Integrating Nature into the IMF-World Bank's Debt Sustainability Framework for Low Income Countries

A New Systematic Approach to Nature-Economy Risk Assessment

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Full Report

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ABOUT THIS REPORT

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ABOUT CLEAN

The CLimate, Environment, and Nature (CLEAN) Helpdesk is a tailored query helpdesk that offers support on climate, environment and nature mainstreaming as well as providing support on Paris Alignment and nature proofing compliance.

The CLEAN Helpdesk aims to support the United Kingdom government's delivery of meaningful contributions to build resilience to current and future climate impacts, halt and reverse global nature loss, as well as halve global emissions.

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“The IMF’s work in these emerging areas with demonstrated criticality for the institution’s macroeconomic and financial stability mandate is not an expansion of the IMF’s mandate, but rather reflects continuing evolution in the economic understanding of what is critical for the achievement of that mandate”

Kristalina Georgieva et al. (2023)

“Studies increasingly confirm that the environment itself may affect macroeconomic conditions. Indeed, research shows that environmental degradation and depletion can give rise to structural balance of payments problems and can reduce economic growth prospects”

V.P. Gandhi et al. (1996), International Monetary Fund

Table of Contents

Acronyms

BES	Biodiversity and Ecosystem Services
CBD	Convention on Biological Diversity
CCDR	Country Climate Development Reports
CDM	Clean Development Mechanism
CER	Certified Emissions Reductions
CGE	Computable General Equilibrium
CLEAN	CLimate, Environment, and Nature Helpdesk
CWON	Changing Wealth of Nations
DCC	Debt-carrying capacity
DDO	Deferred Drawdown Option
DICE	Dynamic Integrated Climate-Economy
DIG	Debt-Investment-Growth
DIGNAD	Debt, Investment, Growth, and Natural Disasters
DSA	Sustainability analyses
DSF	Debt Sustainability Framework
DSGE	Dynamic stochastic general equilibrium models
EE	Environmental-Economic
EMDE	Emerging Market and Developing Economies
EMM	Ecological Macroeconomic Models
EO	Earth Observation
FCDO	Foreign, Commonwealth and Development Office
FIMA	Financial Materiality Assessment
FSAP	Financial sector assessments
GBF	Global Biodiversity Framework
GDP	Gross domestic product
GEDSI	Gender Equality, Disability and Social Inclusion
GEF	Global Environment Facility
GPS	Global Program for Sustainability
GTAP	Global Trade Analysis Project
HIPC	Heavily Indebted Poor Countries
IAM	Integrated Assessment Models
IDA	International Development Association
IEG	Independent Evaluation Group
IFI	???
IMF	International Monetary Fund (
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem
ISD	Integrated Surveillance Decision
KPI	Key performance indicators
LIC-DSF	Low-Income Country Debt Sustainability Framework
MDB	Multinational Banks
MDRI	Multilateral Debt Relief Initiative
MFMod	Macro-econometric models
NBS	Nature-based solutions
NBSAP	National Biodiversity Strategies and Action Plans
NCA	Natural Capital Accounting
NCP	Nature's contribution to people
ND	Natural Disasters
NGFS	Network of Central Banks and Supervisors for Greening the Financial System
NVaR	Nature Value at Risk
PRGT	Poverty Reduction and Growth Trust
SCDI	State-contingent debt instrument
SDG	Sustainable Development Goals
SEEA	United Nations System of Environmental-Economic
SIDS	Small Island Developing States
SNA	System of National Accounts
WBG	World Bank Group

Table of Figures

Table of Tables

Table of Boxes

Executive Summary

This report investigates the rationale, feasibility, and implications of integrating nature-related risks into the IMF-World Bank **Low-Income Country Debt Sustainability Framework (LIC-DSF).** The LIC-DSF is a core tool for assessing debt vulnerabilities in low-income countries (LICs), with significant influence on IMF-World Bank surveillance, concessional financing terms, and broader macroeconomic policy frameworks, as well as private investment and costs of capital. In light of the 2024 IMF–World Bank review of the LIC-DSF's effectiveness, this report evaluates whether nature-related risks meet the threshold of macro-criticality as defined in IMF surveillance guidance and whether they can be systematically integrated into the framework.

Nature as a Macro-Critical Driver of Debt Vulnerability

The integration of nature into the LIC-DSF is warranted based on the IMF's surveillance mandate under Article IV, which requires the identification of macro-critical risks to macroeconomic and financial stability. Nature, defined as natural capital, natural resources and ecosystem services (e.g. water, soil, biodiversity, pollination, disaster protection and climate regulation), is foundational to LIC economies. Many LICs exhibit high dependency on ecosystem services through agriculture, forestry, extractives, and fisheries. These sectors are both productivity- and revenue-critical and are directly influenced by the state of ecosystems.

Empirical evidence indicates that environmental degradation materially affects economic fundamentals:

- **Disasters and ecosystem degradation** cause significant GDP contractions (e.g. >10% in many SIDS and fragile states), reduce fiscal space, and impair recovery capacity.
- **Depletion of natural capital undermines productivity, particularly in agriculture and raw materials** but also related sectors such as manufacturing, which accounts for a large share of GDP and employment in LICs. It also adds to volatility in global prices.
- **Nature-related shocks affect public spending, fiscal balances, and sovereign debt trajectories**, especially when disaster vulnerability is high. There is clear evidence of existing shocks affecting large sectors such as energy, mining and agriculture linked to domestic environmental degradation, particularly through the links to water, but also vulnerabilities to international nature-related transition and physical shocks.

These transmission channels satisfy the definition of macro-criticality as laid out in the 2017 LIC-DSF Guidance Note and reaffirmed in the 2024 Supplement, which requires the framework to account for any factor that could destabilise the fiscal position, impair financial sector resilience, or undermine market confidence.

Structural Nature of Environmental Risk

This report emphasises that nature-related risks in LICs are structural rather than idiosyncratic. The increasing frequency and intensity of disasters, compounded by long-term environmental degradation, are altering the macroeconomic baseline. In many LICs, shocks from environmental degradation and disaster events recur regularly (e.g. two or more major disasters every three years), and their impacts are amplified by degraded ecosystems. Consequently, it is inappropriate for LIC-DSF stress tests to treat these risks as temporary or exogenous deviations from trend, and arguably consideration of environmental factors should already be mandated within existing disaster stress tests.

Environmental degradation also interacts with other structural vulnerabilities—including poverty, financial vulnerabilities and public health—making it a compound risk. As such, failure to integrate these dynamics can lead to systematic underestimation of debt risks, misidentification of fiscal space, and ultimately, policy misalignment.

Feasibility of Integration

This report concludes that incorporating nature into the LIC-DSF is technically feasible using existing data, models, and operational toolkits:

- **Stress testing frameworks** can be extended to incorporate shocks to ecosystem services, nature-dependent sectors, and nature-based investments.
- Tools such as the IMF's **DIGNAD model** are adaptable to include multi-sectoral shocks from nature degradation and to simulate the effects of resilience-enhancing investments.
- Sufficient environmental, geospatial, and economic dependency data exists for most LICs (e.g. via World Bank CCDRs, the World Bank's Changing Wealth of Nations Dataset, tools such as ENCORE and Nature Value at Risk metrics, and UN and national statistics).
- **Integration can initially occur through scenario-based sensitivity testing**, focusing on countries with high exposure to recurrent natural disasters or high sectoral nature dependence.

This approach is consistent with the IMF's principle of maintaining the operational simplicity and transparency of the LIC-DSF while evolving the

framework in line with modern risk understanding. The report provides a new systematic framework to incorporate nature as well as an initial database of relevant indicators to assess the relevance of nature to economies and several examples and case studies of tools that can be used to integrate nature today.

Implications of Non-Integration

Failure to incorporate nature-related risks introduces several technical distortions:

- **Misalignment between projected debt paths and actual fiscal capacity,** potentially resulting in **overly contractionary fiscal guidance or unrealistic financing expectations.**
- Overoptimism of unsustainable growth trajectories based on natural capital depletion.
- Under optimism in public investment in ecosystem restoration and resilience, which may be falsely treated as fiscal liabilities rather than risk-reducing expenditures.

These inaccuracies affect not only IMF-World Bank engagement but also downstream partners, including rating agencies, and may distort sovereign risk pricing in financial markets. Ultimately this is detrimental for LICs economies.

Implementation: What Can Be Done Now

1. **Set clear inclusion criteria for nature:**
   - Adapt existing LIC-DSF climate criteria to prioritise countries highly dependent on ecosystems or facing significant natural capital changes.
2. **Accounting for nature in baselines where this is shown to be macro-critical:**
   - Use the full 20-year LIC-DSF projection period for high-risk countries.
   - Factor environmental degradation into growth assumptions where this has a material impact on growth trajectories (e.g. land, water, soil quality).
   - Recognise natural capital investments as long-term benefits, not just costs.
   - Account for ecosystem service losses due to polluting/extractive sectors.
3. **Enhancing Stress Tests and Sensitivity Analysis:**
   - Stress test key assumptions based on the influence of environmental degradation (and investment) on growth, fiscal balances and costs of capital.
   - **Create alternative scenarios** reflecting nature-protecting policies.
   - **Incorporate environmental risks** (e.g. deforestation, desertification) into disaster stress tests.

- Introduce a “nature-collapse” stress scenario for highly ecosystem-dependent countries, simulating impacts from degraded fisheries, agriculture, or water systems.

4. **Building Collaborations:**
   - Collaborate with researchers to access data and expertise, including considering launching an **IMF innovation challenge** for natural capital (mirroring the Climate Innovation Challenge).
   - Invest in expanding **DIGNAD** to include natural capital and multiple ecosystem-related shocks.
   - Partner with the World Bank’s **Global Program on Sustainability** to refine indices, integrate models, and share tools and scenarios with countries.

5. **Building Capability**:
   - **Within IMF and World Bank**: Provide tailored training for staff and develop simplified tools and nature-related sensitivity test templates.
   - **At country level**: Focus on priority LICs with high nature risks and resource dependence and provide training and user-friendly toolkits; build on existing efforts like natural capital accounting and leverage **IMF training institutions.**

1. Introduction

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The Debt Sustainability Framework for Low Income Countries (LIC-DSF) is a tool used by the International Monetary Fund (IMF) and the World Bank to assess debt sustainability in low-income countries. Sovereign debt sustainability, defined as a country's ability to meet its debt obligations without default or the need for exceptional financial assistance, is traditionally assessed using indicators that relate debt levels to economic capacity, such as GDP, export earnings, and the cost of debt servicing. As of March 2025, 68 of the 70 Poverty Reduction and Growth Trust (PRGT) -eligible countries use the LIC-DSF for joint IMF-World Bank debt sustainability assessments (see Annex) (see IMF, 2025).

Debt Sustainability Analyses (DSAs) are important as they influence many areas as macroeconomic decision making and the terms of which countries can access financing from public financial institutions, like the IMF and World Bank, and the private sector. The LIC-DSF has been the cornerstone of the international community's assessment of risks to debt sustainability in LICs since 2005, with important implications for financing, surveillance and advice that impacts multiple stakeholders (IMF, 2017).

The primary aim of the DSF is to guide borrowing decisions of low-income countries (LICs) in a way that matches their need for funds with their current and prospective ability to service debt, tailored to their specific circumstances. However, the LIC-DSF has wide

ranging implications. The DSF plays a critical role in lending decisions; for example, multilateral lenders including the International Development Association (IDA) have linked their lending policies to the DSF results; and the risk assessment derived by the DSF has informed the IMF's debt limits policy and the World Bank's non-concessional borrowing policy. The DSF results also directly and indirectly affect costs of capital for borrowers from multilaterals and the private sector. The LIC-DSF risk classification acts as a signal to private investors. High or distressed ratings can elevate perceived risk, leading to higher interest rates, restrictive terms, or outright credit denial (Gill & Pinto, 2023)

Given the importance and influence of the LIC-DSF, it is vital to ensure that the macro-critical factors influencing balance of payments, revenues, spending, debt and stability over short, medium and long-timescales are adequately incorporated. The LIC-DSF currently overlooks the role of natural capital in production and the risks to macroeconomic and financial stability inherent in the erosion of ecosystem services such as water, food, clean air and fertile soils, and consequently also fails to account for (and so may disincentivise) the resilience benefits investments in nature and environmental policies.

Recent research, including by the IMF itself, clearly demonstrates the macro-criticality of environmental degradation and its amplifying effects on climate risks. Indeed, the macro-criticality of environmental degradation was recognised by the IMF in 1996: *"research shows that environmental degradation and depletion can give rise to structural balance of payments problems and can reduce economic growth prospects"* IMF (1996). The fact that the LIC-DSF does not capture the value of natural capital for macroeconomic stability, leads to an implicit bias that favours the unsustainable extraction and degradation of natural capital, such as forests, and imposition of environmental externalities, both of which can irreversibly undermine growth and macroeconomic and financial stability on medium to long timescales.

This report explores if there is a rationale for integration of nature within the LIC-DSF – does it meet the threshold for *'macro-criticality'* set by the IMF - and the options for doing so. Several experts have called upon the World Bank and IMF to look to expand the LIC-DSF to integrate nature, including incorporating more transmission channels of ecosystem service loss throughout the economy (see Systemiq, 2024).

In April 2024, a review of the LIC-DSF was launched, including reviewing the predictive power of the LIC-DSF[1] **and approaches to incorporate climate change.** Given the increasing evidence on the macro-criticality of nature, and consequent action

[1] These included: 1) Exploring ways to better differentiate between LICs; 2) Reviewing the adequacy of realism tools and stress tests; 3) Exploring how to strengthen the overall risk assessment; 4) Developing risk models by time-horizon to inform a proper time-differentiation of the risk signal, including a long-term, climate change module; 5) Developing mechanical signal for overall debt sustainability; and 6) Revisiting guidelines on debt coverage (IMF, 2024).

by Central Banks and Ministries of Finance around the world, it is timely to consider if there is a rationale to incorporate nature into the LIC-DSF and how this can be done.

1.1 What Do We Mean by Nature, and Why Is It Relevant to the LIC-DSF?

Statistics on the state of biodiversity and nature degradation are alarming: the extent and condition of ecosystems has declined in 50% natural ecosystems and an average of 25% species are at risk of extinction (IPBES, 2019). However, it is important to be specific on what we mean by *'nature'* here. "Nature" embodies different concepts to different people (IPBES, 2019). Here, we do not consider, for example, the intrinsic value of species, or the wider relationships with society which are important to culture and wellbeing, only the contribution of nature to the economy.

This report focuses on how nature –including natural resources, ecosystem services and biodiversity - contributes to the economy, and specifically its relationship with macroeconomic and financial stability. With this lens, the focus comes naturally to ecosystem services – such as water, clean air, fertile soils, pollinators and protection from climate hazards like floods and droughts – including the provision of natural resources, such as food, timber, minerals, biofuels and other raw materials. Ecosystem services are essential to existence, supporting water and food supplies, health and the stability of local climate (IPBES, 2024). More than half of global gross domestic product (GDP) - US$58tn - is highly or moderately dependent on nature(PwC, 2023). All industries have exposure to nature risk in their value chains. Low-income countries are often particularly heavily dependent on natural resources (agriculture, extractive industries, forestry) and ecosystem services (water supply, flood protection).

Box 1: Definitions

Nature is defined as the natural world (Dasgupta, 2021) with an emphasis on its living components. Within the context of western science, it includes categories such as biodiversity, ecosystems (both structure and functioning), evolution, the biosphere, humankind's shared evolutionary heritage, and biocultural diversity. Within the context of other knowledge systems, it includes categories such as Mother Earth and systems of life, and it is often viewed as inextricably linked to humans, not as a separate entity (IPBES, 2019).

Natural Resources: Resources which are naturally occurring, including renewable resources such as forests and non-renewable resources such as minerals and which are necessary e.g. to support jobs and provide raw materials that people need to survive, manage local climate impacts and contribute to carbon storage and emissions reductions (Dasgupta, 2021).

Natural assets: Naturally occurring living and non-living entities that together comprise ecosystems and deliver ecosystem services that benefit current and future generations. This stock of renewable and non-renewable natural assets yield flow of benefits to people (i.e. ecosystem services).

Natural capital: The stock of renewable and non-renewable natural assets (e.g. ecosystems) that yield a flow of benefits to people (i.e. ecosystem services). The term 'natural capital' is used to emphasise it is a capital asset, like produced capital (roads and buildings) and human capital (knowledge and skills) (Dasgupta, 2021).

Ecosystem services: The flow of goods and services for people produced by ecosystems. These support jobs and provide raw materials that people need to survive, manage local climate impacts and contribute to carbon storage and emissions reductions. The term 'ecosystem services' includes: (i) provisioning services (e.g. food, freshwater, fuel); (ii) regulating and maintenance services (e.g. climate regulation, pollination, soil quality, the flow and purification of water); and (iii) cultural services (e.g. recreation and spiritual enrichment) (Dasgupta, 2021).

Nature's contribution to people (NCP) (Table 1) "are all the contributions, both positive and negative, of living nature (i.e., all organisms, ecosystems, and their associated ecological and evolutionary processes) to people's quality of life" (IPBES, 2019, p. 1046)

Biodiversity is defined as the variety of life in all its forms, and at all levels, including genes, species, and ecosystems. The Convention on Biological Diversity (CBD) defines biodiversity as 'the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems' (Convention on Biological Diversity, 1992).

Nature based Solutions (NbS) are "actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems which address social, economic and environmental challenges effectively and adaptively, while providing human well-being, ecosystem services, resilience and biodiversity benefits" (UNEA, 2022).

Nature-related dependencies, impacts, risks and opportunities. Dependencies – of the economy/organisation on nature; Impacts – on nature caused, or contributed to, by the economy/organisation; risks – to the economy/organisation stemming from their dependencies and impacts; and opportunities – for the economy/organisation that benefit nature through positive impacts or mitigation of negative impacts on nature (TCFD, 2023).

Nature-related financial risks. "risks of negative effects on economies, financial institutions and financial systems that result from: i. the degradation of nature, including its biodiversity, and the loss of ecosystem services that flow from it (i.e., physical risks); or ii. the misalignment of economic actors with actions aimed at protecting, restoring, and/or reducing negative impacts on nature (i.e., transition risks)" (NGFS, 2023).

The 2019 Global Assessment Report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) concluded that fourteen of the eighteen critical ecosystem services that were assessed had declined since the 1970s. It further concluded that *"nature across most of the globe has now been significantly altered by multiple human drivers, with the great majority of indicators of ecosystems and biodiversity showing rapid decline".* These drivers include land-use change, pollution, extraction and climate change (Figure 1). It is well established that *"globally, land-use change is the direct driver with the largest relative impact on terrestrial and freshwater ecosystems, while direct exploitation of fish and seafood has the largest relative impact in the oceans... climate change, pollution and invasive alien species have had a lower relative impact to date but are accelerating" (IPBES, 2019).*

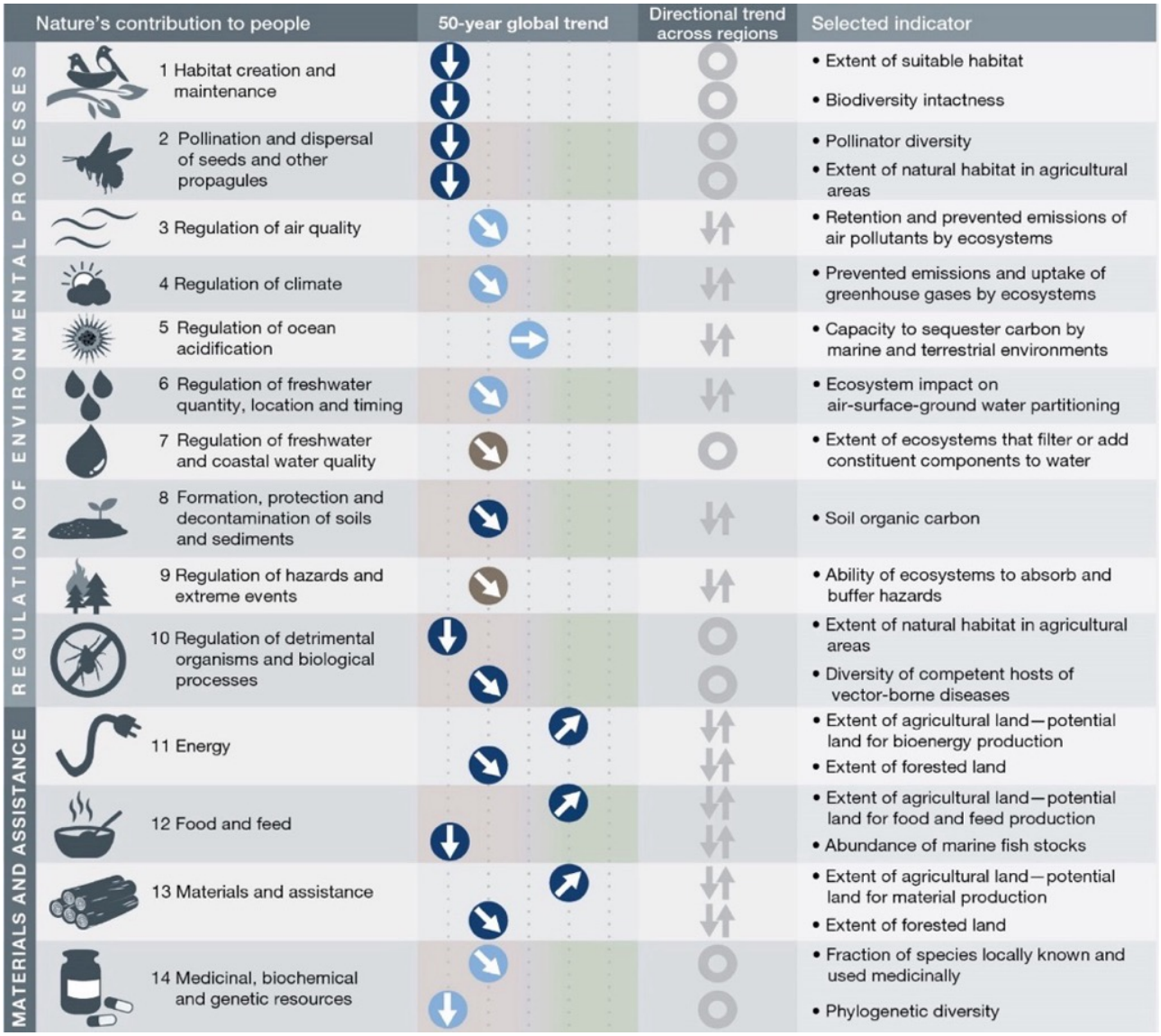


Figure 1: State of change in critical ecosystem services. (Source: IPBES, 2019)

While we often think of nature as being local, there is growing evidence of economic costs of environmental degradation at the macro-scale – nationally and internationally. For example, IPBES (2019) concluded that land degradation has reduced productivity in 23 percent of the global terrestrial area, and between $235 billion and $577 billion in annual global crop output is at risk because of the loss of pollinators. Loss of coastal habitats and coral reefs reduces coastal protection, which increases the risk from floods and hurricanes to life and property for the 100 million to 300 million people living within coastal 100-year flood zones. History, as well as the science, point to the potential scale of the economic impacts.

For example, famous examples such as the American Dust Bowl, where over-intensive agriculture, land-use change and poor land management practices combined with severe drought led to extensive soil erosion, causing dust storms and agricultural collapse (Hornbeck, 2012). In the 1970s, the Baltic Sea became eutrophic due to pollution from agricultural waste, municipal sewage and industry runoff, with massive impacts on fisheries, water supplies and tourism (Yletyinen et al., 2017). In the 1980s, over intensive farming, deforestation, and drought contributed to soil degradation and widespread famine, aggravated by local conflict (combination of "war and drought") in Ethiopia. Over-extraction of water for irrigation and climate variability have led to a significant reduction in the size of Lake Chad, impacting water availability and agricultural systems (Jedwab et al., 2023). These are just a few recent examples from centuries of impacts of environmental degradation.

The negative impacts of environmental change in one country transmit globally via supply chains, financial networks, trade and global macroeconomic conditions (Pörtner et al. 2022). Multiple examples of such transboundary (and trans-biome) impacts can be seen today (Figure 2). For example, droughts combined with local environmental degradation led to 40-100% price increases in the global costs of cocoa and coffee in 2024 and 2025 and a 50% surge in rubber costs in 2024. The FAO estimates at least 20% global crop production can be lost due to diseases and pests in any year. The 2019-2021 outbreak of locusts in East Africa impacted global supplies of tea, coffee and fruits. Seafood supply chains regularly see disruptions due to unsustainable fisheries and pollution. Construction costs have been increased due to rising costs of certain types of timber following wildfires in Indonesia. Developing economies, particularly the LICs, are highly exposed to such volatility.

Figure 2: Nature-related supply chain risks. (Source: Authors)

The immediacy, urgency and macro-scale of the risks are made further clear in the latest assessment of the planetary boundaries framework (Richardson et al, 2023) (which shows that now six of the nine 'planetary boundary' thresholds – those essential to sustain lives and livelihoods - have been breached, including climate change, land and freshwater system change, biochemical flows, novel entities (e.g. plastics). This brings the environment closer to tipping that could lead to rapid collapse of ecosystem services locally, regionally or globally, narrowing the range of options to manage risks.

Our nature-climate-economy system is a complex system, and it is well known that complex systems behave nonlinearly, with unexpected thresholds that can amplify shocks and lead to quasi-irreversible effects locally. For example, soil salination due to clearing land for agriculture can erode soil quality until a threshold is breached, whereupon agricultural productivity can collapse. In Western Australia, for example, the lost agricultural productivity from salinity damage is estimated to be worth at least $519 million per year (Office of the Auditor General Western Australia, 2018). Forests in the Congo and Amazon are known to be critical to regional rainfall patterns, and the science tells us are subject to irreversible tipping points. At least three of the nine Earth tipping points identified in Lenton et al. (2019) are directly linked with systems under threat through biodiversity loss and environmental degradation (the Amazon rainforest, coral reefs and boreal forests), suggesting the potential for nature-related risks to increase the likelihoods for rapid changes in global climate or heighten the impacts and so cause severe and potentially irreversible social and economic impacts.

Considering this evidence, over the past few years, Central Banks and financial institutions have sought to explore if and where environmental degradation poses material financial risks. Studies of nature-related financial risks have been conducted by the Central Banks of the Netherlands (van Toor et al., 2020), France (Svartzman et al., 2021), Brazil (Calice et al., 2021), Malaysia (World Bank & Bank Negara Malaysia, 2022), Hungary (Boffo et al, 2024) and Mexico (Martínez and Montañez, 2021) and for the Euro area (Boldrini et al. 2023). Recent research by the European Central Bank with the London School of Economics and the University of Oxford found that 15% of European economic output is at risk from a 1 in 25-year water scarcity event and around 1.3 trillion euros in loan portfolios (Ceglar, et al., 2025).

