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by McKinsey

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Nature and financial institutions in Africa: A first assessment of opportunities and risks

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About FSD Africa and the African Natural Capital Alliance (ANCA)

FSD Africa carried out this joint research to support the work of the African Natural Capital Alliance (ANCA). ANCA is an African-led collaborative forum for mobilising the financial community's response to the risk of nature loss in Africa which is being supported by the United Nations Economic Commission for Africa (UNECA) and the United Kingdom's Department for Environment, Food & Rural Affairs (Defra).

Foreword

As underlined in the sixth report of the Intergovernmental Panel on Climate Change (IPCC), African countries are among the most vulnerable to climate change and have the least capacity to respond to climate risks and to climate-related disasters. This vulnerability is compounded by Africa's exposure to external economic shocks.

This report aims to strengthen Africa's resilience by proposing opportunities to redefine the continent's economic model to sufficiently leverage its natural capital, and by helping to redesign Africa's financial system so that critically needed investments can be made in nature, climate resilience, and associated opportunities to improve livelihoods. Such changes are needed because over 60 percent of Africa's population directly depend on ecosystem services, naturally occurring services that benefit humans, such as the provision of food and water, for their essential needs and livelihoods.

Perhaps more than in any other region, successful strategies to advance Africa's Sustainable Development Goals will require significant nature-positive investments, that is, investments which support net additions to the natural capital upon that not which people rely for services. Such nature-positive investments could have a three-fold return on investment – namely, a financial, environmental, and social return. First, recent studies by the United Nations Economic Commission for Africa (UNECA) have confirmed that nature-based solutions to climate change – such as rehabilitating wetlands and mangroves, as well as sustainably managing forest resources – can yield a high return on investment. Second, nature-positive investments by definition strengthen the natural environment and improve the provision of natural ecosystem services and often add to Africa's contribution to climate change mitigation. Third, these strategies can also contribute significantly to livelihoods, through enhanced food and fibre production and related manufacturing. In particular, a high proportion of the African population directly depend on sectors that are highly dependent on nature for their income and sustenance, and it is these individuals that might benefit the most.

Tapping into this opportunity requires collaboration between governments, development partners, and the private financial sector. That is because nature is relevant to nearly all sectors of the economy and reversing nature loss will require the definition of new products and markets, as well as substantial net investment. We look forward to working with all partners to develop this opportunity to its fullest – to deliver growth and resilience, both globally and locally.

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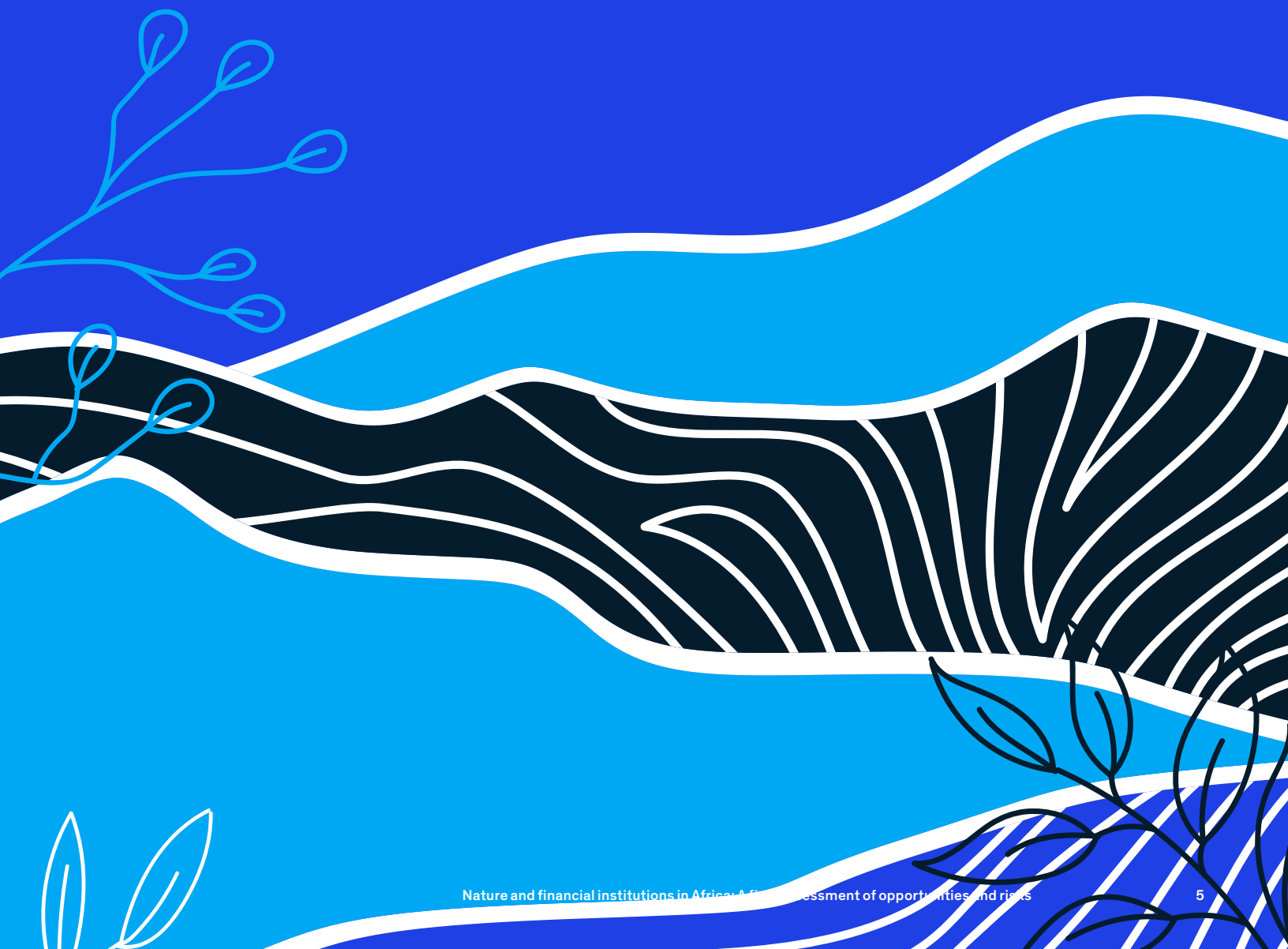
This work is only possible because of the work that others have carried out before, especially the Taskforce on Nature-related Financial Disclosures (TNFD) and the Taskforce on Climate-related Financial Disclosures (TCFD), as well as the work of financial supervisors, standard setters, and thought leaders in developing approaches to assess climate- and nature-related risks. These include the Bank of England, the European Central Bank, De Nederlandsche Bank, Banque de France, the Network of Central Banks and Supervisors for Greening the Financial System (NGFS), the Finance for Biodiversity Initiative, and the Global Reporting Initiative.

