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Nature stress test: Assessing exposure of five African banking systems

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About FSD Africa and the African Natural Capital Alliance

FSD Africa carried out this joint research to support the work of the African Natural Capital Alliance (ANCA).

ANCA is an African-led collaborative and multistakeholder initiative, acting as a vehicle to drive coordinated advocacy and action across the continent. ANCA was established by FSD Africa, a specialist development agency, with support from the United Nations Economic Commission for Africa (UNECA) and the United Kingdom's Department for Environment, Food & Rural Affairs (DEFRA).

Contents

Foreword

Acknowledgements

Executive summary

1. Context and approach

2. Real economy risks and opportunities

- 2.1. Real economy profit impacts across scenarios
- 2.2. Real economy profit impacts for the disorderly GBF-aligned scenario
- 2.3. Real economy mitigation potential for the orderly GBF-aligned scenario

3. Credit risk

- 4. Macroeconomic risks and opportunities
- 5. Enabling environment

References

Appendix: NatuRisk toolkit

Foreword

Africa's economy and the livelihoods of its people are intertwined with the vitality of its natural ecosystems—some of the most biodiverse in the world. The continent is also reliant on sectors that depend heavily on natural ecosystem services, such as agriculture and tourism. These sectors are critical to economic development as they provide employment and livelihoods for a large share of the population. Yet the health of these ecosystems is declining rapidly. For example, 3 percent of Africa's GDP is lost annually due to soil and nutrient depletion of croplands.¹ Deforestation, pollution, and water abstraction all affect the ability of these ecosystems to support the economy in the future.

Halting and reversing nature loss will require coordinated, ambitious, and immediate action across the public and private sectors as well as civil society. The financial sector can work in partnership with businesses across the real economy to benefit from the opportunities created by a nature-positive transition and to minimize its risks. Deploying sustainable finance instruments could support businesses to shift to practices that reduce damage to nature or restore nature and help them incorporate nature into their commercial strategies. The financial sector could also use capacity building, lending conditions, and engagement to support businesses in robustly managing nature-related risks.

This report aims to provide a fact base for how nature-related risks are relevant and material to financial regulators and private financial institutions. It covers both microeconomic and macroeconomic considerations and explores how an enabling environment could accelerate action from the private financial sector to manage nature-related risks and opportunities.



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¹Nature risk rising: Why the crisis engulfing nature matters for business and the economy, World Resources Institute (WRI), November 2023.

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This work is only possible because of the work that others have carried out before, especially the Taskforce on Naturerelated Financial Disclosures and the Taskforce on Climate-related Financial Disclosures, as well as the work of financial supervisors, standard setters, and thought leaders in developing approaches to assess climate- and naturerelated risks. These include the Banco de México, Bank Negara Malaysia, Bank of England, Banque de France, De Nederlandsche Bank, Magyar Nemzeti Bank (of Hungary), Network for Greening the Financial System, the European Central Bank, the Organisation for Economic Co-operation and Development (OECD), the United Nations Development Programme, and the World Bank.

Executive summary

Africa is both heavily dependent on nature and experiencing rapid nature loss. Some 62 percent of African GDP is moderately or highly dependent on the services that nature provides, and 70 percent of communities in sub-Saharan Africa depend on forests and woodlands for their livelihoods.² In parallel, momentum is building in the African financial sector in response.

This report consolidates the findings of a nature stress test on the banking systems in five African countries: Ghana, Mauritius, Morocco, Rwanda, and Zambia. Nature-related risks and opportunities arise from an organization's dependencies and impacts on nature.³ The analysis examines how business profits across these five economies could be impacted—positively or negatively—depending on different nature-positive transition scenarios. It also considers potential knock-on effects for the financial sector and assesses risks driven by 11 impacts and dependencies, such as deforestation, pollution, and water scarcity, across a selection of sectors expected to be at high nature-related risk. The appendix contains a more detailed description of the stress test and methodology. The findings are particularly relevant for financial regulators and private financial institutions in Africa, whose financial systems and portfolios are likely to be exposed to similar levels of risk.

While the financial impact on businesses and commercial lending is the focus of the report, it is only one of many considerations relevant to decision makers. Against the backdrop of a decline in nature and continued global attempts to move toward a net-zero and nature-positive transition, this report seeks to evaluate the financial impact of pursuing an orderly nature transition, in comparison to a disorderly one or not pursuing any transition at all. Understanding the impact of the possible transition scenarios could help the relevant stakeholders to respond accordingly. Risks that impact business profits, the primary focus of this report, can also have important parallel impacts on issues such as job creation, economic growth, and community empowerment, and private companies will be an important funder of the actions required for an orderly and effective transition.

The nature stress test of the five national banking systems represents a spectrum across Africa of economic structures, natural landscapes, and emerging nature-related risks. The countries whose banking systems were examined were chosen based on interest among national stakeholders and to capture a range of different risk profiles across Africa. Some of the economies rely heavily on agriculture, mineral and commodity exports, services, and tourism, while others have more diversified industrial and manufacturing sectors. Their natural landscapes vary, from those with highly biodiverse forest ecosystems to those with arid areas or that are island nations. While the exposure of individual banking systems will vary, the results demonstrate how different factors may increase or reduce risk exposure. These five countries are sufficiently diverse that the insights can be extrapolated to much of the continent.

The stress test presents three key metrics: unweighted profit losses by sector, weighted profit losses for the banking system as a whole, and credit losses. Unweighted profit losses by sector represent the potential change in the net present value of future profits for sectors to which the banking system lends, such as agriculture, mining, and manufacturing. Weighted profit losses for the banking system are an average of the previous metric, which is then weighted by the credit exposure of the national banking system in each country to each of their real economy sectors. Credit losses represent the expected losses to the banking system itself due to changes in the value of its loans to sectors in the real economy. Results for profit impacts in the real economy and expected credit losses for the financial sector are both expressed relative to a baseline scenario in which there are no nature-related risks.

²World Economic Forum, 2012; United Nations Environment Programme (UNEP), 2023.

³ Taskforce on Nature-related Financial Disclosures (TNFD) recommendations, Taskforce on Nature-related Financial Disclosures, 2023.

Real economy risks and opportunities

Across all the scenarios considered, financial risks are lowest under an 'orderly transition' aligned with the goals of the Global Biodiversity Framework (GBF). Exposure to physical and transition risks is assessed across three scenarios using McKinsey's NatuRisk toolkit, exploring the ambitions of decision makers and businesses to implement nature-positive policies and practices.⁴ The stress test compares a "current policies" scenario with two possible transition scenarios aligned with the goals of the GBF. The first scenario is a "disorderly transition" in which decision makers and consumers take action to reverse nature loss in line with the goals of the GBF, yet businesses do not substantially reduce their negative impacts on nature and, in some cases, pay the regulatory costs associated with these damages.⁵ The second scenario is a "orderly transition" in which businesses also take action. Under current policies, businesses in most countries are exposed to moderate levels of profit loss by 2030, weighted by the exposure of the national banking system (Exhibit 1). Under a disorderly transition scenario, risks for businesses are lower than in both the disorderly transition scenario and the current policies. Under an orderly transition scenario, risks for businesses are lower than in both the

⁴ McKinsey's NatuRisk toolkit is a market-leading solution that allows financial institutions to quantify the exposure of their financial portfolios to nature-related risks at the company, sector, and portfolio level. See appendix for more information on the NatuRisk model used for the stress test. ⁵See section 1 for a description of the scenarios used in this analysis.

Exhibit 1

Nature-related risks are lowest under an orderly transition scenario.

Exposure-weighted portfolio NPV profit losses for the real economy, by scenario,





Source: NatuRisk analysis

Transition scenarios

The NatuRisk toolkit assessed three transition scenarios.

Current policies

If current policies and business practices continue, nature-related physical risks could be substantial for some sectors. Under a current policies scenario, the analysis shows that risks could be significant and heavily concentrated in particular sectors, such as agriculture, utilities, and manufacturing.⁶ For example, at their extreme, physical risks such as declining pollinator populations, soil quality, and water availability could decrease net present value (NPV) profits from 2020 to 2050 in the agricultural sector in Ghana by more than 50 percent.⁷ Water shortages in Morocco could cause equivalent losses of 15 percent in food, beverage, and fertilizer manufacturing and of 4 percent in electricity, gas, and utilities.

After weighting by credit exposure, risks for the banking system as a whole are considerably lower, though risks for the broader macroeconomy are still significant. The sectors mentioned above collectively account for a low share of loan book exposure in each banking system (14 to 35 percent).⁸ The highest exposure-weighted NPV profit losses from physical risks are in Morocco, at 7.7 percent from 2020 to 2050, relative to a world in which there are no nature-related risks. The banking systems in the other four countries examined experience exposure-weighted losses of between 0.5 and 3.0 percent over the same period. While exposure-weighted risks for the banking system could be low, risks for the broader economy could be substantial given the importance of these sectors for economic growth, job creation, and community empowerment.

Five key risk drivers could account for most real economy profit losses under a current policies scenario involving extreme physical risks:

- 1. Increasing withdrawals from freshwater sources combined with warming temperatures could result in higher water stress, requiring sectors that depend on water to invest in water-saving measures.
- 2. Increased pollution of freshwater sources could lead to the need for sectors that depend on high-quality water, such as agriculture and food and beverage, to treat incoming water used in production processes.
- 3. Soil erosion and increased soil salinity could degrade arable land, leading to a reduction in yield per hectare for farmers.
- 4. Loss of natural habitats could cause a significant decline in natural pollinator populations, resulting in lower yields per hectare of arable land for crops that depend on pollinators, such as fruit and vegetables.
- 5. Though not quantified within this stress test, increasing rates of land use change and pollution could degrade the health of natural ecosystems with significant impacts on ecotourism.⁹

Disorderly GBF-aligned transition

With concerted global action to reverse nature loss, most of the nature-related physical risks could be mitigated. As demonstrated in Exhibit 1, physical risks are low across all banking systems under the disorderly transition scenario (as well as the orderly transition scenario). This is because global efforts to meet the goals of the GBF reduce the rate

⁸ Based on publicly available data published by central banks; see section 1 for more details; *Annual report 2022*, Bank Al-Maghrib, 2022; *Annual report 2022*, Bank of Ghana, 2022; "Bank loans to other nonfinancial corporations, households and other sectors, end-December 2022," Bank of Mauritius, December 2022; *Annual report 2022*, Bank of Zambia, 2022; *Annual report 2021–2022*, National Bank of Rwanda, 2022.