There is now clear quantitative evidence that environmental degradation can have significant implications for macroeconomic stability. Importantly, the evidence shows that this is systematic not idiosyncratic risk, hence should be considered as a structural feature of the macro fiscal environment. As outlined in the recent IMF Staff Note *"interacting with climate change, nature loss and transformation can generate significant threats to the global economy and financial system"* (Gardes-Landolfini et al., 2024). A World Bank study (2021) found that a partial collapse of key ecosystem services (such as pollination, fisheries, and forestry) could cause a $2.7 trillion drop in global GDP by 2030, with low-income countries seeing GDP losses over 10%. Indeed, this study included only four ecosystem services and did not consider the full second-round macroeconomic implications of shocks globally. Ranger et al. (2024), for the Green Finance Institute, assessed risks to more than twenty ecosystem services to around fifty countries. Using the NiGEM macro model, it ran three scenarios that identified second round effects and projected losses of more than 6% GDP within this decade, even for advanced economies like the UK, and losses of more than 10% for a global pandemic scenario.

Degradation of natural assets such as forests and soils act as a risk multiplier on the impacts of climate change and vice versa (Pörtner et al. 2022). The COP28 Joint Statement on Climate, Nature and People states that *"there is no path to fully achieve the near- and long-term goals of the Paris Agreement or the 2030 goals and targets of the Kunming-Montreal Global Biodiversity Framework without urgently addressing climate change, biodiversity loss and land degradation together in a coherent, synergetic and holistic manner, in accordance with the best available science."* The World Bank Country Climate and Development Reports provide multiple evidence on compounding threats of climate change and nature across many LIC-DSF countries, including for example, severe challenges of land-degradation and changing rainfall patterns in Malawi and Uzbekistan, and compounding effects on food security, wildfire and floods.

Given the growing evidence on the macro-criticality of nature, it is timely to consider if there is a rationale for systematically incorporating nature within the

LIC-DSF. As outlined by Kristalina Georgieva et al. (2023) while the IMF is by design an economic institution, the *"IMF's work in these emerging areas with demonstrated criticality for the institution's macroeconomic and financial stability mandate is not an expansion of the IMF's mandate, but rather reflects continuing evolution in the economic understanding of what is critical for the achievement of that mandate".* The Fund's purposes and broad powers (the 'mandate') have not changed significantly over the past few decades and focus ultimately on macroeconomic and financial stability. However, the substantive issues on which the IMF engages more systematically with its member countries in carrying out this mandate have evolved, underpinned by decisions of general applicability adopted by the Fund's Executive Board that provide more specific content to the purposes and powers specified in the Articles.

The LIC-DSF mandates assessment of macro-critical debt vulnerabilities - defined as any debt risk—domestic or external—that could:

- Destabilise the fiscal position (through unsustainable borrowing or rollover strain),
- Impair the financial sector (via balance sheet pressures or contagion), or
- Undermine market confidence (reducing access or increasing costs).

These requirements are clearly laid out in both the 2017 LIC-DSF Guidance Note and the 2024 Supplement, making the assessment of these risks not just advisable—but mandatory. In this report, we argue that environmental degradation can significantly impact all three.

1.2 Objectives of this report

This report is part of a rapid project commissioned by the UK Foreign, Commonwealth and Development Office through it's technical assistance facility the Climate, Environment and Nature (CLEAN) Helpdesk to promote and support the integration of nature into the Low-Income Country Debt Sustainability Framework (LIC-DSF), informing the ongoing review of the LIC-DSF and future MAC-SRDSF (Debt Sustainability Analysis for Market Access Countries) review. The goal is to enable better informed decision making by IFIs and client governments and indirectly informing decision making by Credit Rating Agencies (see Annex 2 for ToR).

This first report aims to meet the following objectives:

1. **Deepen understanding of the relationship between natural capital, nature-related risks and debt sustainability**, and how nature is currently integrated into IMF and World Banks DSAs, including its interaction with climate analysis.
2. **Synthesise and appraise existing proposals for integrating nature into the LIC-DSF**, drawing out key conclusions and recommendations.

3. **Make preliminary recommendations on how nature can be feasibly incorporated into the LIC-DSF,** with consideration of data, models and capability, both within the IMF and World Bank and at country level.

Importantly, this report takes an IMF perspective, focusing on the rationale in the context of the LIC-DSF objectives. We assess the evidence in the context of the IMF mandate and take lessons from how climate change is incorporated. This report focusses specifically on the LIC-DSF (rather than wider debt sustainability analysis (DSA)).

Further work will consider wider DSA and will consult with key DSA stakeholders to develop a nature integration plan, including:

- Developing standardised tools/methodologies and guidelines for integrating natural capital, nature-related risks and investments.
- Identifying and improving core datasets on natural capital and nature-related risks to inform DSAs.
- Identify capacity gaps in relevant institutions for delivery of the first two points and proposals on how they could be addressed.
- Identify potential pilot countries for implementing the recommendations - considering synergies with related work on World Bank Country Climate and Development Reports.

Section 2 provides the background to the analysis, describing the global policy context and the relationship to the LIC-DSF and how the LIC-DSF has evolved over time, including the inclusion of climate change. Section 3 then explicitly addresses the rationale for incorporating nature in context of the IMF mandate and role of the LIC-DSF. It syntheses evidence and provides new analysis on the macro-criticality of nature across multiple risk transmission channels to the macroeconomy and financial system, including by drawing upon the findings of the World Bank's Country Climate and Development Reports for LICs economies. It also reviews the findings of other independent assessments to date and provides a summary of the main conclusions across existing analyses. It also draws on the analogy of prudential policy and learns from the actions of Central Banks. Finally, it considers the risks of not incorporating nature and the benefits from a country perspective.

Based upon this evidence Section 4 assesses the feasibility of incorporating nature and how to overcome challenges of data and capability. Section 5 concludes with an implementation plan of feasible next steps. To underpin this assessment, we propose a novel framework for nature-economy risk assessment that builds upon those existing frameworks, such as natural capital accounting and dependency analyses (Section 1.3) and develop a database of indices (Annex 4) and models (Annex 5) to be deployed to assess linkages.

Box 2: Debt, Nature and their Relationship with other Emerging Issues: Gender Equality, Disability and Social Inclusion (GEDSI).

The IMF is not an institution with a specific focus on gender, but as explained by Georgieva et al. (2023), there is important evidence on the macro-criticality of gender outcomes, including by IMF staff. Debt, nature and GEDSI issues are closely interlinked (Fresnillo & Achampong, 2024) and the higher vulnerabilities of women and isolated groups to debt issues creates a feedback effect that can amplify the macro-criticality of nature. Environmental risks can amplify pre-existing vulnerabilities. For example, climate events and environmental hazards have a greater impact on women (UN Women, 2025) and socially excluded population groups. These impacts are exacerbated when they occur amid a debt crisis that prevents an adequate response. In this context, the impacts of climate and nature on debt trajectories are intertwined with the vulnerable situation of nature-dependent communities. Indigenous people are generally settled in areas rich in natural resources, making them the most affected.

The IMF's 2022 Strategy to Mainstream Gender calls for an intentional and systematic approach to integrating gender into macroeconomic policies to foster strong, sustainable, and inclusive growth. While the links between debt, nature and GEDSI issues are not a focus of this report, it is important to take note of the potential amplifying effects on the macro-criticality of nature. The IMF itself has recognised that reducing gender disparities goes hand-in-hand with higher economic growth, greater economic stability and resilience, and lower income inequality (IMF, 2022).

Source: Natalia Armijo, GEDSI expert from the CLEAN Helpdesk.

1.3 A New Systematic Approach to Nature-Economy Risk Assessment

To conduct an analysis of the role of nature within the LIC-DSF has necessitated the development of a new systematic framework for nature-economy assessment. Significant existing work is available on the linkages between natural capital and the economy, and many frameworks are operationally available and used extensively by Ministries of Finance, Central Banks and MDBs around the world, most notably natural capital accounting frameworks and dependency analyses (e.g. the ENCORE toolkit). There are also substantial innovations from the insurance industry in risk modelling (e.g. to model the risk reduction effects of mangroves or other nature-based solutions) and extensive relevant existing frameworks, such fiscal risk analysis, contingent liability analyses and public expenditure analyses. However, in analysing the links between debt sustainability and natural capital it became clear that there is no one approach that provides a sufficiently comprehensive assessment. Without such a framework, the macro-criticality of nature will be mis-measured. We argue that this is the core reason why estimates of the macroeconomic value of natural capital are low, despite the high

dependencies of economies on nature and the significant risks of loss of ecosystem services; they only capture part of the picture.

Figure 3 proposes such a framework by combining elements of existing frameworks into one comprehensive approach. This framework provides a basis for the analysis of macro-criticality as well as recommendations on how to incorporate nature into the LIC-DSF and the implications for data, models and capability. Section 3 deploys this framework to assess macro-criticality of nature, drawing upon evidence from existing studies to populate the framework. The rationale behind the framework and its linkages to existing frameworks is included in Annex 3, alongside a table describing the core elements of the framework. Annex 4 provides a preliminary database of indices that can be used to assess risks against this framework for the LICs economies based upon open data sources. Annex 5 analyses current macroeconomic models' capabilities in light of the framework.

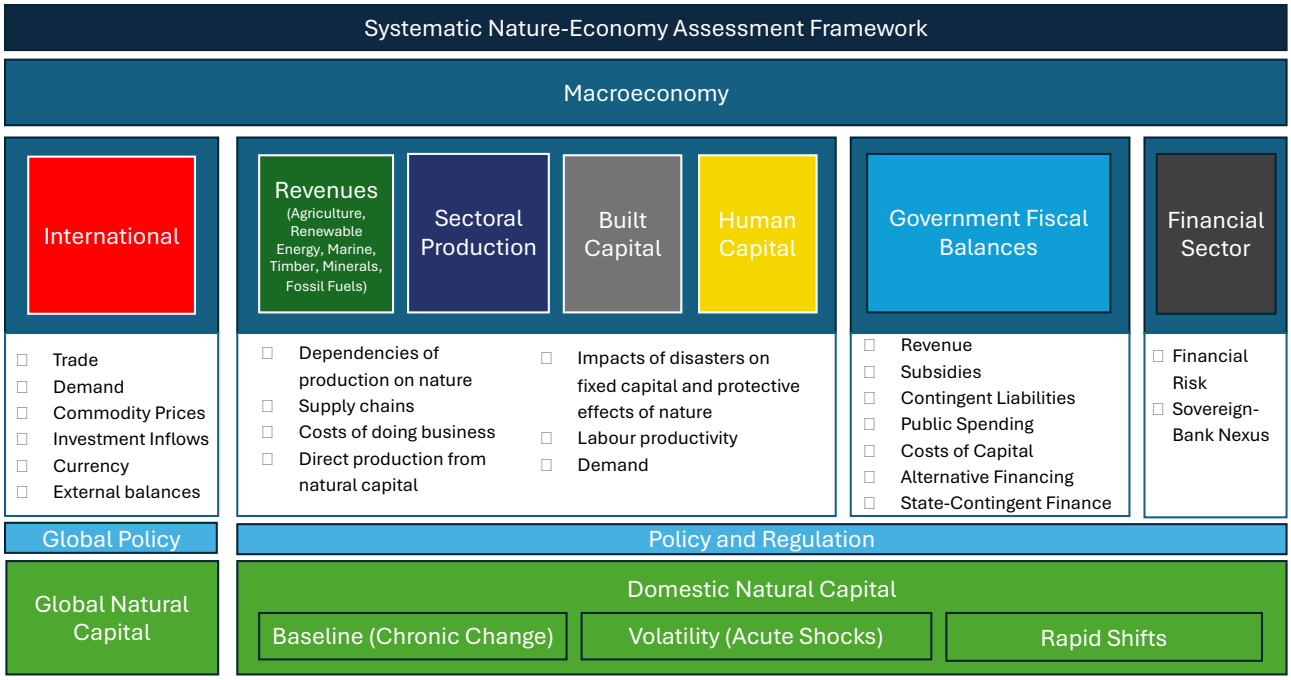


Figure 3: A new comprehensive nature–economy assessment framework. (Source: Authors)

2. Background

Photo by Himshek Kumar on Unsplash

2.1 Global Policy Context and its Relevance to the IMF, World Bank and LIC-DSF

The Kunming-Montreal Global Biodiversity Framework (GBF), adopted in December 2022 under the Convention on Biological Diversity (CBD), represents a landmark international commitment to halt and reverse biodiversity loss by 2030. Structured around four overarching goals and 23 measurable targets, the framework aims to conserve ecosystems, restore degraded lands, and align public and private financial flows with nature-positive outcomes.

Of the 68 countries currently assessed under the LIC-DSF, all are Parties to the Convention on Biological Diversity (CBD) and are all signatories to the Kunming-Montreal Global Biodiversity Framework (GBF). For countries eligible under the Debt Sustainability Framework for Low-Income Countries (LIC-DSF)—many of which are highly dependent on natural capital for livelihoods, economic growth, and climate resilience—the GBF is particularly relevant. These countries face acute challenges in balancing economic development with environmental sustainability, and the GBF provides a strategic roadmap to integrate biodiversity considerations into fiscal policy, debt planning, and investment strategies. Moreover, its emphasis on resource mobilisation (Target 14 and 19), subsidy reform (Target 18), capacity-building (Target 20),

and financial risk disclosure (Target 15) aligns several focal areas of IMF surveillance, the LIC-DSF itself and the World Bank financing and technical assistance (e.g. Table 1).

Table 1: Alignment of GBF Goals and Targets with the LIC-DSF focal areas. (Source: Authors)

GBF Objective / Target	LIC-DSF / IMF Alignment
Goal D – Invest and collaborate	Ensure finance and capacity for biodiversity. Close linkage to LIC-DSF's support for managing key macro-critical risks.
Target 14 - Integrate biodiversity in all decision making	Supports IMF's surveillance and DSA enhancements incorporating environmental risk factors.
Target 15 – Businesses assess, disclose and reduce biodiversity-related risks and negative impacts (including FIs)	Assessing, disclosing and managing environmental risks to enhance national and global macroeconomic stability.
Target 18 – Reduce harmful incentives by at least $500 bilion per year and scale positive incentives for biodiversity	Assessing debt conditions alongside investment needs, including for green economy. Public investment in harmful subsidies.
Target 19 – Mobilise $200 billion per year from all sources	LIC-DSF shapes concessional financing and influences private capital seeking nature-positive outcomes.
Target 20 – Strengthen capacity building, technology transfer and technical cooperation for biodiversity	Aligns with World Bank initiatives offering technical assistance on natural capital and environmental risks.

In 2021, the MDBs reiterated their commitment to assist clients to avoid, minimise and manage environmental and social risks, and to mainstreaming nature into their policies, analyses, assessments, advice, investments and operations, in line with their respective mandates and operating models (World Bank, 2023). They made specific commitments to support government clients to revise their National Biodiversity Strategies and Action Plans (NBSAPs), to supporting countries to implement nature-based solutions, and to looking for opportunities to step up nature financing and efforts to mobilise private finance. For the World Bank, nature featured strongly in the International Development Association 21st cycle (IDA 21) draft documents, for example, including proposals to extend support sustainable management of natural resources, as well as analytics, policies and programs designed to optimise development efforts to ensure that people benefit from nature resources without degrading them (IDA, 2024, pg. 32). In 2022, it committed to support its client countries in implementing the Global Biodiversity Framework and the 30x30 Agenda, which aims to protect 30% of land and sea by 2030. Forests and water form two of the World Bank's six global challenge areas.

Today, multilateral development banks play a central role in the financing of resilience and nature protection and recovery in Emerging Market and Developing Economies (EMDEs). Indeed, the share of finance provided by the MDBs has increased over time. The OECD estimates that multilateral (MDB and ML Fund) biodiversity finance

ranged from $5.7-11.3bn in 2022, more than doubling from the previous year (OECD 2022). The World Bank Group (WBG) is the largest financier of nature (World Banl, 2022). This includes concessional financing from IDA which serves the poorest countries and provides crucial funding for high-impact conservation, including for expansion of protected areas and enhancing their effectiveness across key biodiversity hotspots.

The World Bank is the core implementing agency for the Global Environment Facility (GEF) and helps clients access concessional and non-concessional GEF grants, often integrating these into larger sectoral lending. The World Bank also mobilises and manages considerable multi-donor grant resources and concessional funds to strategically blend, de-risk, and pilot new financing financial instruments that attract private and institutional investors. The World Bank's Global Partnership for Sustainable and Resilient Landscapes (PROGREEN), the World Bank's Blue Economy Program (PROBLUE), and the Global Program for Sustainability (GPS) umbrella trust funds represent nearly US$500 million of grant resources. In October 2024, the World Bank Group committed to double its agricultural finance commitments to $9billion per year by 2030, with a focus on resilience and halting environmental degradation.

In addition to these direct financial flows, the MDBs and the World Bank in particular play a substantial role in shaping wider patterns of public and private investment into nature and adaptation through their awareness raising, technical assistance, capacity building, market reform activities and policy-based lending. The diagnostic tools provided and used by the World Bank in particular play an influential role in policy, investment and markets across EMDEs. The Country Climate Development Reports (CCDRs) are one such diagnostic tool that plays an increasingly influential role through awareness raising, information provision and supporting the dialogue with countries on their priorities as part of the Country Engagement Framework. The World Bank is also active in supporting countries to value the criticality of nature within financial frameworks, for example through natural capital accounting and through integrating nature into research surrounding the financial sector assessments (FSAPs) in some countries. It has invested in innovations to enhance macro models and tools to represent nature-economy linkages.

Several LIC-DSF economies are already working toward embedding nature in their macroeconomic frameworks. For example, Rwanda has published Natural Capital Accounts for Land - compiled, designed and published by the National Institute of Statistics of Rwanda (NISR) and the Ministry of Environment with assistance from the World Bank and the WAVES Global Partnership. In Rwanda, land is the basis for agriculture and rural livelihoods – a key pillar of the national development strategy - but it faces pressures from population growth, the need for jobs, and rapid urbanisation, as well as vulnerability to changes in climate, weather extremes and rainfall patterns (United Nations Statistics Division, 2018). Ethiopia has also produced land accounts and an

investment prioritisation tool; Bangladesh has used natural capital accounting approaches to analyse responses to air quality challenges and Nepal on forest management (World Bank, 2025). Beyond just the LICs, the World Bank reports that as of 2024, more than thirty countries have used natural capital data and analysis to inform World Bank-financed projects and policies.

While the IMF itself is not a signatory to the Global Biodiversity Framework, its surveillance, financing and advisory functions are intertwined with the goals of the GBF. The macro-criticality of nature means that nature-related dependencies and risks require consideration within macroeconomic programming and analyses. DSF results also have a substantial effect on costs and availability of MDB and private capital. The relevance of debt to the Global Biodiversity Framework was explicitly recognised by the CBD. CBD Decision 16/34 requests that the CBD Executive Secretary commissions a study on the relationship between debt sustainability and CBD implementation.

2.2 History and Evolution of the LIC-DSF as Relevant to Nature

The Low-Income Country Debt Sustainability Framework (LIC-DSF) was introduced in 2005 by the International Monetary Fund (IMF) and the World Bank. Its creation responded to the growing recognition that low-income countries (LICs) were at high risk of accumulating unsustainable debt even after benefiting from major debt relief initiatives like the Heavily Indebted Poor Countries (HIPC) Initiative and the Multilateral Debt Relief Initiative (MDRI). The LIC-DSF was designed to (i) prevent new debt crises in LICs by promoting prudent borrowing, (ii) guide borrowing decisions by LICs and lending decisions by donors and creditors, (iii) support sound macroeconomic and debt management policies in low-income countries and (iv) safeguard debt sustainability while allowing space for development financing. It also responded to a need for transparency - there was no consistent or transparent way to assess the sustainability of LIC debt or guide external financing in line with a country's ability to repay.

The LIC-DSF applies to low-income countries that have substantially long-maturity debt with terms that are below market terms (concessional debt), or to countries that are eligible for the World Bank's IDA grants. The LIC-DSF is mandatory in LIC surveillance by the IMF and World Bank —for all countries eligible under the Poverty Reduction and Growth Trust (PRGT) and IDA — with at least one DSA per year, integrated fully in Article IV reports (IMF, 2022e).

The LIC-DSF has been periodically updated to reflect changes in the landscape and advancements in analytical tools, including in 2006, 2009, 2012 and 2017. The current framework became operational in 2018. Reflecting the 2017 comprehensive review, DSAs conducted under the DSF consist of (IMF, 2018):

- **Composite indicator** to assess country's debt-carrying capacity drawing on a set of country-specific and global factors;
- **Realism tools** to facilitate closer scrutiny of the baseline projections;
- **Standardised forward-looking analysis** of the debt and debt service dynamics under a baseline scenario and in the face of plausible shocks, where the scale and interactions of shocks are calibrated to country experience;
- **Newly-introduced tailored stress tests** to better evaluate country-specific risks stemming from contingent liabilities (consistent with the coverage of public sector debt), disasters, volatile commodity prices, and market-financing shocks;
- **Modules that provide a richer characterisation of debt vulnerabilities** (from domestic debt and market financing) and better discrimination across countries within the moderate risk category.

The 2023 Review by the World Bank's Independent Evaluation Group (IEG) concluded that since the reforms to the LIC-DSF were introduced in 2017, there has been increased use of country-specific stress tests covering market financing, contingent liabilities, natural disasters, and commodity price volatility (World Bank, 2023).

More recently, many countries have experienced an increased risk of debt distress because of rising global challenges and this has motivated the IMF and World Bank to review the effectiveness of the LIC-DSF. As noted in the 2023 IEG Review, IDA-eligible countries increased external borrowing in the wake of the 2008 global economic and financial crisis, with much of the new borrowing from non–Paris Club members and from commercial creditors, often on non-concessional terms or in the form of complex lending arrangements under opaque terms. The number of IDA-eligible countries at high risk of or in debt distress more than doubled between 2015 and 2019, increasing further since the start of the COVID-19 pandemic. This has been exacerbated by the war on Ukraine, which has contributed to increasing energy, food, and other commodity prices; as well as broader inflation; a tightening of financial conditions and increased volatility in global financial markets; and a global growth slowdown. As a result, many IDA-eligible countries are now facing or expected to face significant debt-related challenges soon, at the same time as they need to support recovery from COVID-19 and finance investments to support longer-term development, including adaptation to climate change.

The 2024-2026 review aims to assess the performance of the LIC-DSF in this environment – specifically the predictive power and robustness to changes in the debt landscape – and whether the current LIC-DSF remains 'fit for purpose' and 'future proof' in the current context. The predictive power is ultimately determined by the ability of the final risk and sustainability ratings to flag in advance the risks of debt distress and debt restructuring. Analyses by the IMF and World Bank (World Bank, 2024) suggest that the framework has proved successful in accurately flagging debt distress ahead of time,

but that there is a need to strengthen the framework given changes in the underlying debt landscape, including the increasing importance of domestic debt.

2.3 Learning from Climate Change

Environmental degradation and climate share many common attributes from a macroeconomic perspective, so it is instructive to learn from how the LIC-DSF incorporates climate change. Indeed, many scientists would argue that climate change is one manifestation of a wider set of environmental threats related to human activities and that in practice, it is impossible to separate them. As noted above, degradation of natural assets such as forests and soils acts as a risk multiplier on climate impacts. Ranger et al. (2024) for the UK show that nature-related risks can double physical climate risks, largely through increasing vulnerabilities. As such, in many ways, a focus on nature should already be an implicit requirement of the Fund's work on climate change. Ignoring environmental degradation is ignoring a significant risk driver.

In April 2021, the Executive Board of the Fund concluded a comprehensive review of its surveillance activities - finding that *"The macroeconomic relevance of climate change mitigation is beyond doubt".* The review acknowledged that 'climate change is a potentially existential threat with significant macroeconomic and financial implications' and that 'without meaningful action towards mitigation, adaptation, and transition to low-carbon economies, changes in climate are likely to reduce productivity and growth prospects while increasing fiscal sustainability risks. It noted that challenges related to adaptation and transition to low-carbon economy can be macro-critical for countries, as these policies may significantly influence members' balance of payment and domestic stability, and as such they should be discussed in Article IV consultations. The IMF's involvement in climate change therefore rests on the key criterion of its "macro-criticality", i.e. on the premise that climate change can affect both domestic and external stability via transmission channels such as trade flows, fiscal positions, asset prices and exchange rates (IMF, 2015, ECB, 2022) and consequently, can also have a bearing on global macroeconomic and financial stability.

An important outcome of the 2021 comprehensive review was the endorsement by the Executive Board of a more consistent approach to covering climate change issues in IMF surveillance (Georgieva et al. 2023). The 2021 Comprehensive Surveillance Review Background paper on climate change concluded that *"domestic policy challenges related to climate change—such as adaptation efforts for climate vulnerable countries, or policies to deliver a country's Nationally Determined Contribution under the Paris climate accord—are covered by the IMF's bilateral surveillance mandate and therefore valid topics for Article IV consultations wherever these challenges cross the threshold of macro-criticality".*

The July 2024 Supplement to the 2018 guidance on the Bank-Fund LIC-DSF clarifies when climate change risks, investments and policies must be explicitly considered in the DSA and provides guidance on how this should be undertaken. It specifies that coverage of climate change risks and climate investments and policies are encouraged in all cases, with presumption for inclusion where[2]:

- **Mandatory natural disaster stress test for the most vulnerable countries** (IMF, 2016) and **LICs that meet criteria for frequency (2 disasters every 3 years) and economic losses (>5% GDP per year)** (optional for other LICs)
- **Countries where climate change and climate adaptation or transition management policies are assessed as macro-critical** in Fund's Article IV and program reports or considered essential to be implemented in the short- and medium-term to ensure that the macroeconomic policy framework is adequate in the World Bank's Development Policy Financing operations.

As of 2023, about 60 percent of all DSAs discuss climate change or natural disasters. Country clients have expressed a desire to see greater attention to climate change considerations in DSAs. The IEG review concluded that *"the World Bank should continue to give increasing attention in the LIC-DSF to the long-term implications of climate change, in terms of both growth and fiscal requirements of adaptation and mitigation".*

Amongst Small Island Developing States (SIDS) – which face some of the highest exposure to sea-level rise, storms, and long-term environmental degradation – climate risks were incorporated into 13 out of 18 DSAs' baseline projections, and 15 out of 18 included tailored climate-related stress tests. These DSAs re-emphasise the macro-criticality of climate change for LICs, and particularly for SIDs. In countries like Dominica (IMF, 2022a) and the Comoros (IMF, 2021a), climate shocks such as hurricanes and cyclones have already led to downward revisions in potential growth and large spikes in public debt. DSAs for Tonga and Haiti modelled severe disaster scenarios, some assuming damage equivalent to 25–30 percent of GDP, highlighting the scale of fiscal and recovery needs (World Bank, 2023; IMF, 2019a; IMF, 2020b). While some cases, such as Maldives (IMF, 2020c) and Papua New Guinea (IMF, 2022b), still include only limited discussion of climate risks, the broader trend points toward increased integration. Moreover, many DSAs have begun to recognise that financing climate adaptation, though fiscally costly in the short term, is a necessary condition for maintaining debt sustainability in the long run. This includes investments in resilient

2 They are also required in DSAs accompanying requests for Fund Resilience and Sustainability Facility arrangement (RSF arrangement) or World Bank Development Policy Operation with Catastrophic Deferred Drawdown Options (DPOs with CAT DDOs). Also for DSAs accompanying or issued following the publication of World Bank or IMF in-depth topical analyses (CCDRs or IMF Climate Policy Diagnostics), In the absence of new information or analysis that would materially change the implications for the debt risk and/or sustainability assessments, the discussion of climate-related debt risks can be streamlined, drawing upon the findings and models presented in past DSAs, as appropriately referenced.

infrastructure and disaster preparedness, as seen in countries like Grenada (IMF, 2022c) and Vanuatu (IMF, 2021b). These developments show clear progress but also underscore the need to institutionalise climate considerations more systematically across all DSAs, especially as climate shocks become more disruptive.