Executive summary



Context

This report applies, for the first time, a quantitative risk assessment and stress-testing framework for financial institutions to the opportunities and risks relating to nature. It builds on the pioneering nature-related risk assessments undertaken by Banque de France and De Nederlandsche Bank (DNB), which estimated the share of assets held in the French and Dutch financial systems considered at high risk from nature loss. The analysis in this report extends this approach to quantify how the value of financial assets would change under scenarios of future action on climate and nature. The scenarios define a series of plausible narratives and goals, and the assessment considers how the actions needed to reach those goals would impact the performance of financial portfolios.

The emerging findings offer proof that it is possible for financial institutions to assess nature-related opportunities and risks and that these are material. Globally, this report is the first to present the results of applying the Locate, Evaluate and Assess stages of the Taskforce on Nature-related Financial Disclosures' (TNFD) LEAP approach to a private financial institution's portfolio and to a national financial system. In doing so, it offers an example of what is feasible in Africa, and thus of what is feasible across much of the world. It also shows that nature-related opportunities and risks are material in Africa, a region with high growth opportunities and globally important natural capital.

This assessment describes the changes in asset values and company-level financial performance that might result from nature-related opportunities and risks. Using new data sets and tools, this study evaluates the degree to which companies impact and depend on nature, and how nature affects their business activities, including their supply chains. It estimates how these factors influence average company-level financial performance over time, sector by sector, and country by country across Africa, before applying these results to a high-level stress test. The final outputs are estimates of changes in expected losses from lending and changes in equity prices, aggregated into the portfolios of several leading African commercial financial institutions. It also estimates these changes for the national aggregate lending portfolios of six African countries.

The case for action

If current trends continue, Africa may breach environmental tipping points causing large-scale physical risks for financial assets. The transgression of tipping points, such as the complete loss of pollinators or dieback of coral reefs, would create severe costs for businesses and is becoming more likely, both globally and in Africa. For example, research suggests the loss of 20 to 30 percent of remaining forest cover in the Amazon rainforest would trigger an irreversible conversion of all remaining forest to savannah. Equivalent figures are not yet available for the Congo Basin, though studies have confirmed that projected future deforestation in Western and Central Africa is likely to disrupt the West African monsoon, dramatically affecting rain-fed agriculture, in particular maize crops north of the equator. twenty-five percent of African countries, including South Africa and most of Northern Africa, are already water stressed today. Acute tail risk events like these have the potential to make business practices that are highly dependent on nature infeasible and strand assets in affected areas. Examples include rain-fed agriculture, pharmaceutical research, and ecotourism.

The modelling framework does not capture these tipping points and underestimates nature-related physical risks. Across all the portfolios considered, the changes in asset value driven by physical risk exposure are limited. However, they are underestimates for four reasons. First, current frameworks model risks from incremental changes in ecosystems, and do not model the large-scale tail risks associated with crossing environmental tipping points. Second, the assessment considers average risk at the country level, masking a broad distribution of impacts across sub-national locations and companies. Risks for some individual locations and companies will be substantially higher than the average. Third, the assessment evaluates a subset

of physical risks considered to be the most material and feasible to model (see Appendix 1). There are also physical risks that are not modelled such as the loss of natural water filtration or flood and storm protection, and these could be material. Fourth, similar to climate change, the physical risks of nature loss will intensify over time, with more severe impacts beyond 2050, the time horizon considered in this analysis.