⁶See section 1 for a description of the scenarios used in this analysis.

⁷ Note that results are shown from 2020 to 2050 as some of the modeling frameworks and datasets used feature 2020 as the base year.

⁹ Risks to tourism are not quantified due to a lack of robust evidence on the quantitative relationship between the health of local ecosystems and tourist footfall.

at which natural ecosystems are degrading and hence, improve their ability to provide the ecosystem services that businesses depend on.

However, a disorderly nature-positive transition could create significant transition risks. Under this scenario, profit losses due to nature-related risks in the most affected sectors could be similar in magnitude to profit losses due to climate-related risks for emissions-intensive sectors. For example, the analysis shows that, for example, by 2050, annual unweighted profit losses from nature-related risks in agriculture, mining, and some manufacturing subsectors could reach as high as 50, 32, and 18 percent, respectively. By comparison, in a net-zero climate transition scenario, climate-related risks could generate losses in mining, chemicals, and manufacturing of 25, 15, and 10 percent respectively (Exhibit 2).¹⁰

¹⁰McKinsey analysis using Planetrics, based on the Network for Greening the Financial System Net Zero 2050 scenario from REMIND-MAgPIE (REgional Model of Investment and Development-Model of Agricultural Production and its Impacts on the Environment) model version 2.0.

Exhibit 2

Nature-related risks in agriculture, mining, and manufacturing are of the same scale as climate-related risks in emissions-intensive sectors.

Unweighted in-year profit losses for the real economy, % change relative to baseline, disorderly GBF-aligned scenario vs NGFS Net Zero 2050 scenario, 2020–50



Note: Excludes climate-related risks in oil and gas, which are generally larger than nature-related risks in sectors with high nature impacts (~70% profit loss in 2050), Climate-related risk analysis based on the Network for Greening the Financial System (NGFS) Net Zero 2050 scenario from REMIND-MAgPIE (Regional Model of Investment and Development-Model of Agricultural Production and its Impacts on the Environment) model version 2.0. Source: NatuRisk; Planetrics

According to the assumptions of the disorderly transition scenario, five key drivers account for the majority of risks to companies that do not adapt:

- 1. The agriculture sector could experience increases in production costs. Critical action to prevent deforestation and protect highly biodiverse areas, both domestically and internationally, could constrain the land available for agriculture. Producers may then need to quickly adopt new agricultural practices and technologies that use less land but are more expensive.
- 2. The agriculture and broader food and beverage sectors could experience changes in revenue for certain products. Global diet shifts, reduced food waste, and a shift to sustainable farming practices could substantially reduce demand for products such as animal proteins and fertilizers.
- 3. Manufacturers and utilities could experience increases in production costs. Worsening water quality could demonstrate the need for regulations that require heavy-polluting industries to introduce or improve the treatment of their wastewater discharge. This action could tackle pollution and support the health of local ecosystems as well as raise the cost of doing business for these sectors.
- 4. The mining sector could experience changes in revenue. To maintain the health of protected areas and quality of local water supplies, mining companies could face difficulties in securing contracts to open new mines in sensitive locations. This could result in disruptions to production and lost revenue. It could become increasingly important to work with and ensure benefits for local communities.
- 5. Downstream sectors could experience increases in production costs. In response to higher production costs, the price of some agricultural commodities could rise, increasing input costs for other sectors such as manufacturing and retail.

Risks in this scenario are heavily concentrated in seven sectors. The variation in exposure-weighted profits across each banking system can largely be explained by its credit exposure to these seven sectors. Both physical and transition risks in the case of all five countries are concentrated in a handful of sectors: (1) agriculture and forestry; (2) mining and quarrying; (3) food, beverage, and fertilizer manufacturing; (4) consumer goods retail; (5) electricity, gas, and water; (6) construction; and (7) metals and minerals manufacturing. Tourism is also expected to experience high physical risks but these are not quantified in this stress test. In banking systems such as Rwanda, where exposure to priority sectors is lowest (21.0 percent), exposure-weighted NPV profits from 2020 to 2050 decline by only 1.1 percent in the disorderly GBF-aligned scenario. However, in banking systems such as Zambia, where priority sectors make up nearly half of the portfolio exposure, exposure-weighted NPV profit impacts are much greater at –6.7 percent. It is worth noting that a sector can account for a large share of GDP but only a small share of loan exposure. As a result, the macroeconomic consequences of nature-related risks in terms of job and GDP losses could be greater than the exposure-weighted profit results for the banking system. For instance, the mining sector in Zambia accounts for 12 percent of GDPⁿ and more than 50 percent of gross exports,¹² but only 6 percent of commercial loans.

In the disorderly GBF-aligned scenario, cumulative expected credit losses could increase by up to 21 percent by 2050 in some banking systems, with much higher impacts for individual sectors. Banking systems with higher exposure-weighted profit impacts generally see higher credit losses (Exhibit 3). However, the typical credit rating of borrowers within a country is also an important factor in determining credit losses: for any given profit change, losses are generally smaller if the borrower has a better credit rating. As for profit impacts, unweighted expected credit losses could be substantially higher within priority sectors relative to exposure-weighted losses for the portfolio as a whole.

¹¹African economic outlook 2023, African Development Bank Group, 2023.

¹² "Country profile: Zambia," Atlas of economic complexity, Harvard Growth Lab, November 6, 2023.

Exhibit 3

Unweighted expected credit losses in priority sectors could be substantially higher than exposure-weighted losses.



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Orderly GBF-aligned transition

If businesses take action to reduce their impacts on nature and adjust the prices of their products in response to cost shocks, a significant portion of transition risks could be mitigated—up to 4.1 percentage points of exposure-weighted impacts in some cases. As shown in Exhibit 1, an orderly (or mitigated) GBF-aligned scenario, in which businesses reduce their impacts on nature and mitigate risks, could lead to lower overall profit impacts than under a current policies scenario where extreme physical risks occur.¹³

There are various actions businesses can take to adapt in line with the transition, minimize their exposure to naturerelated risk, and leverage nature-related opportunities. For example, in agricultural value chains, sustainable farming practices could be adopted or working with suppliers to reduce upstream deforestation. In mining, it could be ensured that mines are located outside protected areas and away from areas at risk of freshwater contamination. In all sectors, stakeholders may choose to consider amended pricing strategies to absorb some of the cost increase, alongside protecting consumers and recognizing important socioeconomic impacts on food poverty, economic growth, and community empowerment.

¹³See section 1 for a description of the scenarios used in this analysis.

Across the five banking systems, these actions could mitigate 27 to 78 percent of exposure-weighted NPV profit losses under the GBF-aligned scenario. Businesses in countries with a higher share of profit losses from mining license risk have a greater ability to mitigate risks by moving production locations. Businesses in countries with a higher share of profit losses from deforestation regulations have a greater ability to mitigate risks by switching to deforestation-free practices or supply chains. Businesses in countries with a high share of profit losses from demand impacts have less ability to mitigate risks.

Coordinated action in an orderly scenario could also bring several benefits that are not quantified here due to data constraints. These include productivity gains from improved natural capital, such as crop yield improvement from higher quality soil, co-benefits for sectors such as tourism and hospitality as healthier local ecosystems attract more visitors, and new or more diversified revenue streams.

Credit risks

Profit impacts due to nature-related risks can affect the creditworthiness of a business and, in turn, the level of credit risk it poses to financial institutions that lend to it. Under the disorderly GBF-aligned scenario, where businesses do not adapt in line with the transition, projections suggest that nature-related risks could increase exposure-weighted cumulative expected credit losses by up to 9 percent by 2030, and by up to 21 percent by 2050. Similar to the pattern seen for profits, the change in exposure-weighted loan book value can misrepresent the magnitude of expected credit losses in priority sectors, which could reach as high as 75 percent by 2050. By 2030, in four out of five banking systems, unweighted cumulative expected credit losses increase by more than 10 percent in at least one sector. However, business action under the orderly GBF-aligned scenario could lead to a substantial decline in credit risk for most banking systems. The largest reductions in credit risk are seen in Zambia and Ghana, which reduce cumulative losses by 18.5 and 10.2 percentage points, respectively, by 2050. In relative terms, Morocco and Mauritius also see large reductions in cumulative losses, with 2.2 and 1.1 percentage point increases, respectively, in loan book value by 2050.

Macroeconomic risks and opportunities

Beyond changes to credit risk, several additional, important macroeconomic implications could be relevant to central banks' mandates to control price inflation and maintain financial stability:

- If production costs and prices increase for agricultural commodities, food prices would rise causing inflationary
 pressure. This would have important secondary socioeconomic impacts, in particular on low-income and vulnerable
 communities such as the unemployed, presenting challenges for economic growth and local communities. This
 would be more of a concern for countries whose agricultural sectors could experience the highest cost increases,
 and hence potential price increases, such as Ghana and Zambia.
- Financial risks in sectors such as agriculture that support a large share of employment could lead to job losses or disruption in income. This could impact economic growth and have knock-on impacts on the ability of these communities to service personal debt. This is particularly the case for countries such as Ghana, Rwanda, and Zambia, where agriculture accounts for 39 to 59 percent of employment.¹⁴
- If nature-related risks drive cost increases for exports, these could have knock-on impacts on international competitiveness and foreign exchange risk. Countries that rely heavily on exports of primary commodities, such as Ghana, Rwanda, and Zambia, are more exposed to these risks.

¹⁴ "Employment in agriculture (percent of total employment) 2021," World Development Indicators, World Bank, November 6, 2023.

- Specialized lenders with high exposure to sectors heavily exposed to nature-related risks may face acute risks and even solvency concerns. These risks are more of a concern for countries with financial institutions specializing in agriculture, mining, and food and beverage sectors.
- Nature-related risks could lead to large and systemic second-order socioeconomic impacts. For example, food
 and freshwater shortages may increase the risk of forced migration and subsequent challenges.
- An orderly nature-positive transition could help mitigate physical and transition risks, but also drive a broader range of benefits not quantified here, such as new nature-linked financial instruments, additional revenue streams, and productivity-driven economic growth.