Reviews by the IEG suggest that despite the growing recognition of the macro criticality of climate change, the scope and depth of incorporation of climate change risks and policies remains uneven, pointing to the need for additional tools[3]. It also noted the need and opportunity to ensure that analyses contained in the World Bank's CCDRs are adequately and systematically integrated into DSAs, with more forward-looking assessments of vulnerability to climate change for both the medium and the long-term. It recommends that the forecast horizon for DSAs is extended to 20 years, at least for countries most vulnerable to climate change (the guidance species that the forecast scenario of all LIC-DSAs is 20 years). The November 2024 internal review noted that better and more transparent treatment of long-term considerations is important. It noted that development of a long-term climate change module would help improve consistency in the application of judgement to bring climate change considerations into the risk assessment.

Given the strong interrelationships between climate and nature, it can be argued that it is impossible to fully incorporate climate into the LIC-DSF without consideration of the changes to the wider natural environment. For example, for SIDS, other human drivers related to nature and land-use change such as the removal of mangroves and building near the coasts can have a more significant and immediate impact on climate-related risks than global warming. Similarly, for LICs like Malawi or Ethiopia, land degradation has a significant and immediate impact on agricultural output that amplifies the impacts of droughts today and in the future. The Malawi CCDR for example, modelled the impacts of climate change and land degradation and determined that land degradation is a core driver of damages. In the high-emissions scenario (RCP8.5), in 2050, the World Bank found that increased land degradation and climate change impacts combined increase losses by almost 25 percent, versus considering climate alone.

Nature-related shocks and stresses do share some common characteristics to climate risks, hence there are important lessons that can be learnt from the frameworks and approaches to climate within the LIC-DSF. Risks related to nature can similarly manifest

3 The Management response to the 2024 IEG review stated that: "Management agrees with the fourth recommendation on the need to strengthen the climate analytical content of DSAs". It stressed the complementary role of the CCDRs and CEM2.0 (Country Economic Memorandum) in providing analytical content on the nexus between growth, climate, and debt vulnerabilities in DSAs. As noted, plans are underway to enhance CEM-based long-term growth analytics, including climate analytical components. In addition, the LIC-DSF guides the user to "carefully consider the social and political feasibility of fiscal adjustment plans in the context of a country's development priorities, poverty reduction plans, and/or need to comply with standards of human rights or social protection" (IMF 2018, 22–23). Management believes this gives the flexibility to incorporate climate issues identified in CCDR and CEM 2.0 diagnostics.

over time (chronic risks) or as shocks (acute risks), with the most significant macroeconomic and fiscal risks likely associated with acute shocks, but with chronic risks creating a drag on productivity and mounting fiscal expenditures over time. The transmission channels for both climate and nature similarly exhibit non-linearities and complexity that can mean that ecosystem services can shift rapidly with significant social and economic impacts, both locally and globally. For example, over-intensive agriculture and water abstraction and land-use can lead to desertification and the collapse of agricultural productivity, as experienced around Lake Chad. Like climate change, this also creates difficulties in predictability and means that the past is not a good guide to the future. Like climate change, the implications of environmental degradation play out at multiple scales; nature-related shocks and stresses can transmit either through domestic impacts (e.g. reduced regulation of local flood risk or suppressed productivity in agriculture) or internationally (e.g. through changing terms of trade or commodity prices).

There are also important differences between climate and nature. The impacts of biodiversity loss and environmental degradation can be more directly local and much faster acting – with impacts manifesting immediately rather than over decades - as well as to some extent global and accumulative. For example, the removal of a hectare of forest in Southern Africa could lead to immediate impacts on local climate and flood risk, with direct impacts on local fixed capital assets and industries. It also means that nature risks are location specific – the impact of the removal of a hectare of forest in Africa will look very different to Europe, and requires a detailed understanding of the local landscape, creating challenges for risk assessment. Environmental degradation contributes to the long-term global impacts on the climate change through the removal of carbon sinks. The following section considers the rationale for inclusion.

3. Rationale for Incorporating Nature Systematically into the LIC-DSF

Dried up lake in Yala National Park, Sri Lanka. Photo by Chamika Jayasri on Unsplash

3.1 Conditions for Incorporating Emerging Issues into the LIC-DSF

We argue above that given the interconnectedness of climate and nature risks, nature should already be implicit in the Fund's mandate to incorporate climate change in the LIC DSA, but the evidence points also to the need for explicit inclusion as an emerging issue. The LIC-DSF - as laid out in the 2017 Guidance Note (IMF & World Bank, 2018) - mandates assessment of macro-critical debt vulnerabilities, defined as any debt risk that could: destabilise the fiscal position; impair the financial sector; or undermine market confidence. The 2024 Supplement updates the framework provide more details on this criterion, expanding staff guidance to more explicitly highlight macro-critical debt risks, such as: severe domestic-debt vulnerabilities, risks to financial stability; external market-financing pressures; or signalling strains on investor

confidence or debt rollover capacity. Where debt risks related to nature threaten fiscal solvency, financial sector health, or market access, they are categorically macro-critical.

With respect to surveillance, the 2012 Integrated Surveillance Decision (ISD) defines the criterion for macro-criticality in terms of the ability to 'significantly influence present or prospective balance of payments and domestic stability'. IMF guidance documents define "macro-critical" issues quite broadly, as those which *"affect, or [have] the potential to affect domestic or external stability, or global stability".* The relevant time horizon for measuring macro-criticality was traditionally the short to medium term (up to five years), however given the ISD's focus on not only present but also 'prospective' (or future) stability, the Fund has increasingly also focused on issues that are more structural in nature and can pose longer-term stability risks. The most recent guidance specifies a time horizon of 20 years.

In this context, the principal rationale for and extension of the DSF (whether to reflect changing creditor landscape, increased frequency of extreme weather events, or threats to natural capital), is to ensure the framework does not systematically under- or over-state risks to debt sustainability and hence lead to macro-fiscal policy guidance and actions that place the economy on too tight or too loose a trajectory. Given its mandate focus on macro-stability rather than growth and development, there is a stronger case to address problems associated with failures to reflect downside risk than upside potential. Hence, in the past, the DSF been more responsive to concerns that is properly reflects the emergence of expensive private Eurobond debt (which often presents liquidity and roll-over problems) than reflecting the debates about the positive impact of infrastructure investment on growth. For this reason, in this report, we focus more on the downside risks.

With these definitions established, this section assesses if, where and how, nature-related issues are macro-critical for LICs economies and therefore, the rationale for their systematic inclusion in the DSF, deploying the framework proposed in Figure 3.

3.2 Evidence on Macro-Criticality of Nature for LICs

Developing economies, and particularly LICs, are particularly exposed to nature-related dependencies and risks, given their larger fraction of GDP emerging from nature-dependent sectors such as agriculture, forestry, fisheries and mining and higher vulnerabilities to shocks. For example, Figure 4 presents three basic indicators of nature-related exposures and risks: agricultural %GDP, water dependency of the economy (%output exposed) and level of water stress for a selection of LIC-DSF countries, taken from the indicator database developed for this report (Annex 4). We focus here on water as previous research, for example by the NGFS (Ranger et al. 2023) and the European

Central Bank (Ceglar et al. 2025) demonstrates that water is one of the most material sources of risk, with high dependencies in sectors such as agriculture but also energy production, mining and manufacturing.

Water scarcity has both climate-related and wider human drivers, including over-abstraction of water (from aquifers and for irrigation), growing demand and poor water management, which aggravate the risks of extreme weather events. Most LIC-DSF countries have more than 40% of their economies highly or moderately dependent on water. Yemen, Uzbekistan and Tajikistan stand out with relatively high-water dependencies of their economies and water stress.

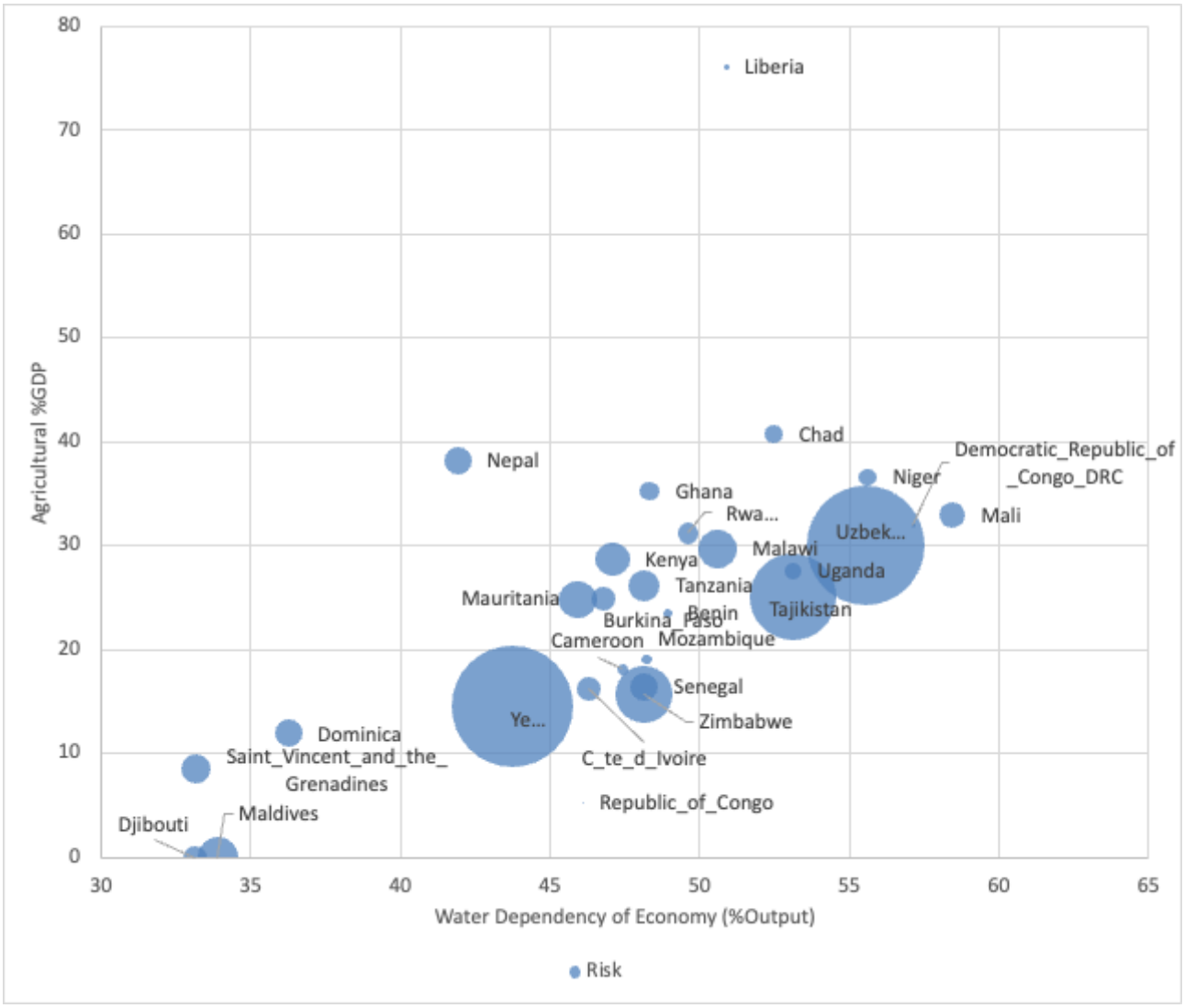


Figure 4: Three indices of nature-related dependencies and risks: water dependency of the economy, agricultural & GDP and water scarcity (size of bubbles). (Source: Authors, see Annex 4)

Biodiversity is declining across many LICs economies, impacting ecosystem functioning, water availability and quality, food security and nutrition, human, plant and animal health and vulnerability to climate change. The extent and condition of ecosystems has declined globally, including more than 85% of wetland area lost (IPBES, 2019).

Figure 5 summarises some key indicators from Annex 4. Several LIC-DSF countries are experiencing rapid declines in biodiversity intactness, including Chad, Tanzania, Senegal, Tajikistan – suggesting significant changes to land-use with implications for a wide variety of ecosystem services and nature-related risks (water, soils, pollinators) and potential negative pressures on economic productivity. Many countries have also seen long-term declines in forest areas - Cambodia, Chad, Benin, Mauritania, Malawi and DRC - which erodes soil fertility and can threaten agricultural production as well as increase risks of drought, flood, water scarcity and wildfire, Mangrove areas are also declining across many LICs, with implications for fisheries and flood risks. Land degradation in Benin, Malawi, Bangladesh and Rwanda threatens agricultural productivity and while poor water quality in Senegal and Mali is linked with threats to health and water supplies.

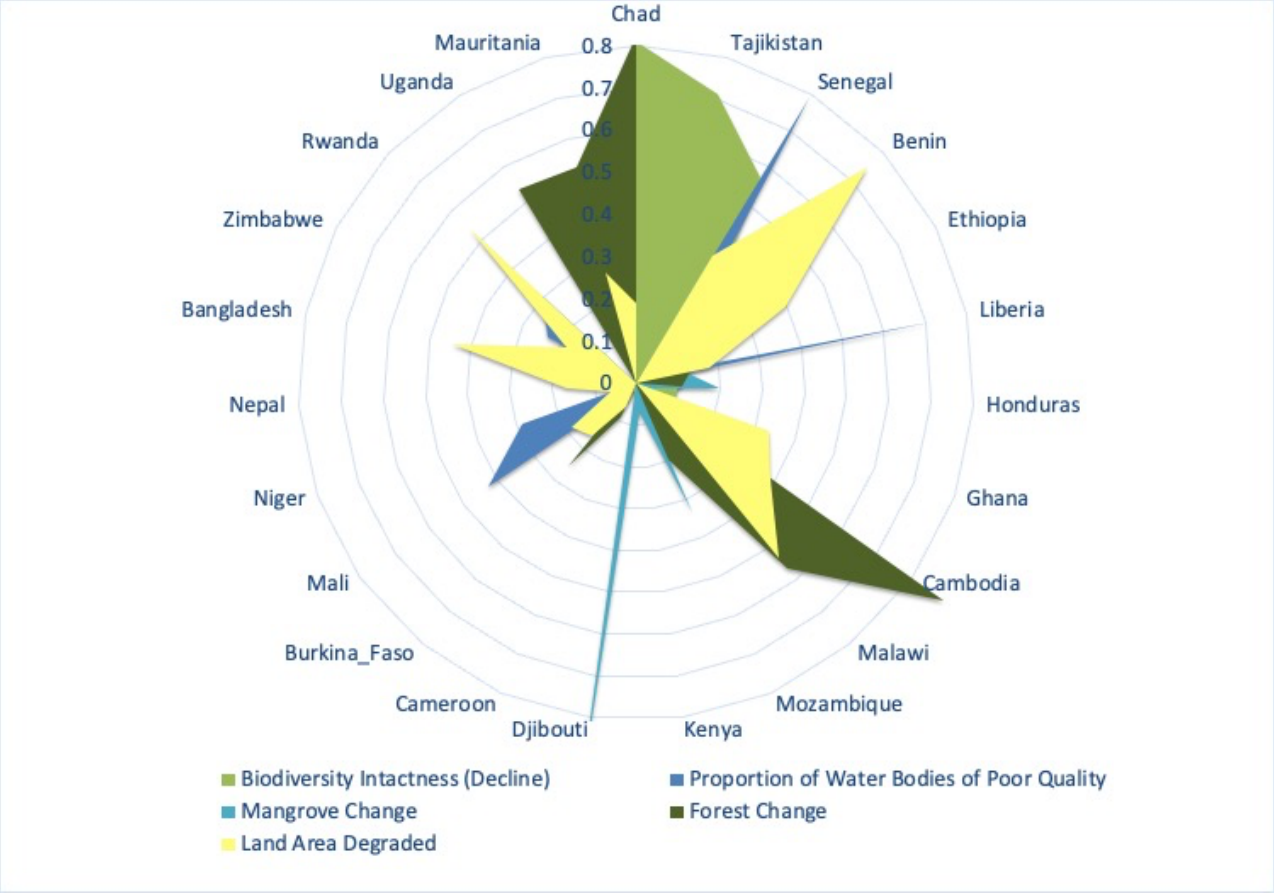


Figure 5: Performance of countries five ecological indicators linked to fiscal and macroeconomic risks – land area degraded, change in biodiversity intactness, forest and mangrove area changes and proportion of water bodies of poor quality. (Source: authors, based on data in Annex 4)

The erosion of natural capital generates significant and long-term risks to society and economies, from increasing the risk and impacts of pandemics, floods and droughts, to undermining water quality and supplies, damaging agricultural production and creating risks to human health (Ranger et al. 2023). This is particularly acute for LIC-DSF countries where vulnerability to disasters is generally high due to underlying vulnerabilities. High exposure to weather events like droughts and floods is compounded by environmental degradation, and levels of public health are generally lower. Figure 6 presents three further indicators of relevance from the indicator database (Annex 4) from INFORM, including disaster risk, food security risks and health conditions. This clearly shows a group of LICs economies at high disaster risk, food insecurity risk and poor health conditions, including Uganda, Kenya, Yemen, Chad, Mozambique, DRC and Ethiopia. For such countries, environmental degradation could significantly increase disaster risks, with implications for fiscal expenditures, inflation and stability.

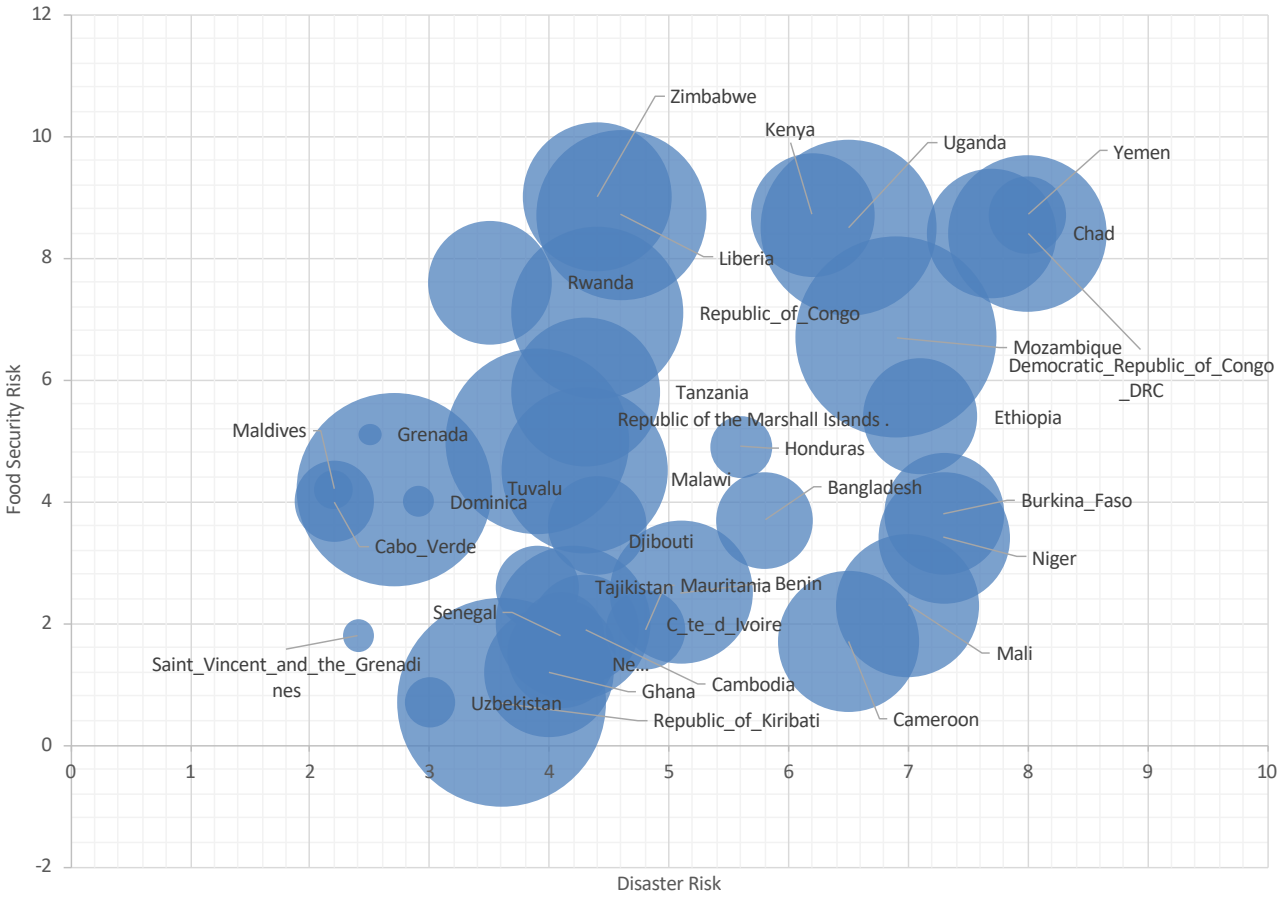


Figure 6: Indices of vulnerabilities to disasters: INFORM disaster risk score, INFORM food security score and size of bubbles represents the risks related to health. (Source: authors, based on data in Annex 4)

Evidence on the quantitative economic and financial impacts of environmental degradation on the macroeconomy is now clear. As noted above, Johnson et al. (2021) demonstrate that low-income economies are most vulnerable to environmental degradation and could see a 10% impact on GDP by 2030, largely driven by impacts of

deforestation (Figure 7). However, the Johnson et al. (2021) study explores only a narrow range of direct risk transmission channels, and arguably not those most likely to drive macro-critical impacts. For example, it focusses on only the implications of deforestation for timber production, missing out the more systemic implications for rainfall, soil quality and pests and diseases that can have significant implications across multiple sectors, including energy and mining. For example, in Brazil, deforestation and land-use change, coupled with growing water demand, have already led to more frequent water crises. This in the country where more than 80% of electricity is driven by hydropower and water-dependent sectors like mining play an important role in economic growth. Timber production is not the key source of concern of macroeconomists. In Indonesia, deforestation has led to an increased risk of flooding near cities and wildfires in rural areas.

In 2019, fires cost US$5.2 billion (0.5% GDP) through their impact on agriculture, forestry, tourism, transportation, health, and school closures. Such impacts are missed by current macroeconomic models. Work by Ranger et al. (2024) captured the wider macroeconomic impacts of environmental degradation, as well as secondary impacts via global supply chains, revealing far higher potential losses to sectoral outputs and GDP. Figure 8 shows preliminary results for four middle income countries, Argentina, Indonesia, Vietnam and Mexico. This reveals far higher GDP impacts for an international supply chain disruption scenario than captured by Johnson et al. (2021). Ranger et al. (2024) did not assess risks to LICs, but the framework could be easily extended to LICs based on available input-output databases and open ecological and economic datasets.

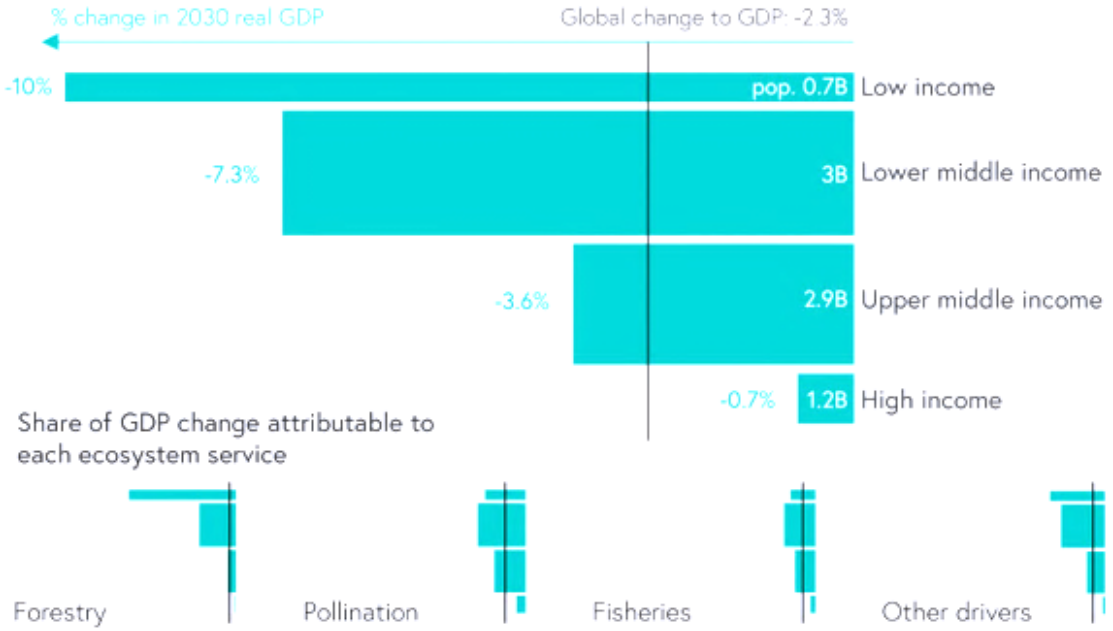


Figure 7: Change in 2030 real GDP under Biodiversity and Ecosystem Services (BES) collapse scenario relative to baseline, by country income group. (Source: Johnson et al. 2021)

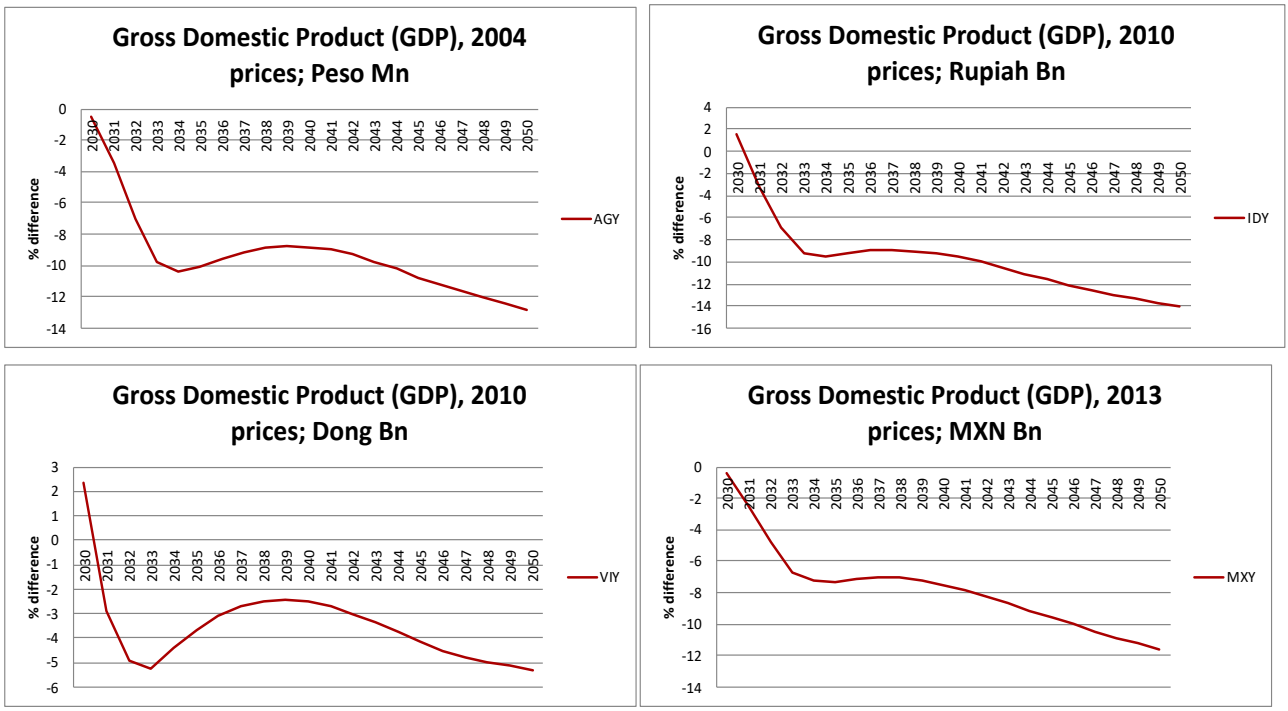


Figure 8: Preliminary modelled GDP impacts of the Ranger et al. (2024) international supply chain disruption scenario for (top) Argentina and Indonesia and (bottom) Vietnam and Mexico using the NiGEM model. The scenario shock begins in 2030.