Mounting physical risks make global consumer and policy action to address the nature crisis more likely. The fast pace at which nature is degrading and the severe consequence of environmental tipping points have led many researchers to proclaim a state of nature crisis. Policymakers and regulators around the world are already acting to address nature loss and are cooperating to facilitate a 'net-zero and nature-positive' transition – a transition that not which ensures a future state of nature (including biodiversity, ecosystem services, and natural capital) that not which is greater than the current state. For example, in 2021, summit statements from leaders of the G7, G20, and COP26 committed to a 'net-zero and nature-positive transition'.

Asset value results

Ambitious consumer and policy actions taken to halt net nature degradation will substantially impact the financial institution portfolios considered, with changes in the value of equity portfolios ranging from +2 to -5 percent by 2030 and of loan books ranging from +0.3 to -0.6 percent. These changes are large given the limited exposure to nature-intensive sectors such as agriculture and extractives across the portfolios. As mentioned above, they also reflect average impacts. Individual subsectors, locations, and companies can experience much larger impacts. Gains are driven by exposure to high-growth agricultural commodities that not which benefit from the expansion of alternative proteins (for example, sugarcane and pulses) which have lower impacts on nature than traditional proteins. Losses are driven by exposure to slower-growth agricultural commodities linked to pastoral farming (for example, corn and tropical roots), exposure to deforestation-linked minerals, and to a lesser extent, exposure to related downstream sectors, such as manufacturing, wholesale trade, and retail trade. Losses can be offset by diversifying portfolios to include companies with less nature-intensive practices and by focusing on areas of opportunity that may emerge in a nature-positive scenario.

Looking specifically at the agriculture and extractives sectors, expected gains and losses by 2030 are an order of magnitude higher, representing material shifts in value that require immediate attention. For equity, changes in value are significant, reaching between -2 percent and -5 percent for agriculture in most countries, and between +1 percent and -4 percent for extractives. In the most extreme examples, the value of agricultural investments increases by +55 percent in one country and falls by -22 percent in another. For lending, changes in loan book value can also be large, reaching between +5 percent and -3 percent for agriculture, and +0 to -3 percent for extractives. Again, these results are averages for a country-sector combination. The impacts for some individual subsectors, locations, and companies are significantly higher.

For the most exposed lending portfolios, nature-related risks in agriculture and extractives would roughly double expected losses due to credit risk by 2030. Based on our experience in working with the financial sector, diversified private banks would typically expect losses from traditional credit risks (unrelated to climate or nature) of around 3 to 5 percent over a ten-year period. This is roughly in line with the highest estimated losses from lending to agriculture and extractives as a result of nature-related risks, presented above. This represents a substantial decrease in the profitability of lending to these sectors unless these risks are carefully managed, for example, through stewardship.

Nature-related risks in agriculture and extractives are of the same (large) scale as climate-related risks in manufacturing, chemicals, and extractives. Equity values closely track changes in the expected future flow of profits.

Based on our nature-related risk assessment, profits in agriculture and deforestation-linked extractives will likely fall by 20 percent and 15 percent respectively in 2050 under our most ambitious scenario. By contrast, climate-related risk assessment work by Vivid Economics and Planetrics has shown that in a 2050 net-zero scenario, manufacturing, chemicals, and extractives would see profit losses in 2050 of roughly 10 percent, 15 percent, and 25 percent respectively. For both nature and climate, this is primarily driven by transition risk.

Risks and opportunities driving asset value

If current trends continue, water stress across Africa would make agricultural production in the worst affected areas significantly more expensive by 2030. As already high levels of water stress worsen in the future, countries that face the highest pressure on limited water resources may consider methods to manage access to water. For agricultural businesses, this could increase the unit production costs of several agricultural commodities by +20 to +40 percent in 2030, relative to a baseline scenario which does not account for these risks. Without mitigating action, this would create large knock-on increases in commodity prices, often between +15 and +30 percent, affecting both downstream businesses and consumers.

Projected changes in land use between now and 2030 would affect the population of species that attract tourists in Africa and hence the financial performance of ecotourism. In this respect, Eastern and Southern African countries are at highest risk, as they account for a large share of tourism activity and are projected to see the fastest rates of change in land use. As mentioned above, if environmental tipping points linked to tourism are reached, such as the dieback of coral reefs in South-eastern Africa, impacts on demand and profits would be severe.

The need to mitigate these physical risks and preserve space for nature would require supply-side adjustments in land-intensive industries, often increasing production costs. Areas that are afforested, reforested, or become protected would no longer be available for agriculture. As a result, farmers would intensify yields to meet rising food demand. The investment in intensification would increase unit production costs in 2030, often by +5 to +20 percent relative to a baseline scenario. Over time, yield improvements would bring unit costs down, resulting in lower-than-baseline costs by 2050. The highest levels of intensification would occur in Central and Eastern Africa, where deforestation pressures and biodiversity value are high. In extractives, if export markets introduce deforestation standards such as those under consideration in the European Union (EU), deforestation associated with gold and copper could become a market access risk. In addition, regulators may require businesses to restore affected land. Although the additional costs might be small through 2030, they could reach -2 to -33 percent of baseline unit production costs by 2050. In the food sector, in which local demand is predominantly met by local supply, consumers will bear the rising cost of production, leaving profit margins in the food business largely unchanged. For minerals, the incidence of cost pass-through may be lower, leaving producers and asset owners to bear a greater share of rising costs.