Enabling environment

The right enabling environment could help support action across the commercial financial sector and, in turn, real economy sectors. A clear business case could help commercial financial institutions to assist in creating a nature-positive impact. Such a business case would need to both demonstrate the materiality of nature-related risks to their activities (for example, by using a stress test similar to the one used in this report), as well as a clear understanding of what possible first steps they could take. If they make the decision to help create a nature-positive impact, financial institutions could benefit from having training materials and services available to upskill teams across the organization that may have not had such exposure before—for example, relationship managers and risk practitioners. The development of market infrastructure similar to that which currently exists for climate-related issues could be unlocked by a nature-positive impact. For example, the inclusion of nature in green taxonomies could help channel finance to activities with nature-positive impacts, and the standardization of disclosure requirements could help to develop best practices and minimize the reporting burden on the private sector.

The stress test results demonstrate that nature-related risks could be minimized if businesses adapt in line with the orderly transition scenario which also adheres to the GBF goals. Expected profit and credit losses could be considerably lower if businesses, alongside decision makers and consumers, act together to reverse nature loss in line with the goals of the GBF. In addition, there are a range of possible macroeconomic benefits including improved employment, stronger export receipts, and reduced pressure on household debt. This demonstrates how the alignment of the private sector with the nature-positive transition could generate a range of environmental and economic benefits.

1. Context and approach

Context and approach

Africa is both heavily dependent on nature and experiencing rapid nature loss. Some 62 percent of African GDP is moderately or highly dependent on the services that nature provides: 70 percent of communities in sub-Saharan Africa depend on forests and woodlands for their livelihoods.¹⁵ Yet nature, and hence its ability to provide these services, is being rapidly degraded. A quarter of African countries are currently experiencing a water crisis; 3 percent of GDP is lost annually from soil and nutrient depletion of croplands.¹⁶ In line with global coordinated efforts to halt and reverse these trends, almost all countries in Africa signed the Kunming-Montreal Global Biodiversity Framework (GBF) in 2022. In parallel, momentum is building in the African financial sector in response: 19 institutions across seven African nations participated in a pilot program run by FSD Africa, based on the Taskforce on Nature-related Financial Disclosures framework, to assess their vulnerability to nature loss, paving the way for more sustainable financial practices. The pilot involved banks, insurers, asset managers, and development finance institutions.¹⁷

This report presents the consolidated findings of a nature stress test conducted for the banking system in five African countries: Ghana, Mauritius, Morocco, Rwanda, and

Zambia. Nature-related risks and opportunities arise from an organization's dependencies and impacts on nature.¹⁸ The analysis examines how the profits of businesses across these five economies could be impacted—positively or negatively—under scenarios of different naturepositive transition pathways. It also considers how this could create knock-on effects for the financial sector. It assesses risks driven by 11 impacts and dependencies such as deforestation, pollution, and water scarcity, across a selection of sectors for which nature-related risks are expected to be highly material. A more detailed description of the stress test and methodology including a list of the risk drivers and sectors included can be found in the appendix. The findings are particularly relevant for financial regulators and private financial institutions in Africa, whose financial systems and portfolios are likely to be exposed to similar levels of risk.

While financial impacts for businesses and commercial lending are the focus of the report, it is only one of many considerations relevant to decision makers. The unprecedented rate of nature decline described above makes it clear that it is critical that the world continues to move toward a net-zero and nature-positive transition. In outlining the potential for negative financial impact, this report does not seek to suggest deviating from this transition. Instead, it seeks to help relevant stakeholders understand the impact of the transition so that they can respond accordingly. Risks that impact business profits, the primary focus of this report, also have important secondary impacts on issues such as job creation, economic growth, and community empowerment. Financial performance in the private sector is an important consideration as private companies will be an important funder of the actions required for an orderly transition that protects nature, strengthens economic growth, and supports local communities.

The nature stress test examines five national banking systems that represent a spectrum of diversity across Africa in terms of economic

¹⁶McKinsey analysis using NatuRisk, drawing on data from the World Resource Institute's Aqueduct Water Risk Atlas version 4.0, World Resource Institute, 2023.

¹⁷FSD Africa coordinated pilots (2021 to 2023); "Promoting an African voice for the Taskforce on Nature-related Financial Disclosures (TNFD) and nature-related financial risk management," FSD Africa, October 2023.

¹⁸Taskforce on Nature-related Financial Disclosures (TNFD) recommendations, Taskforce on Nature-related Financial Disclosures, 2023.

structures, natural landscapes, and emerging nature-related risks. While the exposure of any individual banking system will vary, the results demonstrate how different factors may increase or reduce risk exposure. The five banking systems include tropical and subtropical African countries that have highly biodiverse forest ecosystems, as well as arid and island nations. The set includes economies that rely heavily on agriculture, mineral and commodity exports, services, and tourism, as well as more diversified industrial and manufacturing sectors. The five banking systems examined were chosen based on interest among national stakeholders and to capture a range of different risk profiles across Africa. The key drivers of risk will be similar for other banking systems in Africa, though the precise level of financial risk will vary depending on the sectoral distribution of the national loan book, health of local ecosystems, and other factors.

The exercise focuses on banks lending to corporates, assuming the distribution of current loans across sectors will remain constant in the future. It quantifies the effects of nature-related risks on corporate profits and loans issued to corporates. Across the banking systems considered, the largest amount of lending was provided to sectors such as services, finance, real estate, manufacturing, and trade. Risks to noncorporate loans such as mortgages are not quantified but are discussed qualitatively. The distribution of corporate loans by sector is taken from publicly available data published by the respective central banks.¹⁹ Because nature-related risks can vary within sectors, when detailed data on loans within sectors (for example, loans by commodity) is not available, it is proxied using additional data on the national

economy.²⁰ The analysis assumes that the sectoral distribution of loans remains constant. As a result, future exposure of the loan book by sector is identical to current exposure. This is analogous to the current loan book "rolling over" once existing loans have matured.

Exposure to physical and transition risks is assessed across three scenarios, which explore the ambitions of decision makers and businesses to implement nature-positive policies and practices. The stress test models the most material types of nature-related risks for a broad range of sectors. It does not model all nature-related risks for all sectors. For example, risks related to deforestation and protected areas in the mining sector are only modeled for a selection of commodities judged to be the most exposed to these risks. This includes commodities that have strong historical links to deforestation, such as coal, iron ore, gold, and copper. It also includes commodities where reserves are in ecologically sensitive locations, such as lithium, nickel, and cobalt.²¹

Exhibit 4 describes each scenario and its exposure to physical and transition risks.

The stress test presents three key metrics: unweighted profit losses by sector, weighted profit losses for the banking system, and credit losses. Unweighted profit losses by sector represent the potential change in the net present value of future profits for individual sectors that the banking system lends to, such as agriculture, mining, and manufacturing. Weighted profit losses for the banking system are an average of the previous metric that is then weighted by the credit exposure of the national banking system in each country to each of their real economy

¹⁹Annual report 2022, Bank AI-Maghrib, 2022; Annual report 2022, Bank of Ghana, 2022; "Bank loans to other nonfinancial corporations, households and other sectors end-December 2022," Bank of Mauritius, December 2022; Annual report 2022, Bank of Zambia, 2022; Annual report 2021 to 2022, National Bank of Rwanda, 2022.

²⁰ Gross value added (GVA), National Statistical Offices; British Geological Survey, September 2023; "Agricultural value of production," Food and Agriculture Organization of the United Nations (FAOSTAT); Ghana Statistical Services; Ministry of Economics and Finance, Kingdom of Morocco; National Institute of Statistics of Rwanda; World mineral production database; "Integrated trade solution," World Bank; and data on listed companies.

²¹McKinsey analysis using NatuRisk.

Exhibit 4

The nature stress test compares risk exposure under three different scenarios.

Low risk	High risk	Stress test focuses on scenarios aligned with the GBF		
	Current policies	Disorderly GBF-aligned	Orderly GBF-aligned	
Global action on nature	Continuation of current nature policies and commitments, with no expected increase in ambition for either nature or climate. Biodi- versity loss continues to accelerate and leads to significant decline in quality and quantity of ecosystem services	Policymakers take ambitious, holistic, and early nature action the meets all GBF targets and is well coordinated with climate action Protected areas reach maximum feasible limits and there are his shifts in diets and food waste		
Risks	Upper bound: nature loss is nonlinear and self-reinforcing, so significant losses of ecosystem services are felt widely across geographies and sectors ¹ Lower bound: nature loss is incremental and reversible, and ecosystems exhibit relatively high resilience to impacts	Disorderly: businesses only take actions to mitigate impacts on nature and risks that they are required to by regulation	Orderly: businesses take additional voluntary actions to mitigate their impacts on nature, minimize risks, and take advantage of opportunities	
Physical nature risk				
Transition nature risk				
Compar- able NGFS climate scenarios	Hothouse world scenarios	Disorderly scenarios	Orderly scenarios	

Note: Underpinning these scenarios are a narrative and specification for a wide range of risk drivers across policy, demand, and technology drivers, including but not limited to: protected areas, deforestation regulation, agricultural subsidies and taxes, bioenergy demand, recycling, and agricultural innovation. ¹For example, by 2030, 60 countries face water scarcity, 180 million ha of cropland becomes degraded, and pollinator populations decline by 70%. Source: NatuRisk analysis

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sectors. Credit losses represent the expected losses to the banking system itself due to changes in the value of its loans to sectors in the real economy.

Results for profit impacts in the real economy and expected credit losses for the financial sector are both expressed relative to a baseline scenario in which there are no nature-related

risks. Future profits and expected credit losses are calculated in each of the three scenarios shown. To isolate the impacts of nature-related factors, risk is measured as the difference in profits under a given scenario relative to the baseline scenario (where businesses face no physical or transition risks) and is expressed as a percentage change. Unless stated otherwise,

profit impacts between a scenario and the baseline scenario are typically expressed in net present value (NPV) terms. This means that future losses are discounted and are therefore worth less than if the same losses were to occur today. Credit losses are expressed in cumulative terms. This means that annual losses from default are summed over time starting at the base year. The appendix describes how these metrics are calculated in more detail. Both real economy profit impacts and credit risk results are often weighted by loan book exposure to determine the overall risk for the country or banking system. Loan book exposure refers to the percentage share of total loan book value that is accounted for by a given sector.

