of mitigation strategies to respond effectively to the transition risks towards a less carbon-intensive world economy. These are important and welcome steps and deserve praise.

But the DSA tools used by the IMF still disregard nature risks. The Fund has begun to explicitly reflect nature risks in its economic assessments (Article IV) of some of its member countries.<sup>5</sup> This is a welcome development. But these remain isolated cases. It is time for the IMF to start introducing biodiversity and natural capital risks systematically into its DSA frameworks.

The argument for the inclusion of nature risks in DSAs is compelling. Contrary to climate change, which is a largely global phenomenon caused by global greenhouse gas emissions, the threat to biodiversity can be more localised. A coal-fired power plant in China will have the same marginal impact as hurricane risks in the Caribbean as a similar coal-fired power plant in Germany. But cutting down the biologically diverse rainforest in Sumatra to set up monocultural plantations will not meaningfully affect natural capital in the forest in the Congo basin or the Chesapeake Bay. The spatial concentration of ecosystems providing critical services to humans makes the economic impact of its degradation more regionally attributable than climate change. Nine-tenths of critical "natural infrastructure" is concentrated in only 39% of land and 24% of ocean area. The local impact of nature loss is therefore well suited to be applied to nationally applied DSAs.

Moreover, like climate risk, nature risk is prone to sudden phenomena known as tipping points. Biodiversity loss can be self-reinforcing, rapidly accelerating what had previously been a more gradual deterioration in biodiversity. Consider the Amazon. Model results suggest that when more than 40% of the original extent of the Amazon Forest becomes deforested, rainfall decreases significantly across eastern Amazonia (Sampaio et al. 2007). It has been suggested that this may be a tipping point beyond which forest loss causes climate impacts which cause further forest loss. Once this point of no return has been crossed, the abundant biodiversity embedded in the Amazon will be subjected to a vicious circle leading to a rapid transformation of rainforest into savannah. Changing patterns of rainfall will be one direct consequence, with longer and hotter dry spells, making Brazil's large agricultural sector unviable. Export and tax revenues will be hit, and debt sustainability will be undermined.

Climate change and biodiversity loss are closely interlinked. Climate change exacerbates risks to biodiversity and natural and managed habitats; at the same time, natural and managed ecosystems and their biodiversity play a key role in the fluxes of greenhouse gases, as well as in supporting climate adaptation. Climatic conditions will continue to change and become more volatile, even if mankind were to become carbon-neutral tomorrow. This implies that the risks to the depletion of the quantity and quality of biodiversity are bound to rise for some time to come.

Nature risks to debt sustainability will become increasingly prominent and no longer just a "green swan" tail-risk. For evermore regions and countries, those risks will rise in materiality, especially if the natural endowment is locally exploited in an unsustainable manner. Accordingly, continuing to omit nature risk from DSAs would become an ever more glaring omission of a growing threat to debt sustainability.

However, integrating nature risks into DSAs is not without problems. Like climate change, the risks of nature loss are non-linear. Nature tipping points can have a significant impact but are hard to predict. Moreover, the analysis is complicated by a lack of reliable data to quantify nature risks. DSAs are fundamentally quantitative models.

If risks cannot be quantified, however remotely, they cannot be incorporated into a DSA analysis without jeopardising the credibility of the entire DSA exercise.

Natural capital data have been only partially developed in most countries, reflecting a lack of common metrics and monetary values. Existing accounts are often incomplete in their scope and valuation measures (e.g. market vs. nonmarket values) (Brandon et al. 2021). Yet, this downbeat assessment is not fully reflective of the advances made in quantifying the risks that depletion of nature can pose to individual countries' economies.

The data is getting better and now allows for real progress on nature-enhanced DSAs. Ground-breaking research by World Bank-sponsored research has made it possible to estimate the decline of GDP that could be caused by a collapse of nature services by the end of the current decade (Johnson et al. 2021). Such services comprise, for example, natural pollination and human harvesting from marine and forest resources. While this research cannot predict with precision when and how severe nature collapses will occur (or indeed, whether they will occur at all), it allows for the first time for a point estimate of the economic decline that would follow should such an event occur.

This is exactly the type of quantitative foundation on which scenario analysis and stress tests are built. Against the backdrop of rapidly improving data quality for tracking biodiversity loss and its economic implications, it is now becoming possible to conduct credible scenario analysis and stress testing that allow for the incorporation of nature risks into DSAs. Indeed, given the significance of nature losses for macroeconomic and financial stability in many countries, not doing so would undermine the credibility of DSAs.

Building on the experiences with climate risk analysis, the most promising approach to incorporate nature into DSAs is therefore via scenario analysis and nature-stress tests. In the following, we will lay out how DSAs can be developed to include nature risk.

# 4

# Methodological approach

To stay as close as possible to the practice applied by the relevant multilateral institutions, we have chosen the debt sustainability framework (DSF) for market access countries used by the IMF (2021c). This approach is also appropriate because the countries we will be investigating are generally classified as having governments with access to capital markets. The IMF template is Excel-based and publicly available on the IMF website.<sup>6</sup> A methodological annex describes in detail how the template is to be used.

The nature of the analysis makes the template very data-heavy and any significant part of the work consists of collecting the relevant data from different sources. We use data mostly from official international sources such as the IMF. The main source for macroeconomic forecasts through 2026 is the World Economic Outlook of October 2021 (IMF 2021b). Data from national authorities and complementary private sector sources such as rating agencies are also applied selectively where official international sources do not provide the needed information.

The DSF is providing a consistent and replicable framework to assess debt sustainability through the medium term. It also allows the user to apply specific scenarios of adverse shocks. In this context, we will apply a scenario representing the economic and fiscal ramifications off a sudden and substantial loss of biodiversity.

We apply a four-step process for integrating nature risks into DSAs:

**1**

Identifying the economic impact of biodiversity loss

**2**

Determining the resulting size and structure of the government borrowing requirement

**3**

Adjusting the funding costs for government debt

**4**

Implementing assumptions into debt sustainability template

# First step: Identifying the economic impact of biodiversity loss

To size the shock of a sudden drop in biodiversity and the ecological services provided by nature, we draw on the World Bank's report *The Economic Case for Nature* (Johnson et al. 2021). This study broke new ground by estimating on a country level the macroeconomic cost of a partial collapse of the services provided by nature, measured in terms of potential GDP loss. A global general equilibrium model is linked to a suite of science-driven environmental economic models of ecosystem service provision, covering pollination, timber provision, fisheries, and carbon sequestration. The framework paints a landscape of possible scenarios of the interaction between these ecosystem services and the economy to 2030.

Figure 1 displays the estimates of GDP losses for a partial ecosystem collapse scenario derived by the World Bank. The numbers presented reflect the impact of a hypothetical rapid collapse of many nature services by 2030, following the crossing of tipping points. Since the timing of crossing those tipping points cannot be predicted, the 2030-time frame is first and foremost for illustrative purposes. It is a simulation, not a prediction. The tipping points can be reached earlier or later, or indeed not at all. If and when the critical threshold will be crossed will depend on country-specific circumstances. To take account of the facts that 2026 is the outer-most year that can be modelled by the IMF DSA template and that the IMF's macroeconomic forecasts we use to populate the template currently extend up to 2026 as well, we therefore, standardise our simulations by assuming that the partial collapse of biodiversity services will spread over two years (2025 and 2026). The GDP hit is distributed equally between those two years.

Using World Bank data has the benefit of enhancing the relevance of nature shocks for the official debt sustainability analysis of the Bretton Woods institutions. While the IMF typically takes the lead in the DSA over the short to medium term, the analysis is a collaboration between the Fund and the Bank with the latter focusing on longer-term structural issues, including climate change impacts. With our research, we demonstrate that nature shock scenarios can and should be included as well in the framework applied by the Bretton Woods institutions.