Multiple lines of evidence demonstrate that nature-driven shocks and stresses can significantly worsen debt trajectories. Multiple studies have now modelled this explicitly using tools that are openly available and accessible. Kraemer and Volz (2022) use the findings from Johnson et al. (2021) to demonstrate the impact of integrating nature-related risks into DSAs and show that nature loss matters for debt sustainability. For their six-country pilot (Bangladesh, Vietnam, Indonesia, Nigeria, Brazil, Canada), a partial ecosystem-service collapse raises the public-debt-to-GDP ratio by 10–15 percentage - often a larger hit than any of the IMF's standard macro-stress scenarios. The simplicity of this exercise demonstrated by Kraemer and Volz (2022) demonstrates that nature-risk stress tests are both feasible and policy-relevant, without requiring fundamental changes to the DSF engine. In countries such as Bangladesh and Vietnam, the partial collapse of ecosystem services represents the most severe stress scenario, exceeding the impacts of shocks to the primary balance, real GDP growth, interest rates, exchange rates, or even the IMF's combined macro-fiscal stress scenarios, which bundle multiple shocks. For Bangladesh, the country in the sample most affected by the partial nature collapse scenario, a simulated collapse in ecosystem services was shown to increase the debt-to-GDP ratio by 15 percentage points within a single year – three to four times greater than the fiscal impact of the COVID-19 shock (Agarwala et al., 2022).

3.3 New Analysis of Nature-Economy Macro-Criticality

The IMF Staff Note, Gardes-Landolfini et al. (2024), outlines the key transmission channels through which nature interacts with the macro-economy, building upon the conceptual framework laid out by the Network of Central Banks and Supervisors for Greening the Financial System (NGFS). The NGFS defines nature-related financial risks as *"risks of negative effects on economies, financial institutions and financial systems that result from: i. the degradation of nature, including its biodiversity, and the loss of ecosystem services that flow from it (i.e., physical risks); or ii. the misalignment of economic actors with actions aimed at protecting, restoring, and/or reducing negative impacts on nature (i.e., transition risks)"* (NGFS, 2023).

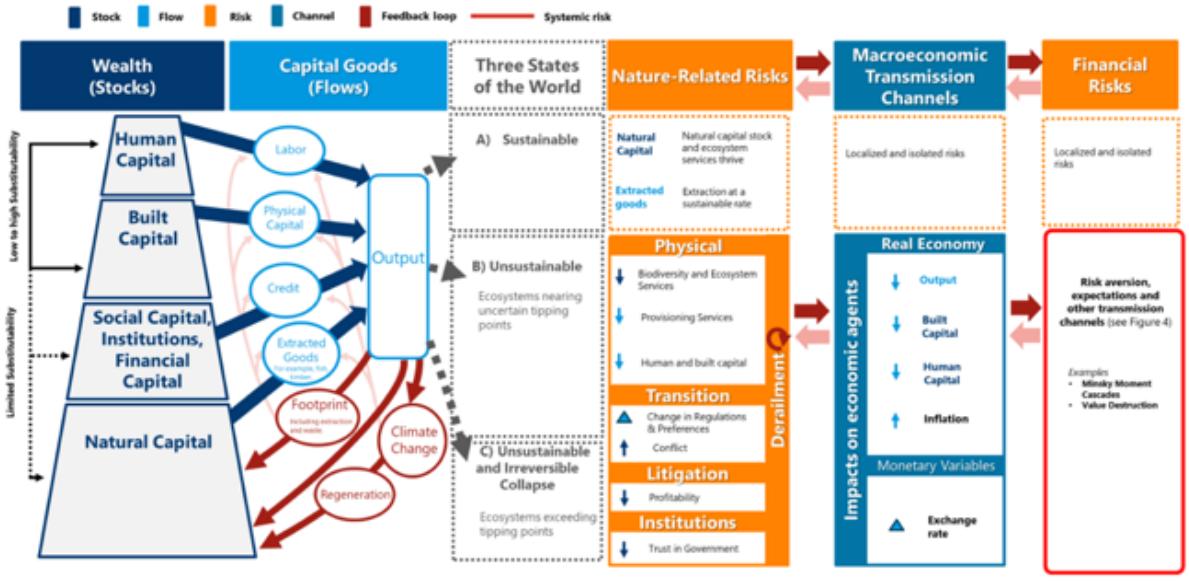


Figure 9: Granular Conceptual Framework: Nature-Related Macroeconomic and Financial Risks. (Source: Gardes-Landolfini et al., 2024)

Physical nature-related risks, like climate risks, can be acute (i.e. shocks such as forest fires or pests affecting a harvest) and/or chronic (i.e. gradual changes such as pollution stemming from pesticide use). Most previous studies, like Johnson et al. (2021), focus on chronic changes in ecosystem services over time, whereas from experience it is the acute risks that can have the most severe macroeconomic implications. Closer assessment shows many transmission channels from ecosystem services to the economy directly and indirectly. For example, Ranger et al. (2023) laid out more than sixty potential risk transmission channels between nature and the economy; an example for land-use change and its linkages to real-estate valuation, agriculture, business interruption and public expenditures is illustrated in Figure 10. Few of these are currently captured in risk assessments leading to underestimates of risks. These inputs feed into the new systematic nature-economy approach introduced in Figure 3.

NATURE-RELATED DRIVER	CHRONIC CLIMATE AMPLIFIER	ACUTE CLIMATE AMPLIFIER	NATURAL CAPITAL IMPACTED (PRIMARY)	ECOSYSTEM SERVICE AFFECTED-ENCORE (PRIMARY)	NATURE HAZARD/SHOCK	TIME SCALE	GEO SCALE	ECOSYSTEM DEPENDENCY IMPACTED	PRIMARY ECONOMIC RECEPTOR
Land-use change/ removal vegetation	Climate change	DROUGHT/ HEAT	LAND	Climate regulation; Dilution by atmosphere and ecosystems	WILDFIRES & HEATWAVES, AIR POLLUTION FROM LOSS VEGETATION (including URBAN HIGH RISK)	ACUTE	LOCAL (URBAN)		HUMAN HEALTH
Land-use change/ removal vegetation	Climate change	DROUGHT/ HEAT	LAND	Climate regulation; Dilution by atmosphere and ecosystems	WILDFIRES & HEATWAVES, AIR POLLUTION FROM LOSS VEGETATION (including URBAN HIGH RISK)	ACUTE	LOCAL (URBAN)		BUSINESS INTERRUPTION
Land-use change/ removal vegetation	Climate change	DROUGHT/ HEAT	LAND	Climate regulation; Dilution by atmosphere and ecosystems	WILDFIRES & HEATWAVES, AIR POLLUTION FROM LOSS VEGETATION (including URBAN HIGH RISK)	ACUTE	LOCAL (URBAN)		PUBLIC EXPENDITURE
Land-use change/ removal vegetation	Climate Change	DROUGHT/ HEAT	LAND/AIR	Climate regulation; Dilution by atmosphere and ecosystems	DUST STORMS	ACUTE	LOCAL		HUMAN HEALTH
Land-use change/ removal vegetation	Climate Change	DROUGHT/ HEAT	LAND/AIR	Climate regulation; Dilution by atmosphere and ecosystems	DUST STORMS	ACUTE	LOCAL		BUSINESS INTERRUPTION
Land-use change/ removal vegetation	Climate Change	DROUGHT/ HEAT	LAND/AIR	Climate regulation; Dilution by atmosphere and ecosystems	DUST STORMS	ACUTE	LOCAL		REAL ESTATE
Land-use change/ removal vegetation	Climate Change	DROUGHT/ HEAT	LAND/AIR	Climate regulation; Dilution by atmosphere and ecosystems	DUST STORMS	ACUTE	LOCAL		AGRICULTURE

Figure 10: Extract from Ranger et al. (2023) showing transmission channels from land-use change to economic and social risks to health, business, real-estate and public expenditure. The full table shows more than 60 potential transmission channels.

As explained by Gardes-Landolfini et al. (2024), ecosystems differ from produced capital in three ways: (1) depreciation is in many cases irreversible, (2) it is not possible to replicate a depleted or degraded ecosystem, and (3) ecosystems can collapse abruptly. On the other hand, ecosystems depreciate if they are misused or overused, as is the case for produced capital. The substitutability between natural capital and other forms of capital is limited. There are "little-to-no substitution possibilities between key forms of natural capital and produced capital and for that matter any other form of capital" (Dasgupta 2021, p. 328). This "strong sustainability" approach (as opposed to the "weak sustainability" approach, which assumes that nature and the ecosystem services it provides can be replaced by labour and man-made capital) is consistent with a review of the literature that concludes that forms of natural capital that serve basic life-support functions for human beings (for example, the global climate, biodiversity) are non-substitutable in their totality (Neumayer 2013, p. 193). This has critical implications for how nature is included in models and why current models are arguably not fit for purpose.

In this section, we draw upon the proposed new systematic approach to nature-economy assessment (Figure 3) and populate this framework with evidence from previous studies, to provide a new assessment of key risk transmission channels in terms of their macro-relevance and potential to generate macro-critical risks. We draw upon existing research, including the new FCDO report that synthesises findings from the World Bank CCDR report (Ranger et al. 2025) and new data analysis following the methodology of Ranger et al. (2023) for the NGFS and Ranger et al. (2024) with the Green Finance Institute. Ranger et al. (2025) provides a deep dive on six countries: Indonesia, Morocco, DRC, Malawi, Pakistan, Brazil, only two of which are LICs, however the findings are relevant to LICs. Drawing evidence from the CCDRs and previous studies demonstrates the availability of data and methods that can be used in the DSF.

Sector Production and Labour: Dependencies on Ecosystem Services and Risks

The economic dependencies of economic sectors on ecosystem services are well understood and there is growing evidence of the impacts on production and revenues. These impacts can be manifested as a chronic 'drag' on productivity or more acute shocks related to specific events, such as a disease outbreak or drought. Nature-related stresses and shocks can also impact on labour productivity, adding further drag to overall productivity and the potential for acute shocks. For example:

Chronic: The Pakistan CCDR provides detailed analyses on water risks, concluding that demand could increase by 60% leading to intersectoral trade-offs, including declining water for irrigation that could derail much needed increases in agricultural productivity. Soil erosion, over intensive agriculture and excess use of fertilisers has also led to land degradation and declining water quality with significant impacts on agricultural production. The Malawi CCDR notes that land degradation is a major risk, especially soil erosion, with major risks to agriculture and water infrastructure. It estimates 80% of Malawi's land area needs restoration. For water, the Morocco CCDR clearly highlights the significant risks to agriculture, energy and wider macroeconomic volatility, that could contain opportunities e.g. in green hydrogen. The Brazil CCDR similarly focusses on water risks to productivity in power (particularly hydropower), mining and agriculture. The Pakistan CCDR, for example, highlights that high air pollution levels alone create a significant drag on economic performance equivalent to approximately 10 percent of GDP through its effects on both labour productivity and public expenditure on health.

Acute: Pakistan also faces significant challenges related to water quality and risks of disease outbreaks as a result of pollution and environmental degradation. In Indonesia, urban heat stress linked to the removal of vegetation contributes to reduced labour productivity and spikes in public expenditures during heat waves. The Brazil CCDR notes the link between loss of vegetation cover and heat risks, citing evidence that native vegetation loss cost to soy industry US$99 per hectare. Such shocks can significantly increase prices locally and globally, as seen with recent experience in cocoa. Looking at longer-term, it also highlights the risks of a major tipping point in the Amazon that could lead to the collapse of that ecosystem with losses of $184 billion for Brazil alone.

Figure 11 illustrates economic dependencies for six ecosystem services for a set of LICs economies. Underlying this is a disaggregated assessment of dependencies by economic sector, where sectors like agriculture have the highest dependencies on services like water, soil quality and pollinators, however sectors like mining, manufacturing and energy also have important dependencies. Countries such as Niger, Mali, Liberia and Ethiopia are ranked as the most highly dependent on ecosystem services, mainly due to their high economic dependence on agriculture. Less dependent are small-island states such as Tuvalu and Grenada. These analyses are based only on data in the World Bank database

and combined with the ENCORE tool to assess economic dependencies. More sophisticated analyses are possible using input-out tables to assess indirect supply chains and to couple dependency data with hazard data on the state of ecosystem services to assess risks, as in Ranger et al. (2023). Note that the World Bank's Changing Wealth of Nations dataset also includes valuation of some ecosystem services, such as forest protection services, however it is not possible to link this to particular sectors.

Figure 11: Aggregated score of economic dependencies for six ecosystem services across the economy of the LICs economies. (Source: authors, based on Annex 3)

Direct Production and Revenues from Natural Capital

Existing frameworks, such as the World Bank's Changing Wealth of Nations (CWON) approach, also demonstrate the substantial economic value that is derived from the direct exploitation of natural capital. This includes renewable natural capital, such as timber and fisheries but also recreation and ecotourism, and non-renewable natural capital, such as fossil fuels and mining. These flows, particularly those related to non-renewable natural capital, are traditionally captured within macroeconomic analyses. Not captured are the spillover effects of exploitation of this non-renewable natural capital on other sectors, spending and revenues related to the environmental damage inherent in their exploitation, for example, the impacts of mining on water quality and consequent public expenditures on clean-up and health care. Most assessments also fail to capture the important revenues directly related to renewable natural capital including fisheries, food, timber, ecotourism and hydropower.

Figure 12 shows relevant indices from the CWON database, demonstrating the significant economic value of natural capital in LICs economies. Capturing the sustainability of such production is important in macroeconomic analyses. The World Bank's CCDR for DRC for example, includes modelling of scenarios of forest protection and the benefits for a range of ecosystem services and production across DRC, as well as the linkages to mining through water. The DRC CCDR stresses that DRC is endowed with huge renewable and non-renewable natural capital with the potential for very significant benefits for livelihoods, jobs and growth. This includes 143 million hectares of forest are estimated to be able to generate up to $400 billion a year from stored carbon and ecosystem services, including flood avoidance and timber production. Further it highlights that sustainable management of forest resources can lead to job creation; in DRC every $1 invested in landscape and forest restoration, yields a gain of $15 benefits by 2050. Forests provide timber, food production, fuelwood, erosion and sedimentation control, regulate and purify water.

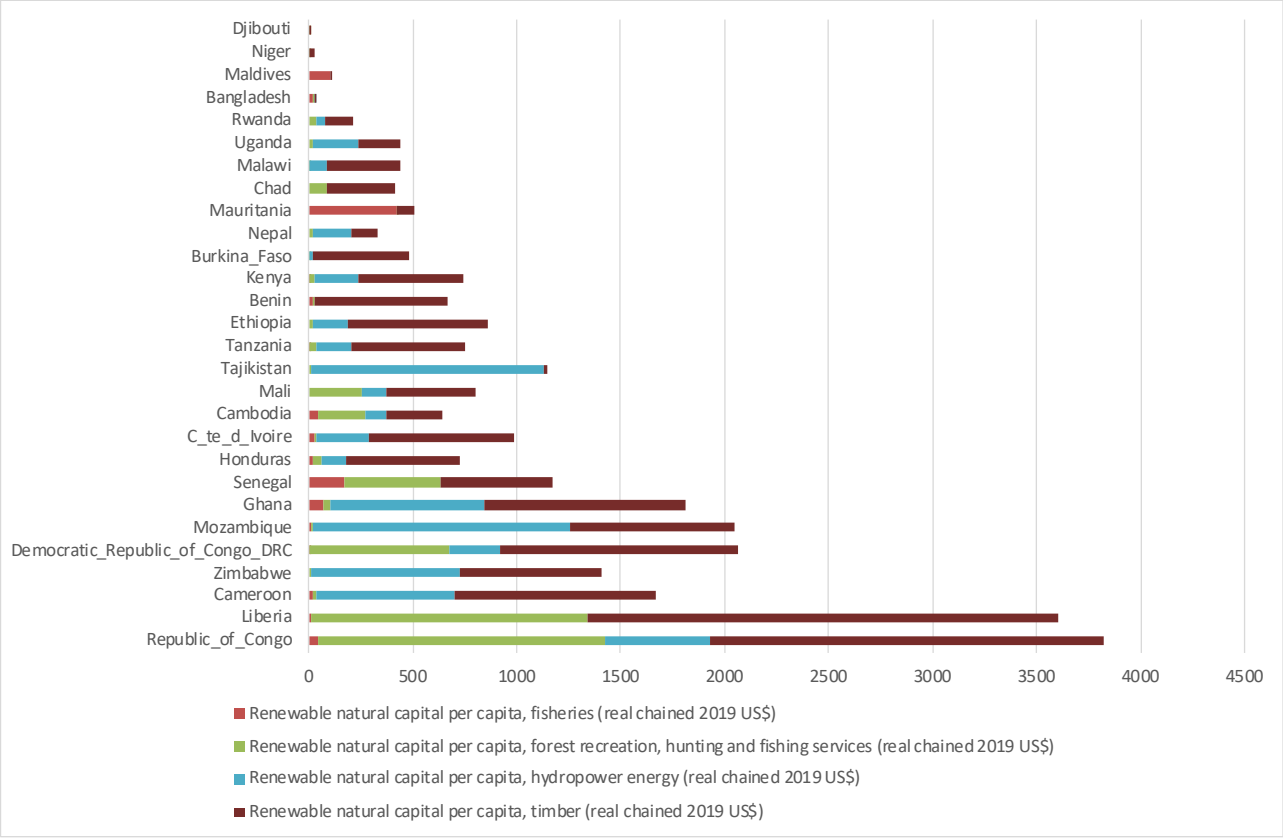


Figure 12: Four indices of economic value of renewable natural capital: fisheries, forests, timber and hydropower for a selection of LICs economies. (Source: World Bank Changing Wealth of Nations database)

Transition Risks and International Supply Chains

Transition Risks: **The past years have seen several examples of the rapid implementation of nature-related policies and regulations in LICs and internationally with local impacts on production and revenues**. For example, contamination of water in India and Bangladesh by the textile industry has led to temporary shutdowns in factories and disruptions to supply chains. Critical mineral supply chains, including lithium, cobalt and copper, have been impacted by environmental regulations as well as reputational risks, causing temporary closures that have reduced revenues to government. LICs economies are exposed to growing environmental regulations, changing consumer and investor sentiments and reputational issues from advanced economies. For example, the recent implementation of the EU Deforestation Regulation in Europe is expected to increase compliance costs by around 5-10% to businesses operating in sectors including rubber, timber, soy, cocoa, palm oil, coffee, leather and beef. Mining is estimated to be linked with around 7% annual forest loss in developing countries. This has led to increased scrutiny on sourcing practices. The London Metal Exchange (LME) faced legal scrutiny over trading copper sourced from the Grasberg mine in Indonesia, known for environmentally damaging practices like riverine tailings disposal. The Grasberg copper mine in Indonesia, operated by PT Freeport Indonesia, has been criticised for discharging around 200,000 tonnes of mining waste daily into Ajkwa River delta, affecting its consumer base. Similar environmental scrutiny is seen on mines across many LICs, including in DRC and Zambia. Such events can have sudden impacts on fiscal revenues and longer-term implications for growth through their effects on economic production.

Physical Risks: **LICs economies are also highly exposed to volatility in global value chains and macroeconomic conditions associated with global nature-related risks.** For example, food represents 7 – 40% of the total imported value of goods for the LICs economies included in the database (Annex 4). Minerals represent up to 50% of the value of exported goods for the LICs, demonstrating very high vulnerability to global commodity prices. Tourism also represents up to 45% of exports for some countries (e.g. Tanzania, Ethiopia, Kenya, Grenada, Cape Verde), which is highly dependent on the state of ecosystems and biodiversity in those countries.

Built Capital and Contingent liabilities: risks and opportunities

Shocks, such as extreme weather, disease and pandemics, are made more severe by environmental degradation, leading to greater price volatility, increased rates of depreciation and rising public costs of recovery and reconstruction, as well as higher costs for business. Environmental degradation also puts growing pressures on public expenditures related to health and environmental clean-up of contamination and pollution.

Chronic: As noted above, chronic stresses related to air pollution, water quality (bacterial and nitrate contamination), water scarcity leads to continued stress on public budgets.

Acute: Rising risks of disasters associated with land-use change impact on both people and physical infrastructure, putting stress on fiscal balances as governments fund response, recovery and reconstruction efforts. In Indonesia, land subsidence and increased vulnerability to flooding is linked with deforestation and land-use change, particularly around urban centres. In addition, health damages from smoke associated with forest clearing for agriculture were estimated to cost US$23.5 billion over 2008-2017, and the CCDR reports that 2019 fires cost US$5.2 billion. CGE and DSGE analyses show that shocks to natural systems can have outsized effects on growth and debt trajectories in LICs. For LICs in the LIC-DSF, which typically have narrower economic bases and less financial buffer, integrating such risks is therefore critical (Agarwala et al., 2022).[4] IMF's own recognition of climate "macro-criticality" (e.g. more frequent droughts cutting GDP growth by several percentage points) has led to recent guidance to incorporate climate shocks into baseline forecasts. Extending this to nature (biodiversity and ecosystems) is a logical next step, given evidence that biodiversity loss can rival climate change in economic impact.

The World Bank's CCDR reports also note the opportunities from public (and private) investment in nature-based solutions to build resilience to disasters. The Pakistan CCDR emphasises that building resilience through NbS is an important priority following the 2022 devastating floods. It mentions the Ten Billion Tree Tsunami Program (TBTTP), a four-year project that will have the quadruple benefits of natural capital restoration, carbon sequestration, and livelihood improvements, especially for poor households, and also recommends that NbS should be prioritised in all urban areas. The Indonesia CCDR discusses opportunities for flood mitigation e.g. through restoration of agricultural lands (surprisingly references to NbS for urban flooding are weak) and urban cooling. Indonesia recently committed to restore 600,000 hectares of mangroves by 2024 – the largest such effort to date in the world.

Fiscal Policy: Environmentally-Damaging Subsidies

Governments invest huge public funds in environmentally damaging subsidies - 'shooting themselves in the foot' by locking-in reduced productivity and revenues from other areas of the economy and increasing the need for public expenditures to clean-up the impacts. This is highlighted in all the World Bank's CCDR reports.

For example, the Morocco CCDR notes implicit subsidies linked to water tariffs and their environmentally damaging implications that undermine economic resilience. In Brazil, taxes, subsidies and credit schemes promote extensive agriculture and carbon intensive practices, e.g. cattle ranching. The Pakistan CCDR notes the large and unproductive

[4] Specifically see the case studies for Bangladesh and Vietnam in Agarwala et al., 2022.

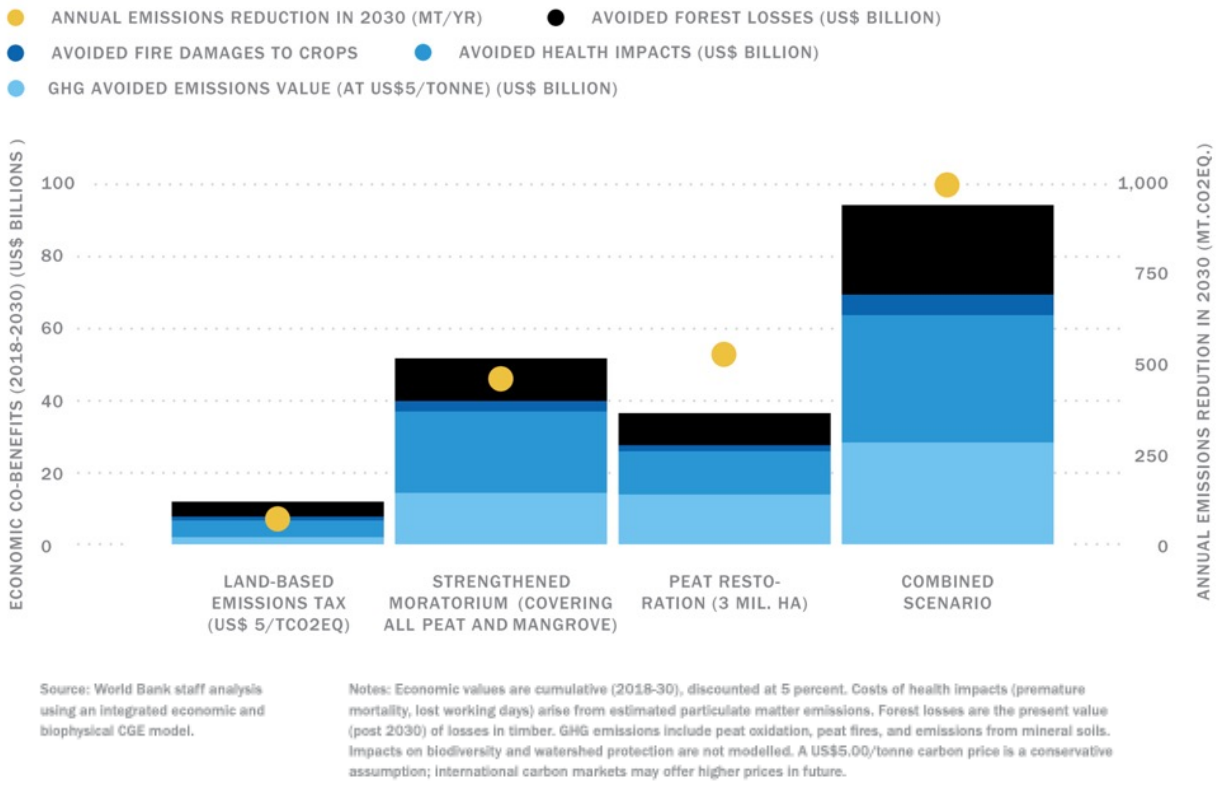
subsidy regimes in the energy, agriculture, and irrigation sectors, which underlie the chronic fiscal stress faced by the country. It describes that the agri-food system is awash with inefficient, costly, inequitable subsidies that are an economic burden and create a distorted incentive structure, which plays a significant role in the sector's poor performance. In recent years, direct and indirect subsidy support to agriculture and irrigation in Punjab and Sindh has amounted to about US$2.2 billion to US$2.7 billion in public spending per year. This includes direct subsidy programs, tax relief for inputs, import and export subsidies, and revenue gap financing. Subsidy programs disincentivise water conservation and can incentivise greater use of fertilisers and over-intensive agriculture damaging soil quality.