2. Real economy risks and opportunities

Real economy risks and opportunities

2.1. Real economy profit impacts across scenarios

If current policies and business practices continue, nature-related physical risks could be substantial for some banking systems.

Exhibit 5 shows exposure-weighted NPV profit losses for the portfolios of all five banking systems under each scenario.²² At the upper bound of physical risks-that is, where nature loss is nonlinear and self-reinforcing, resulting in significant loss of ecosystem services and extreme physical risks-exposure-weighted

portfolio NPV profits from 2020 to 2050 could decline between 1 and 7 percent relative to the baseline.23

Yet these risks are heavily concentrated in a small number of sectors such as agriculture, utilities, and manufacturing, which are characterized by high dependencies on ecosystem services. For example, the Ghanaian agricultural sector could see unweighted NPV profits from 2020 to 2050 fall by more than 50 percent due to physical risks such as declining pollinator populations, soil quality, and water availability. Other sectors such

Exhibit 5

Nature-related risks are lowest under an orderly transition scenario.

Exposure-weighted portfolio NPV profit losses for the real economy, by scenario, % change relative to baseline, disorderly GBF-aligned scenario, 2020-50



²² This metric refers to the profit losses of banking clients weighted by the exposure of the banking system's credit exposure to each sector. ²³This upper bound quantifies extreme physical risk from water availability, water quality, soil degradation, and pollinator population declines. Under this scenario, by 2030, 60 countries face water scarcity, 180 million hectares of cropland have become degraded, and pollinator populations have declined by 70 percent. Other physical risk channels (for example, invasive species) and nature-related tipping points are not captured in this analysis.

as food, beverage, and fertilizer manufacturing, and electricity, gas, and utilities could also see large NPV profit losses from physical risks, reaching as high as 15 and 4 percent, respectively, due to water shortages in arid countries such as Morocco. Though not quantified within this stress test, increasing rates of land use change and pollution are likely to degrade the health of natural ecosystems and have significant knockon impacts on ecotourism.²⁴ Profit impacts in all these sectors could also have important secondary socioeconomic impacts for relevant stakeholders to consider, including weighing down economic growth, job creation, and community development.

If decision makers act to reverse nature losses and meet the goals of the GBF, but businesses do not substantially change their practices, the average business in these countries could see NPV profits from 2020 to 2050 fall by as much as 6.7 percent. The disorderly GBF-aligned scenario results in a significant reduction in physical risks but in turn creates potentially significant transition-related risks if businesses do not adapt in line with policy.²⁵ These costs could be substantial for sectors such as agriculture, where unweighted NPV profit losses could reach as high as 44 percent in some countries relative to the baseline. As shown in Exhibit 5, the transition-related risks from a disorderly transition result in an overall outcome that is worse than the current policies in four of the five countries analyzed.

Morocco is the only banking system where risks under the disorderly GBF-aligned scenario are potentially lower than under a current policies scenario, given its relatively high exposure to physical risks. For the other four banking systems, the disorderly transition scenario could create more real economy risks than under current policies. Exposure-weighted NPV profit losses are highest in Zambia and Ghana, at 6.7 and 4.7 percent, respectively. The portfolios of Rwanda and Mauritius are the least exposed to naturerelated risks, with estimated NPV profit losses of 1.1 and 1.7 percent, respectively, from 2020 to 2050. This is not to say that a current policies scenario is a preferable outcome. As discussed later in the report, for most countries, risk levels are lowest under an orderly GBF-aligned transition. This underscores both the need for a transition and the need for that transition to be well coordinated.

However, if businesses act to mitigate risks, they could face lower risks than if current policies continued. In all five banking systems, mitigation leads to a significant reduction in NPV profit losses from 2020 to 2050. Ghana, Mauritius, Morocco, and Zambia see relatively large benefits from mitigation, avoiding most profit losses of the disorderly GBF-aligned scenario. Rwanda is the only banking system where the orderly outcome does not reduce more than half of all disorderly profit losses.²⁶ Furthermore, in all banking systems except Rwanda, the orderly GBF-aligned scenario leads to a reduction in exposure-weighted NPV profit losses relative to a current policies scenario at the upper bound of physical risks. This demonstrates that an orderly transition scenario could be in the interests of the private sector if policy and business practices were coordinated. It could also have important positive parallel impacts on economic growth, job creation, and local communities.

2.2. Real economy profit impacts for the disorderly GBF-aligned scenario

According to the assumptions of the disorderly transition scenario, five key drivers account for the majority of risks to companies that do not adapt:

1. The agriculture sector could experience increases in production costs. Critical

²⁴Risks to tourism are not quantified due to a lack of robust evidence on the quantitative relationship between the health of local _____ecosystems and tourist footfall.

²⁵See section 2.3 for further information on disorderly versus mitigated Global Diversity Framework–aligned scenarios.

²⁶See section 2.3 for an explanation of differences in mitigation potential across countries.

action to prevent deforestation and protect highly biodiverse areas, both domestically and internationally, could constrain the land available for agriculture. Producers may then need to quickly adopt new agricultural practices and technologies that use less land but are more expensive. Significant global action to curb deforestation and protect critical ecosystems would be needed to achieve the GBF's ambition. These actions are essential and would lead to positive environmental outcomes with many benefits, but also some costs if stakeholders are not able to adapt. In particular, this could require land use policiesdomestic and international—that (a) financially penalize deforestation, and (b) accelerate investments in sustainable agricultural solutions. These policies have a significant effect on agricultural value chains across all five countries. Impacts are larger for countries such as Ghana, which are characterized by (i) a relatively greater volume of loans to agriculture and forestry, (ii) high levels of deforestation, and (iii) high exports to selling markets with stringent deforestation-linked import policies such as the European Union. These factors are potentially less important for countries like Mauritius and Rwanda and so deforestation

and protected area risk drivers are lower (Exhibit 6). It is worth noting that switching to zero-deforestation practices in Africa often involves creating incentives, building capabilities, and making inputs available for more intensive farming to very large numbers of smallholder farmers, which is complex and challenging.

2. The agriculture and broader food and beverage sectors could experience changes in revenue for certain products. Global diet shifts, reduced food waste, and a shift to sustainable farming practices could substantially reduce demand for products such as animal proteins and fertilizers. In the long term, global demand for environmentally harmful products reduces relative to the baseline scenario as consumers seek out sustainable alternatives and change their consumption preferences. Likewise, demand for agricultural inputs, such as fertilizer, decreases relative to the baseline as farmers switch to organic alternatives and increase the efficiency of application. The analysis shows that demand impacts are significant in most banking systems but have the largest impacts in Rwanda and Zambia, accounting

Exhibit 6

The importance of each risk driver varies significantly across countries.



Exposure-weighted portfolio NPV profit losses for the real economy,

% share of total change relative to baseline, disorderly GBF-aligned scenario, 2020–50

Note: Figures may not sum to 100%, because of rounding. Source: NatuRisk analysis

for 50 percent and 35 percent, respectively, of total exposure-weighted NPV profit losses from 2020 to 2050. This is principally due to the relatively larger volume of commercial loans going to food and beverage manufacturing and fertilizer manufacturing for these two countries (15 percent and 11 percent, respectively).

- 3. Manufacturers and utilities could experience increases in production costs. Worsening water quality could demonstrate the need for regulations that require heavy-polluting industries to introduce or improve the treatment of their wastewater discharge. This action could tackle pollution and support the health of local ecosystems as well as raise the cost of doing business for these sectors. Decision makers take critical action to ensure commercial and residential access to clean water under the GBF-aligned scenario. Water pollution policies are implemented, requiring commercial sectors to invest in processes and technologies to treat wastewater before it is discharged, improving local environmental outcomes. Additional costs from strengthened water pollution policies are highest in countries with existing water pollution issues or high levels of water stress, or both, such as Mauritius and Morocco, where it accounts for 48 and 37 percent, respectively, of total exposureweighted NPV profit losses by 2050. The relative importance of water pollution for these two countries is also related to a comparatively higher share of loans to sectors where water pollution is the key risk. For example, nearly a guarter of commercial loans in Mauritius are for construction, which could contribute significantly to water pollution but not to deforestation or protected area loss.²⁷
- 4. The mining sector could experience changes in revenue. To maintain the health of protected areas and quality of local water supplies, mining companies could face difficulties in securing contracts to open

new mines in sensitive locations. This could result in disruptions to production and lost revenue. It will be increasingly important to work with and ensure benefits for local communities. New mining projects come under increased scrutiny due to their land use, water consumption, and pollution impacts under the GBF-aligned scenario. Future planned mining locations could increasingly overlap with expanding protected areas in these countries. Companies operating in critical areas would need to demonstrate sufficient measures to mitigate these impacts and ensure collaboration and benefits for local communities to operate. This risk driver is most significant for banking systems with high credit exposure to mining, such as Zambia and Ghana, where mining accounts for 34 and 5 percent, respectively, of total exposure-weighted NPV profit losses from 2020 to 2050.

5. Downstream sectors could experience increases in production costs. In response to higher production costs, the price of some agricultural commodities could rise, increasing input costs for other sectors, such as manufacturing and retail.²⁸ Upstream sectors, such as agriculture and mining, are subject to various risk drivers that increase production costs. Due to low profit margins, agricultural and forestry commodity producers may need to increase prices to stay in business. In mining, lack of substitutes for critical minerals such as copper, lithium, and iron also leads to higher prices. This would increase the price of inputs for midstream manufacturers and downstream retailers. There is minimal variation in the magnitude of input price increases across countries. Rather, the analysis shows that input costs are a more significant risk driver for banking systems with higher credit exposure to mid- and downstream sectors such as Mauritius, where these risks account for 26 percent of total exposure-weighted NPV profit losses by 2050.

²⁷The deforestation from timber is attributed to the timber sector, not the construction sector. For the construction footprint, there is very little forest clearing directly associated with erecting buildings.

²⁸Upstream sectors in this report refer to agriculture, forestry, and mining and quarrying, which produce raw or unprocessed commodities. Midstream sectors include refining, processing, manufacturing, transport, and distribution, as well as the ancillary or financial services that support these activities. Downstream sectors refer to sectors that directly interface with consumers such as retail, hospitality, restaurants, and bars.