## Second step: Determining the resulting size and structure of the government borrowing requirement

The technical assumptions required to make an estimate the budgetary and debt implications of the nature collapse scenario take elements from a methodology developed by ratings agency S&P Global to assess the respective impacts caused by natural disasters (Kraemer et al. 2015). We modify that methodology to reflect the different characteristics of the implications of a collapse of nature. For example, we exclude fiscal cost for reconstruction, which is a factor in the aftermath of a natural disaster, but not for our purposes. Destroyed physical infrastructure can be rebuilt by spending money. Depleted nature cannot. Reconstruction cost is therefore not a relevant issue here, even if governments may increase other expenditure items in an attempt to mitigate the negative economic and social consequences of the collapse of biodiversity.

Accordingly, we assume that government revenue as a share of GDP will remain constant after crossing the tipping point. Since GDP will have declined in real terms, so would revenue. Primary government spending, i.e., excluding interest payments, is expected to rise by one percentage point of GDP in 2025 and another one percentage point in 2026. This assumption reflects governments' aforementioned attempts to cushion the economic blow caused by the collapse of ecosystem services, along the line of what has been observed during the pandemic.<sup>7</sup> In combination, declining real revenue and rising real primary expenditure will increase the government's borrowing requirement, to which additional interest cost will have to be added.

The government's interest outlays depend on the debt structure (especially tenor and currency composition) as well as on the assumptions on future borrowing practises between now and the onset of the shock. We assume that governments will not modify their hitherto observed debt management practices. In other words, tenor and currency composition remain unchanged from the observed debt structure.

Since some government debt is in foreign currency, we need a method to model exchange rate movements. If the local currency depreciates, foreign debt becomes more expensive to service and debt sustainability experiences further pressure.

When the nature shock hits beginning in 2025, we assume a depreciation of the effective exchange rate in proportion to the growth shock, reflecting the pressure on the current account resulting from the loss of export capacity and increase in imports to offset falling domestic production. For example, a cumulative GDP loss over 2025 and 2026 caused by a sudden biodiversity loss of 10% would lead to a depreciation of 15% distributed evenly over both years.

These exchange rate movements exceed what has been observed during the pandemic shock in 2020. We believe this is appropriate as 2020 was a global shock affecting all countries to varying degrees, whereas the current scenario models an idiosyncratic economic shock to an individual country. The impact on the exchange rate should therefore be larger than in the pandemic scenario.

The impact on the government debt ratio, which is the key metric for debt sustainability, will partly be mitigated by an increase in inflation (and thus the GDP deflator). Inflation increases as the currency depreciates. Given the recessionary environment following the negative shock caused by the partial collapse of ecosystem services, we assume a relatively low elasticity, meaning that the feed-through is quite limited.

An increase of the nominal exchange rate (which is equivalent to depreciation) by one percentage point will lead to an inflationary impulse of 0.25 percentage points. It is identical to the standard IMF pass-through assumption for emerging economies. The IMF does furthermore apply an inflation (and thus GDP deflator) dampener in its GDP growth shock scenario: for each percentage point GDP decline the Fund assumes that inflation will decline by 0.2% points (both relative to baseline). If we were to apply this relationship, the mitigating factor of depreciation-induced inflation described above would be partially or fully offset by recession-induced deflation, depending on the intensity of the GDP loss relative to baseline. Since we do not apply the deflationary impact of GDP losses the results can be considered conservative. Introducing recession-induced deflation would make the resulting debt ratios somewhat larger and thus also the risks to debt sustainability.

## Third step: Adjusting the funding costs for government debt

Other things being equal the interest burden of government debt depends on the size of the debt burden relative to the size of the economy. It is important to keep in mind that the increase in interest rates will impact government finances and thus debt sustainability only to the extent that the government issues new debt. The debt outstanding before the shock hits will continue to be serviced at the interest rates that prevailed at the time of issuance. The full burden of increasing interest rates in line with an increasing debt burden will only be felt after several, sometimes many years when a substantial part of the outstanding debt with lower interest rates will have been rolled over into new debt at higher interest rates. If there is only a short spike in interest rates on government debt followed by a swift normalisation, the overall impact of interest outlays on public finances will be modest. The shorter the average maturities are, the faster-deteriorating funding conditions will feed into debt sustainability.

The nature shock will reduce economic output and resilience and is likely to impair the country's growth potential going forward. It is therefore reasonable to assume that creditors will demand compensation for higher credit risk. Interest rate spreads are therefore expected to rise, and the effective interest burden will increase in tandem. The global interest rate environment will not be affected by the country-specific nature crisis. The global interest rate environment, in contrast, will remain unchanged, as the nature crisis in the country under consideration will not influence global central bank policies or inflation expectations embedded in safe assets such as US-Treasuries. This approach is in line with deteriorating funding conditions of governments hit by a big idiosyncratic shock like a natural disaster (Mallucci 2020).

Specifically, we assume that the effective interest rate on debt issued after nature's collapse will be proportional to the severity of the economic impact. No empirical observation exists concerning such a scenario unfolding that could provide robust guidance on how strong the interest rate reaction might be. We, therefore, make the following technical assumption, which appears reasonable considering the generally observed fluctuations of sovereign funding conditions in national and international capital markets. In 2025 the government securities yield curve moves upward in parallel by a quarter of the cumulative GDP loss caused by biodiversity collapse. For example, if GDP shrinks by 10%, the yield curve shifts up by 2.5%. As the nature collapse scenario continues in the following year (2026), investors get additionally cautious and we expect that the yield curve moves up an additional 50%, in the example from 2.5% to 3.75%.

## Fourth step: Implementing assumptions into the debt sustainability template

In the final step, we bring all the forecasts and assumptions together in the IMF's debt sustainability template. We run two separate simulations. The first excludes the impact of changing funding costs, whereas the second one does explicitly include the assumptions on rising interest rates (the third step described in the preceding paragraphs). We calculate the two standard key metrics used by the IMF, namely the debt to GDP ratio and the gross financing needs as a share of GDP. Those metrics are calculated up to 2026, the outer year of the DSA template.

## 5

# Discussion of empirical results

We ran debt sustainability analyses for six countries (see Table 1). Our sample includes one advanced economy (Canada), one emerging economy that the World Bank assumes is less severely affected by biodiversity loss (Brazil), and four which are heavily affected, with an impact of around 10% of GDP or more (Bangladesh, Vietnam, Indonesia, and Nigeria). The GDP loss assumptions are identical to those depicted in Figure 1 and are shown in parenthesis next to the country names. To provide some context regarding the severity of the nature collapse scenario, we also ran the standard stress scenarios applied by the IMF. They are all displayed in Table 1. The countries are ordered left to right by descending GDP loss (in parenthesis next to the country names).

For each scenario, we calculate the outcome in the year 2026 for the two fundamental DSA variables: government debt to GDP (in the first column under each country label) and the government's gross financing needs as a share of GDP (second column). For example, under the base case in Bangladesh, the public debt ratio would be at 40.8% of GDP (up from 37.3% in 2022). A standard IMF primary fiscal balance shock would lead to a debt ratio of 41.6% in 2026. This is only a mild increase versus the 2026 debt load under the base case (40.8%). The partial nature collapse scenario, on the other hand, would drive up the debt ratio to 56% in 2026 and be a little higher at 56.6% if we allow for increasing borrowing costs in the aftermath of declining biodiversity. The lower panel of Table 1 shows the difference in the ratios compared to the 2026 base case.

To make the data easier to compare, the data is colour coded for each country and each variable. Red implies being the most severe of all scenarios and light green the least impactful one. The colour coding is identical in both panels of table one as the lower panel is merely a transformation of the upper panel. Note that the colour coding is applied for each column separately. It indicates, which is the most severe scenario for a given country. For example, the combined macro shock scenario is the most severe for Canada's financing requirement and therefore shaded red (4% higher than the base case, see lower panel). That does not preclude the possibility that other countries may have impacts on their respective financing requirements above 4% highlighted in a colour lighter than deep red (e.g. the nature collapse scenario Indonesia is 4.2% and shown in orange).<sup>8</sup>

**Table 1**

Summary table: The colour coding is applied for each column separately and indicates the most severe scenario for a give country. Red implies the most severe of all scenarios, light green the least impactful one.