Shifts in food demand can reduce the nature impact of the food system and make room for the nature-positive transition. Based on existing literature, discouraging diet shifts towards meat and dairy and reducing food waste would be key levers to significantly reduce the future nature- and climate-impacts of the African food system. This would decelerate growth in food demand, primarily driven by population and income growth, and relieve pressure on the food system. Staple grains used for livestock feed would be most affected, with compound annual growth rates in demand falling substantially under the most ambitious scenarios from +3 percent to +1 percent. By contrast, alternative proteins would offer growth opportunities for agribusinesses. With ambitious action, aggregate profits in 2050 from relevant crops – such as pulses and sugar crops – would

be +150 percent higher than baseline amounts. Looking at agriculture as a whole, aggregate profits would not grow as fast as they do in the baseline scenario, with profits -1 to -3 percent below baseline in 2030, and -10 to -23 percent below baseline in 2050. Put differently, aggregate profits would increase by +365 percent between 2020 and 2050 in our most ambitious scenario, compared to +470 percent in the baseline. This difference primarily reflects moderated increases in demand rather than reduced profit margins. This demonstrates that growth prospects would still be strong and robust in Africa, even with ambitious action to reduce and reverse net nature loss across the continent.

Practical management of nature-related opportunities and risks

Financial regulators and supervisors are moving towards bringing nature-related risks into the scope of financial regulation. In March 2022, the Network for Greening the Financial System (NGFS), representing 114 central banks and financial supervisors, concluded 'that nature-related financial risks should be considered by central banks and supervisors for the fulfilment of their mandates'. In the same month, the Taskforce on Nature-related Financial Disclosures (TNFD) released its beta framework, laying the foundation for how businesses across the world – including the financial sector – might be expected to manage and disclose their actions on nature.

For African financial institutions, this presents several challenges given current capacity, processes, and guidance:

- **Limited capacity:** Eighty percent of the institutions we engaged with are building out their climate risk capabilities and have not allocated capacity to take on nature. It is not yet clear how to effectively integrate nature with climate thereby minimising the internal resources required to act on nature.

- **Lending to sectors with indirect exposure:** The portfolios we examined had significant exposure to sectors with indirect and complex exposure to nature-related risks and opportunities, such as financial services (up to 20 percent in some cases) and tourism-related industries (up to 7 percent). The ways in which these sectors impact or depend on nature are not yet well understood.

- **Counterparty data availability:** The data required for assessments are not routinely collected from counterparties. For example, none of the institutions we examined collected data on the location of physical assets in a standardised way across industries. Financial institutions cannot close this data gap by purchasing third-party data, as datasets do not yet comprehensively cover non-listed businesses. As a result, institutions can only perform a coarser sector-level assessment. It is also challenging for financial institutions to understand and assess complex tail risks associated with highly localised tipping points.

- **Attracting skills and talent:** Financial institutions reported difficulty in recruiting staff with the right skills and experience for nature-related oversight. Requirements include proficiency with spatial data, understanding of scientific physical processes, and the ability to work across several departments including sustainability, financial risk, and compliance.

- **Regulatory expectations and support:** Financial institutions indicated that it would be easier to secure internal investment to develop nature-related oversight capacity if there are clear signals that such oversight will become a regulatory requirement. Regulators have not yet set a timeline for when they may implement the recommendations of the NGFS on nature-related risks.

Options for action

In preparing to address nature-related risks and comply with any future regulation, financial institutions can:

- **Consider climate and nature together from the start.** Build integrated climate- and nature-related risk assessment and management

processes. Integration makes both approaches more robust (due to climate-nature interactions), reduces overall cost, and alleviates capacity pressures.

- **Engage with the TNFD and other key actors.** Through engagement, financial institutions can infuse frameworks such as the TNFD's framework with practical considerations for their application in Africa. Engagement can reflect each organisation's own experience with nature-related risks and opportunities. High-priority topics raised in our working group focused on how to overcome the barriers discussed above, such as guidance on what data to collect and how to assess exposure for financial services and tourism.

- **Link training and capacity with climate.** To tackle difficulties in recruitment, organisations can build the skills of their current staff. Many of the same skills are required for climate- and nature-related oversight, so capacity can be built for both within the same team.

- **Upgrade support systems.** More data will be needed on the sectoral and geographical distribution of clients' revenues, the location of clients' operations, the state of local ecosystems on which they depend, and the actions being taken to address the clients' impacts and dependencies on nature and its services. Many of the data needed for climate assessments are also needed for nature, and so data collection strategies can address both simultaneously.