Public Spending and Regulations: Green Investment and Green Fiscal Policies

Investments in environmental protection and sustainable practices can deliver improved fiscal balances through greater economic resilience, sectoral productivity and new sources of economic outputs and revenues.

Productivity: The Indonesian government as part of its FOLU Net Sink 2030 plan plans to restore 2.7 million hectares of peatlands, rehabilitate 5.3 million hectares of degraded forestlands, and continue progress in reducing deforestation and forest degradation rates (Figure 13). The Indonesia CCDR references the benefits of halting mangrove loss for aquaculture development and the benefits for smallholder palm oil producers of increasing yields in ways that can enhance livelihoods and reduce forest loss, as well as presenting quantitative analyses on the economic co-benefits of peatland restoration and avoiding deforestation.

The DRC CCDR emphasises the benefits of reversing landscape degradation and forest loss for resilience and productivity. The DRC CCDR reports that DRCs 143 million hectares of forest are valued at $6.4 trillion and could generate up to $400 billion a year from stored carbon and ecosystem services, including flood avoidance and timber production (Figure 14). Further it highlights that sustainable management of forest resources can lead to job creation; in DRC every $1 invested in landscape and forest restoration, yields a gain of $15 benefits by 2050. Forests provide timber, food production, fuelwood, erosion and sedimentation control, regulate and purify water. The Brazil CCDR strongly underlines the benefits of preserving natural capital for resilience. The Pakistan CCDR recognises the benefits of increasing soil organic carbon for its water holding capacity and resistance to extremes. The Malawi CCDR clearly sees forest/land restoration as core to climate resilience, highlighting, for example, the Bonn Challenge pledge to restore 4.5 million hectares.



Source: World Bank staff analysis using an integrated economic and biophysical CGE model.

Notes: Economic values are cumulative (2018-30), discounted at 5 percent. Costs of health impacts (premature mortality, lost working days) arise from estimated particulate matter emissions. Forest losses are the present value (post 2030) of losses in timber. GHG emissions include peat oxidation, peat fires, and emissions from mineral soils. Impacts on biodiversity and watershed protection are not modelled. A US$5.00/tonne carbon price is a conservative assumption; international carbon markets may offer higher prices in future.

Figure 13: Economic co-benefits from policies to reduce land-based emissions. (Source: World Bank Indonesia CCDR)

Ecosystem services valued in DRC's Congo Forest and Brazil Amazon forest

Ecosystem service	*Estimated annual values*		*Notes*
	Amazon	*DRC forest*	
Area in standing forest *(million hectares)*	350 M hectares	143 M hectares	
Timber production *(billion US$)*	$ 1	$ 0.4	Slightly different methodology for areas considered to be not harvestable
Non-timber forest services (water regulation, tourism, habitat) *(billion US$)*	$ 19.7	$ 15.5	Amazon study covered a wider range of forest products, Congo uses CWON[169] data
Global value of carbon storage *(billion US$)*	$ 210	$ 207.1 to 382.5	Amazon used social cost of carbon at $40/t and 3% discount rate. DRC study used shadow price of carbon at $75/t and 6% discount rate. The range reflects different estimates of total carbon stored in DRC's forests
Total standing forest stock value *(trillion US$)*	7	6.4	
Agriculture production	$ 7.5	not estimated	
Regional climate regulation	$ 2.3	not estimated	
Fire protection	$ 1.5	not estimated	
Existence value	$ 65	not estimated	
Biodiversity option value	$ 10	not estimated	
TOTAL annual value (all ecosystems services including carbon) (billion US$)	**$ 317**	***$ 223 to $398***	

Figure 14: Valuation of benefits of forests in Brazil and DRC. (Source: World Bank DRC CCDR)

Revenues: There are also significant potential opportunities for new revenue generation, including ecotourism, renewable natural resources and carbon finance. For example, the Brazil CCDR notes the significant opportunities related to carbon markets. Brazil is the fourth largest global seller of Certified Emissions Reductions (CERs) and third largest country for registered Clean Development Mechanism (CDM) project activities, as well as a main player in voluntary carbon markets. The Article VI mechanism could increase flows in the coming decades to Brazil (estimated at $300bn to $1trillion globally by 2050). This is similarly a feature of the DRC CCDR (Figure 14).

The Malawi CCDR notes opportunities to finance forest/land restoration from international demand for carbon offsets. It finds that land restoration investments will create opportunities for carbon credits but will require targeting investments in the watershed to optimise carbon capture. The analysis shows that the potential value of additional carbon sequestered that could be linked to the voluntary carbon markets ranges from US$24.8 million to US$74.3 million per year if Malawi meets forest/land restoration targets (depending on the global carbon price).

Financial Stability and Sovereign-Bank Nexus

There is growing evidence on the links between nature and financial stability. Research by Financial Sector Deepening Africa (FSDA) and McKinsey (2022) takes the projections from Johnson et al. (2021) and combines this with other scenario information to calculates risks associated with environmental policies to financial portfolios in Africa, for example finding between -2 percent and -5 percent impact on agricultural asset values by 2030 (Figure 15). For the most exposed lending portfolios, nature-related risks in agriculture and extractives would roughly double expected losses due to credit risk by 2030. These risks in agriculture and extractives are same (large) scale as climate-related risks in manufacturing, chemicals and extractives (FSDA and McKinsey, 2022). The scale of the risks captured here is very limited; modelling framework does not capture these tipping points and underestimates nature-related physical risks. Given the strong linkages between the banking sector and government debt in LICs (i.e. the sovereign-bank nexus), risks to the banking sector and sovereigns can amplify, creating significant fiscal issues for countries (World Bank, 2024b).

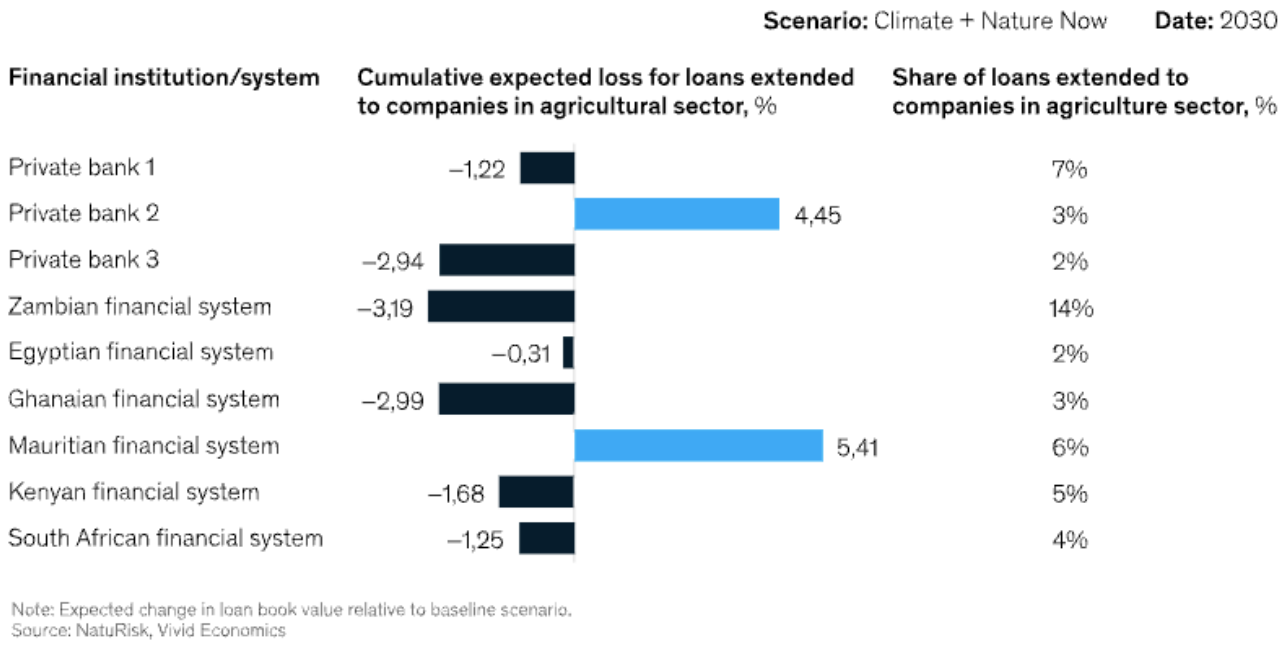


Figure 15: Projected implications of physical and transition nature risks. (Source: FSDA and McKinsey, 2022)

Fiscal and Costs of Capital

There is growing evidence of the linkages between environmental degradation and costs of capital at the sovereign level, but also the benefits of investment in resilience and natural capital. Previous studies – noted above – have assessed the implications of environmental degradation for public debt to GDP. Agarwala et al. 2024 plugs the Johnson et al. (2021) results into simple sovereign credit risk model. They find that for the partial ecosystem services collapse scenario, 15 out of 26 sovereigns (58% of the sample) would face a downgrade of one notch or more, resulting in approximately $28-53 billion in additional costs of interest payments borne by these nations. Countries with the lowest sovereign credit ratings – including the LICs – are found to be most at risk from sovereign credit downgrades. Ethiopia and Bangladesh, for example, are two of the most impacted countries in the study and could face an increased cost of borrowing anywhere from $0.04 – 0.21 billion and $0.15 – 0.76 billion respectively.

Figure 16 shows new preliminary results based on the modelling of Ranger et al. (2024), demonstrating how a nature-shock scenario could affect sovereign credit ratings for the international supply chain risk scenario, revealing significant risks of downgrades to middle-income countries such as Chile, Mexico, India and Argentina. Bernhofen et al. (2024) assesses the potential implications of rising flood risk on fiscal risks in Thailand using the DIGNAD (Debt, Investment, Growth, and Natural Disasters) model and the benefits of investing in different adaptation measures. Similar analyses have been developed for flood protection from mangroves, for example Menéndez et al. (2020). Such analyses also demonstrate the risk reduction benefits of investment in resilience and nature for sovereign financing (Figure 17).

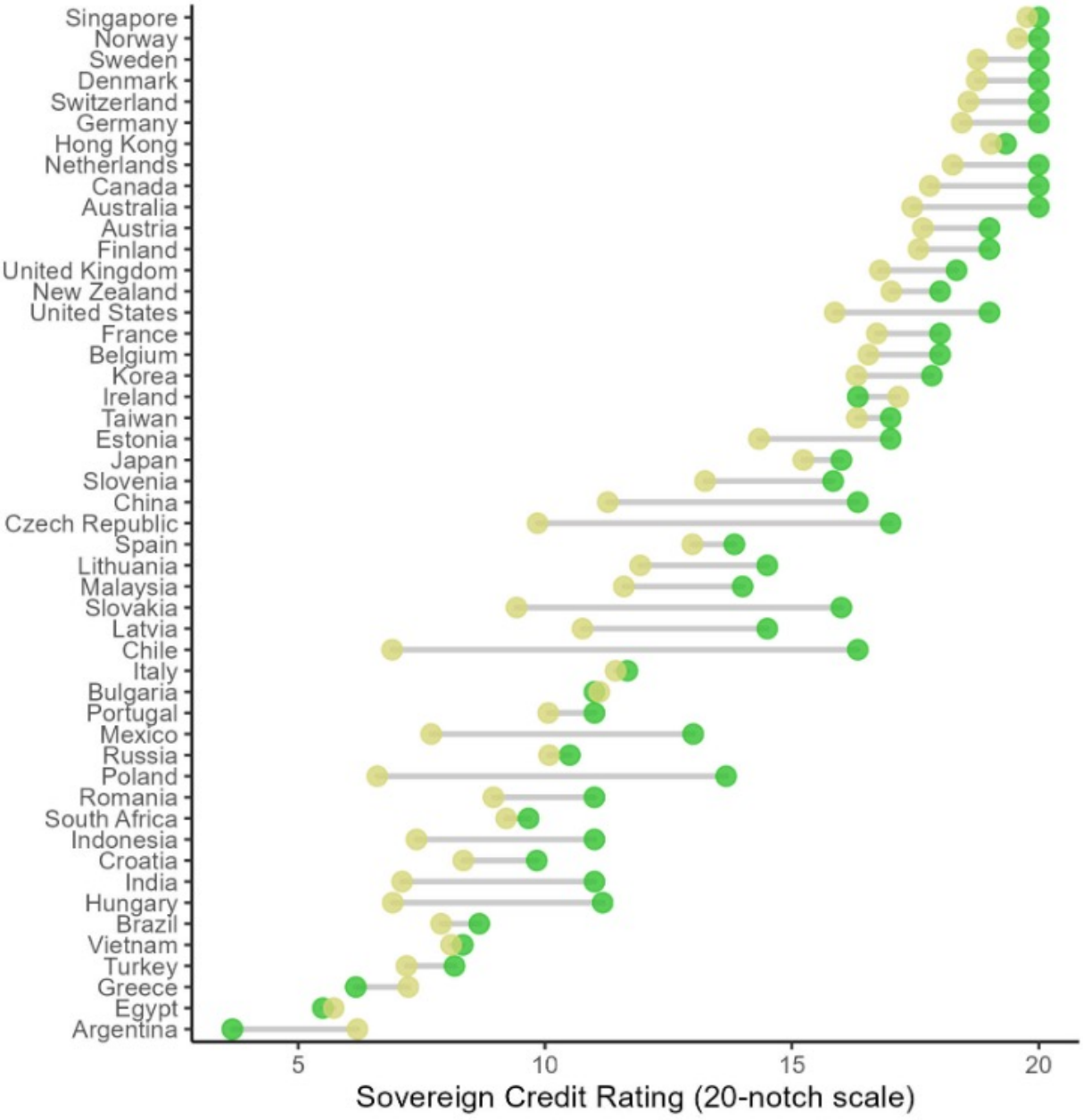
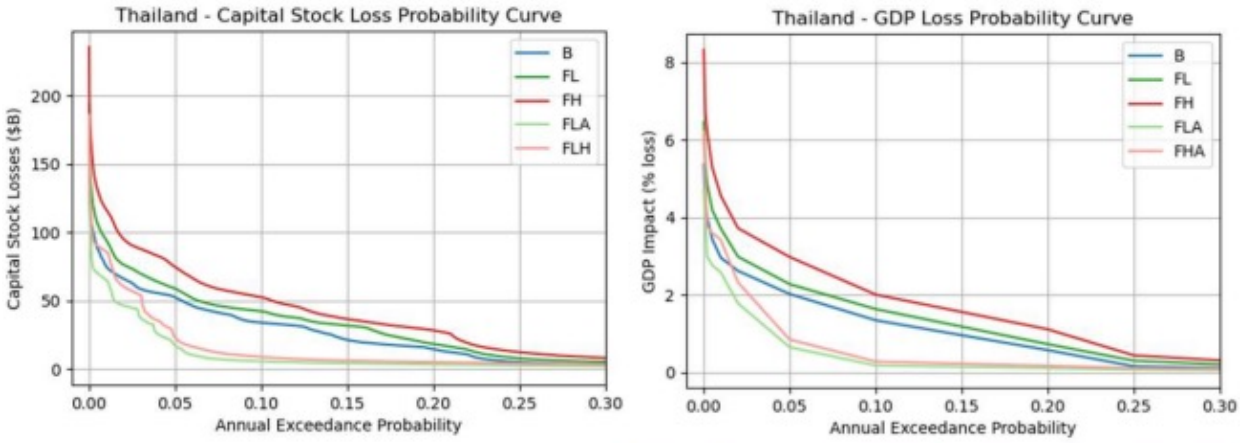


Figure 16: Preliminary estimates of the impacts of a nature shock scenario on sovereign credit ratings, based on the methodology of Ranger et al. (2024). (Source: Ranger et al. forthcoming)



			1 in 100 loss year					1 in 1000 loss year				
Grade	Rating	Numerical	B	FL	FH	FLA	FHA	B	FL	FH	FLA	FHA
Investment	BBB+	13	Thailand's current sovereign rating									
	BBB	12	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
	BBB-	11		↓	↓		↓	↓	↓	↓	↓	↓
Non-Investment	BB+	10							↓	↓		
	BB	9								↓		

Figure 17: Modelled impacts of flood on capital stock and GDP in Thailand and benefits of adaptation measures for multiple scenarios: B=Baseline (Historical), FL and FH are future with low and high emissions, FLA and FHA are the same with adaptation. (Source: Bernhofen et al., 2024)

Alternative Financing and State-Contingent Financing Instruments

Recent years have also seen a growing number of sovereign financing transactions linked to nature, in particular debt for nature swaps and more recently, sustainability-linked financing instruments. These instruments enable countries to reduce their debt burden while mobilising concessional capital for investment in nature protection and recovery. Examples include blue bonds in Belize and Gabon. There are also important potential linkages to more well-established state-contingent debt instruments, such as the World Bank Catastrophe Deferred Drawdown Option (Cat DDO), sovereign insurance mechanisms and climate resilient debt pause clauses. Such mechanisms can enhance debt sustainability immediately and contribute to long-term debt sustainability through stabilising sectoral outputs and building economic resilience through strategic investments in natural capital. At present, climate-related state-contingent debt instrument (SCDI) do not feature in the debt portfolios of most LICs. As the market for SCDIs expands, the DSF will need mechanisms for evaluating the implications of these instruments.

3.4 Findings of Independent Reviews on the LIC-DSF, Nature and Resilience

Existing independent work on the relationships between debt, nature and resilience strongly calls for their integration within the LIC-DSF. LIC-DSF reform has been the focus of several independent reports calling for the integration of nature and climate risks. These analyses argue that failing to incorporate environmental factors can lead to flawed debt assessments and hinder climate-resilient development. Below is a review of key proposals from various independent reviews, followed by a comparative table summarising their recommendations, rationale, and suggested tools. The reports reviewed in the Table 2 below converge on three common themes:

- Environmental shocks are now structural drivers of debt distress;
- Spending on adaptation and NbS should be treated as debt-stabilising investment, not a fiscal drag;
- The analytical upgrades needed are already technically feasible.

The reports also provide comprehensive recommendations for how nature can be integrated in a way that is feasible and practical. These are summarised in Box 3 and Table 2.

Box 3: A four-step methodology for integrating nature risk into the LIC-DSF. (Source: Kraemer & Volz, Nature Finance / Finance for Biodiversity Initiative, 2022)

Step	What the authors propose
1. **Identify the economic impact of biodiversity loss**	Take the country-level GDP shock from The Economic Case for Nature (World Bank, 2021). That study links a global CGE model to four ecosystem-service modules (pollination, timber, fisheries, carbon) and estimates the percentage fall in GDP under a partial ecosystem-service collapse by 2030.
2. **Determine the resulting borrowing requirement**	Feed the GDP shock into the IMF's DSF template populated with baseline macro-fiscal data. Adjust the primary balance by allowing (i) lower revenues; (ii) higher primary spending.
3. **Translate into macro-fiscal shocks and adjust funding costs for government debt**	Assume that investors respond proportionally to the depth of the GDP hit. Exchange-rate depreciation is set in line with the GDP decline, with only a modest inflation pass-through.
4. **Implement in the DSF template**	Enter the growth, fiscal, exchange-rate and interest-rate shocks into the publicly available IMF Excel template for market-access countries. Run two simulations: (a) growth/exchange-rate shock only; (b) growth & funding-cost shock. Compare the resulting debt-to-GDP ratio and gross-financing-needs ratio with the base case and with standard IMF stress tests.

Table 2: Synthesis of existing independent reviews on DSA and nature. (Source: Authors, based on existing literature)

Report	Proposed LIC-DSF Reforms	Rationale & Evidence	Suggested Tools/Models
Nature Finance (Kraemer & Volz 2022) – "Integrating Nature into DSA"	Integrate nature-related risk scenarios into DSAs (e.g. biodiversity loss, ecosystem collapse). Include nature risk in IMF/World Bank debt framework to avoid missing key risks.	Omitting nature risks leads to inaccurate policy recommendations and increase the risk of debt distress and avoidable crises. Partial ecosystem collapse would sharply worsen debt ratios (e.g. +15%-pts of GDP in Bangladesh) – often a larger impact than COVID-19 shocks.	Adopt scenario stress-testing for nature loss to model macro-fiscal impacts of losing services (pollination, fisheries, etc.). Four-step methodology 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; and 4) Implementing assumptions into debt sustainability template. Apply World Bank natural capital data to quantify GDP and fiscal effects, feeding into DSA projections.
Systemiq (2024) – "Integrating Climate Adaptation & Natural Capital"	Make climate change and nature degradation part of the baseline in DSAs (not just an optional scenario). Treat natural capital as productive capital for economic growth, e.g. in debt models, alongside physical and human capital. Revise IMF's framework (LIC-DSF and MAC SRDSF) to account for adaptation investment needs and nature-based solutions, thus enabling financing on terms that do not	Current DSAs assume a "stable climate" baseline, which is unrealistic given escalating climate impacts. Ignoring nature and climate risks means underestimating volatility and long-term growth paths, especially for vulnerable economies.	Incorporate NbS as adaptation investments (e.g. valuing mangrove protection like infrastructure). Include high-adaptation vs. low-resilience scenarios in DSAs to gauge debt outcomes under different climate futures. Improve data on climate risks and adaptation costs (e.g. using models capturing non-linear climate effects and "tipping points" rather than linear projections).

	add to unsustainable debt burdens).		
Bridgetown Initiative 3.0 (2024)	Revise DSA methodology to count resilience-building as investment, rather than an expenditure. Update debt sustainability criteria so that spending on green tech, climate adaptation, etc., improves a country's assessed debt outlook (reflecting future growth benefits).	Traditional DSAs undervalue long-term growth from climate action and hence may discourage critical investments. Climate adaptation and mitigation strengthen economic stability and in turn enable vulnerable countries to borrow for these purposes without punitive debt ratings.	Extended horizon analysis to consider longer-term impacts of climate investments on debt paths. Incorporate vulnerability metrics or resilience indicators into DSA risk thresholds to better reflect a country's climate risk exposure (mentioned as a broader reform for concessional finance access). *NB: Bridgetown's recommendations are high-level; they emphasise policy shifts and complementary tools like SDR reallocation and climate swap mechanisms.*
Debt-Nature-Climate Expert Group (2025) – "Healthy Debt on a Healthy Planet"	Embed climate and nature risks, and benefits of mitigation/adaptation, in all DSF analyses. Require DSAs to identify country-specific climate and nature "shock" risks and quantify potential GDP and fiscal losses, plus the debt impact of investments that enhance resilience. Align IMF's LIC-DSF and World Bank tools with these integrated risk assessments (and encourage credit rating agencies to follow suit).	Climate change and nature loss are already impacting growth and fiscal stability, and these effects will intensify. Current DSFs only partially capture climate risks and *not at all* nature risks, missing critical drivers of debt distress. Environmental shocks raise debt, which then crowds out resilience investment – breaking this vicious cycle requires DSFs to show the payoff of investing in adaptation/nature protection.	Incorporate standardised resilience scenarios in DSAs (e.g. a high adaptation vs a business-as-usual scenario) to illustrate long-term debt outcomes under different policy paths. Use stock-flow consistent and other new models that integrate environmental stocks (natural capital) and allow for feedback loops between ecological changes and the economy. Consider extending DSA forecasts beyond the typical 10 years (NB: the report aligns with 20+ year horizons for climate-vulnerable states, as per IEG).
Boston University GDP Center	Integrate climate risks and development financing needs into the LIC-DSF to make it "fit	IMF DSAs underestimate debt vulnerabilities. They omit the scale of investment required for	Climate-adjusted DSA template: BU developed an alternative DSA that factors in annual climate investment

Task Force (2024) – Climate & Development DSAs	for purpose" for the Paris Agreement and SDGs. Enhance the LIC-DSF in four areas: data (climate-risk data granularity); scenarios (up-to-date climate scenarios and realistic financing plans); macro-models (include non-linear and persistent climate effects); risk assessment (probabilistic approach). Adjust the framework to support investment-led growth – allowing space for green and resilient investments without triggering debt distress labels.	climate adaptation and the SDGs. BU analysis shows that once these needed investments are included, the majority of studied countries would breach debt sustainability thresholds. Climate shocks and external stresses (pandemics, commodity swings) are making the old debt metrics insufficient; a development-centric DSA would highlight the true financing gaps and spur global support (debt relief, concessional funds) rather than austerity.	requirements and shock scenarios, which other analysts can build on. Use downscaled climate risk data and incorporate climate finance needs explicitly into DSA baseline scenarios (e.g. assume grant financing for x% of adaptation costs). Use complementary measures and pair DSA reforms with debt relief initiatives and increased concessional financing to ensure countries can invest in resilience without insolvency. The Task Force emphasises that analytic fixes alone are not enough – the output of climate-informed DSAs should guide actual debt restructuring and new financing.

3.5 Lessons from Prudential Policy

While the DSF sits within the realm of fiscal and macroeconomic analysis, there are important lessons to be learned within the prudential policy domain, particularly how central banks and financial supervisors are addressing climate and environmental risks. From a mandate perspective, institutions such as the European Central Bank (ECB), and the broader Network for Greening the Financial System (NGFS) have acknowledged that integrating climate and nature risks is not optional, but a mandate-driven responsibility. Indeed, they have interpreted their financial stability mandates to include physical and transition risks from climate change, recognising that environmental shocks can undermine the soundness of economies and financial systems.[5] As ECB Executive Board Member Frank Elderson has put it, nature loss is necessarily a financial stability issue (see Elderson, 2024).