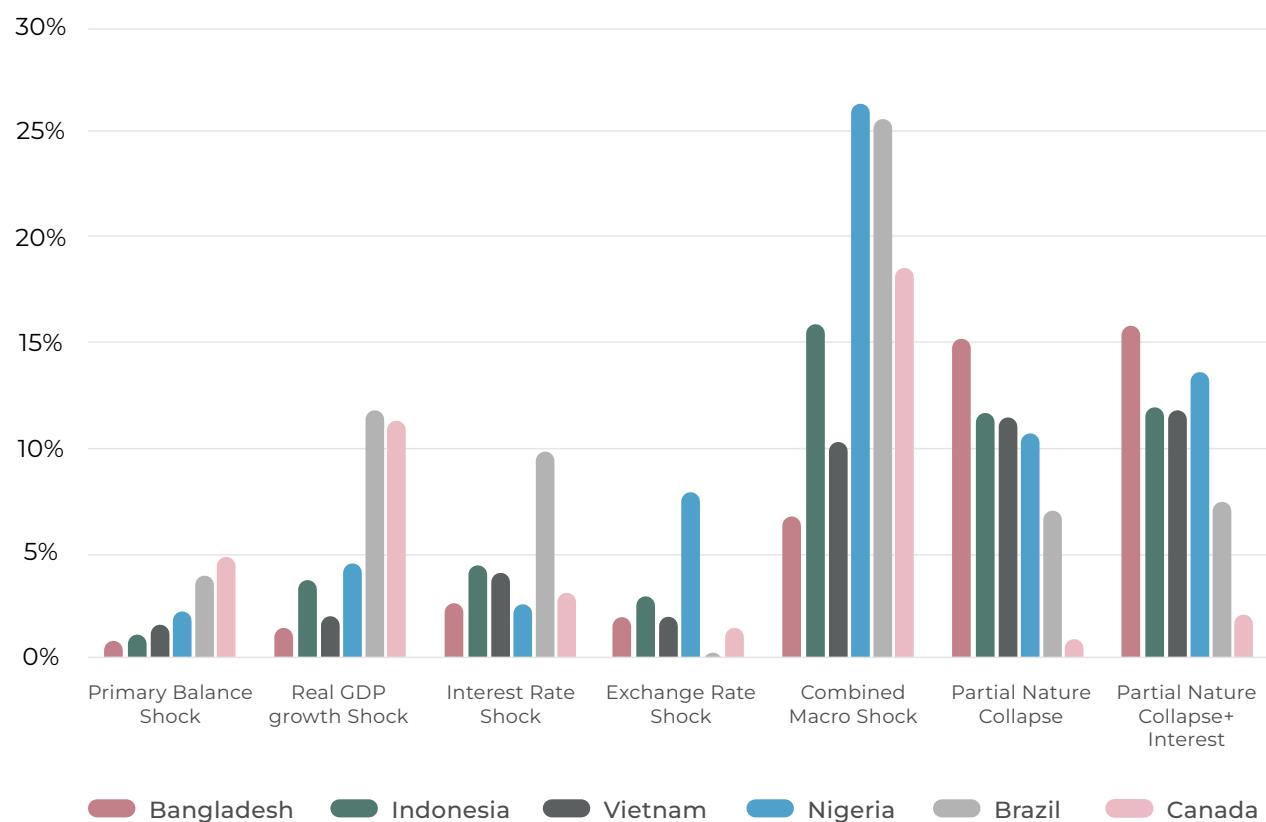
Bangladesh (-20.4%)		Indonesia (-11.0%)		Vietnam (-9.6%)		Nigeria (-9.5%)		Brazil (-4.4%)		Canada (-0.7%)	
% of GDP	GG Debt/GDP	Gross Financing Needs/GDP	GG Debt/GDP								
Base Case 2022	37.3%	9.0%	46.7%	10.9%	52.4%	12.6%	46.7%	10.9%	100.5%	21.1%	115.9%
Base case 2026	40.8%	11.5%	51.9%	14.8%	55.3%	14.7%	62.4%	18.2%	127.5%	33.0%	122.4%
Primary Balance Shock	41.6%	11.7%	53.0%	15.1%	56.9%	15.0%	64.6%	18.8%	131.4%	33.8%	127.2%
Real GDP growth Shock	42.2%	11.8%	55.6%	15.7%	57.3%	15.2%	66.9%	19.4%	139.2%	35.7%	133.7%
Interest Rate Shock	43.4%	12.7%	56.3%	17.0%	59.3%	16.6%	64.9%	19.5%	137.3%	37.7%	125.5%
Exchange Rate Shock	42.7%	11.9%	54.8%	15.6%	57.3%	15.2%	70.3%	20.4%	118.3%	30.9%	123.8%
Combined Macro Shock	47.5%	13.8%	67.8%	20.1%	65.5%	18.0%	88.8%	26.0%	153.1%	41.5%	141.0%
Partial Nature Collapse	56.0%	16.4%	63.5%	19.0%	66.8%	18.5%	73.1%	23.4%	134.5%	35.9%	123.3%
Partial Nature Collapse + Interest	56.6%	17.0%	63.8%	19.3%	67.1%	18.9%	76.1%	23.4%	134.9%	36.2%	124.5%
%points change vs baseline	GG Debt/GDP	Gross Financing Needs/GDP	GG Debt/GDP								
Primary Balance Shock	0.8%	0.2%	1.1%	0.3%	1.6%	0.3%	2.2%	0.6%	3.9%	0.8%	4.8%
Real GDP growth Shock	1.4%	0.3%	3.7%	0.9%	2.0%	0.5%	4.5%	1.2%	11.7%	2.7%	11.3%
Interest Rate Shock	2.6%	1.2%	4.4%	2.2%	4.0%	1.9%	2.5%	1.3%	9.8%	4.7%	3.1%
Exchange Rate Shock	1.9%	0.4%	2.9%	0.8%	2.0%	0.5%	7.9%	2.2%	-9.2%	-2.1%	1.4%
Combined Macro Shock	6.7%	2.3%	15.9%	5.3%	10.2%	3.3%	26.4%	7.8%	25.6%	8.5%	18.6%
Partial Nature Collapse	15.2%	4.9%	11.6%	4.2%	11.5%	3.8%	10.7%	5.2%	7.0%	2.9%	0.9%
Partial Nature Collapse + Interest	15.8%	5.5%	11.9%	4.5%	11.8%	4.2%	13.7%	5.2%	7.4%	3.2%	2.1%

Source: Compiled by authors.

For Bangladesh and Vietnam, the collapse of biodiversity would eclipse all other stress scenarios in severity. The impact on debt sustainability eclipses even the combined macro-fiscal stress scenario, in which the IMF lumps together the individual macro shocks. For Indonesia and Nigeria, nature is the second-largest shock, only behind the combined IMF shock. For Canada, the only advanced economy in the sample, the nature shock is almost immaterial. Unsurprisingly, this finding that countries in the Global South are more affected by the risk of nature collapse, resonates with the findings of the World Bank report, whose data is being used to size the nature shock.

Figures 3 and 4 illustrate the impact of the multiple shock scenarios on the two debt sustainability variables (debt ratio in Figure 3 and financing requirement in Figure 4) by comparing the outcome to the base case without any shocks. They graphically depict the content of the lower panel of Table 1.