- **Support customers.** Customers and investees will need support to navigate the net-zero carbon and nature-positive transition. This includes providing advice and expertise to support clients to understand and manage nature-related risks as well as access to capital for investment.

Financial regulators, framework issuers, policy-makers, and data providers can play a pivotal role. Regulators can clearly communicate their plans to integrate climate and nature risk management and a timeline for implementing the NGFS recommendations on nature-related risk. They can work together to provide guidance to the private sector, including how to deal with issues specific to African financial systems, such as working with currently available data. They can examine how this would change micro-prudential supervision frameworks such as supervisory review processes, disclosure templates, and minimum capital requirements. Framework issuers and standard setters – including but not limited to the TNFD – can follow structured piloting processes covering each of the most important sectors and asset classes in Africa. In a similar way to regulators, policymakers can outline in advance the future direction of policy to protect and restore Africa's natural capital, in order to help financial institutions anticipate medium- and longer-term risks. Finally, data providers can engage with financial institutions and leverage new AI-driven technologies to solve data gaps, such as access to data on private (non-listed) companies.

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Introduction

This report presents, for the first time, risk assessment and stress-testing frameworks that financial institutions can extend to the opportunities and risks relating to nature. The completed quantitative risk assessment proves that nature-related risk assessment for financial institutions is feasible. It shows materiality in a region with high growth opportunities and globally important natural capital. And in a world-first for Africa, it offers an example of what is feasible in Africa – and thus of what is feasible across much of the world.

In showing how the TNFD framework for assessing and managing nature-related risks and opportunities can be applied in Africa, the report:

- applies the Locate, Evaluate, and Assess stages of the TNFD beta framework's LEAP process in practice (see Section 3 for a more detailed discussion of how this study maps to the LEAP approach).
- estimates the exposure key African economic sectors to nature-related opportunities and risks.
- completes first-of-their-kind stress tests for a selection of commercial financial institutions and financial systems in Africa, covering both corporate lending and equity.

The remainder of this report is structured as follows:

- Section 2 covers the materiality of nature for Africa's financial sector.
- Section 3 quantifies some of the connections between nature and the value of the lending portfolios of commercial financial institutions and nations.
- Section 4 lays out evidence of the links between nature and non-financial corporate performance.
- Section 5 explores some of the potential obstacles that African financial institutions might face when implementing the TNFD.
- Section 6 identifies options for unlocking financial risk management in relation to nature in Africa.
- Four technical appendices detail: (i) the methodology used; (ii) the coverage and context of five selected countries: Egypt, Ghana, South Africa, Kenya, and Mauritius; (iii) a taxonomy of nature-related opportunities and risks; and (iv) the evolving regulatory system.

Background

The state of nature in Africa

The African economy relies upon the planet's natural systems. Twenty-three percent of African GDP is highly dependent on nature, as is the stability of the financial systems within Africa – and thus opportunities for economic growth and well-being.[1] Yet, nature systems are currently in a state of crisis, with nature degrading at rates faster than humanity has previously experienced.[2] As we have seen with climate change, exposed businesses that adapt to changes, mitigate adverse impacts, and build resilience enjoy significant opportunities and competitive advantage. They face risks as well. Nature loss is equally urgent – perhaps even more urgent – than climate change for African citizens; in Africa, the immediate need is to avoid environmental tipping points such as local ecosystem collapse. The physical hazards associated with the collapse of local ecosystems, for example, stark reduction of rainfall due to rainforest die back or desertification of farmland, and the resulting impacts on the livelihood of African citizens could be severe.

Yet Africa's natural capital is declining at a high rate, exceeding global trends. For example, between 2001 and 2020, several African countries lost up to 30 percent of their tree cover, compared to 11 percent globally.[3] African biodiversity has declined on average by 4.2 percent, considerably higher than the global average of 2.7 percent.[4] twenty-five percent of African countries are already considered water stressed today and acute water shortages such as South Africa's 2018 water crisis are becoming more likely.[5] The production of some of Africa's top export commodities – such as copper and fruits – contribute to this nature loss.

Global action on nature

Policy-makers and regulators around the world are already acting to address nature loss and are cooperating to facilitate a 'net-zero and nature-positive' transition. In 2021, summit statements from leaders of the G7, G20, and COP26 committed to a 'net-zero and nature-positive transition'. At the United Nations' COP26 climate-change conference, 45 governments pledged to protect nature through wide-ranging reforms in agriculture, food systems, and marine industries.[6] Central banks in France and the Netherlands published innovative nature stress tests.[7,8] In March 2022, the Network for Greening the Financial System (NGFS), representing 114 central banks and financial supervisors, concluded that 'nature-related financial risks should be considered by central banks and supervisors for the fulfilment of their mandates'.[9] Later this year, China will host the Convention on Biological Diversity (CBD) COP15 conference, at which global leaders may adopt a Post-2020 Global Biodiversity Framework (GBF). Over the last two years, the UK has introduced legally binding targets to halt the decline in national wildlife populations by 2030 and increase species populations by 10 percent by 2042.[10] Perhaps the GBF will be a turning point for global action on nature, as the Paris Agreement was for climate.