From an operational standpoint, the same institutions have offered approaches that acknowledge the structural, long-horizon, and uncertainty around climate and nature risks. Overall, three main insights can be drawn:

i) **Forward-looking scenarios:** central banks employ systemic risk over decades, and in a similar way the DSF should move beyond historical averages to include nature and disaster scenarios in both baseline and stress paths.

ii) **Exposure-based assessments**: As demonstrated in a pilot by Ranger et al. with the ECB (2025) exposure- and risk-based approaches – such as the Nature Value at Risk (NVaR) framework—can offer powerful tools for evaluating systemic risks. These approaches could be mirrored in DSAs to better capture forward-looking climate and nature-related vulnerabilities.

iii) **Systemic risk framing:** just as central banks now view climate and nature as system-wide risks that can affect multiple sectors simultaneously, the DSF should recognise that repeated or compounding environmental shocks can threaten macro-fiscal stability, especially in vulnerable low-income countries.

Similarly, the IMF's Article IV mandate calls for comprehensive surveillance of risks to macroeconomic and fiscal stability. In countries facing recurrent natural disasters or ecosystem degradation, these risks are structural and material (see World Bank, 2023).

5 The ECB's 2020 Guide on Climate-Related and Environmental Risks framed ecosystem degradation as a material driver of credit, market and operational risk and set out 13 supervisory expectations covering governance, strategy and disclosures.

Just as central banks are evolving their prudential frameworks, there is a clear case for the DSF, central to IMF-World Bank fiscal guidance, to evolve to integrate nature-related risks to meet its mandate to anticipate, assess, and address systemic macroeconomic and financial stability risks.

3.6 Risks of Not Incorporating Nature and the Benefits for Countries

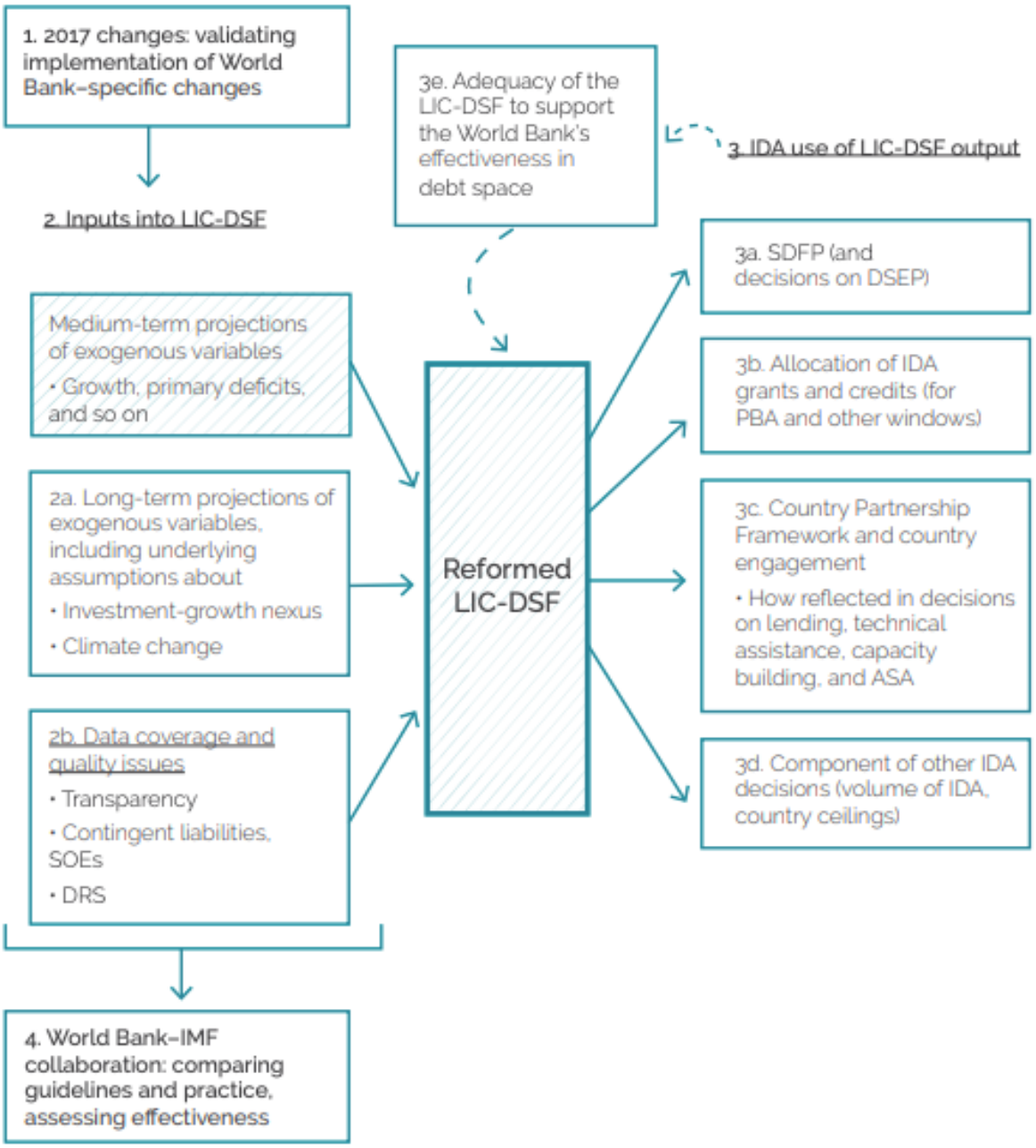
Given the significant influence of the LIC-DSF in macroeconomic decision making and costs of capital *(see for example, Figure 18)***, not incorporating nature brings risks to countries and to the international monetary system**. Many low-income countries face pressing short-term financing needs and prioritising nature in debt analysis could be seen as a non-priority. Indeed, integrating nature could cause LICs being labelled at “higher risk” and these LIC could face higher borrowing costs. However, not incorporating nature unfairly penalises LICs by undervaluing their natural capital and the benefits of investment and can lead to inappropriate macroeconomic policies. For example, for countries, failure to reflect the benefits of public investments that protect natural capital and improve the underlying growth potential (relative to the counterfactual) may lead to the adoption of an inefficiently tight fiscal stance (i.e. austerity), overly constraining countries.

On the other hand, failure to reflect the effects of natural capital depletion, either on the correct measurement of genuine savings (which underpins debt sustainability) or directly on fiscal and growth performance over the medium term, may encourage too positive a view of the likely trajectory for growth and the capacity to service debt, leading to increased risk of debt distress and default and hence difficult adjustment down the line. These misrepresentations can then in turn lead to incorrect issues being highlighted in country partnership strategies of the IMF, World Bank and other actors.

It is notable that most country authorities surveyed by the IEG 2024 Review believed that DSAs could better assess climate change and its impact on long-term growth. For example, the IMF's 2025 Article IV consultation for Kiribati highlights how deeply the country’s economic vulnerabilities, such as volatile fishing revenue and fiscal pressures, are tied to nature degradation. Calibrating fiscal policy to counter volatility from fishing revenues and grants would help support macroeconomic stability. By integrating nature-related risks into DSF framework, countries like Kiribati can better account for the economic costs of environmental degradation and the long-term value of nature-based resilience. For example, DSF stress tests could model the fiscal impact of climate-driven declines in fisheries or

rising disaster-related expenditures, while also capturing the debt-stabilising benefits of investments in coastal protection or ecosystem restoration. Aligning DSF analysis with the realities flagged in Article IV consultations would provide a more accurate, forward-looking picture of debt sustainability in vulnerable states, as well as strengthen the case for nature-positive investment and concessional finance.

For the international monetary system, not capturing the significant macroeconomic risks associated with environmental degradation within the LIC-DSF could lead to a lack of monitoring and management of these risks and an accumulation of risk over time. This would also mean the sovereign risk is not appropriately priced in private markets. This not only leaves the international monetary system exposed but also reduces the incentives, tools and support available for countries to manage risks. At a global level, it means that nature-related risks are not fully endogenised within the international monetary system, leading to a potential build-up of systemic risks that could precipitate a crisis. This is particularly critical in the case of systemic nature-related risks, for example major failures of ecosystems at the regional level and disruptions to critical supply chains.



Source: Independent Evaluation Group.

Figure 18: The World Bank's Role in and Use of the 2017 LIC-DSF: An Evaluation. (Source: IEG). Note the LIC-DSF is also used to anchor debt restructuring negotiations and as an input to IMF programming.

3.7 Summary – the Rationale for Integrating Nature

The evidence presents a clear case for the macro-criticality of natural capital for LICs economies and the immediate relevance to the LIC-DSF. The clear conclusion from this analysis is that not incorporating natural capital into the LIC-DSF is a failure of the IMFs mandate and could lead to distortions in macroeconomic policies that would undermine LICs. Returning to the three sources of debt risk laid out in the previous section, nature-related dependencies and risks have the potential to influence all three for LICs economies.

Table 3: Summary of evidence on macro-criticality of nature for LICs.

Criterion	Macro-criticality of nature
Destabilise the fiscal position	Clear evidence of the implications of both chronic and acute nature-related shocks and stresses for production, revenues, macro stability and public expenditure.
Impair the financial sector	Evidence of nature-related risks to the financial sector, including balance sheet pressures and risks of sovereign-bank contagion.
Undermine market confidence	Evidence of rising costs of capital.

The risks are particularly high for countries with high dependencies on sectors exposed to nature-related risks, material levels of environmental degradation, including land degradation, land-use change and deforestation, and high pre-existing vulnerabilities to natural disasters. This suggests that the criteria for including nature into the LIC-DSF would look similar to that for climate change, for example:

- Mandatory natural disaster stress test for the most vulnerable countries and LICs that meet criteria for frequency (2 disasters every 3 years), economic losses (>5% GDP per year) or *where economic dependencies on ecosystem services are high*.
- Countries where climate change, climate adaptation, *environmental degradation* or transition management policies are assessed as macro-critical in Fund's Article IV and program reports or considered essential to be implemented in the short- and medium-term to ensure that the macroeconomic policy framework is adequate in the World Bank's Development Policy Financing operations.

Importantly, this synthesis of the evidence demonstrates that environmental degradation and nature-related risks are a systematic not idiosyncratic risk, hence the DSF should not treat it as temporary or exogenous but in LICs, it should be considered as structural features of the macro fiscal environment.

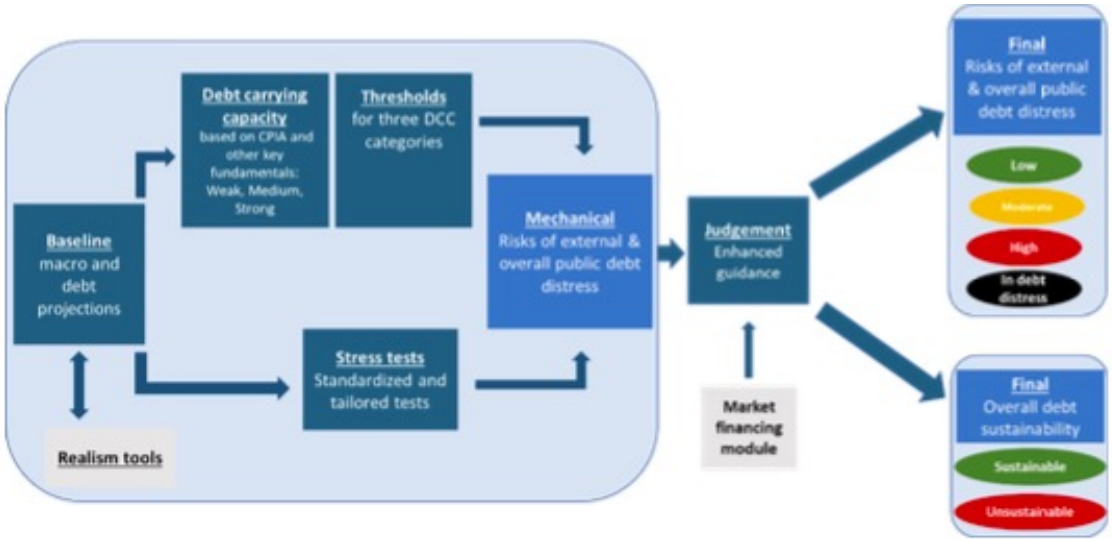
4. Feasibility

Amansuri Lake, Ghana. Photo by Ato Aikins on Unsplash

A key principle to guide the work on future-proofing the LIC-DSF set by the IMF is to keep the framework transparent and easy to use. The design of the LIC-DSF aims to balance analytical rigor with the need for transparency and ease of use by both staff on IMF-World Bank country desks and by country authorities. The risk assessments in the LIC-DSF draw from analyses of risks under a baseline projection and their distribution in stress-test scenarios, informed by mechanical signals from estimated near-term debt distress models combined with expert judgment. The operational strength of the DSF lies in its simplicity which, in turn emerges from it being essentially a spreadsheet-based exercise (Box 4) that is built up by applying basic accounting rules to debtors' balance sheets. This makes it relatively easy to mechanically construct debt profiles for a country in terms of a small number of driving factors.

Box 4: The LIC-DSF

The LIC-DSF provides a standardised yet flexible tool for assessing debt-related vulnerabilities in LICs. Developed jointly by the IMF and World Bank, the framework is implemented through an Excel-based template (see the Interactive Guide on Debt Sustainability Framework for Low-Income Countries (World Bank, nd). that integrates macroeconomic projections, financing strategies, and stress testing to assess the sustainability of public and publicly guaranteed (PPG) debt.



Source: Staff analysis of 2017 LIC-DSF econometric model and of DSA ratings.

At its core, the change in a country's debt-to-GDP ratio over time is governed by the relationship:

$$\Delta\left(\frac{D}{Y}\right) = (r-g)\cdot\left(\frac{D}{Y}\right) - \text{Primary Surplus}$$

Where D is Debt, Y is GDP, r is the real interest rate on debt and g is the real GDP growth rate. When (r-g) is positive (which it typically the case), debt stabilisation requires a positive primary fiscal balance (after grant financing).

The challenge facing the DSF is that while it is easy to track the basic accounting relationship in a small set of spreadsheets, the analysis of the core drivers of the relationship (growth, the marginal cost of funds, the fiscal stance) are all 'external' and not necessarily derived from the same internally consistent framework. So those constructing a DSF may make assumptions about growth prospects, but there is no guarantee that these projections are consistent with independent assumptions about fiscal capacity. Good expert judgement often plays a role. In principle the simple arithmetic of the DSF should hold exactly but in practice, there are often significant 'errors and omissions' which reflect a range of specific measurement problems. Some scholars have shown that these errors and omissions are often the single largest component of changes in measured public debt, especially in LICs.

A key innovation of the LIC-DSF is the use of a composite indicator of debt-carrying capacity, which classifies countries as having strong, medium, or weak capacity based on economic and institutional fundamentals. This determines the relevant debt thresholds used to flag solvency and liquidity risks. The framework also includes built-in consistency checks to validate the realism of baseline assumptions, ensuring that projections align with historical trends and country-specific context. Central to the LIC-DSF are tailored stress tests that simulate adverse macroeconomic and financing shocks, such as lower growth, currency depreciation, or contingent liabilities, to examine the resilience of a country's debt profile. These scenarios are calibrated to reflect the specific risks a country may face. Importantly, while the LIC-DSF framework produces mechanical risk signals based on the breach of indicator thresholds under baseline and stress scenarios, the final debt distress risk rating incorporates expert judgment, allowing for consideration of country-specific factors not fully captured in the model.

(Source: World Bank and IMF and authors)

The main constraint is staff time and timeliness - while embedding plausible models is within the technical scope of the Fund, the resources required to calibrate and maintain sophisticated country-level macro-models for DSF is beyond current operational capacity. Many countries seek to maintain macro-models that in principle are suitable for this task, e.g. the World Bank Macro-MOD, but to-date these have not been systematically integrated. In this context, it is instructive to learn from the Fund's approach to integrating climate risks to date – outlined in its July 2024 Supplement - which draws upon standalone models to develop baseline and alternative scenarios as well as stress tests (Box 5) or alternatively historical analyses for near-term debt analysis.

In 2020, the IMF introduced the DIGNAD model (short for Debt, Investment, Growth, and Natural Disasters) which is a Dynamic General Equilibrium Model developed to help analyse the complex interactions between public investment, debt sustainability, economic growth, and natural disasters, particularly in low-income and disaster-prone countries, as part of the LIC-DSF (Aligishiev, Ruane and Sultanov, 2023). DIGNAD has been applied in several countries as part of IMF programs but is not yet systematically used within DSAs including the LIC-DSF.

Box 5: Summarised guidance on how climate change is incorporated

Climate change can be incorporated in the baseline or in alternative scenarios via:

- Results from standalone macro models and tools, for example the World Bank CCDR or IMF CMD.
- Alternative scenarios calibrated using findings from World Bank CCDRs, IMF CPDs, C-PIMA and FSRs[6], including tools such as World Bank MANAGE, CC-MFMOD, DIGNAD.
- If no models or in-depth analysis is available, historical analyses can be used for near-term, noting the need to account for projected changes.
- Using stress tests to capture the impact of extreme but plausible weather events, including tailored natural disaster stress test or customised stress tests on external and overall public debt (e.g. using CC-MFMOD or DIGNAD).

(Source: July 2024 Supplement to 2018 Guidance. (IMF, 2024b))

We propose that in the near-term it is not practical to suggest a radical revision of the LIC-DSF to incorporate nature fully and *directly* into the analytical framework underpinning the DSF. However, there are important opportunities to reflect key linkages in the sensitivity analysis around central DSF projections for individual countries, baselines and alternative scenarios. We stress three principal channels, each of which will be informed by the on-going research at low cost (taking place in the Bank, Fund, academia and elsewhere).

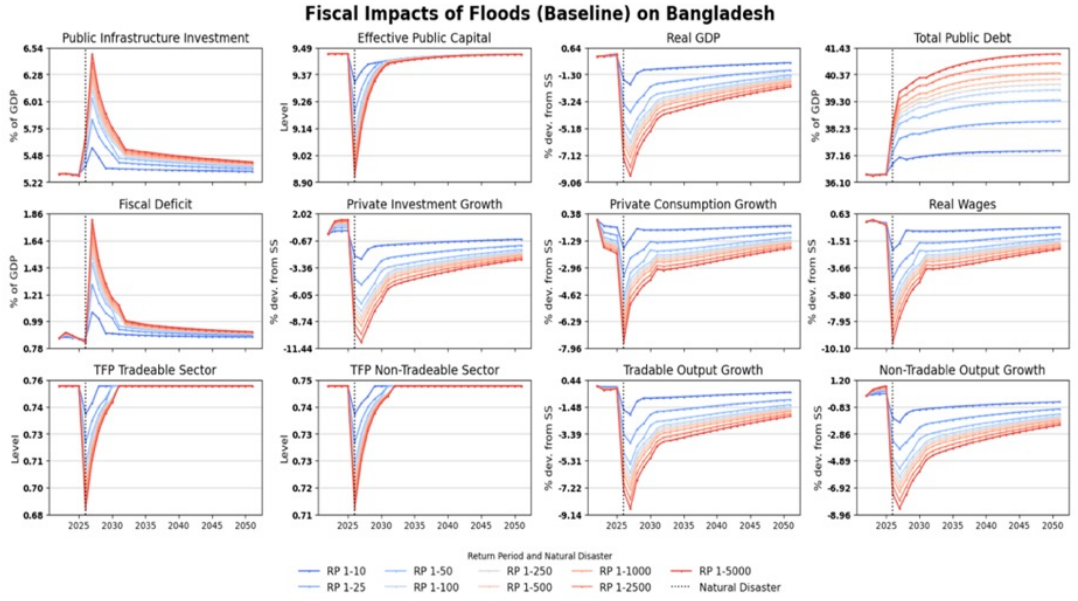
- **Natural capital and growth:** incorporating assumptions about how degradation of natural capital affects growth and how investments in the preservation of natural capital impact growth over the short- to medium-term, and any non-linearities. For example, degradation could initially boost output in the short-term but at long-term cost and with irreversibility. This could be achieved through incorporating scenarios based on external models (e.g. Johnson et al., World Bank MANAGE model, DIGNAD (Box 4), FIMA as in Kulenkampff et al. 2025, nVaR from Ranger et al. 2024) or through simple assumptions based upon current economic dependencies (e.g. datasets contained in Annex 4) or the findings from World Bank CCDRs.
- **Natural capital and the fiscal balance:** incorporating assumptions about the resilience of the fiscal balance (revenue and expenditure) to changes in natural capital, either gradual or large changes arising from policy or other actions (e.g. purposive closures of polluting/brown sectors such as mining), and to the fiscal framework for ecosystem pricing. This could build upon examples such as Bernhofen et al. (2024) and more recent work with the DIGNAD model (e.g. Box 6).

6 Climate-Public Investment Management Assessment and Government Fiscal risk statement.

- **Nature and the changing cost of borrowing** (at margin): incorporating assumptions about nature-related changes in country-specific sovereign risk premia, learning from examples such as Kraemer and Volz (2022) and Bernhofen et al. (2024) (Figure 15).

Box 6: Building Natural Shocks into the DIGNAD Model

The University of Oxford and the London School of Economics have collaborated with the IMF to develop baseline and alternative stress test scenarios for the impacts of disasters on debt across multiple countries using the DIGNAD model. The system utilises natural disaster risk data from the Global Infrastructure Risk Model and Resilience Index (https://giri.unepgrid.ch/) to assess the impacts of disasters on debt dynamics and the benefits of resilience measures. The flexibility of the DIGNAD model allows the easy development of multiple scenarios. Shown below are ten scenarios for flood risks to fiscal and macroeconomic indices in Bangladesh. The macro-criticality of the impacts on debt and GDP are clear from these figures.



(Source: Akaraseth Puranasamriddhi, Jim Hall and Nicola Ranger)

In the near-term, recent innovations in nature-related financial risk modelling by Central Banks, the World Bank and researchers provide opportunities to develop nature-adjusted scenarios as stress tests. For example, work by Nature Finance has demonstrated how the results from the World Bank-supported GTAP-Invest Model (Johnson et al., 2021) can feed into the DSF through directly incorporating GDP impacts generated by the external macroeconomic model (Kraemer and Volz 2022).

More recent work by Nature Finance has developed simple tools to directly incorporate nature into the DSA, designed to be compatible with the LIC-DSF (Box

7). Box 8 provides a fully operationalised example of how the FIMA (Financial Materiality Assessment) tool can be used to assess debt trajectories under different assumptions linked to forestry in Ghana, also demonstrating the macro-criticality of forestry for the country's debt dynamics. The Nature Value-at-Risk method developed for the NGFS (Ranger et al., 2024) can also provide simple scenarios. Work by the University of Oxford and the London School of Economics with the IMF has explored how to more fully integrate natural shocks into the DIGNAD model. The World Bank's nature-economy models (e.g. MANAGE) are currently applied to only a subset of countries within the CCDRs but could be built upon in collaboration with the IMF to serve the LIC-DSF.

As the research and evidence base around the core linkages between nature and macroeconomic dynamics (and vice versa) matures, there may be a case for seeking to embed these in the core DSF framework. This is, however, a long-run project. Even today, embedding much more basic links between public investment and growth remain vestigial within the core DSF. To fully accommodate natural capital could require core adjustments to the DSF. For instance, standard DSAs emphasise solvency and liquidity indicators (debt ratios, debt service), which don't directly account for asset depletion. In the meantime, using external models to generate scenarios to input into the DSA is effective and mirrors the approach currently recommended in the July 2024 Supplement for climate change (Box 5).

Box 7: Financial Materiality Assessment (FIMA) Explorer for the DSA

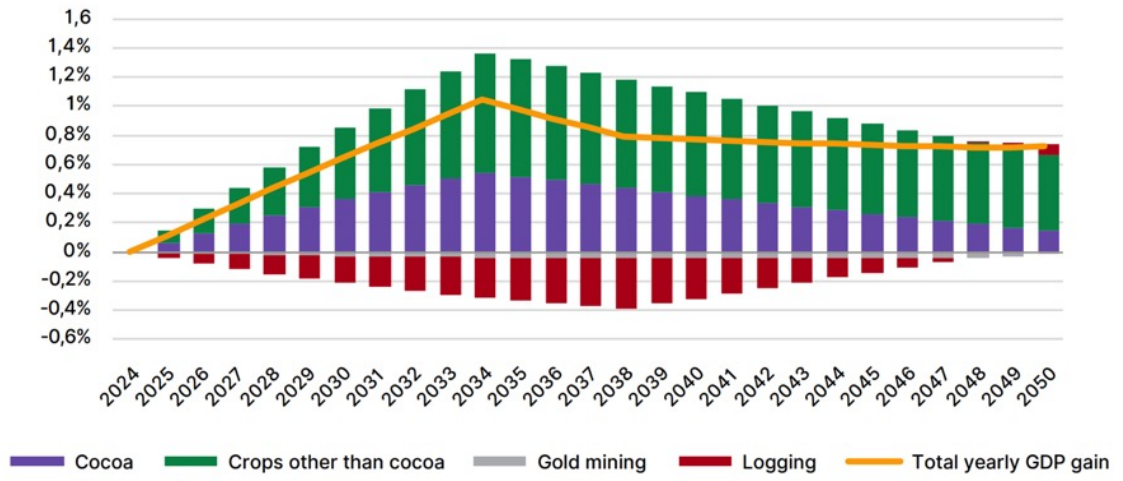
The FIMA Explorer was developed by Nature Finance and Teal Insights with feedback from the IMF and allows users to develop baseline and alternative scenarios for country DSAs based upon simple assumptions and test the implications of different policies and instruments, including policies around land-use change, potential new revenue streams from carbon markets and alternative financing instruments such as debt for nature swaps and sustainability-linked bonds. The simple dashboard approach is designed to feed directly into the DSA and be easy to use and transparent.

(Source: Nature Finance, and Teal Insights)

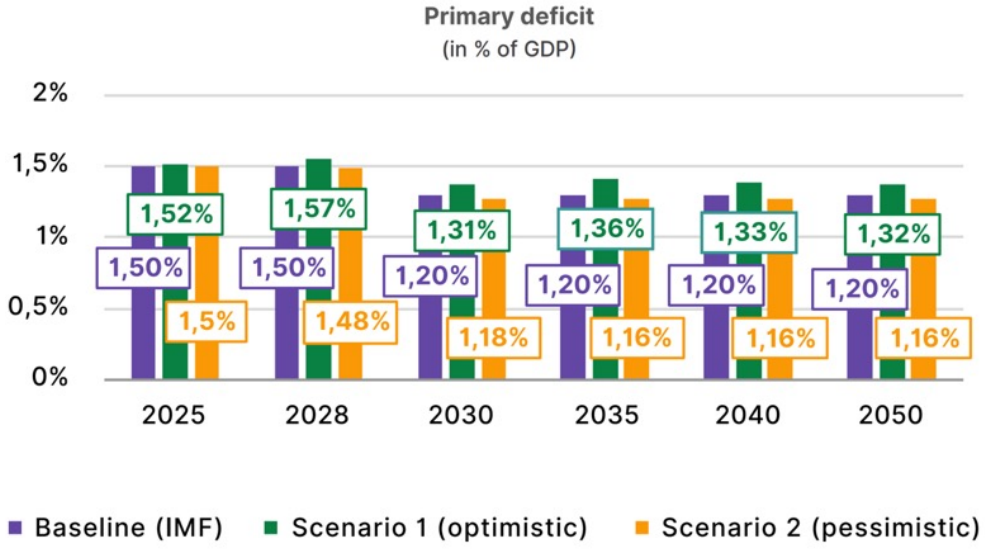
Box 8: Demonstration of the Application of the FIMA Tool in Ghana

The FIMA framework was designed to assess the macro-criticality of key performance indicators (KPI) for sustainability-linked debt instruments but has wider applications to generating scenarios of debt dynamics under different assumptions about environmental degradation and nature-positive policies and investments. For Ghana, FIMA uses deforestation rate as the Headline KPI, assessing how outcomes under baseline, pessimistic, and optimistic deforestation scenarios affect public debt dynamics and sovereign credit ratings.