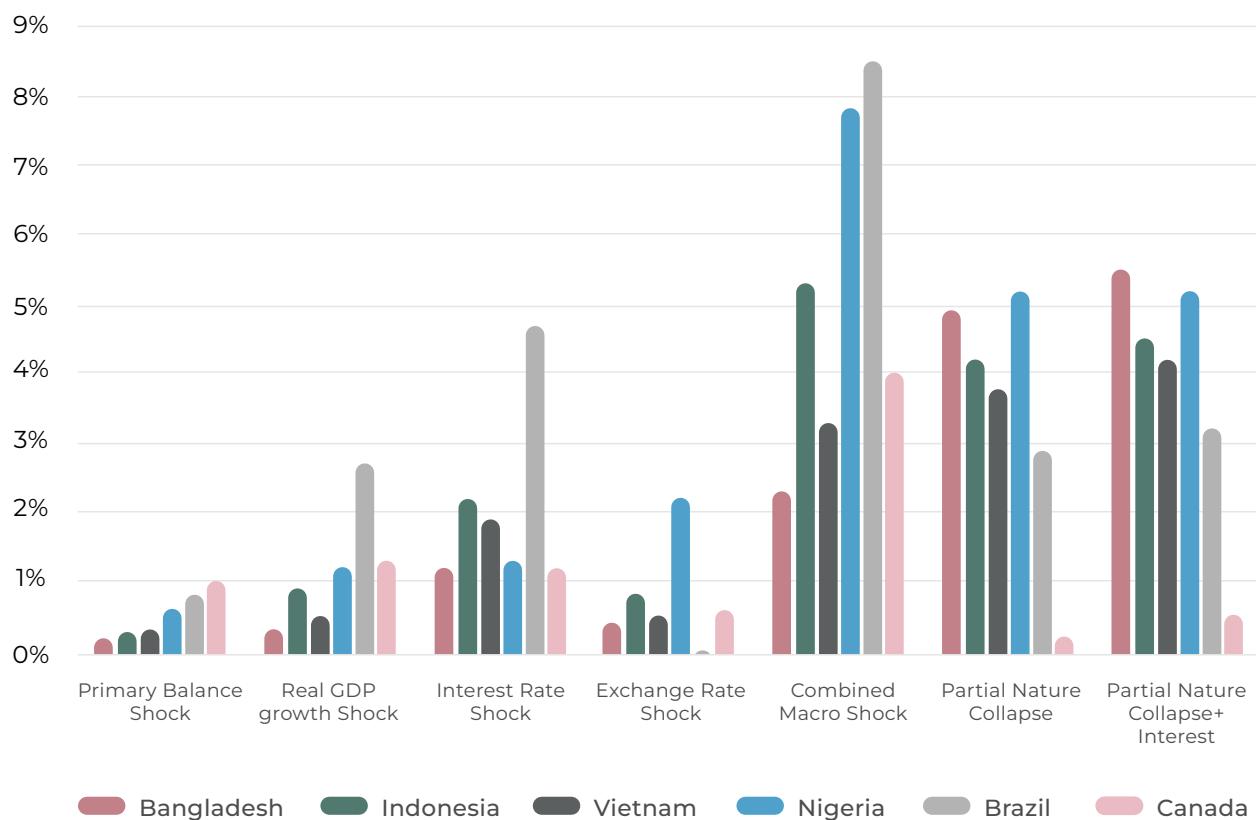
**Figure 3** | Simulated change in general government debt ratio compared to baseline (2026, % of GDP)



**Source:** Compiled by authors.

**Figure 4**

Simulated change in general government financing requirement compared to base case (2026, % of GDP)



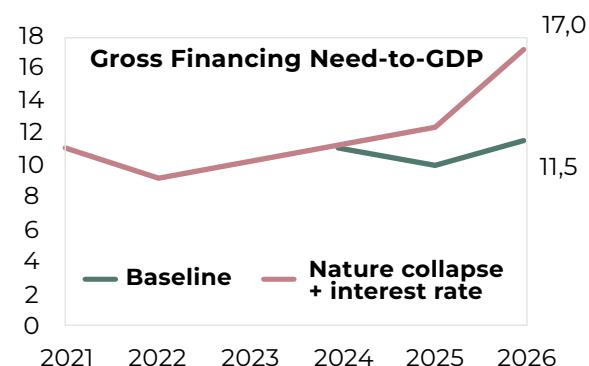
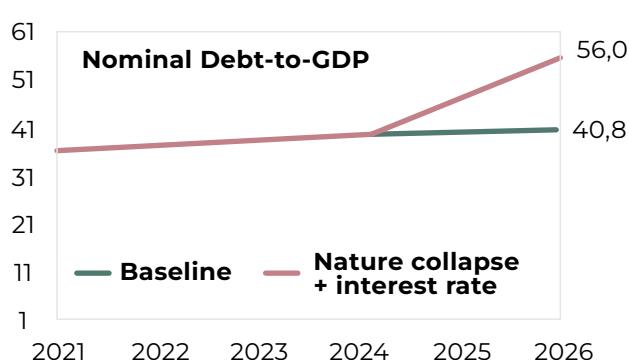
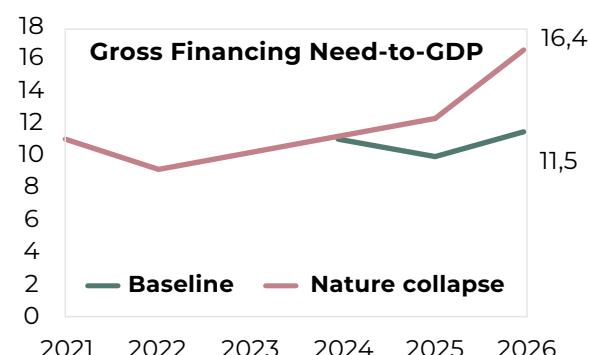
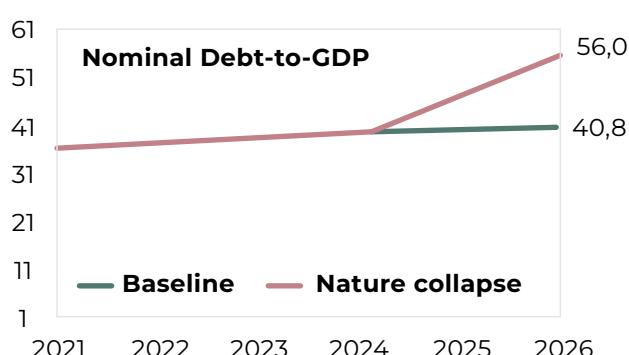
**Source:** Compiled by authors.

In the following, we provide some more detailed results for Bangladesh, which is the country most affected by a hypothetical collapse of nature in our sample. Figure 5 displays critical debt sustainability metrics, which are identical to the key output variables used by the IMF. Up to 2024, the scenario profile completely overlaps with the baseline without shocks. This is to be expected as the nature shock only kicks in in 2025. From 2025 onwards, the severity of the nature shock is immediately visible. By 2026, Bangladesh's debt-to-GDP ratio will rise to 56% without increases in interest rates on government debt and 56.6% with an interest rate reaction, compared to a debt ratio of 40.8% under the baseline scenario with no shocks. This corresponds to an increase vis-à-vis the baseline of 15.2 percentage points without interest rate reaction and 15.8 in the scenario including increasing interest rates.

In comparison, Bangladesh's debt ratio increased by 4.2 percentage points between 2019 and 2021 (from 35.7% to 39.9% of GDP). In other words, the nature collapse shock would be between three and four times as damaging to Bangladesh's debt sustainability than even the pandemic has been. Similarly, gross financing needs will rise sharply when ecosystem services collapse as deficits rise, and GDP (the denominator) shrinks.