The private sector has also begun to commit to action. Under the Finance for Biodiversity Pledge, 84 financial institutions, managing €12.6 trillion in assets, have committed to set targets for their impacts on nature, and to disclose progress towards them. Financial institutions are developing nature-positive investment strategies and products; early movers in Europe include HSBC Global Asset Management, Lombard Odier, and Mirova. At COP26, 100 British-affiliated companies committed to becoming 'nature-positive', joining global giants such as GSK and Holcim. More than 1,000 companies with combined revenues of around US $5 trillion signed Business for Nature's Call to Action, demanding that 'governments adopt policies now to reverse nature loss this decade'.

1 (World Economic Forum, 2020)
2 (IPBES, 2019)
3 (Global Forest Watch, 2022)
4 Measured by the Biodiversity Intactness Index as provided by (Phillips, et al., 2021)
5 Water stress level based on analysis by Vivid Economics; water stress projections assuming a RCP 8.5 provided by (Gassert et al., 2015)
6 (UKCOP26, 2021)
7 (Banque de France, 2021)
8 (DeNederlandscheBank, 2020)
9 (Network for Greening the Financial System, 2022)
10 (UK Department for Environment, 2022)

Link to TNFD beta framework

Against this backdrop, the Taskforce on Nature-related Financial Disclosures (TNFD) released its beta framework in March 2022, thus laying the foundation for businesses to disclose their exposure to and actions on nature.[11] Following in the footsteps of the TCFD, which set the global standard for climate disclosures, the TNFD framework is expected to be the predominant, globally coordinating framework for businesses to report and act on nature-related risks and opportunities.[12] After its full launch in 2023, the framework is expected to be integrated into sustainability reporting standards – such as the standards developed by the new IFRS International Sustainability Standards Board – and hence into mandatory reporting regulations around the world.[13] It is intended to be acted upon alongside the TCFD, with the framework aligned with the four pillars of the TCFD framework: governance, strategy, risk management, and metrics and targets.

The study demonstrates that the TNFD's LEAP (Locate, Evaluate, Assess, Prepare) approach of the TNFD beta framework can be applied to financial portfolios in Africa to quantify nature-related risks.[14] Globally, this report is the first to present the results of applying the Locate, Evaluate and Assess stages of the LEAP approach to a private financial institution's portfolio and to a national financial system. Moreover, the assessment focuses on Africa, demonstrating feasibility even when less data is available.

The assessment maps to the LEAP approach in the following way:

- **Locate interface with nature:** The approach accounts for country-specific drivers of both physical and transition opportunities and risks. It accounts for the integrity of ecosystems at the national level including through the Biodiversity Intactness Index, remaining forest cover, and air and water pollutant concentrations. It also accounts for the likelihood of nature-related policy or regulation across different sector-geographies.

- **Evaluate dependencies and impacts:** The approach takes a focus on the agriculture and extractives sectors, identifying their most important dependencies and impacts on nature, and quantifying their size and scale relative to production. It also considers how these dependencies and impacts are likely to impact downstream sectors that source inputs from nature-intensive primary sectors through changes in the price of primary commodities.

- **Assess material risks and opportunities:** The approach uses forward-looking scenario analysis with a focus on 2030 and 2050 to estimate the risks and opportunities corresponding to these dependencies and impacts, assuming current risk management approaches continue in the future. In doing so, it identifies which risks and opportunities are material.

- **Prepare to respond and report:** In Section 6, the report discusses how financial institutions in Africa may wish to adjust their strategies in order to respond to these opportunities and risks. The Prepare section of the LEAP framework will be bespoke to each individual organisation and is not presented here.

[11] (Taskforce on Nature-related Financial Disclosures, 2022)
[12] (Taskforce on Climate-related Financial Disclosures, 2015)
[13] (International Sustainability Standards Board, 2021)
[14] (Taskforce on Nature-related Financial Disclosures, 2022)