Nature risk could result in financially material impacts on the business sector in Africa before

2030. Rapid policy change is required in the short term to meet the GBF's 2030 targets. Across all five banking systems, loans to sectors with high transition risks account for 21 to 44 percent of loan book exposure. As a result, some banking systems could see a material increase in transition risks before 2030. Exposure-weighted in-year profit losses for the five banking systems are shown in Exhibit 7, which demonstrates that nature-related risks could reduce profits by 5 percent or more as early as 2030 for those banking systems that are characterized by high commercial loan exposure to sectors like agriculture, forestry, and mining that are most impacted by nature policy-driven cost or revenue shocks.

Risks are unevenly distributed across sectors, with a small handful of highly exposed sectors accounting for most profit impacts. Specifically, 83 to 98 percent of all profit losses in the five countries are concentrated in three to five sectors, which account for 21 to 44 percent of loan book exposure. The list of priority sectors—those sectors with the highest exposure-weighted NPV profit losses from 2020 to 2050—for each banking system is shown in Exhibit 8. Exposure-weighted NPV profit losses are a product of loan book exposure to the sector and profit losses. As a result, a sector that sees large profit impacts may not be deemed a priority if credit exposure is limited. That said, some sectors are more likely to feature as priorities than others:

- Agriculture and forestry features as a highrisk priority for all five banking systems. This is because agriculture has high materiality impacts and dependencies on nature, including on deforestation, pollination, soil quality, and water availability and quality.
- Food, beverage, and fertilizer manufacturing also features as a high-risk priority for all five countries, but this is driven principally by technology and market risks which influence demand. For example, farmers could reduce their use of inorganic fertilizer or consumers their consumption of products that adversely impact nature.

Exhibit 7

Businesses in some banking systems could see material financial risks in the next ten years.

Exposure-weighted portfolio in-year profit losses for the real economy, % change relative to baseline, disorderly GBF-aligned scenario, 2020–50



Exhibit 8

Risks in seven priority sectors likely drive the majority of profit losses.

Concentration of loan book and NPV profit losses for the real economy in priority sectors, by country, % change relative to baseline, disorderly GBF-aligned scenario, 2020–50

	Ghana	Mauritius	Morocco	Rwanda	Zambia	
Agriculture and forestry						Priority sectorsOther
Mining and quarrying						
Food, beverage, and fertilizer manufacturing						
Consumer goods retail						
Electricity, gas, and water						
Construction						
Metals and minerals manufacturing						
% of 2020 loan book exposure	42	33	33	21	44	
% of total NPV profit impacts by 2050	90	83	84	95	98	

Note: Modelling of the mining and quarrying sector did not include phosphate, and hence the impacts of this sector in countries that are significant producers (like Morocco) was not accounted for in the analysis. Source: NatuRisk analysis

McKinsey & Company

- Mining and quarrying are classified as a priority for three of the five banking systems, depending on the types of minerals that are extracted, but also, more importantly, the extent to which proven reserves are located in sensitive locations, such as forests, speciesrich areas, or areas in close proximity to crucial freshwater sources, or both.
- Construction and utilities are considered high-risk priorities in three and two of the five banking systems, respectively. Risk in these sectors is typically driven by dependencies on water availability, water quality, and changes in input costs (for example, raw materials).

The list reflects the financial materiality of nature-related risks for each sector, rather than the materiality of a sector's impacts and dependencies on nature. Some sectors not shown here may still have substantial impacts or dependencies on nature, but these impacts and dependencies may not translate into financially material risks. Equally, some sectors not included here, such as tourism, may have high exposure to nature-related risks though these are not quantified within this stress test. In addition, in some cases, sectors may have low average risks but material risks within specific subsectors or commodities. Exposure-weighted impacts may undermine the substantial risks seen in these highly exposed sectors, with unweighted NPV profit losses from 2020 to 2050 reaching as high as 44 percent in some sectors.

Exhibit 9 compares unweighted sector-level NPV profit impacts from 2020 to 2050 across priority sectors for each banking system. The magnitude of profit impacts, shown by the bubble position along the horizontal axis, demonstrates two findings:

 Exposure-weighted portfolio-level estimates can understate the magnitude of risk in priority sectors. Although unweighted NPV profit losses in most sectors are moderate, between 0 and 10 percent from 2020 to 2050, some sectors see much larger profit losses. This is particularly true for agriculture, where all countries except Mauritius see unweighted NPV profit losses greater than 15 percent from 2020 to 2050. Other examples include mining and quarrying in Zambia (22 percent), as well as food, beverage, and fertilizer manufacturing in Morocco (13 percent).

2. Nature-related risks within sectors can vary substantially by country. Many factors can drive nature-related risks, including the health of ecosystems (or the state of nature) within a country, its policy action on nature, economic structure, supply chain links, and consumer preferences. For example, African countries are generally more biodiverse than European ones, with a narrower set of initiatives to tackle nature loss in the short term, and the market for sustainable alternative products may be relatively smaller.²⁹ As a result, although risks

Exhibit 9 Risks are unevenly distributed across sectors.

Unweighted sector-level NPV profit losses for the real economy, % change relative to baseline, disorderly GBF-aligned scenario, 2020–50



²⁹ For example, they tend to have more "key biodiversity areas" sites that contribute significantly to the global persistence of biodiversity (for further information, see BirdLife International's website, birdlife.org and Key Biodiversity Areas' website for biodiversity areas, 2022, keybiodiversity.org); they tended to rank lower in the Environmental Performance Index's "Habitat and biodiversity" category (Wolf, M. J. et al., *Environmental performance index, 2022*, Yale Center for Environmental Law and Policy).

Nature stress test: Assessing exposure of five African banking systems

for the agricultural sector in Europe are of a similar magnitude to most of the African countries considered here-typically around a 10 to 30 percent NPV profit loss from 2020 to 2050-the source of risk is different. European countries generally face higher risks from pollution and consumer demand shifts, whereas African countries face higher risks from deforestation, violation of protected areas, and water stress. For food and beverage manufacturers and retailers, nature-related risks are usually larger in Europe relative to most of the African countries considered here, at around 10 percent NPV profit loss from 2020 to 2050. This is because companies typically source more inputs from areas connected to high levels of deforestation, such as palm oil from Southeast Asia, and there is stricter regulation of links to deforestation within supply chains.

Nature-related risks in sectors such as agriculture and mining are comparable in magnitude to climate-related risks for emissions-intensive sectors.

Exhibit 10 compares a selection of in-year, undiscounted (not NPV) sector-level profit impacts from nature-related risks in 2050—the losses that a business would face at that point in time—to the same metric but driven by climate-related risks in emissions-intensive sectors globally.³⁰ The comparison shows that profit losses from naturerelated risks in the most affected sectors are broadly comparable to climate-related risks. This underscores the importance of treating nature with the same attention as climate, especially in these priority sectors.

³⁰Long-term profit impacts are smaller in NPV terms due to compound discounting. When this discounting factor is removed, the annual or in-year profit impacts reflect the additional costs or revenue losses that a company will face at that point in time, and hence tend to be much greater.

Exhibit 10

Nature-related risks in agriculture, mining, and manufacturing are of the same scale as climate-related risks in emissions-intensive sectors.

Unweighted in-year profit losses for the real economy, % change relative to baseline, disorderly GBF-aligned scenario vs NGFS Net Zero 2050 scenario, 2020–50



Note: Excludes climate-related risks in oil and gas, which are generally larger than nature-related risks in sectors with high nature impacts (~70% profit loss in 2050). Climate-related risk analysis based on the Network for Greening the Financial System (NGFS) Net Zero 2050 scenario from REMIND-MAgPIE (REgional Model of Investment and Development-Model of Agricultural Production and its Impacts on the Environment) model version 2.0. Source: NatuRisk; Planetrics

Profit impacts can also vary substantially within a given sector, ranging from 12 to -70 percent across subsectors. Similar to how exposureweighted NPV profit losses can understate the magnitude of risk for a given sector, the same can be said for sector-level and subsector-level impacts.

Exhibit 11 looks at the distribution of NPV profit losses within all priority sectors across all banking systems. It reveals two findings:

 Subsector profit impacts can be considerably higher or lower than the sector average for a given banking system. For example, in agriculture, some subsectors experience profit losses above 60 percent, whereas others experience profit gains above 10 percent. For instance, Rwandan cocoa production is associated with more adverse nature impacts relative to fruit, nuts, and vegetables in Morocco. This is due to both its location and consumption of water. As a result, Rwandan cocoa production faces a higher level of financial risk relative to Moroccan fruit, nuts, and vegetables. Large variations can also occur in mid- or downstream sectors: in Morocco, fertilizer manufacturing sees a 12 percent NPV profit loss due to a shift to more sustainable farming practices that require less fertilizer per unit of output, whereas processed fruit and vegetable products see a 2 percent NPV profit gain as consumers begin to consume more fruit and vegetables in their diets.

2. Some banking systems have far greater loan book exposure to the most-affected subsectors than others. Zambia is the most exposed to tail end risks, with 20 percent of its portfolio exposed to unweighted NPV profit losses greater than 20 percent from 2020 to 2050, followed by Ghana at 10 percent. However, Rwanda and Mauritius have relatively low exposure to tail end risks, with only 3 and 2 percent, respectively, of their portfolios exposed to unweighted NPV profit losses greater than 10 percent.

Exhibit 11

Profit losses can vary substantially within sectors and countries most exposed to high-risk subsectors face the largest losses.



Note: Figures may not sum to 100%, because of rounding. Source: NatuRisk analysis

Nature stress test: Assessing exposure of five African banking systems

It is primarily the distribution of loans that is driving the difference between banking systems, not the magnitude of profit losses at the sector level. Those banking systems with the largest portfolio-level impacts have relatively larger exposure to high-risk subsectors.

Exhibit 12 demonstrates the importance of sector loan book exposure in determining overall portfolio impacts. This figure shows that exposure-weighted profit losses are highly correlated with exposure to the subsectors with the highest level of risk. If all countries had a similar level of exposure to these subsectors, then total exposure-weighted profit losses could be more comparable. For example, Zambia, which sees a 7 percent exposure-weighted NPV profit loss by 2050, has by far the highest exposure to high-risk subsectors within agriculture, forestry, and mining and quarrying. If the loan book of each banking system had the same sector weights as Zambia, the magnitude and relative difference between banking systems would change significantly. Specifically, NPV profit impacts in the other four banking systems would increase between two and five times. After applying these equal weights, Ghana becomes the banking system with the largest profit impacts and Rwanda is no longer a relatively low-risk banking system.