**Figure 5**

Evolution of debt sustainability metrics for Bangladesh (%)

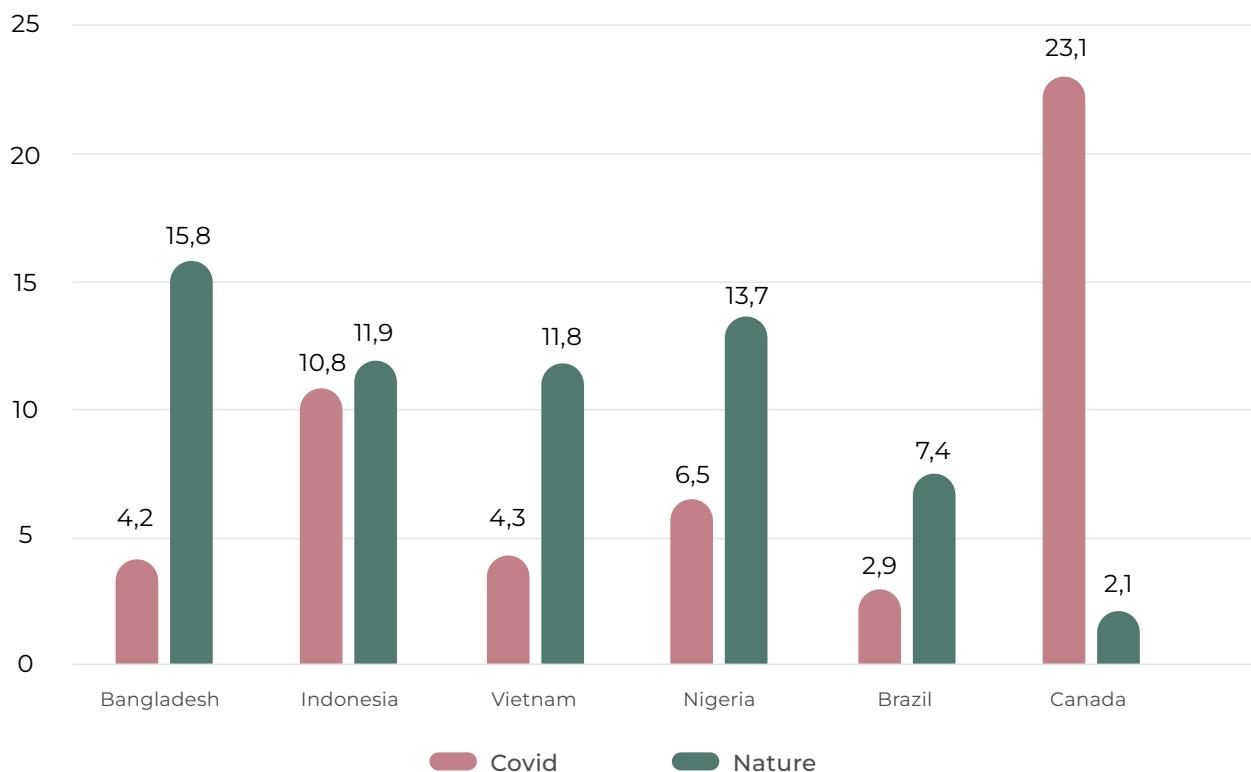


**Source:** Compiled by authors.

Figure 6 compares the simulated change in the debt-to-GDP burden under a nature collapse scenario with the debt increase during the Covid-shock (change of debt ratio between 2019 and 2021) for all countries in the sample. The contrast is stark. The repercussions for debt sustainability have already been bad as a consequence of the pandemic. But suffering a partial collapse of a country's biodiversity would be worse for all countries bar Canada.

**Figure 6**

Change of general government debt-to-GDP burden under the nature collapse plus interest rate reaction scenario compared with the change in the debt-to-GDP ratio during the pandemic (percentage points)



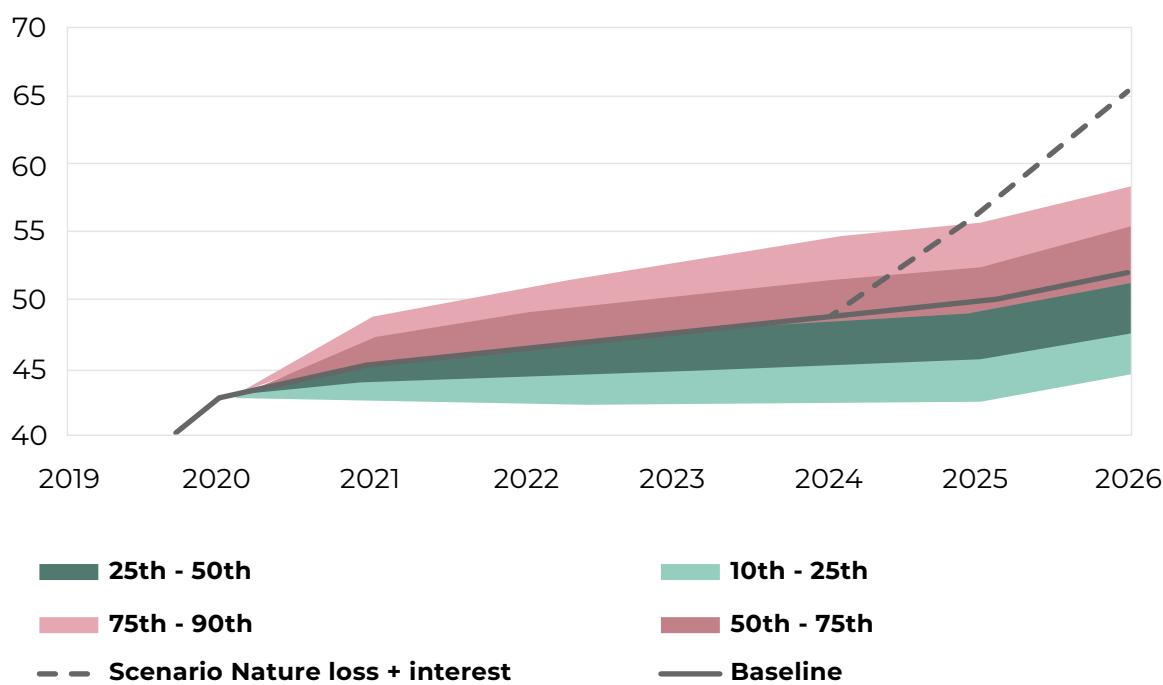
**Source:** Compiled by authors.

A fan chart for the debt-to-GDP ratio can further illustrate the relative severity of the biodiversity shock. It puts the scenario into the context of shocks that can be expected in the light of a country's historical economic volatility. Fan charts are generated based on the calculations of historical averages, variances and covariances of relevant macroeconomic variables (especially real GDP growth and primary fiscal balance). The fan chart is derived from 6,000 random draws from a joint normal distribution of the underlying macroeconomic variables (see methodological appendix for details).

Figure 7 shows the fan chart for Indonesia. It illustrates that the nature collapse stress scenario is large and must be considered as a "green swan" event: not likely and/or hard to predict, but extremely harmful if it occurs. In 2025, the debt ratio under the nature loss scenario moves into the most negative decile and by 2026 it is within the worst 5% of any of the 6,000 randomly simulated scenarios.

**Figure 7**

Fan chart – evolution of debt-to-GDP ratio in Indonesia (%)