Exhibit 20 GDP gain by sector (GDP % change)



In this case, the model indicates that the optimistic scenario, when compared to baseline "business as usual" assumptions, boosted growth by up to 1 percentage points (pps) with a cumulative effect of 18% between 2024 and 2050. All else being equal, achieving the performance target all along could decrease Ghana's debt stock by 2.5 pps, save US$500m in interest payments, and lower its interest-to-revenue ratio by 1.7 pps by 2034. Leveraging Ghana's standing forest to sell carbon credits could add up to 0.5% of GDP to this accounting (depending on the price assumption). Taking all these gains together and feeding them into credit rating models suggests a potential uplift of up to two notches. The application finds that Ghana's fiscal space would be significantly impacted together with its ability to invest in nature restoration and climate adaptation measures, thus lowering vulnerability to future shocks, debts distress and potential default.



(Source: Nature Finance SSD Hub, Kulenkampff et al,. 2025)

4.1 Availability of Data

Availability of nature-related data is often regarded as a key challenge, however in this report we have demonstrated that there is sufficient data available to inform the development of debt scenarios, even for the LICs. Certainly, data gaps remain, for example regarding the specific elasticities of sectoral output to ecosystem service provision, or the state of nature at a local level, but there is sufficient data to calibrate scenarios. For example:

World Bank CCDRs: while nature is not yet systematically integrated within the CCDRs, the reports provide valuable insights for many risk transmission channels. As the World Bank begins to more systematically incorporate nature, this will strengthen the DSF. To date, the CCDRs cover more than 70 countries, including 37 LIC-DSF countries.[7]

World Bank CWON: the changing wealth of nations dataset is a rich source of data on the monetary value of flows of natural resources and the value of ecosystem services that can provide important inputs to a DSA. This dataset covers more than 150 countries and data over more than decade so allowing trend analysis and scenario construction (see also Annex 4).

Nature-Related Geospatial Disaster Assessments: researchers have been active in developing open tools to assess the benefits of nature-based solutions for disaster risk. For example, the Resilient Planet Data Hub[8] (UNDRR, Insurance Development Forum, London School of Economics and Oxford), includes many datasets of hazards, exposure, vulnerability and risk, as well as global assessments of the resilience benefits of nature-based solutions including mangroves and agroforestry projects developed in collaboration with the Global Center on Adaptation with support of FCDO[9]. The GIRI platform provides comprehensive global data on risks related to infrastructure[10]. Other toolkits include the CLIMADA toolkit and global mangrove modelling by Michael Beck (2022).

Opportunities from Earth Observation (EO): EO provides unprecedented opportunities to analyse the state of ecosystem services in a globally consistent way. For example, the European Space Agency's Copernicus platform (EU Commission, nd) includes a large number of nature-relevant datasets, including land use and land cover mapping, forestry and other vegetation, water quantity and quality, pollution and ocean resources. ESA recently launched the Leveraging Earth

[7] **See**the Country Climate and Development Reports (CCDRs) here.
[8] **See** Resilient Planet Data Hub. Available here.
[9] **See** GRI Risk Viewer. Available here.
[10] https://giri.unepgrid.ch/

Observation for Nature Finance (LEON)[11] project which is working with financial institutions, including the IMF, to explore opportunities to apply EO more systematically in financial decision making related to natural capital.

UN and other country-level databases: Annex 4 synthesises relevant nature-related indices from a wide range of open sources, covering a wide range of risk transmission channels for almost forty LICs economies. This includes sectoral dependency and impact analyses generated for this report, using data on sectoral output from World Bank's World Development Indicators using the ENCORE toolkit and method from Ranger et al. (2023); disaster-related indices from INFORM (EU Commission Joint Research Centre [12]; the UN SDG Indicators database[13]; as well as indicators related to the Global Biodiversity Framework[14].

4.2 Integrating Nature Within Macroeconomic Models

The integration of nature-related factors within macroeconomic models is arguably less advanced than for climate change but is advancing rapidly. Annex 5 includes a review of available models. A range of macroeconomic and macro-fiscal models have been developed to incorporate natural capital, ecosystem services, and climate-related factors. These include computable general equilibrium models (CGE), including Earth-Economy Models, integrated assessment models, dynamic stochastic general equilibrium models (DSGE), macro-econometric frameworks, and natural capital accounting systems. A recent paper by Kedward et al. (2025), exploring Ecological Macroeconomic Models (EMMs), shows that stock-flow-consistent, post-Keynesian frameworks, such as E3ME-Nat, GEMMES, and EIRIN, are also increasingly used to simulate biodiversity transition risks alongside financial dynamics.

Emerging Environmental-Economic (EE) tools (e.g. Costing Nature and InVEST) are useful to provide spatially explicit estimates of ecosystem services that can serve as valuable inputs for macroeconomic models like CGEs and IAMs. Overall, each offers a different approach to modelling the economy–nature nexus, and each has relevance for debt sustainability analysis. See Annex 5 for a full literature review and discussion of how different models integrate nature.

[11] **See** *Leon Initiative.* Available here.
[12] **See** European Commission Joint Research Centre, *INFORM Risk Index.* Available here:
[13] **See** United Nations Statistics Division, *SDG Global Database.* Available here.
[14] **See** UNEP-WCMC, *Monitoring Framework for the Kunming-Montreal Global Biodiversity Framework (GBF Indicators).* Available here.

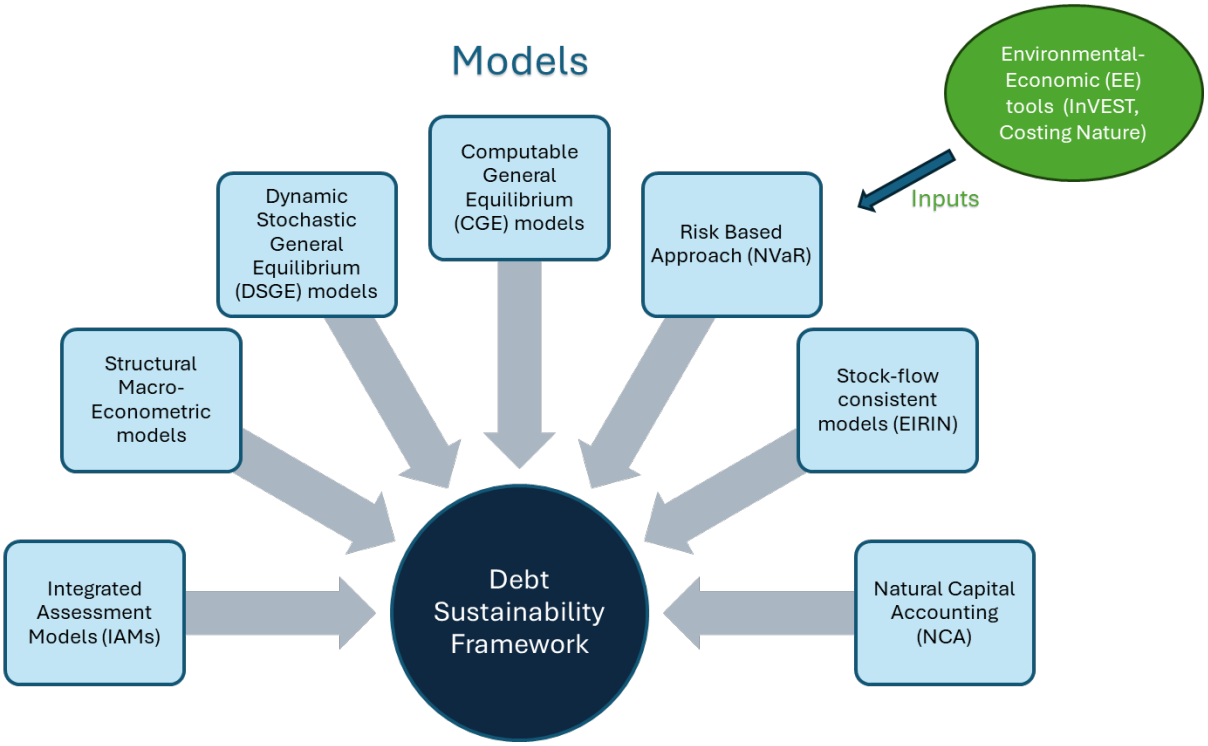


Figure 19: Integrating Nature into DSF - see Annex 5 for full description. (Source: Authors)

An underlying challenge for modelling is that risks are highly specific to individual countries and local communities, driven by a large and diverse number of interrelated and interacting factors that are unique to the local ecological, social, economic context. In addition, all models inevitably reduce complexity through for example, only representing certain drivers, sectors or transmission channels. This can mean that important feedback is excluded. The World Bank's ecosystem-economy CGE, for example, uses conservative assumptions and still find significant impacts, but they inevitably leave out many ecosystem interactions. Despite these challenges models can be used where interpreted effectively. Further work to more fully integrate nature within macroeconomic models, particularly simple models tailored for the DSA, like DIGNAD, would be highly beneficial in supporting the integration of nature within DSAs. There are also opportunities to build upon work done by the World Bank, for example through the Global Program on Sustainability, and collaborate to enhance World Bank models for DSA applications.

Despite being a relatively nascent field within macroeconomic modelling, these tools can already help identify hidden risks to debt trajectories as well as opportunities that standard DSAs might overlook and reduce the risk of distortions within macroeconomic programs that can result from ignoring the risks of growth pathways that are unsustainable. Nature-integrated models bring a more realistic and forward-looking lens to DSA in LIC contexts, especially where

economies are tightly interwoven with the natural environment and there is a high risk of debt distress. For example:

1. **Informing long-term growth assumptions:** DSAs hinge on projections of GDP growth, exports, and fiscal balances. Traditional frameworks might assume a country's natural resource output grows steadily, or that no major environmental shock will derail the economy – assumptions that may be overly optimistic. By using models like those above, macro-modellers can adjust growth paths for environmental (un)sustainability. For example, a country experiencing unsustainable deforestation might, in a nature-integrated DSA, project slowing growth or higher expenditures (for environmental damage) over time, leading to more prudent debt thresholds. Ignoring this, would implicitly lead to over-optimistic assumptions about future growth and biases in macroeconomic policies that promote continued unsustainable exploitation of nature resources. As another example, a country investing in reef protection, e.g. boosting fisheries and ecotourism, could justify more optimistic growth and revenue projections in its DSA. Overall, recognising natural capital as *productive capital* (analogous to human or physical capital) reflects the idea that nature contributes to debt-carrying capacity, avoids the incorrect assumption that natural capital is substitutable.
2. **Accounting for country heterogeneity– integrating nature-related economic structures:** As highlighted in the 2024 review of the Bank-Fund Debt Sustainability Framework for Low-Income Countries, there is scope to improve how the framework classifies countries by debt-carrying capacity (DCC) (world Bank, 2024a). In the context of nature-related risks, this calls for incorporating country-specific exposure to environmental shocks and dependence on natural capital. Many LICs – particularly small island developing states, biodiversity-rich countries, and those with economies reliant on climate-sensitive sectors such as agriculture, fisheries, or tourism – face structurally distinct macro-fiscal dynamics shaped by ecosystem degradation and climate variability. These long-term vulnerabilities are not adequately captured by the current DCC classification, which is based on backward-looking macroeconomic indicators and omits ecological and climate-related dimensions. A more differentiated approach that integrates nature-related risk factors would provide a more accurate assessment of debt-carrying capacity and enable better-informed policy and financing decisions.
3. **Nature-adjusted indicators** - such as the share of GDP tied to ecosystem services, exposure to biodiversity loss, or natural capital per capita (see Annex 3 for preliminary database) —would better reflect countries' true fiscal resilience and long-term debt sustainability. This would enhance the analytical robustness of DSAs and enable more targeted, risk-informed policy responses, including access to concessional finance and tailored debt instruments. Incorporating

these factors would also support the design of sustainability-linked fiscal frameworks that are aligned with countries' ecological realities.

4. **Expert judgment in determining debt sustainability ratings must be supported by more rigorous modelling of long-term risks:** At present, judgments that attempt to account for climate and environmental risks without model-based backing have led to inconsistencies and a higher incidence of false alarms (von Luckner, 2024). Integrating nature-related risk scenarios and ecosystem-driven economic shocks into core macro-fiscal models would provide a sound empirical basis for judgment, improving the transparency and predictive value of sustainability assessments. This dual enhancement (points iii and iv) through refined classification and model-informed judgment) would make the LIC-DSF more responsive to the realities of nature-dependent economies.
5. **Enhancing stress tests and scenario analysis:** The LIC-DSF already employs stress tests (e.g. for export shocks, natural disasters, commodity price drops) to understand how debt indicators deteriorate under adverse conditions. Integrating nature allows for new scenario dimensions: for instance, a "biodiversity collapse" stress test where key ecosystem services fail, as Kraemer and Volz (2022) simulated; or an international supply chain failure, as in Ranger et al. (2024). Incorporating these scenarios provides a fuller picture of risk. In fact, the IMF/World Bank 2024 update to the LIC-DSF has started moving this direction by explicitly acknowledging climate risks in DSAs. The update encourages staff to use alternative scenarios and reference climate impact analyses (such as CCDRs) when crafting DSA baselines. Building on this, integrating nature scenarios is feasible – especially as data on natural capital and ecosystem valuation improve.
6. **Policy analysis returns and financing instruments for nature:** A nature-integrated framework can also highlight the fiscal dividends of investing in nature. For example, adaptation models that include nature-based solutions (like wetland restoration for flood control) can show how upfront spending on natural capital reduces future debt distress by averting disaster losses. Similarly, models that assess conservation policies can support targeted debt negotiations with development partners over instruments such as debt-for-nature swaps (e.g. guiding debt-for-nature swaps by quantifying how debt relief linked to conservation might improve solvency via ecosystem service benefits). This is particularly relevant for resource-rich LICs: many such countries are exploring mechanisms like debt swaps and green bonds that channel debt proceeds into conservation. A robust analytic framework strengthens the case by making the nature–debt link explicit (for instance, showing how conserving fisheries improves future government revenues and lowers default risk). Recent examples include Belize's debt-for-marine-conservation swap, which was facilitated by demonstrating the economic value of its coral reefs and fisheries to creditors.

5. Implementation

Gaomei Wetlands, Taiwan. Photo by Stephen H on Unsplash

5.1 Recommendation - What Can Be Done Now

Setting clear criteria for the inclusion of nature:

- **Nature can be integrated within the existing LIC-DSF criteria for inclusion of climate change** (section 3.3), for example, prioritising those countries with high sectoral dependencies on ecosystem services, where indices suggest significant changes in natural capital or where parallel work suggests particularly high nature risks.

Baseline:

- **Taking a longer-term view and accounting for the drag of environmental degradation on growth where there is clear evidence of materiality:** The existing 20-year projection block within the LIC-DSF framework should be routinely used for countries facing significant climate and nature risk. This would better capture both the slow-onset deterioration of environmental conditions and the long-term economic returns of investing in resilience. Growth assumptions should account for environmental degradation where there is clear evidence on materiality, for example ensuring that assumptions around future agricultural production account for the state of land degradation, soil quality and water availability as well as climate change. The World Bank's CCDRs already provide evidence of materiality for many LICs economies.

- **Treat investment in natural capital as a benefit, not just a cost.** At present, spending on climate adaptation or nature-based solutions is often classified in DSAs purely as a cost, without recognising its long-term benefits. However, these investments reduce future risks, much like insurance or infrastructure maintenance, and can help stabilise public finances over time. This was clearly demonstrated in the Ghana case in Box 8. Updating DSF guidance to treat such expenditures as risk-reducing investments would ensure the framework better reflects economic reality.
- **Where revenues and growth trajectories are derived from highly damaging extractive or polluting sectors, account for the direct and immediate implications for provision of ecosystem services and output in other parts of the economy**. This ensures that the full macroeconomic impacts of economic activities are internalised in the models.

Informing stress tests and sensitivity analysis:

- **Sensitivity test assumptions around growth trajectories, fiscal balances and costs of capital to assumptions about the linkages between growth and the state of nature** (for example, is it realistic that agricultural productivity increases even though indicators show significant land degradation which is slowing output).
- **Develop alternative scenarios that test trajectories** with policies that reduce pressures on ecosystem services and increase investment in nature recovery (e.g. Box 7).
- **Integrate the environmental drivers of risk within the existing mandatory disaster stress test.** For example, ensure assumptions account for greater vulnerabilities in physical climate risks due to environmental degradation (e.g. removal of mangroves, deforestation, desertification, changes in land-use), for example for inland and coastal flood risks, drought and wildfires. Not doing this already means that climate risk assessments are underestimated, so arguably this is already in scope.
- **Introduce a nature-component to the mandatory disaster stress test for countries that are highly ecosystem-dependent or otherwise vulnerable to local or global nature-related shocks**. For example, a standardised "nature-collapse" shock could be added to simulate the systemic economic consequences of degraded ecosystems, such as declining fisheries, reduced agricultural productivity, or loss of water regulation services, or global disruptions to critical supply chains related to food and commodities, as developed for the UK (Ranger et al. 2024), Europe (Ceglar et al. 2025) and globally (Johnson et al. 2021).

5.2 Medium to Long-Term Agenda

Building Collaborations:

- **The IMF and the World Bank can build collaborations with experts to strengthen methods and models to bring nature into the LIC-DSF**. More fully incorporating nature requires interdisciplinary expertise and new workflows that current DSA teams may lack. Debt sustainability analysis has traditionally been the domain of economists in finance ministries or IFIs, using standard financial programming. Introducing concepts like ecosystem service depreciation or climate hazard models means analysts must collaborate with ecologists, climatologists, and statisticians. There are opportunities to build collaborations with leading research institutions to access models, data and expertise. The IMF has done this successfully for climate, for example through the Climate Innovation Challenge to explore new collaborations in a low-risk way[15]. The IMF could consider launching a similar challenge for natural capital and the macroeconomy.
- **Invest in integrating natural capital within DIGNAD**. DIGNAD provides for the analysis of the macroeconomic consequences of discrete climate events, typically tropical storms, floods and droughts, where the principal mechanism at work is the destruction of either physical public- and/or private-sector capital stocks (across one or two sectors). The model usually examines the consequence of single 'shocks' but could consider multiple shocks, including related to nature, tracing out macro dynamics (for growth, consumption, investment, public finances and debt under different assumptions under alternative public investment rebuilding rules. Building natural capital fully into a DIGNAD style model (see Adam, Ranger and Wildemeersch, 2025), using a framework such as that proposed in Figure 3, is feasible but is an ongoing research program that involves significant re-conceptualisation of the core model. Natural capital needs to be incorporated into the supply-side of the model; the price mechanisms need to reflect the (shadow) pricing of ecosystem services; and the fiscal structures need to reflect the taxation / subsidy of natural capital and ecosystem services.
- **Work with the Global Program on Sustainability to (1) update the CWON approach to incorporate more DSA-relevant data and indices, following the systemic framework outlined above (Figure 3) and (2) collaborate to enhance and apply nature-integrated macroeconomic models to the DSF**. The indices within Annex 4 provide a starting point to build upon a full database

15 For example, The IMF Portwatch Tool was developed in collaboration with the University of Oxford as an outcome of the IMF Climate Innovation Challenge programme. See here.

of new indices suitable for the LIC-DSF, both as indicators of materiality to help inform the design of scenarios and to directly inform assumptions in sensitivity tests and scenario design. The IMF and World Bank can provide a platform to gather data, and work with partners across academia, UN, NGOs and business to populate this, potentially building upon existing platforms such as the World Bank's Sovereign ESG Data Portal[16] or the IMF's Climate Change Dashboard[17]. The IMF can also learn from GPOS work to build nature-economy modelling and collaborate with the World Bank to bring these insights into the IMF's standard models or use World Bank models directly. Working collaboratively, the World Bank and IMF can construct DSA-relevant assumptions and scenarios that can be used within the LIC-DSF, as well as the World Bank CCDRs, and share with countries to build them into their own models.

Building capability:

Strengthening capability within the IMF and World Bank: The internal capacity constraints facing the Fund are not technical. Area department country desks are already under significant pressure to produce high-quality operational analysis including timely DSA reports. For program countries, teams may be producing multiple country reports per year and are under pressure to widen their mandate in a variety of directions. There is, consequently, a limited appetite for significant additional work to produce the DSA. Any further work on extending the scope of the DSF needs to be limited and focused (based around a modest set of nature-focused sensitivity runs, for example). A tailored training course for staff on the latest science, economics and toolkits, would mean a meaningful first step towards raising awareness of the importance of nature. The development of simple tools, clear criteria and simple benchmark assumptions and scenarios can also make incorporating nature into the LIC-DSF can build capability.

Building capability at country level: Capacity is limited in many LIC institutions – there may be few staff trained in using tools like CGE or IAM models, let alone ones that include nature. Scaling LIC-DSF with nature and climate to all LIC-DSF countries will require significant training, user-friendly toolkits, and resources. The Bank's Global Program for Sustainability[18] and similar initiatives are addressing this by building capacity in natural capital accounting and analysis, but it remains a work in progress. Initial efforts could prioritise those countries most at risk and with significant natural resources.

Leveraging IMF training institutions. The Fund's technical assistance work – led by the Institute for Capacity Development (ICD) and the regional training institutes

16 **See** World Bank, *ESG Data Portal.* Available here.
17 **See** International Monetary Fund, *Climate Change Indicators Dashboard.* Available here.
18 See here.

(including ATI Africa Training Institute) - has, over recent years, pivoted decisively to add training on the macroeconomic, fiscal and monetary implications of climate change to their portfolio. At this stage, at least amongst many LICs, the focus is overwhelmingly on integrating climate change and the increase in extreme events into short- to medium-term fiscal and monetary frameworks (for example in thinking about how climate change should be built into the ‘near-term forecasting' models (horizon 3-12 months) and ‘quarterly projection models’ (QPM) that are used to support monetary policy formulation. To a lesser degree, technical assistance is supporting work on links between climate volatility and revenue and the roll-out of DIGNAD frameworks to country authorities.

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Annexures

Annex 1: LIC-DSF Eligible Countries as of March 2025

List of LIC DSAs for PRGT-Eligible Countries
As of March 31, 2025

Count	Country	*Per recent DSA publication* Latest publication date	Risk of external debt distress 1/	Debt sustainability assessment 2/	Joint with the World Bank	Latest DSA discussed by the Executive Board but not yet published 3/
1	Afghanistan	6/28/2021	High	Sustainable	Yes	...
2	Bangladesh	6/24/2024	Low	...	Yes	...
3	Benin	12/19/2024	Moderate	...	Yes	...
4	Bhutan	9/19/2024	Moderate	...	Yes	...
5	Burkina Faso	7/29/2024	Moderate	...	Yes	...
6	Burundi	7/25/2023	High	Sustainable	Yes	...
7	Cambodia	1/27/2025	Low	...	Yes	...
8	Cameroon 4/	3/24/2025	High	Sustainable	Yes	...
9	Cabo Verde 4/	2/11/2025	Moderate	...	Yes	...
10	Central African Republic	6/28/2024	High	Sustainable	Yes	...
11	Chad	12/12/2024	High	Sustainable	Yes	...
12	Comoros	12/19/2024	High	Sustainable	Yes	...
13	Congo, Democratic Republic of	1/27/2025	Moderate	...	Yes	...
14	Congo, Republic of 4/	3/24/2025	In debt distress	Sustainable	Yes	...
15	Côte d'Ivoire	7/15/2024	Moderate	...	Yes	12/11/2024
16	Djibouti	6/4/2024	In debt distress	Unsustainable	Yes	...
17	Dominica 4/	6/27/2024	High	Sustainable	Yes	...
18	Eritrea	...	...	...	...	7/22/2019
19	Ethiopia	1/29/2025	In debt distress	Unsustainable 6/	Yes	...
20	Gambia, The	1/14/2025	High	Sustainable	Yes	...
21	Ghana	12/10/2024	High	Sustainable 6/	Yes	...
22	Grenada 4/	2/4/2025	In debt distress 5/	Sustainable	Yes	...
23	Guinea	5/17/2024	Moderate	...	Yes	...
24	Guinea-Bissau	12/19/2024	High	Sustainable	Yes	...
25	Haiti	12/10/2024	High	Sustainable	Yes	...
26	Honduras	12/10/2024	Low	...	Yes	...
27	Kenya 4/	11/1/2024	High	Sustainable	Yes	...
28	Kiribati	5/10/2024	High	Sustainable	Yes	...
29	Kyrgyz Republic	3/4/2024	Moderate	...	Yes	...
30	Lao P.D.R.	11/8/2024	In debt distress 5/	Unsustainable	Yes	...
31	Lesotho	9/11/2024	Moderate	...	Yes	...
32	Liberia	10/11/2024	Moderate	...	Yes	...
33	Madagascar	3/21/2025	Moderate	...	Yes	...
34	Malawi	11/22/2023	In debt distress	Unsustainable 6/	Yes	...
35	Maldives	5/13/2024	High	Unsustainable	Yes	3/26/2025
36	Mali	6/14/2023	Moderate	...	Yes	...
37	Marshall Islands	10/26/2023	High	Sustainable	Yes	...
38	Mauritania	12/20/2024	Moderate	...	Yes	...
39	Micronesia	3/4/2024	Moderate	...	Yes	...
40	Moldova	12/19/2024	Low	...	Yes	...
41	Mozambique	7/12/2024	High	Sustainable	Yes	...
42	Myanmar	1/28/2021	Low	...	Yes	...
43	Nepal	7/15/2024	Low	...	Yes	...
44	Nicaragua	2/7/2025	Moderate	...	Yes	...
45	Niger	1/28/2025	High	Sustainable	Yes	...
46	Papua New Guinea 4/	12/17/2024	High	Sustainable	Yes	...
47	Rwanda	12/16/2024	Moderate	...	Yes	...
48	Samoa	1/31/2025	Moderate	...	Yes	...