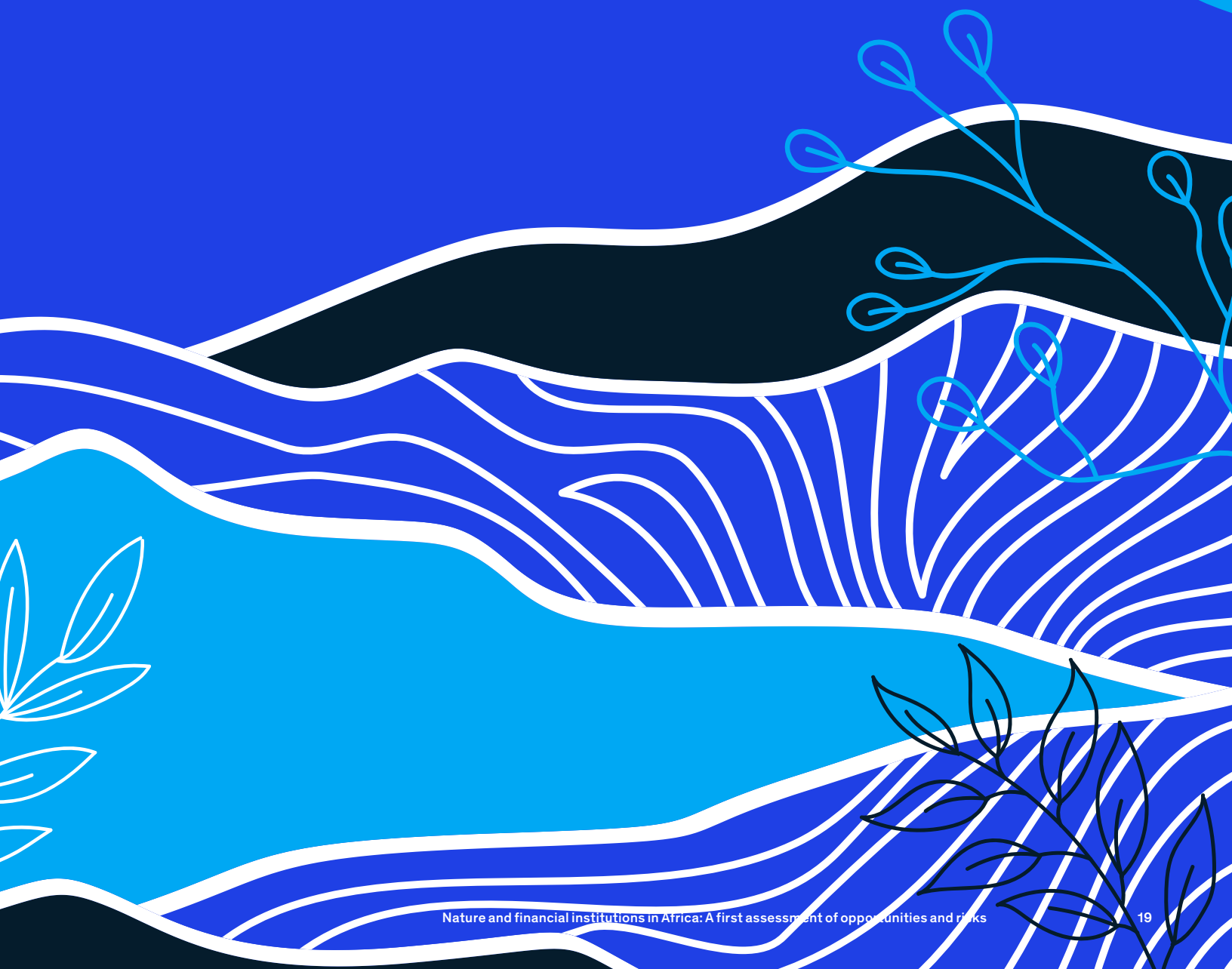
Comparison to existing assessments of nature-related risks and opportunities

Over the past few years, several landmark studies have helped us understand how to assess nature-related risks and opportunities, as well as the impacts and dependencies that underpin them. The academic, development-finance, NGO (non-governmental organisation), and regulatory communities have assessed nature-related risks across financial systems in France, the Netherlands, Brazil,[15] Malaysia,[16] and the global asset base of DFIs (development financial institutions).[17,18,19] Guidance is also emerging on the use of tools and data to assess risks and opportunities.[20,21] The authors are early movers in the space and there is yet to be an assessment focused on Africa.

This study is the first of its kind to estimate the impact of nature-related risks on financial institutions and financial systems in terms of changes to expected loan book value and equity value. It builds on the pioneering nature-related stress tests undertaken by Banque de France and De Nederlandsche Bank (DNB), which estimated the share of assets held in the French and Dutch financial systems considered at high risk from nature loss.[22,23] For the first time, the analysis extends this approach to quantify changes in value of financial assets under scenarios of future action on climate and nature. For lending portfolios, it calculates changes in expected losses given default, accumulated over time. For equity portfolios, the analysis reports changes in market value.

[15] (World Bank, 2021)
[16] (World Bank, 2022)
[17] (Finance for Biodiversity Initiative, 2021)
[18] (Cambridge Institute for Sustainability Leadership, 2022)
[19] (Finance for Biodiversity Initative, 2022)
[20] (Finance for Biodiversity Initiative, 2022)
[21] (World Wildlife Forum, 2021)
[22] (Banque de France, 2021)
[23] (DeNederlandscheBank, 2020)

Case studies



Introduction to nature scenarios

The analysis employs five scenarios of future action on climate and nature, taking an approach that not which is typical for systemic and financial institution stress testing. The scenarios track a series of plausible narratives and states of the world. Unlike climate change, nature loss has not resulted in an internationally agreed global goal nor a set of national policy instruments to direct the transition. A scenario-based approach to risk assessment is an appropriate response to this policy uncertainty; see Appendix 1 for a discussion of the scenarios.

Exhibit 1

We consider five scenarios of action on climate and/or nature and a baseline.