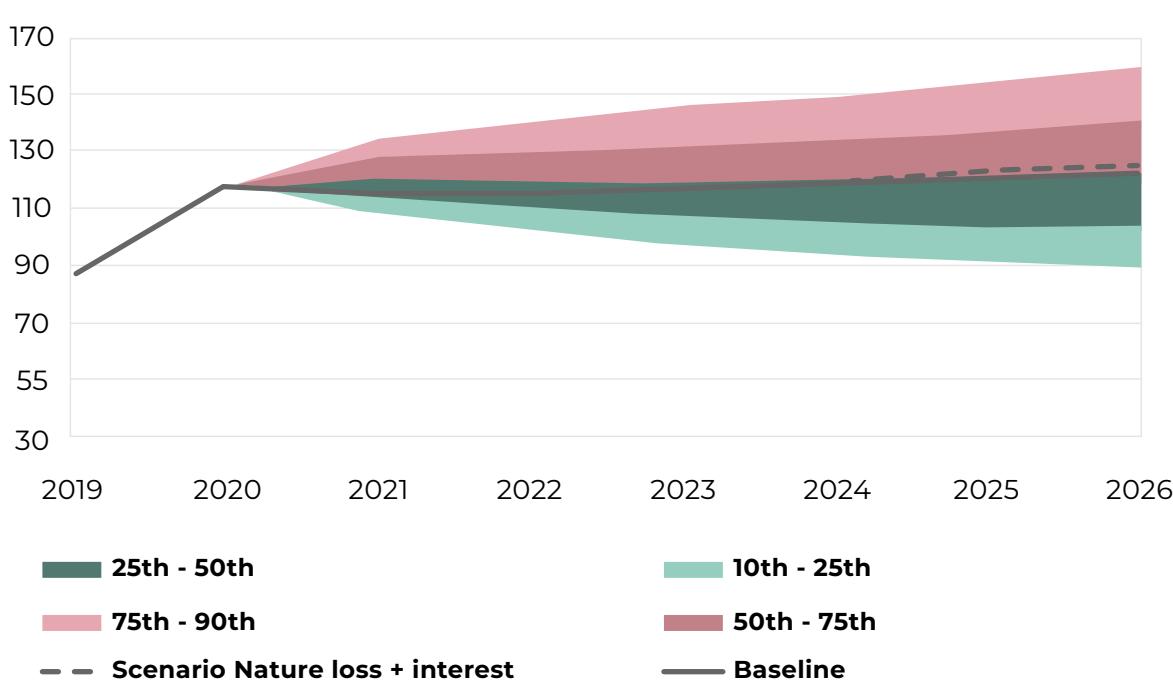


**Source:** Compiled by authors.

Figure 8, in contrast, shows that for Canada the nature loss scenario would likely be very limited with respect to debt sustainability. Considering the low GDP loss estimates by the World Bank in the aforementioned report, similar results could be expected for other advanced economies.

**Figure 8**

Fan chart – evolution of debt-to-GDP ratio in Canada (%)



**Source:** Compiled by authors.

# 6

# Conclusions and policy recommendations

Awareness that nature's services are a critical underpinning to our well-being is rapidly rising. The pandemic has sharpened our collective sensitivity to severe risks that materialise suddenly and unexpectedly. We have seen the direct and unforgiving way that public debt sustainability can be impacted.

Even without the added risk of nature collapse, there is now widespread expectation that sovereign defaults will materially rise, with developing countries, which are often biodiversity-rich, believed to be the most likely to face an unsustainable debt burden. The accelerating drum-beats of climate-related disasters, from floods and droughts to storms, forest fires and heat waves are also paving the way for policy-makers to be more responsive to the need to have a more comprehensive view of macroeconomic risks.

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## The simulations in this study have shown that a partial collapse of biodiversity and ecosystem services can have a substantial impact on debt sustainability metrics

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The timing of such calamitous events cannot confidently be predicted by biologists, even less so by economists. But this should not provide an argument against including such shocks in the DSA toolbox. Indeed, a financial crisis and the concomitant bail-out costs can also not be predicted with any degree of precision. Nevertheless, such a scenario is part of the standard scenarios regularly applied by the IMF. It is time to do the same for biodiversity shocks and thus sharpen awareness of the debt sustainability risks governments potentially face.

The pandemic has made us more cognizant that it is forward-looking to expect the unexpected and prepare for it. Scoping the severity of a nature shock would be an important first step for the international development community to prepare contingency plans to assist countries affected by such idiosyncratic shocks. This study has shown that improving data availability including nature collapse scenarios into debt sustainability analyses is not only possible, but clearly necessary, especially for emerging and less developed countries that often depend heavily on the ecological services provided by nature.

By developing a global macroeconomic model that is linked to a suite of science-driven environmental economic models of ecosystem service provision, the World Bank has laid the groundwork for incorporating scenarios for the macroeconomic consequences of nature loss into macroeconomic and financial risk analysis. While the availability of necessary data has already improved dramatically, it is bound to continue to do so further. The work conducted by the TNFD and other initiatives will allow ever-improving financial transparency with respect to nature risks, from a corporate micro-level up towards a more comprehensive macro view. The time has come to bring in the missing link: connecting debt sustainability assessments with the nature and biodiversity risks mankind has itself created.

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## The IMF needs to mainstream the analysis of nature-related risks in its macroeconomic and financial analyses

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Given the significant macroeconomic implications that nature-related risks have for our economies, it is high time that the IMF mainstreams the analysis of these risks in its macroeconomic and financial analyses. Not doing so would amount to negligence. The IMF has made great strides in strengthening its work on climate change (Volz 2022), and in May 2021, the IMF Executive Board “recognized the importance of a more systematic integration into surveillance of macro-critical emerging topics, including climate change” (IMF 2021e). The Board now needs to recognise that nature risks are also a “macro-critical” factor, that is, crucial to the achievement of macroeconomic and financial stability, which is at the core of the Fund’s mandate, and request IMF staff to start integrating nature-related risks into DSAs and the Fund’s other surveillance activities.

By explicitly accounting for nature-related risks in DSAs, the IMF can contribute to building greater awareness among governments and financial markets of the devastating effects the erosion of our natural habitat has on future macroeconomic stability and economic development. Importantly, countries need to realise that the overuse of renewable natural resources and the destruction of ecosystems can undermine macroeconomic stability and threaten debt sustainability, and that preserving their natural capital will create greater wealth in the long run than the short-term benefits from depleting it.

Integrating nature-related (as well as climate-related) risks into DSAs is critical at a time when many developing and emerging economies are facing a sovereign debt crisis. The IMF’s DSAs play an important role in sovereign debt restructurings. Getting DSAs right has never been more important than when countries scramble to recover from the pandemic and cope with rising food and commodity prices and monetary tightening in the US and elsewhere (Volz et al. 2022). Overindebted countries may resort to depleting their natural capital to stay afloat, even if this undermines their future development. By recognising nature-related risks in DSAs, the IMF can and should support its member countries in developing sustainable economic policies and preserving their natural wealth.

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# Endnotes

<sup>1</sup> See Buhr et al. (2018), Kling et al. (2018), Volz et al. (2020), Cevik et al. (2020), and Klusak et al. (2021).

<sup>2</sup> See Pinzón and Robins (2020) and Moody's (2021).

<sup>3</sup> See Joint NGFS-INSPIRE Study Group on Biodiversity and Financial Stability (2022).

<sup>4</sup> For an overview of The IMF's efforts to address climate risks, see Volz (2022). See Maldonado and Gallagher (2022) on the inclusion of climate into DSAs.

<sup>5</sup> One example is the 2019 Article IV consultations with the Solomon Islands. The IMF (2020, Annex VII) staff report notes: "Since the late 1980s, the rate of extraction of logging has been massively above the sustainable rate, although there have been periodic efforts to control the industry. Between 2006 and 2018 logging grew by 15% per year and represented 60% of domestic exports on average. Logging accounted for 22% of government revenues and 10% of GDP in 2018. Nearly half of the workforce is thought to be directly or indirectly associated with the logging sector. The World Bank estimates that logging activity is at about 17 times the sustainable rate of extraction, causing rapid deforestation."

<sup>6</sup> See: [https://www.imf.org/external/pubs/ft/dsa/templ/dsatemp\\_june18.xlsm](https://www.imf.org/external/pubs/ft/dsa/templ/dsatemp_june18.xlsm).

<sup>7</sup> In cases where the GDP loss caused by partial collapse of biodiversity is small (less than 3% of GDP) we factor in no countercyclical fiscal reaction.

<sup>8</sup> The exchange rate shock scenario for Brazil results in better debt sustainability ratios than the base case. At first sight this appears counter intuitive. But it has an analytical explanation. Brazil's government debt is almost entirely in local currency. The depreciation of the currency would lead to inflation and a concomitant increase of the GDP deflator. This in turn increased the denominator (nominal GDP), reducing the debt and financing ratios. In the longer term the outcome could be less positive as creditors will demand higher nominal interest rates to protect against future depreciation and inflation episodes. But this possible reaction falls outside our simulation horizon.