49	São Tomé and Príncipe	1/3/2025	In debt distress	5/	Sustainable		Yes	...
50	Senegal	7/7/2023	Moderate		...		Yes	...
51	Sierra Leone	11/22/2024	High		Sustainable		Yes	...
52	Solomon Islands	2/25/2025	Low		...		Yes	...
53	Somalia	12/17/2024	Moderate		...		Yes	...
54	South Sudan	6/10/2024	High		Sustainable		Yes	...
55	St. Vincent and the Grenadines 4/	7/22/2024	High		Sustainable		Yes	...
56	Sudan	7/1/2021	In debt distress	5/	Sustainable		Yes	...
57	Tajikistan	4/2/2024	High		Sustainable		Yes	...
58	Tanzania	6/25/2024	Moderate		...		Yes	...
59	Timor Leste 4/	12/17/2024	Moderate		...		Yes	...
60	Togo	1/16/2025	Moderate		...		Yes	...
61	Tonga	11/25/2024	High		Sustainable		Yes	...
62	Tuvalu	7/21/2023	High		Sustainable		Yes	...
63	Uganda	9/11/2024	Moderate		...		Yes	...
64	Uzbekistan 4/	7/11/2024	Low		...		Yes	...
65	Vanuatu	9/3/2024	High		Sustainable		Yes	...
66	Yemen, Republic of	9/24/2014	Moderate		...		Yes	6/1/2016
67	Zambia	12/17/2024	High		Sustainable	6/	Yes	...
68	Zimbabwe 4/	4/8/2022	In debt distress	5/	Unsustainable		Yes	7/31/2024

Notes: Out of the 70 PRGT-eligible countries 68 use the LIC DSA. (Syria became PRGT-eligible in 2024 and there has not yet been a DSA prepared). Eritrea has not published any DSA. One (St. Lucia) currently uses the MAC SR DSF. One non-PRGT eligible country (Guyana) uses the LIC DSA.

Annex 2: Key Questions from the TOR and Recommendations

A: Key Questions

1. What is the role of natural capital and nature-related risks in debt sustainability?
2. Are there good practice examples where nature has been integrated effectively e.g. via the incorporation of climate-change risks and climate investments and policies in analysis?
3. What are the main gaps in the LIC-DSF? Could nature risks and investments be incorporated in a long-term climate change module? What are the barriers to integrating nature in DSAs?
4. How effective are the current models in capturing the interactions between nature and growth, and what improvements are needed to achieve generalisable integration of environmental variables into macroeconomic and fiscal projections?
5. How feasible is the integration of nature into baseline scenarios as well as stress tests?
6. What standardised guidelines and methodologies are currently in place for incorporating nature-related risks and investments into DSAs, and what additional guidelines are needed to ensure consistency across different countries and assessments?
7. What is the current state of data collection on biodiversity, ecosystem services, and their economic impacts in low-income countries, and what gaps exist that need to be addressed?
8. What capacity constraints do low-income countries currently face in collecting relevant data and applying advanced modelling techniques for assessing and managing nature-related risks?
9. What are the political economic barriers, incentives and risks to transparent and consistent data collection and analysis in low-income countries?
10. What are the current training and capacity-building needs of IMF and World Bank country teams to enhance their ability to incorporate nature-related risks into Debt Sustainability Analyses (DSAs)?

B: Recommendations to be provided in the final report on how to:

1. Develop standardised tools and guidelines for integrating natural capital and nature-related risks and investments into DSAs.

2. Identify and improve core datasets on biodiversity, ecosystem services, and their economic impacts. Including the potential role of the World Bank Global Program on Sustainability.
3. Establish a Science-Based framework for incorporating natural capital and nature-related risks and investments into DSAs
4. Develop a consistent approach for the modelling of nature in baselines and forecasts of the LIC-DSF as well as potential further improvements on the model over time.
5. Ensure complementarity of Nature and Climate resilience in the LIC-DSF, including potential for an overall Environmental module.
6. Deliver capacity building for IMF and World Bank Personnel to deliver the proposed approach to LIC-DSF nature integration.
7. Piloting the proposed approach in key countries

Annex 3: A New Framework for Nature-Economy Assessment

Substantial methods, data and toolkits already exist that can be built upon to develop a holistic approach to integrate nature into the LIC-DSF. No one existing toolkit holds all the answers but by combining insights a simple, yet comprehensive approach can be developed. In this section, we look first at the overall framework and how this can build upon existing methods and then discuss how this can be integrated within the LIC-DSF tools and macroeconomic models, including an illustration using the IMF's DIGNAD tool.

Our proposed approach combines three common methods already used by Ministries of Finance, Central Banks, the World Bank and the IMF:

1. **Natural capital accounting.** Natural Capital Accounting frameworks are structured methods for measuring and valuing nature's contributions to the economy and human well-being and tracking this over time. Several well-known frameworks exist e.g. the United Nations System of Environmental-Economic Accounting (SEEA). The World Bank's "Changing Wealth of Nations" (CWON) approach builds upon SEEA and the System of National Accounts (SNA) and aims to provides a comprehensive measure of a nation's wealth across produced, human, and natural capital, including both renewable (e.g. forests) and non-renewable (fossil fuels and minerals) resources. The World Bank publishes a CWON database covering all LICs. This framework quantifies the 'value' of natural capital in terms of the net present value of revenues (or in the case of mangroves, losses avoided). For example, the value of timber produced or fisheries. Arguably this is analogous to the approach taken in Johnson et al. based on loss of revenues. This revenue data can be an important input to the DSA. However, it tells nothing about the risks or opportunities to this revenue. It also significantly underplays the value of natural capital by missing that all economic sectors have dependencies on natural capital, therefore the true value – and risks of loss – is far greater.

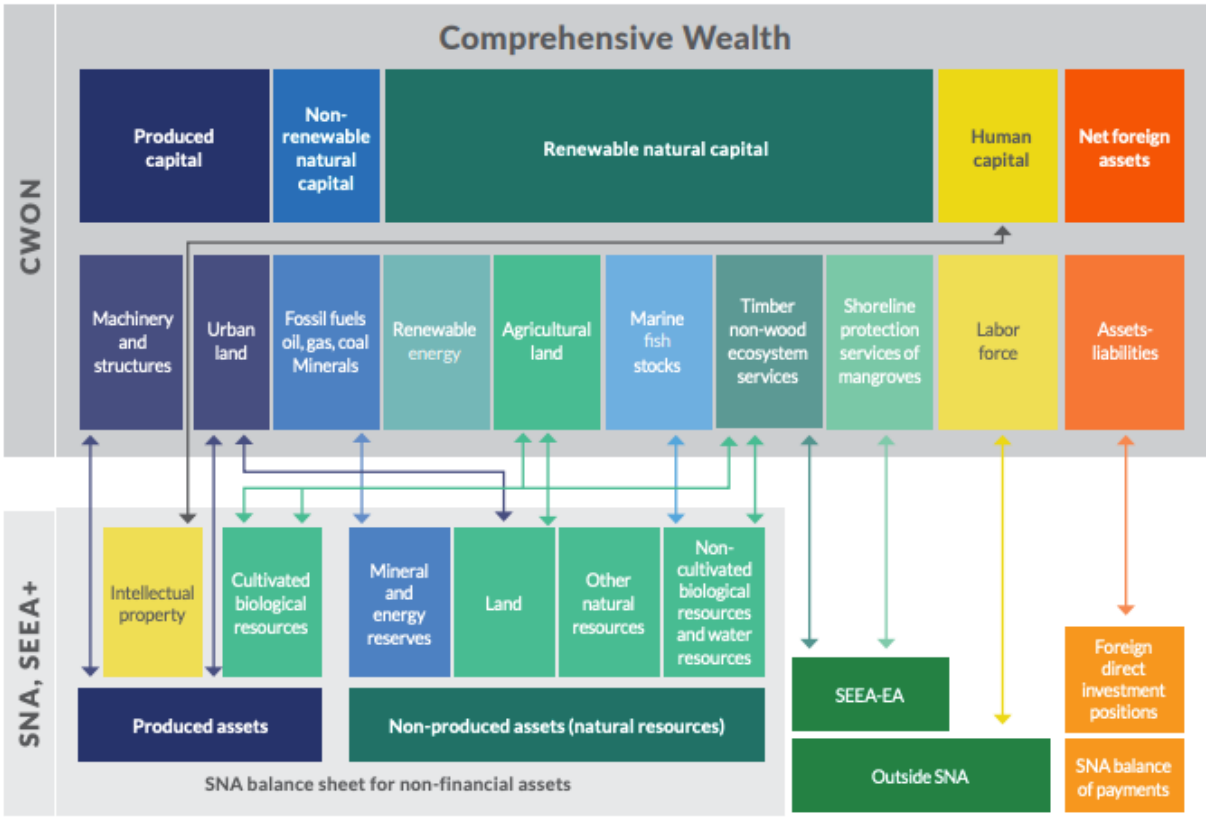

Figure 20: The 'Changing Wealth of Nations' approach (2024) and relationship to SNA and SEEA. Source: World Bank 2024.

2. **Dependency analysis**: Analyses of economic dependencies on nature have been commonly used by Central Banks in assessing nature-related financial risks. These approaches rank dependencies of sectors and sub-sectors on ecosystem services, using tools like ENCORE.

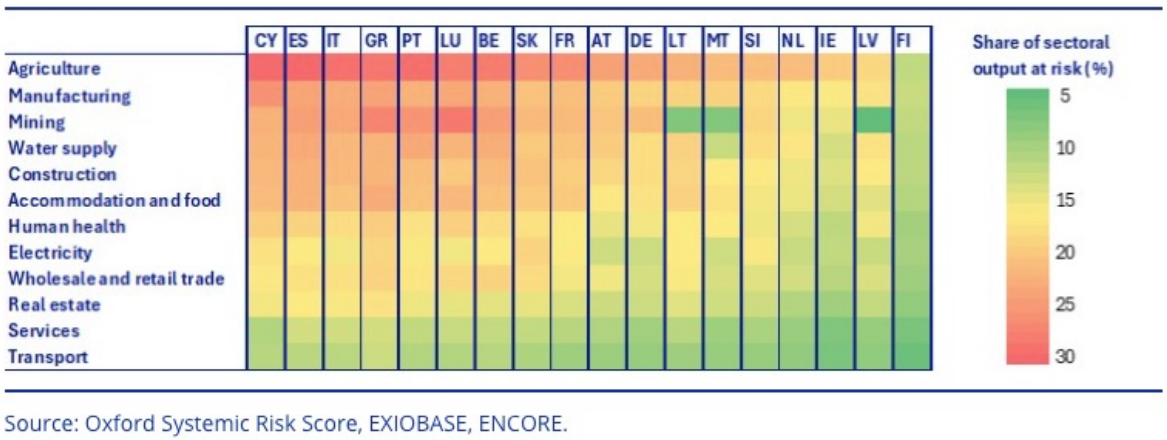

Figure 21: Share of national sectoral euro area economic output at risk from surface water scarcity. Source: Ceglar et al. 2025, based upon methodology of Ranger et al. 2024.

Catastrophe risk modelling - inspired by the insurance industry to assess risk - and now commonly used in climate stress testing of fiscal risks and financial risks by both the World Bank and IMF. For example, Ranger et al. 2023 builds upon the standard dependency approach using catastrophe risk modelling methods to estimate acute risks in a way that is more compatible with a LIC-DSF stress test. This provides information on, for example, where there is a 100% dependency on nature, what is the potential loss for a 1 in 100-year event that disrupts that ecosystem service? This was the methodology adopted in the recent ECB analysis (Ceglar et al. 2025). Figure 21 shows analysis of the risks of a 1-in-25 year drought combined with environmental degradation, revealing a potential 15% loss in economic output across the EU. Catastrophe risk modelling approach can also be used to capture the fiscal risks of loss of ecosystem services through reduced protection against disasters like floods or heatwaves, e.g. associated with loss of mangroves and other vegetation, and the benefits of investment in nature-based solutions (e.g. Bernhofen et al. 2024).

These elements can be combined to create a new version of CWON that is suited for the LIC-DSF as well as a foundation for other modelling studies (e.g. CCDRs). This systemic framework for nature-economy assessment is included in Figure 3 (section 1.3 above)

Annex 4: Nature-Related Materiality Indices

See attached excel spreadsheet including:

Indices of Sectoral Production and Economic Materiality Related to Nature

Agricultural land (% of land area)

Agriculture, forestry, and fishing, value added (% of GDP)

Employment in agriculture (% of total employment)

Electricity production from hydroelectric sources (% of total)

Fisheries

Mineral rents (% of GDP)

Indices of Vulnerabilities to Disasters

INFORM Disaster Score

INFORM Food Insecurity Score

INFORM Health Risks

Indices of Vulnerabilities to International Nature-Related Shocks:

Food imports (% of merchandise imports)

International tourism, receipts (% of total exports)

Ores and metals exports (% of merchandise exports)

Total natural resources rents (% of GDP)

Indices of State of Environmental Degradation

BII Change

BHI Change

Forest Change

Forest area (sq. km)

Land Area Degraded

Mangrove Change

PM2.5 air pollution, mean annual exposure (micrograms per cubic meter)

Level of water stress: freshwater withdrawal as a proportion of available freshwater resources

Water Quality

Indices Related to Transition Risks and Opportunities

LULUCF Emissions and fraction of total Emissions

Biodiversity HotSpots

IUCN Red List

Sectoral Dependencies on Ecosystem Services (percent of output)

Water - Sectoral Dependencies

Pollinators - Sectoral Dependencies

Soil Quality - Sectoral Dependencies

Biomass – Sectoral Dependencies

Water Purification – Sectoral Dependencies

Rainfall Pattern Regulation – Sectoral Dependencies

Production/Revenues Directed Related to Renewable Natural Capital:

Renewable natural capital per capita, agricultural land (real chained 2019 US$)

Renewable natural capital per capita, fisheries (real chained 2019 US$)

Renewable natural capital per capita, forest recreation, hunting and fishing services

Renewable natural capital per capita, forest water ecosystem services (real chained 2019 US$) Renewable natural capital per capita, hydropower energy (real chained 2019 US$)

Renewable natural capital per capita, mangroves (real chained 2019 US$)

Renewable natural capital per capita, nonwood forest protection ecosystem services (2019 US$)

Renewable natural capital per capita, timber (real chained 2019 US$)

Renewable natural capital per capita, total (real chained 2019 US$)

Sources: UN SDG Dashboard; World Bank World Development Indicators; INFORM Database; Ranger et al. 2023; World Bank Changing Wealth of Nations Database; UNEP WCMC Indicators for the Kunming – Montreal Global Biodiversity Framework

Annex 5: Literature Review: Models and Frameworks Integrating Nature into Macroeconomic Analysis

Table 4: Representative macroeconomic models and frameworks integrating nature, with their characteristics and uses (Source: authors' synthesis).

Model / Framework	Type	Nature Integration	Users & Purpose
"Global Earth-Economy (EE) Model" GTAP-INvest (Johnson et al., 2021)	CGE (Computable General Equilibrium)	GTAP-InVEST is an Earth-Economy model that combines the Global Trade Analysis Project (GTAP) with InVEST, a model for assessing ecosystem services. Integrates key ecosystem services (e.g. wild pollination, fisheries, timber, carbon sequestration) into a global CGE model. Simulates how ecosystem service declines impact sectoral output and GDP, and vice versa.	The benefits of using Earth-Economy models such as GTAP-InVEST include: • Quantifying the economic losses from ecosystem degradation to support evidence-based environmental decision-making. • Informing policymakers of the GDP and welfare impacts of ecosystem decline under different policy scenarios. • Illustrating the macroeconomic costs of biodiversity loss and the potential gains from nature-smart policies.
WORLD Bank "MANAGE" & "ENVISAGE" models (World Bank)	CGE (Dynamic-recursive CGE models)	**MANAGE:** country-level CGE model with detailed climate damage and adaptation modules. It allows for substitution between capital, labour, and energy, fuel switching, and features a multi-output, multi-input production structure. The model assesses climate impacts on sectors like agriculture and infrastructure, and evaluates adaptation options, including nature-based solutions.	**MANAGE** is used in CCDRs to model long-term growth under climate risks and adaptation strategies (PBL, 2023). **ENVISAGE** supports global scenario exercises to assess climate policy trade-offs. Both tools help estimate how climate and nature factors alter growth, fiscal balances, and poverty outcomes.

		ENVISAGE: Global CGE model (covering 127 countries and aggregating the remaining into 20 regions) aggregating to global and regional scenarios; focuses on climate mitigation/adaptation policies' impacts on economies.[19] NB: Strengths lie in their micro-foundations and sectoral detail. This means they can provide a more disaggregated accounting of losers and winners from economic damages and climate policies than the MFmod system (World bank, 2022).	
IAMs (Integrated Assessment Models)	IAM (Integrated climate-economy models)	Integrated Assessment Models (IAMs) link simplified climate science with macroeconomic growth models through damage functions and mitigation cost modules. IAMs are used for climate cost-benefit analysis, scenario planning, and carbon pricing, highlighting the long-term macroeconomic impacts of climate risks. Increasingly, they also consider land-use and biodiversity feedbacks.	Integrated Assessment Models are particularly used by academia and central banks (i.e., *NGFS*[20]*).* Extensions to biodiversity (e.g. linking ecosystem service loss to productivity) are in early stages but conceptually align with DSA stress-testing of long-term risks.
IMF debt-investment growth-Natural disaster "DIGNAD" model (IMF)	DSGE (Dynamic Stochastic General Equilibrium)	A small open-economy DSGE that extends the IMF's Debt-Investment-Growth (DIG) model to include Natural Disasters (ND). It simulates the macro-fiscal effects of climate shocks – e.g. hurricanes or floods – and adaptation. investments. Nature is implicit via disaster shock frequency/intensity and the protective effect of	According to the IMF, DIGNAD is a "workhorse" model for climate stress tests.[21] Used to quantify disaster impacts on debt trajectories and the payoffs of investing in resilience. For example, IMF staff apply DIGNAD when conducting DSAs for climate-vulnerable states (including Rwanda (2022), Seychelles (2023),

19 According to the World Bank, both ENVISAGE and MANAGE are calibrated on data at a single point in time, using elasticities drawn from the literature and, where available, supplemented with country-specific estimates. Source: https://documents1.worldbank.org/curated/en/490571642086593026/pdf/World-Bank-Group-Macroeconomic-Models-for-Climate-Policy-Analysis.pdf

20 IAM models used for the NGFS scenarios are REMIND-MAgPIE, MESSAGEix-GLOBIOM and GCAM.

21 See IMF, https://climatedata.imf.org/pages/dignad

		adaptation (which could include nature-based infrastructure).	and Kenya (2023), to project how a cyclone or drought would raise debt ratios and to evaluate adaptation loans in reducing that risk.
Macro-Fiscal Model (MFMod) (World Bank)	Macro-econometric (structural model)	A country-tailored macro-fiscal model blending empirical estimation with theory. Incorporates climate change impacts on productivity and budgets – including damage from extreme weather, lower agricultural and labour productivity from warming, and climate co-benefits (e.g. health gains from less pollution). Also includes a basic module for adaptation costs, which can be expanded with country data.	MFMod is used for baseline projections and scenario analysis in many developing countries (including CCDRs). It can simulate how climate trends or shocks alter growth, inflation, and fiscal indicators. In DSA context, MFMod's outputs (e.g. lower GDP growth from climate stress) can feed into debt sustainability projections. Its integration of climate damage and adaptation spending helps align fiscal forecasts with climate reality, as called for in recent LIC-DSF guidance.
Natural Capital Accounting (NCA) Systems (e.g. UN SEEA)	Statistical accounts (not a simulation model)	Framework to measure natural assets and ecosystem service flows in monetary and physical terms, complementing national accounts. Produces indicators like "natural capital stock value", renewable resource depletion, and ecosystem service contribution to GDP. Helps internalise nature's economic role (e.g. forest value, groundwater, pollination) in fiscal analysis.	NCA data provide the foundation for nature-integrated modelling and policy. For instance, the World Bank's WAVES partnership and Global Program for Sustainability have helped countries (Ghana, Indonesia, etc.) compile natural capital accounts. Such accounts enable analysts to assess how depletion of natural wealth affects long-term fiscal sustainability. The African Development Bank notes that Africa's GDP ($2.5 trn in 2018) was only *40% of the estimated value of its natural capital* (~$6.2 trn) (AfDB,, 2024). By using NCA, countries can reflect this "hidden wealth" or conversely the liabilities from nature loss in debt analyses.
NVAR (ranger, 2024)	Risk-based approach	Nature-related Value-at-Risk (NVaR) is a forward-looking, probabilistic metric that estimates the maximum expected loss in economic output (or asset value) over a given time horizon, at a	Developed by researchers at the University of Oxford and the London School of Economics, and now being piloted by the European Central Bank (ECB, 2025), NVaR is woven into financial-sector stress-testing frameworks to let banks

		specified confidence level, that can be attributed to nature-related risks	and supervisors quantify how nature-related shocks could erode the balance-sheet strength of institutions with high exposure to biodiversity-dependent borrowers.
E3ME-Nat / GEMMES / EIRIN (Ecological Macro-Models)	Stock-flow-consistent / Post-Keynesian	Endogenous biodiversity modules; land-use change; sectoral dependency matrices; feedback to bank balance-sheets and household income.	Universities (SOAS, Cambridge, EDHEC); Banque de France; NGFS pilots – used to stress-test biodiversity transition and distributional impacts.

Different modelling approaches capture nature in various ways relevant to DSAs:

i. CGE models allow the direct incorporation of ecosystem services into production and consumption relationships, allowing simulation of how biodiversity loss can constrain GDP and fiscal revenues.
ii. IAMs link environmental dynamics (e.g. climate change or land-use change) with economic growth, illustrating long-term trajectories under different policy scenarios – useful for *debt sustainability under climate transition scenarios*.
iii. DSGE models like DIGNAD explicitly introduce stochastic environmental shocks and adaptation investment into macro dynamics, which can be used to stress-test debt paths under, say, repeated natural disasters.
iv. Structural macro-econometric models (e.g. MFMod) integrate climate effects into country forecasts in a more data-driven way, aligning baseline debt projections with expected climate-adjusted growth.
v. Natural Capital Accounting frameworks provide the *data backbone*, quantifying natural resource depletion or ecosystem degradation which can then be incorporated as depreciation of national wealth or lost income in fiscal analysis.

Each model type integrates "nature" somewhat differently:

Ecosystem services in CGE models: Ecosystem services can be systematically integrated into Computable General Equilibrium (CGE) models to assess how nature affects economic performance. In models such as the World Bank's GTAP-InVEST, services like pollination, fisheries yields, and forest timber are treated as endogenous inputs that influence productivity in sectors such as agriculture and forestry. When these services decline, they act as productivity shocks, triggering wider economic impacts including lower exports, reduced employment, and diminished public revenues. Typically, ecosystem services are incorporated via satellite accounts or ecological-economic linkages that connect natural stocks (e.g. fish populations, forest cover, pollinator density) to sectoral outputs.

The literature identifies three widely used approaches to modelling environmental shocks in CGEs: (1) shifting supply curves to reflect production changes, (2) applying factor-augmenting technological change (e.g. enhanced capital or labour productivity), and (3) introducing factor-neutral productivity shocks - commonly used to represent declines in services like pollination. A more recent and policy-relevant innovation involves endogenising land-use change by removing specific land areas from potential economic use, thereby shifting the land-supply curve. This spatially explicit method enables more accurate assessments of the economic implications of land degradation, conservation efforts, and nature-based policy interventions.

Climate and natural capital in IAMs: Integrated Assessment Models (IAMs) serve as critical tools for evaluating the long-term economic impacts of climate change by linking climate science with macroeconomic growth projections. These models typically

incorporate damage functions that estimate economic losses, such as reductions in GDP, associated with increases in global temperatures, accounting for effects like storms, droughts, and sea-level rise. For instance, the Dynamic Integrated Climate-Economy (DICE) model, developed by Nordhaus, includes the "natural capital" of the climate system as an additional kind of capital stock[22], allowing for the assessment of how investments in emissions reductions can mitigate economically harmful climate change and enhance future consumption possibilities. While traditional IAMs like DICE have not extensively modelled biodiversity, recent advancements have begun to incorporate natural capital more explicitly. For example, research has expanded the DICE model to include a natural capital variable affected by both climate change and depletive effects, enabling a more comprehensive analysis of the interplay between natural capital and economic growth.[23]

DSGE and macro-fiscal models with nature: In IMF's DIGNAD and similar dynamic models, nature mostly features as external shocks or additional state variables. The DIGNAD model, for example, introduces a probabilistic natural disaster shock that destroys capital and output, influencing debt via reconstruction costs and lost revenue. Government investment in adaptation (e.g. building seawalls or climate-proof infrastructure) can mitigate the expected losses, improving sustainability. An important extension now being advocated is to include nature-based solutions in these models – treating natural capital (e.g. mangroves, forests) as a form of productive capital that can reduce disaster impact or enhance growth. Indeed, analysts note that preserving a mangrove forest for coastal protection can be as effective as a concrete seawall for climate adaptation. Incorporating such ecosystem-based adaptation in DSGE frameworks would allow DSAs to credit countries for investing in natural infrastructure and resilience. Beyond disasters, stochastic DSGE models could also simulate gradual depletion of natural resources (for resource-based economies) as a drag on TFP (total factor productivity) growth, thereby affecting debt paths – though this is an area for further model development.

Natural capital in accounting frameworks: Rather than simulate scenarios, NCA provides baseline measurements for nature-economy linkages. For example, the UN's System of Environmental-Economic Accounting (SEEA) enables countries to calculate the monetary value of natural asset stocks (minerals, forests, water) and the annual ecosystem service flows they provide (like water filtration worth X% of GDP). Such data can feed into fiscal sustainability metrics: e.g. the World Bank's *Changing Wealth of Nations* reports derive an "adjusted net savings" indicator that subtracts natural capital depletion from national savings. If a country's forests are shrinking or soil fertility is declining, its true wealth is eroding, which signals future fiscal stress even if current debt

22 Nordhaus (2017), https://www.nber.org/reporter/2017number3/integrated-assessment-models-climate-change
23 Hackett et al (2015) https://www.sciencedirect.com/science/article/abs/pii/S0921800915002244

levels appear manageable. Conversely, if a country maintains or increases natural capital (through conservation or restoration), it arguably improves its long-term solvency. In practice, these accounts are gradually being linked to policy – for instance, Uganda and Rwanda have used natural capital accounts to inform water and land management strategies, and Kenya's Treasury is exploring how to integrate wildlife and water accounts into development planning.[24] While not yet formalised in DSAs, NCA offers a widely adopted method to incorporate nature into debt analysis by extending the notion of national balance sheets and fiscal space to include nature's assets and liabilities.

24 https://www.financeministersforclimate.org/sites/cape/files/inline-files/GPS_World%20Bank_NCA%20and%20Valuation%20of%20ES%20to%20Inform%20Policies-CFM%20July%202024.pdf#:~:text=%E2%80%A2%20Technical%20and%20financial%20support,conservation%2Frestoration

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