Exhibit 12

Countries with the largest portfolio-level impacts have relatively greater exposure to high-risk subsectors.

Exposure-weighted NPV profit losses for the real economy,

% change relative to baseline, disorderly GBF-aligned scenario, 2020-50



Source: NatuRisk analysis

2.3. Real economy mitigation potential for the orderly GBF-aligned scenario

There are various actions businesses can take to adapt in line with the transition, minimize their exposure to nature-related risk, and leverage nature-related opportunities. The analysis models the effect of a limited set of mitigation options in the orderly GBF-aligned scenario. This considers a selection of actions that have the most significant impacts on risk exposure. The actions are not intended to be exhaustive. In practice, actions described below should be thought of as a subset within a broader possible suite of actions embedded in a holistic nature strategy. This might include actions across governance, business planning, strategy, and reporting. That said, the orderly (or mitigated) GBF-aligned scenario explores three ways companies could reduce financial materiality:

- In agricultural value chains, by adopting sustainable farming practices, working with suppliers to reduce upstream deforestation, or switching suppliers toward those not associated with deforestation. Such changes would be required for producers that export to Europe to comply with EU regulations on deforestation. This switch would require building capabilities and making inputs available for more intensive farming, which can be complex in many contexts across Africa.
- 2. In mining, by ensuring mines are located outside protected areas and away from areas at risk of freshwater contamination.
- In all sectors, stakeholders may choose to consider amended pricing strategies to absorb some of the cost increase, alongside protecting consumers and recognizing important socioeconomic impacts on food poverty, economic growth, and community empowerment. Note that for many commodities, local prices closely track global market dynamics or indices,

meaning that individual producers have only limited influence to change those prices. The modeling here aims to capture potential changes that could happen considering different market dynamics and what share of producers face changes in costs.

Across the five banking systems, these actions could mitigate 27 to 78 percent of exposure-weighted NPV profit losses under the GBF-aligned scenario. This demonstrates that there is considerable variation in businesses' ability to mitigate risks. Businesses in Ghana, Mauritius, Morocco, and Zambia could mitigate most risks, while businesses in Rwanda could mitigate a smaller proportion. Differences in mitigation potential between businesses in different countries are attributable to four factors, which can be illustrated by comparing Ghana and Rwanda as shown in Exhibit 13.

1. Businesses in countries with a higher share of profit losses from mining license risk have a greater ability to mitigate risks by moving production locations. Mining license risk arises when the impacts of a mine on nature lead to its license being taken away. In Ghana, mining license risk leads to a 0.2 percent decrease in portfolio-level exposureweighted NPV profits. As a start, companies could ensure mining operations and proposed developments work in conjunction with and ensure benefits for local communities and also implement the highest environmental safeguards. In some cases, proposed locations will be too environmentally sensitive even when following these measures. In these circumstances, companies could mitigate almost all the risk by moving to new locations outside protected areas or further away from freshwater bodies. However, this comes with potential trade-offs: alternative locations could result in higher production costs due to factors including the lack of or a disadvantageous location for transport infrastructure as well as poorer-grade deposits. These additional costs are reflected in the mitigated outcome.

Exhibit 13

Businesses in all countries can act to minimize risks but in different ways.

Exposure-weighted NPV profit loss for Ghana and Rwanda,

% change relative to baseline, orderly and disorderly GBF-aligned scenarios, 2020–50



Source: NatuRisk analysis

McKinsey & Company

- 2. Businesses in countries with a higher share of profit losses from deforestation regulations have a greater ability to mitigate risks by switching to deforestation-free practices or supply chains. In Ghana, deforestation regulations reduce portfolio-level exposure-weighted NPV profits by 1.3 percent. Switching to deforestation-free products or supply chains could reduce this loss to 0.6 percent nearly halving the impact. In Rwanda, risks are principally from drivers other than deforestation, for which effective mitigation options are less available, leading to a lower overall mitigation potential.
- 3. Businesses in countries with a high share of profit losses from demand impacts have less ability to mitigate risks. The modeling considers how companies could gain market share in comparison to other companies, but it does not consider how they could change

their product characteristics to increase overall market demand for the product. In reality, a company may mitigate demandrelated impacts by switching production to different products—for example, if a farmer were to switch grazing land for livestock to the production of a different agricultural crop; however, this action is not modeled within the nature stress test. In both Ghana and Rwanda, demand impacts reduce portfoliolevel exposure-weighted NPV profits by 0.6 percent. In both cases, an option to mitigate these demand impacts is not modeled.

4. Asymmetrical cost shocks across countries mean some businesses perform better than others when competing in international markets. If prices rise because of nature-related cost shocks, it may affect market dynamics. These cost shocks are location specific, meaning that companies can often face different cost increases than

their competitors. When companies experience relatively smaller cost shocks, they can gain an advantage over their competitors, allowing them to increase their profit margins and gain market share (and vice versa). In Rwanda, gold miners benefit, while in Ghana, food retailers benefit. The total reduction in portfolio-level exposureweighted NPV profit losses is larger for Ghana (3.3 percent) relative to Rwanda (0.4 percent) because food retailers in Ghana account for a larger share of the loan book than Rwandan gold miners. These considerations should be taken in the context of protecting consumers and the wider socioeconomic impacts on household purchasing power, poverty alleviation, and economic development.

A GBF-aligned transition could also create opportunities for growth not quantified in this nature stress test. These could include the following aspects:

 The economy could benefit from growing demand for goods with relatively low impacts on nature. This can be seen for products such as plant-based alternatives to meat and dairy, like fruit, nuts, and vegetables, which see gains in unweighted NPV profits as high as 15 percent in some countries by 2050. Over time, demand for these goods replaces demand for traditional alternatives with high nature and climate impacts, such as beef, pork, and dairy. Firms that shift production toward these goods could see substantial increases in revenues and profits. More broadly, this could lead to an expansion of new export sectors, increases in economic growth, and job creation.

- Sustainable products could generate higher
 'value add' than traditional alternatives
 supporting economic growth. With new
 sustainable technologies and practices that
 help companies generate more value through
 their production processes, and growth in
 corporate commitments to zero-deforestation
 supply chains more broadly, sustainable
 products in some cases could generate higher
 profit margins than traditional alternatives.³¹ The
 evidence for this benefit is emerging and in the
 short term is only likely to apply to a range of
 luxury commodities, such as cocoa or flowers.
 Over time, similar dynamics may emerge for
 other commodities.
- Nature-positive practices could create new income streams for companies—for example, through payments for ecosystem services or emerging financial instruments, such as biodiversity credits.

³¹For example: "Fairtrade minimum price and premium information," Fairtrade International, October 2023; "Fair rubber standards version 3.2, May 2021," Fair Rubber Association, 2023; "The inevitable policy response—supply chain analysis," United Nations Principles for Responsible Investment, 2023.

3. Credit risk

Credit risk

If a business experiences profit impacts due to nature-related risks, this can affect its creditworthiness and, in turn, the level of credit risk it poses to financial institutions that lend to it. In general, profit losses increase the risk that a company will be unable to meet its financial obligations and defaults on its loans (the probability of default). It also reduces the amount of capital that a lender may be able to recover in the event of business defaults (loss given default). A higher probability of default and higher loss given default reduce the value of a loan to a financial institution as it expects to incur higher losses on that loan. Under the disorderly GBF-aligned scenario, where businesses do not adapt in line with the transition, projections suggest that nature-related risks could increase exposureweighted cumulative expected credit losses by up to 9 percent by 2030, and by up to 21 percent by 2050.

Exhibit 14 shows the range of exposure-weighted cumulative expected credit losses due to naturerelated risks among the five banking systems. It measures the expected change in losses over time from default for all counterparties in all sectors of the loan book, excluding personal loans.

Exhibit 14

Exposure-weighted cumulative expected credit losses could reach nine percent by 2030, driven by agriculture, mining, and consumer goods retail.

Exposure-weighted cumulative change in expected credit losses, % change relative to baseline, disorderly GBF-aligned scenario, 2020–50



Exposure-weighted cumulative change in expected credit losses, % change relative to baseline, disorderly GBF-aligned scenario, 2020–30



Source: NatuRisk analysis

Zambia and Ghana see the largest potential impacts, with projected cumulative losses reaching 21 and 11 percent, respectively, by 2050 relative to the baseline. Equivalent losses in Morocco are moderate, at 5 percent, whereas losses in both Mauritius and Rwanda are relatively low, at approximately 2 percent. The impact of real economy profit losses from nature risk on credit losses to the banking system is amplified in countries with lower credit ratings, such as Ghana and Zambia.

Similar to the pattern seen for profits, the change in exposure-weighted loan book value can misrepresent the magnitude of expected credit losses in priority sectors, which could reach as high as 75 percent by 2050. Exhibit 15 shows projections of unweighted cumulative expected credit losses over time in priority sectors:

- By 2030, in four out of five banking systems, unweighted cumulative expected credit losses increase by more than 10 percent in at least one sector.
- In agriculture and forestry, unweighted cumulative expected credit losses reach at least 40 percent by 2050 for all banking systems, except Mauritius which predominantly produces crops with low-risk exposure, such as fruit, nuts, and vegetables. Losses are highest in Ghana principally due to the magnitude of land-use-related policy risks which have a large impact on important crops like tropical roots and cocoa.
- In mining and quarrying, Ghana, Rwanda, and Zambia see unweighted cumulative expected credit losses of over 10 percent by 2030, and over 20 percent by 2050, with losses by far

the largest in Zambia. Differences between countries are closely linked to the location of proven reserves for precious minerals as well as critical minerals required for the energy transition, in particular the proximity of potential mining sites to sensitive ecosystems. For example, in Zambia, new mining projects could threaten species-rich areas and contaminate nearby freshwater bodies. In countries like Morocco, a major phosphate producer, mining activities are significantly less exposed to license risks due to the proximity of mining assets to ecologically sensitive areas.