# Annex:

## Step-by-step instructions on filling in the DSA templates

1.

**Download the IMF Debt Sustainability Framework for market access countries (MAC DSA)**  
[https://www.imf.org/external/pubs/ft/dsa/templ/dsatemp\\_june18.xlsm](https://www.imf.org/external/pubs/ft/dsa/templ/dsatemp_june18.xlsm). In this study we apply the Basic DSA module.

2.

**Use a separate file for each country**

3.

**Populate the yellow shaded cells in each tab**  
The data sources and links are provided in comments in the respective cells. All data can be sourced from publicly available sources. There is no need for a subscription to a financial data provider such as Bloomberg or Refinitiv. Macroeconomic data comes mostly from the IMF's World Economic Outlook. For the study, the October 2021 version was used. For general government debt structure data the principal source is the Sovereign Risk Indicators published quarterly by S&P Global. For this study the Dec. 13, 2021 version was applied.

4.

**Unless otherwise specified all data is entered in local currency units (normally in billions)**  
Do not enter ratios (e.g. as a percentage of GDP unless explicitly instructed).

5.

**Go to Tab "Input 1 - Basics" and fill in the relevant descriptive information**

- a. Line 7 (Exceptional Access) choose "No".
- b. Line 9 choose (General Government)
- c. Line 10, choose "No" to including public guarantees. If those are important for a given country chose "yes" and add them, but in most cases, they will not make a notable difference.
- d. Lines 13 to 15 chose "No", as the complementary analysis is not required for our purposes.
- e. Line 17 First year of projections =2021. In the WEO database estimates begin at the time of writing after 2020 for most countries, in some rare instances indicators are estimated after 2019.
- f. Line 19, leave default at 0%.
- g. Line 23: Fill in current rating from <https://tradingeconomics.com/country-list/rating>.
- h. Line 32: Enter financial bond data, e.g. from Bloomberg, Refinitiv, or <http://www.worldgovernmentbonds.com/country/indonesia/> (in the latter case, please adjust country name in URL)
- i. Line 41, enter "millions" or "billions", depending on customary macroeconomic data reporting in the IMF's World Economic Outlook database. In most cases the unit will be "billions".

# 6.

## Tab “Input 2 – Data”

- a.** Fill in the yellow shaded cells. Most easily available data sources are IMF (WEO database, for lines 5, 6, 7, 10, 16, 19, 20 and 39), IMF International Financial Statistics for lines 11 and 12, S&P Global Sovereign Risk Indicators ([spratings.com/sri](http://spratings.com/sri)) for lines 23, 42 and 44, and Bruegel Real Exchange Rate Index (line 13, <https://www.bruegel.org/publications/datasets/real-effective-exchange-rates-for-178-countries-a-new-database/>). All other lines can be kept empty for our purposes.
- b.** For lines 11 and 12 use data from the IMF’s International Financial Statistics (IFS), codes ENDA\_XDC\_USD\_RATE and ENDE\_XDC\_USD\_RATE for period average and end of period, respectively. For the forecast years apply a technical assumption and let the average and end of period nominal exchange rates grow by the change in the country’s GDP individual deflator growth (derived from line 6), minus 1.5%, with the latter meant to reflect long-term GDP-deflator trends of the country’s trading partners.
- c.** For line 16 (public sector non-interest revenue and grants) the more commonly available item “general government revenue” can be used. Exception: in countries with large assets (such as those owning sizeable sovereign wealth funds), interest revenues must be deducted. The countries in our sample have negligible interest income and the equalisation of the two concepts is therefore justified.
- d.** For line 20, derive “public sector interest expenditures” by subtracting the general government primary balance (in local currency) from the general government balance (in local currency).
- e.** For line 21 and 22 use as a common source the Sovereign Risk Indicators (SRI) of S&P Global Ratings, updated quarterly. Download the country data and use the “Central Government Debt and Borrowing” tab to find the share of the government’s debt denominated in foreign currencies. The remainder of the debt is by definition in local currency, since foreign and local currency need to add up to 100%. The currency composition is important when performing exchange rate shocks on debt sustainability. No forecasts should be made for those lines. They are calculated within the template.
- f.** For line 23 use as a common source the Sovereign Risk Indicators (SRI) of S&P Global Ratings, updated quarterly. Download the country data and use the “Central Government Debt and Borrowing” tab to find the roll-over ratio as a percent of GDP. Where alternative national sources are available, absolute numbers in local currency would be preferable. However, they are usually not in the public domain and where they are they may differ in definition and scope. It is therefore recommended to use the S&P data, which has been processed for comparability. Since the annual amortization profile can be subject to significant variations, we use the six-year average of the data provided by S&P. No forecasts should be made for those lines. They are calculated within the template.
- g.** All macroeconomic and fiscal data needs to be entered in absolute numbers in local currency, unless explicitly instructed otherwise.

# 7.

## Tab “Input 3 – Debt and Banking”

**a.** In Line 8 you multiply the share of short-term debt in total government financial obligations (from S&P Global Sovereign Risk Indicators, See 6.e above) with the Liabilities, from the IMF IFS (Code GG\_GAL\_G01\_XDC). Be sure to use the right units, as the IFS normally reports the data in “millions of local currency”, whereas the template operates with “billions of local currency”. Where alternative national sources are available for short- and long-term debt composition, they can be used instead of S&P. However, where they are in the public domain national sources may differ in definition and scope. It is therefore recommended to use the S&P data, which has been processed for comparability. To smooth out volatility in the debt composition we use a five-year average of the share of short-term debt. Up to the last non-forecast year, in this case 2020.

**b.** In some cases, the IMF IFS do not report absolute local currency numbers for government debt under the “Government Finance selected indicators”. This is the case, for example, for Bangladesh. The most convenient workaround is to use a public source providing the general government debt ratio (e.g. World Bank or S&P SRI) and multiply that ratio with nominal GDP in current prices in local currency (Tab “Input 2 - Data” line 7).

**c.** For the purposes of this report the distinction between domestically (residents) and externally (non-residents) held debt is not relevant and can be omitted. We can approximate the that local currency debt is broadly held domestically (line 11) and foreign currency debt (line 13) held by non-residents.

**d.** The section Banking Debt Data is not required here. The IMF MAC DSA reports it to allow staff to simulate banking stress and potential financial crises emanating from the financial sector. This is not relevant for our analysis on the impact of biodiversity losses.

# 8.

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## Tab “Input 4 – forecasts”

- a.** Lines 14-22 are directly imported from the tab “Input 2 – Data”.
- b.** Lines 27-28: Principal payments for first projection year is to be entered numerically. For the other forecast years, a technical assumption needs to be made about the expected average amortization of the existing debt stock per year. In a typical emerging market debt structure around one fifth of the debt matures each year. This assumption is entered into cell “I (eye) 24” and can be adjusted if a more detailed future amortization schedule were to be available.
- c.** Lines 24-25: Interest expenditures on existing debt. Data entry required for the first forecast year only. The remaining forecast years will auto compute with data entered elsewhere. The breakdown between existing and new debt (debt to be issued over the projection period) is important for capturing roll-over risks and interest rate risks. The breakdown between domestic- and foreign-currency denominated debt is important for capturing exchange rate risks.
- d.** Line 37 is important and shows the total financing need of the general government in any given year. It is calculated automatically from lines 20 through 35. All those lines have been determined by other forecasts made in tabs Input 2 and Input 4. It adds the primary balance (revenue minus non-interest expenditure) to debt service (interest and principal). In lines 39 to 43 one of adjustments can be added manually if required to reflect below the line operations such as asset sales, debt relief or change of arrears. For the purposes of this model these lines can be kept at zero.