- Losses are also potentially significant in food, beverage, and fertilizer manufacturing for all five countries, but especially in Ghana, Morocco, and Zambia where unweighted cumulative expected credit losses reach over 20 percent by 2050 primarily due to reduced demand from market and technology shifts.
- Unweighted cumulative expected credit losses in other sectors tend to be low to moderate, with some notable exceptions, such as consumer goods and utilities in Ghana (21 and 15 percent, respectively, by 2050), metals and minerals manufacturing in Mauritius (11 percent by 2050), and consumer goods in Morocco (7 percent by 2050). Credit losses for consumer goods tend to be the result of import penalties on deforestationlinked products for major consumer markets like the European Union or reductions in demand for retail food items associated with high nature impacts. Losses for utilities and metals and minerals manufacturing are primarily due to water-related risk channelsfor example, water needs for thermal power generation, as well as rising prices for mineral inputs.32

³² High credit risk for utilities in Ghana is mainly driven by high exposure to LPG, propane, and other distributors that see relatively large profit impacts from water pollution.

Exhibit 15

Exposure-weighted losses mask much larger losses in priority sectors, reaching as high as 75 percent in some cases.

Unweighted cumulative change in expected credit losses, % change relative to baseline, disorderly GBF-aligned scenario, 2020–50





- Ghana - Mauritius - Morocco - Rwanda - Zambia

Food, beverage, and fertilizer manufacturing







McKinsey & Company

2020

0

-10

-20

-30

-40 _

Significant increases in expected credit losses are also feasible over shorter durations. Long-

term changes in loan book value demonstrate that expected credit losses in priority sectors are significant. However, the 2020 to 2050 time horizon is significantly longer than the typical tenor of a loan. Exhibit 16 compares how naturerelated risks could affect the value of a five-year loan to select priority sectors issued at different points in time. The results show that projections of cumulative expected credit losses over shorter durations could still be significant in some sectors.

For example, a five-year loan to an agricultural producer in Ghana issued in 2030 could see projected losses as high as 39 percent relative

Exhibit 16 Nature-related risks could be material even for five-year loans.

Unweighted cumulative change in expected credit losses for 5-year loans issued in 2030,

% change relative to baseline, disorderly GBF-aligned scenario

Banking system	Agriculture and forestry	Food, beverage, and fertilizer manufacturing	Mining and quarrying	Electricity, gas, and water
	5-year loan issued in 2030	5-year loan issued in 2030	5-year loan issued in 2030	5-year loan issued in 2030
Ghana	-39%	-10%	-12%	-3%
Mauritius	-1%	-2%	-1%	<1%
Morocco	-17%	-6%	-1%	<1%
Rwanda	-9%	-2%	-5%	<1%
Zambia	-20%	-10%	-24%	<1%

Source: NatuRisk analysis

to a baseline with no nature-related risks. This is relevant for both regulators and private financial institutions as it demonstrates that (a) naturerelated risks could be material for typical loan tenors and could be integrated into credit risk models; and (b), when issuing loans to high-risk sectors such as agriculture, due diligence on risk mitigation among counterparties is crucial.

Business action under the orderly GBF-aligned scenario could lead to a substantial decline in credit risk for most banking systems. All things being equal, a reduction in profit impacts for a business could lead to a reduction in expected credit losses for a financial institution lending to that business. Exhibit 17 compares exposure-weighted cumulative expected credit losses due to naturerelated risk by 2050 in the disorderly versus orderly GBF-aligned scenarios. The largest reductions in credit risk are seen in Zambia and Ghana, which reduce cumulative losses by 18.5 and 10.2 percentage points, respectively, by 2050. In relative terms, Morocco and Mauritius also see large reductions in cumulative losses, with 2.2 and 1.1 percentage point increases, respectively, in loan book value by 2050. The change in credit risk for Rwanda in the disorderly versus orderly scenarios is negligible given that the overall nature-related risks and potential to mitigate these risks are both low. Exhibit 17

If regulators and banks help borrowers mitigate risks, expected credit losses could be reduced by up to ten times.



Source: NatuRisk analysis

4. Macroeconomic risks and opportunities

Macroeconomic risks and opportunities

The risk dynamics discussed in the previous two sections have important macroeconomic considerations relevant to central banks' mandates:

- If production costs and prices rise for agricultural commodities, food prices would rise causing inflationary pressure as well as important parallel socioeconomic impacts for local communities including reduced purchasing power, poverty concerns, and lower economic growth.
- Financial risks in sectors such as agriculture, that support a large share of employment, could lead to job losses or disruption in income. This could impact economic growth and have knock-on impacts on the ability of these communities to service personal debt.
- If nature-related risks drive cost increases for exports, these could have knock-on impacts on international competitiveness and foreign exchange risk.
- Specialized lenders with high exposure to sectors heavily exposed to nature-related risks may face acute risks and even solvency concerns.
- Nature-related risks could lead to large and systemic second-order socioeconomic impacts. For example, food and freshwater shortages may increase the risk of forced migration and subsequent challenges.
- The orderly transition could help mitigate physical and transition risks, but also drive a broader range of benefits not quantified here, such as new nature-linked financial instruments, additional revenue streams, and productivity-driven economic growth.

Higher production costs for agricultural commodities could lead to price inflation for key household items. This could create inflationary pressure, particularly if it affects staple household items, such as food and beverage products. Additionally, this could have significant impact on local communities, such as reducing their purchasing power and increasing economic challenges. Ultimately, this is likely to dampen economic growth.

Exhibit 18 demonstrates potential price increases due to nature-related cost increases for a selection of agricultural commodities across the five countries, which could reach as high as 20 percent relative to the baseline by 2030. This will be more of a concern for countries whose agricultural sectors experience the highest cost increases, and hence price increases, such as Ghana and Zambia. Inflation is a direct concern to central banks' mandates.

Pressure on profit margins in agriculture could lead to increases in unemployment given the socioeconomic importance of the sector. The agricultural sector is a critical employer for many African economies. This is particularly the case for countries such as Ghana, Rwanda, and Zambia, where 39 to 59 percent of the population work in the sector.³³ Even after mitigation takes place, sectors such as agriculture and forestry could still see significant increases in credit losses. If nature-related risks push agricultural producers into insolvency, this could lead to increases in unemployment and create knock-on impacts on consumer spending and hence economic growth. Unemployment might also increase the risk of defaulting on personal debt and reduce demand in other sectors, such as services, which rely on income stability and consumer sentiment. This highlights a significant challenge and a consideration for central banks that care both about inflation and employment: price rises may

³³"Employment in agriculture (% of total employment) (modeled ILO estimate)," World Bank database, October 2023.

Exhibit 18

Nature-related risks could increase the price of staple goods as costs are passed on to consumers.

25 Ghana: wood Zambia: pulses 20 Zambia: poultry production Ghana: tropical roots Rwanda: fruits, nuts, vegetables 15 Ghana: cocoa 10 Rwanda: coffee Morocco: fruits, nuts, vegetables 5 Mauritius: egg production 0 2025 2030 2020 Source: NatuRisk analysis

Increases in prices of select agricultural commodities, % change relative to baseline, orderly GBF-aligned scenario, 2020–30

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allow producers to maintain solvency and protect employment but will create inflation.

Cost increases due to nature-related risks could lead to reduced export revenues, placing downward pressure on the exchange rate. If economies experience larger cost increases for agricultural production relative to their international competitors, they may become less competitive in export markets. Equally, shifting consumer preferences could reduce global demand for key export products that have high impacts on nature. These factors could lead to lower export revenues and, in extreme cases, downward pressure on the exchange rate due to lower demand for local currency.

Countries such as Zambia, that rely heavily on exports of a select number of commodities, in this case copper and gold, which account for a large percentage (77 percent) of export revenues, are more exposed to this risk.³⁴ This could have two relevant impacts for financial supervisors: (1) debt denominated in foreign currencies

³⁴ "Country profile: Zambia," Atlas of economic complexity, Harvard Growth Lab, November 6, 2023.

could become more costly to service; and (2) the relative prices of imported products and services could increase. The latter could have pronounced effects on economies that rely heavily on the import of energy or food items, such as Mauritius.

Specialized lenders with high exposure to sectors most affected by nature-related risks may face acute risks and solvency concerns.

The credit risk results demonstrate that naturerelated risks are heavily concentrated in a small selection of sectors. Large, diversified banks with exposure across many sectors could face moderate credit losses due to nature-related risks, especially after mitigation. However, lenders with higher exposure than average to high-risk sectors such as agriculture, coupled with a lower ability to perform due diligence on clients' resilience to nature-related risks, could face substantial losses and, in extreme cases, risk of insolvency. This could, in turn, raise concerns of financial contagion between institutions, depending on the structure and interdependencies of the domestic financial sector. This risk is a greater concern for countries with financial institutions specializing in agriculture, mining, and food and beverage sectors.

A nature-positive transition will bring a wide range of environmental and economic benefits to the world, first and foremost in protecting the health of natural ecosystems and wildlife. Broader economic benefits for businesses, governments, and the macroeconomy not quantified within the nature stress test could include the following aspects:

- New financial instruments, such as debt-for-nature swaps and nature-linked sovereign bonds, could financially reward governments for nature-positive outcomes.
 Debt-for-nature swaps allow governments to relieve debt in exchange for either expenditure on nature restoration or verified improved national nature outcomes. Nature-linked sovereign bonds provide favorable terms of finance if targets on national nature performance are met.
- New revenue streams could be created for businesses that are able to generate nature-positive impacts. Businesses in sectors such as agriculture and mining could integrate approaches to improve the health of local ecosystems into their practices. There is increased interest in ways to monetize and hence incentivize activities such as these, for example, through biodiversity credits.
- The nature stress test focuses on how nature loss could create physical risks, but nature restoration could also lead to important productivity gains for the economy. For example, increased pollinator populations could improve agricultural yields, cleaner water could reduce treatment costs for water utilities, and stronger natural flood defenses could reduce damage to real estate.

5. Enabling environment

Enabling environment

The right enabling environment can help support action across the commercial financial sector and, in turn, real economy sectors. Exhibit 19 explores an illustrative journey that a commercial financial institution could take on nature as well as the enabling conditions that could support it in doing so. To act on nature, commercial financial institutions need to be able to demonstrate a clear business case. This requires being able to both demonstrate the materiality of nature-related risks to their activities (through exercises like this stress test), as well as a clear understanding of what possible first steps they could take. If they make the decision to act on nature, financial institutions can benefit from the availability of training materials and services to upskill teams across the organization that have not dealt with nature before, such as relationship managers and risk practitioners. Action on nature could also be unlocked by the development of market

infrastructure like that which exists today for climate. For example, the inclusion of nature in green taxonomies could help channel finance to activities with nature-positive impacts.

The nature stress test results demonstrate that nature-related risks would be minimized under an orderly transition scenario in which businesses adapt in line with the transition. Expected profit and credit losses are considerably lower if businesses, alongside decision makers and consumers, act together to reverse nature loss in line with the goals of the GBF. In addition, there are a range of macroeconomic benefits including improved employment, stronger export receipts, and reduced pressure on household debt. This demonstrates how the alignment of the private sector with the nature-positive transition could generate a range of environmental and economic benefits.

Exhibit 19

The enabling environment can support private sector action on nature.

Illustrative journey for private financial institution

- Build internal capabilities on nature. Determine how nature interfaces with different teams within the bank; develop risk taxonomy and transmission mechanisms; assess current data landscape; develop roadmap (eg, using the OECD's recent supervisory framework)¹
- Collaborate with industry working groups on nature, such as UN PRB, F4B Pledge, PBAF, to share experiences, lessons learnt, and best practice²
- Oualitative risk assessment to prioritize sectors and risks
 that are most pertinent for the financing portfolio exposure
- Quantitative stress test to robustly assess materiality of nature-related risks across the portfolio, similar to the stress test presented in this report
- Assess entry points for nature in risk management framework across, eg, due diligence procedures, credit risk assessment, credit origination, and credit pricing

Relevant enabling conditions

- Evidence on materiality, eg, conceptual frameworks, transmission mechanisms, estimated scale of risk
- Guidance on first steps, laying out synergies with climate program roll out, assessment of data landscape and gaps
- Training materials and services to support the upskilling of relationship managers to engage with clients on nature and risk practitioners to assess nature risk
- Inclusion of nature in green taxonomies to support the provision and recognition of finance for activities with positive impacts for nature
- Standardization of nature-related disclosure requirements through the translation of frameworks—such as TNFD³—to clear, verifiable accounting standards

Increasing ambition over time

¹For further information, see, A supervisory framework for assessing nature-related financial risks, OECD 2023. ²UN PRB: UN Principles for Responsible Banking; F4B Pledge: Finance for Biodiversity Pledge; PBAF: Partnership for Biodiversity Accounting Financials. ³TNFD: Taskforce on Nature-Related Financial Disclosures. Source: Central banking and supervision in the biosphere, NGFS, 2022; NatuRisk analysis

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Appendix: NatuRisk toolkit

McKinsey's NatuRisk toolkit is a market-leading solution that allows financial institutions to quantify the exposure of their financial portfolios to nature-related risks at the company, sector, and portfolio level. It examines both physical risks driven by companies' dependencies on nature, and transition risks driven by their impacts on nature, as well as how these may translate into financial risks and opportunities under forward-looking scenarios. The NatuRisk toolkit is aligned with the LEAP (locate, evaluate, assess, and prepare) framework created by the Taskforce on Nature-related Financial Disclosures. Outputs cover a range of physical impact metrics (for example, deforestation, water pollution, air pollution), financial impacts on counterparty profit and losses disaggregated by risk driver, as well as financial impacts for financial institutions due to changes in market and credit risk. The framework follows six steps, as outlined in Exhibit 20.

- 1. **Scenario narratives** define possible future pathways and levels of ambition for the nature transition, which in turn define exposure to nature-related physical and transition risk. This stress test used three scenarios.
- 2. Scenario variables translate scenario narratives into quantitative projections of state of nature variables (for example, future levels of deforestation). These define the health of local ecosystems and are often highly spatially granular. The state of nature variables have important implications for the exposure to both physical and transition risks in local markets.
- 3. **Transmission channels** are used to calculate the scale of cost and sales shocks

for companies producing or selling specific commodities in specific countries. They combine the scenario variables with additional information, such as regulatory action, technological costs, and demand shifts. Exhibit 21 displays the transmission channels modeled within this stress testing exercise, the sectors that they affect, as well as how they impact counterparty profit and losses.

- 4. Value chain mapping estimates the value chain relationships of each individual company to assess their unique individual exposure to cost and sales shocks from the transmission channels described above. Value chain relationships are estimates using best-in-class approaches leveraging international trade data and input-output tables. This is necessary as nature risks are extremely localized and commercially available data on the location of production facilities and supply chain relationships is neither comprehensive nor robust.
- Market competition models how counterparties are likely to respond to these shocks based on competitive dynamics of the market, such as changes in the price of goods, market share adjustments, and choice of production location.
- 6. **Risk outputs** quantify the changes in counterparty profit and losses and the resulting change in expected credit losses or equity valuation for the financial institution financing those counterparties. Exhibit 22 and Exhibit 23 show how the output metrics used in the stress test are calculated.

Exhibit 20

The NatuRisk toolkit follows six methodological steps.

	Links to TNFD LEAP framework ¹				
1. Scenario narratives	2. Scenario variables	3. Transmission channels	4. Value chain mapping	5. Market competition	6. Risk outputs
Define future narratives of the integrated nature and climate transition	Project state of nature variables and assess production patterns consistent with these	Calculate cost and sales shocks by commodity and country due to transition/ physical risk drivers	Calculate individual counterparty exposure to shocks based on value chain	Model how counterparties are likely to respond to shocks based on market dynamics	Ouantified impacts on nature (eg, deforestation footprint) and financial risks (eg, expected credit losses)
¹ LEAP (locate, evaluate, a Source: NatuRisk analysi	ssess, and prepare) framewo	ork created by the Taskforc	e on Nature-related Finar	icial Disclosures (TNFD).	

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Exhibit 21

The stress test examines the impact of 11 transmission channels on counterparty profit and losses.

	State of nature variable	Direct risk for	Indirect risk for	Impact on profit and loss for counterparty	
Transition risks	Water pollution (%, N and P as a share of natural rate of breakdown, and m3 gray water footprint)	Agriculture, extractives, textiles, manufacturing, chemicals	Manufacturers, retailers, processors, industry, tech, services, textiles, etc	Cost shock (\$/t of output) Agriculture: cost of riparian buffer strips Extractives: water treatment and risk of license loss Downstream: water treatment	
	Deforestation (ha)	Agriculture, extractives	Manufacturers, retailers, processors, industry, tech, services, textiles, etc	Cost shock (\$/t of output) Agriculture and forestry: tax Extractives: reforestation cost Demand shock (\$ of revenue): All sectors sourcing agricultura and extractive inputs: reputational and regulatory risks	
	Protected area expansion (ha)	Agriculture, forestry, extractives	Manufacturers, retailers, processors, industry, tech, services, textiles, etc	Cost shock (\$/t of output) Agriculture and forestry: shift to sustainable farming/ management Extractives: restoration cost and risk of license loss	
	index)	Airsectors		All sectors: air pollution tax/ penalty	

Continued on next page

Exhibit 21 continued

	State of nature variable	Direct risk for	Indirect risk for	Impact on profit and loss for counterparty
Transition	Demand, particularly for products that cause deforestation (eg, beef)	Agriculture, food and beverage	N/A	Demand shock (\$ of revenue) All sectors: diet shifts and reduced food waste
	Sustainable yield improvements (ha)	Agriculture	N/A	Cost shock (\$/t of output) Agriculture: costs of innovation/ fertilizer to improve yields per ha
	Water deficit	All sectors	N/A	Cost shock (\$/t of output)
	(m3, local renewable water sources unable to meet water demand)			All sectors: cost of implementing water-saving technologies
	Water quality	All sectors	N/A	Cost shock (\$/t of output)
Physical risks	(µS/cm, electrical conductivity of water supply)			Agriculture: cost of mulching Downstream: wastewater treatment cost
	Soil quality (pH,	Agriculture	Manufacturers, retailers, processors, food services	Cost shock (\$/t of output)
	measured by soil salinity)			Agriculture: higher production costs due to yield reduction
	Pollinator population (% change)	Agriculture	Manufacturers, retailers, processors, food services	Cost shock (\$/t of output) Agriculture: higher production costs due to yield reduction
Input	Supply chain cost	Manufacturers,	N/A	Cost shock (\$/t output)
costs	snocks (ie, the portion of cost shocks passed down from upstream sectors)	retailers, food and bev, tech, services, textiles, etc		Downstream: changes in input prices for downstream firms

Source: NatuRisk analysis

Exhibit 22

Results for real economy sectors show the change in the NPV of future profits relative to a baseline scenario.

Process Illustrative example Baseline — Comparison Start year End year 1. Estimate future profits of businesses In-year profits of borrowers in a baseline scenario in which there are no nature-related risks, and in a comparison scenario in which there are nature-related risks 2. Discount the future flow of profits to NPV profits of borrowers calculate the net present value (NPV) of future profits in the baseline and comparison scenarios 3. Calculate the difference between the NPV of profits in the comparison scenario and the NPV of profits in the NPV profit losses for the real economy, % change relative to baseline baseline scenario scenario, exposure weighted or unweighted NPV profits are X% lower in 4. Results are either presented as a the comparison scenario weighted average of real economy profits based on the exposure of each sector in the national loan book, or as unweighted results for each sector Start year End year Source: NatuRisk analysis

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Exhibit 23

Results for the banking sector show the cumulative change in expected credit losses relative to a baseline scenario.

Process

- 1. Using the estimated future flow of profits under the baseline and comparison scenarios, estimate whether the borrower's credit rating might change in the future
- 2. Estimate the annual expected credit losses (ECL) from loans based on how a change in credit rating would change the probability of default and the loss given default of the borrower
- 3. Calculate the cumulative ECL over time for both the baseline and comparison scenarios
- 4. Calculate the difference in cumulative ECL between the comparison scenarios-this is analogous to loan value; eg, if cumulative ECL change by 1%, loan value changes by 1%
- 5. Results are either presented as a weighted average based on the exposure of each sector in the national loan book, or as unweighted results for each sector



Source: NatuRisk analysis