- e.** Section “Issuance of New Debt to Fill Fiscal Needs” (lines 50 and below). The template allows a wide range of debt instruments to finance the government, which can be differentiated by interest rate, grace period, maturity, currency and residency. Not all debt instruments in the template need to be filled in. In principle, a single summary instrument could be used as an approximation. For the purpose of this study we applied the same distribution across the yield curve for foreign currency debt and local currency debt. In reality this is not likely to be the case. Foreign currency debt tends to have a longer average tenor. But since the time frame considered here reaches until 2026 only, the simplified assumption has no material impact on the outcome. It is also assumed that the currency composition of the new debt is identical to the currency composition of existing debt. A priori there is no reason to strongly argue for an increase or a decrease of the foreign currency debt share.
- i.** A distinction can be made in issuance in domestic debt (lines to 70) and external debt (lines 71 to 87). The distinction is not critical for this specific exercise of assessing biodiversity risks, however.
- ii.** In column M the user needs to enter the data available from the country's yield curve (column L). Users without access to Bloomberg or other professional commercial data sources can use the data provided by <http://www.worldgovernment-bonds.com/country/bangladesh/> (adapt last element in URL to reflect the country required). The data is to be entered in lines 56 to 70. Financial instruments that do not exist in the country (e.g. zero bonds in line 70) can be omitted. Lines J and K can be safely ignored.
- iii.** Columns N through R depict the yield curves in the outer forecast years. Unless there are specific reasons to deviate the recommendation is that the users leave the shape of the yield curve unchanged throughout the forecast period.
- iv.** The user needs to decide how future issuance covering the financing gap is going to be distributed between instruments of different tenors and currency. Unless there are compelling reasons to proceed otherwise, we recommend to not distinguish debt by residency of holder and record all issuance in lines 71 through 87 (external debt by residence). The local currency versus foreign currency mix should be kept identical to the most recent observation as entered in Tab “Input 2 – Data”. Unless there are compelling reasons to do it differently, the user should consider distributing gross issuance for each currency class in across the yield curve in equal amounts at 2, 3, 5 and 10 years.

# 9.

## Tab “Input 5 – Scenario design”

**a.** This tab calculates the standard shock scenarios applied by the IMF. It also contains the biodiversity loss scenario (“Nature collapse” from line 112 onwards). In cell A113 you enter the percentage reduction of GDP caused by a sudden loss of biodiversity services. This number is taken from Figure 12 of the 2021 World Bank report “The Economic case for Nature” (<https://openknowledge.worldbank.org/handle/10986/35882>).

**b.** We suggest a technical assumption in line 116 with respect to primary spending. Primary government spending, i.e., excluding interest payments, are assumed to rise by one percentage point of GDP in 2025 (cell A116) and another one percentage point in 2026 (cell B116). This assumption reflects governments' attempts to cushion the economic blow caused by the collapse of ecosystem services, along the line of what has been observed during the pandemic. This assumption is dropped for countries with a biodiversity loss of less than 3% as calculated by the 2021 World Bank report “The Economic case for Nature” (Table 12). In such cases of marginal economic impact of partial nature collapse the incentive for the government to offset it through deficit spending will be low.

**c.** A shock like the sudden nature collapse will hit trade and confidence and lead to a weakening of the domestic currency. A technical assumption is required with respect to the currency depreciation. It is assumed that the cumulative depreciation over 2025 and 2026 (the two years over which nature collapse occurs) will be 1.5 times the GDP loss caused by the shock. For example, a 10% GDP decline because of a nature shock will lead to a 15% depreciation over two years (7.5% in 2025 and 7.5% in 2026). These exchange rate movements exceed what has been observed during the pandemic shock in 2020. We believe this is appropriate as 2020 was a global shock, whereas the current scenario models an idiosyncratic shock to an individual country. The impact on the exchange rate should therefore be larger than in the pandemic scenario, where all countries are hit to various degrees simultaneously. We consider this exchange rate reaction as conservative. The user can modify this multiple in any direction by changing the formula in cell A118.

**d.** We follow standard practice applied by the IMF staff of a recessionary shock on inflation and the GDP deflator. The IMF does apply an inflation (and thus GDP deflation dampener) in its GDP growth shock scenario: for each percentage point GDP decline the Fund assumes that inflation will decline by 0.2% points (both relative to baseline, cell B114).

**e.** The user can enhance the debt sustainability analysis by modelling an increase in borrowing costs because of the nature collapse scenario. This can be done in the scenario “Nature collapse + interest rate” in lines 122 to 130. It is reasonable to assume that the cost of borrowing will increase. By how much is subject to a technical assumption. The user can modify the pre-set assumption in the formulas underlying cells A130 and B130. The standard assumption is that the increase in borrowing cost is proportionate to the total cumulative loss of output caused by nature collapse (as expressed in cells A113 and A123). For each 1% loss of GDP in 2025 borrowing costs are assumed to increase by 50 basis points. In the second nature collapse year (2026) the model assumes another, milder, increase in borrowing costs by 50% relative to 2025. For example, if funding costs rise by 100 basis points in 2025 (relative to baseline of unchanged borrowing costs), borrowing costs in 2026 will rise by another 50 basis points (50% of 100bp) to a total of 50% above baselines. The user can modify these standard assumptions by changing the formulas underlying cells A130 and B130.

# 10.

## Fan Chart (optional)

**a.** Fan charts are generated based on the calculations of historical averages, variances and covariances of relevant macroeconomic variables. In this exercise we apply real GDP growth, general government primary balance and the change in the real exchange rate. As a default, averages, variances and covariances are calculated based on the same historical data as the rest of the DSA (last 11 years). For better results, users may wish to extend the historical period in order to better capture country-specific circumstances by populating the yellow-shaded cells in rows 7-10. Data can be entered as far back as 1970. Recommended sources are the IMF World Economic Outlook database for GDP growth and primary balance and the Bruegel database for the real exchange rate (<https://www.bruegel.org/publications/datasets/real-effective-exchange-rates-for-178-countries-a-new-database/>).

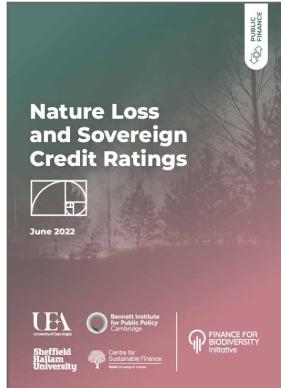
**b.** Before running the fan chart the right shocks need to be set. B42, B44 and B45 need to be set "On" using the dropdown menu, and B43 off. We do not use the effective real interest rate shock due to data limitations, as no source reports comparable time series to our knowledge.

**c.** By clicking on the blue button, the model runs 6,000 random draws from a joint normal distribution. From the outcomes it calculates the 10th, 25th, 50th, 75th and 90th percentiles that are shown in different colours. It also shows automatically the baseline, which should normally run near the 50th percentile.

**d.** The trajectory of the scenario under consideration ("Nature Loss + interest") will be displayed in the fan chart as well. The data underlying the chart can be found in cells AG39 to AL39.

e. The relevant fan chart is "Option A: No restrictions on the distribution". Option B allows for manual limits in D42 to D45 on the maximum positive deviation permitted on the respective variable in the random simulations. For the simulation of a nature collapse shock this functionality adds no analytical value and should be omitted by the user.

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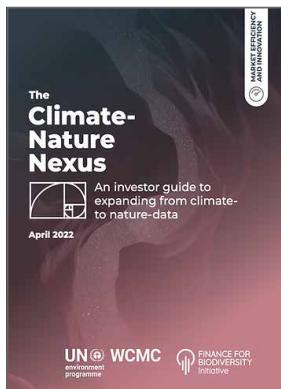
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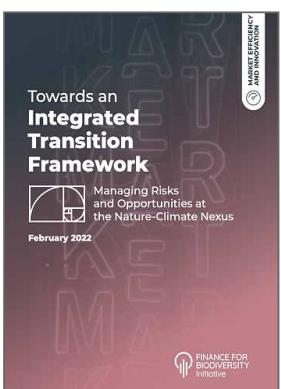
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