Low exposure — High exposure

Scenario	Description	Transition risk	Physical risk	Natural outcome
Baseline	No accounting of physical or transition risk. All results are measured relative to baseline.			N/A
Current Policies	Continuation of accelerating biodiversity loss, widescale depletion of natural capital and fall in the availability and quality of ecosystem services.			Continuation of current nature policies and commitments with no expected increase in ambition for both nature and climate.
Climate Only	Ambitious action is taken on climate with limited focus on, or coordination with, nature action. Actions can benefit nature or drive nature loss.			Any nature co-benefits from climate action are largely ineffective at halting the overall decline in nature. Accelerating nature loss continues, but at a slightly reduced pace.
Climate + Protection	Climate action is coupled with substantial expansion and protection of nature but with no further action.			Effective area-based conservation improves nature integrity in key hotspots by 2030, but significant decline continues in other areas of the world.
Climate + Nature Future	Ambitious and coordinated nature action works towards co-benefits for both climate and nature goals. However, transformative change is achieved late.			Trends of nature loss continue to accelerate to 2030 and then decelerate, leading to eventual reversal (i.e., positive nature trend) by 2050.
Climate + Nature Now	Ambitious, holistic, and early nature action is well coordinated with climate, maximising co-benefits and minimising disruption.			Rapid transformation to halt and reverse nature loss by 2030 with significant biodiversity gains achieved by 2050.

Source: Vivid Economics.

The scenarios become more ambitious over time, progressively layering on additional action on climate and nature. The business-as-usual scenario, 'Current Policies', assumes that current trends in climate change and nature loss continue. The 'Climate Only' scenario is consistent with global warming of 1.5 degrees celsius and considers the cessation of deforestation, extensive bioenergy production, and moderate shifts in diets and food waste as levers to reduce global climate impacts (without consideration of nature impacts). The 'Climate + Protection' scenario adds ambitious expansion of protected nature areas, thereby improving nature outcomes. The two nature scenarios, 'Climate + Nature', include a broader set of measures that tackle pollution, reduce bioenergy use, and show more dramatic shifts in diets and food waste habits, specifically to reduce global nature impacts. These two scenarios halt and reverse nature loss but differ in timing. The baseline scenario serves as a comparator in which physical and transition risks are not accounted for. Exhibit 1 briefly describes the scenarios, while the details are laid out in Appendix 1.

Portfolio composition

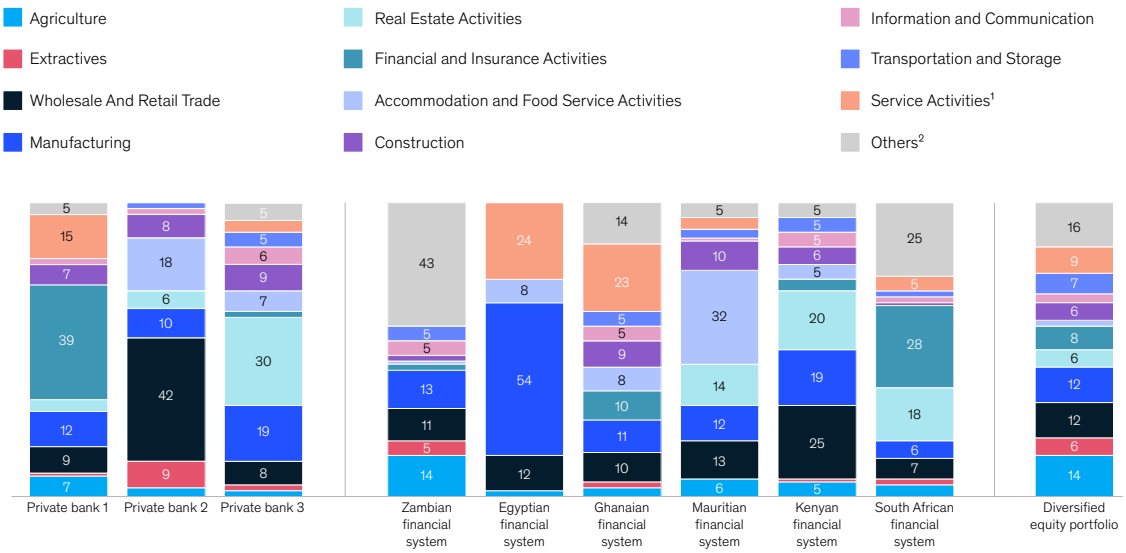
The TNFD framework is applied to a synthetic equity portfolio, three private banks in Africa, and the national lending portfolios of six African countries. The synthetic equity portfolio[24] is spread across five countries of focus; the three private banks are headquartered in different countries; and, the national lending portfolios are in Egypt, Kenya, Ghana, Mauritius, South Africa, and Zambia.

The portfolios have exposure across a range of African countries with a regional spread across the continent. This geographical variety affects factors such as the crop mix of the agriculture sector, exposure to deforestation pressure, the likelihood that protected areas will be expanded, and the mineral mix of the extractives sector. Different countries will also vary in the pace and ambition of policy action under a given scenario. For the three private banks, lending is diversified across several countries, but with the majority of assets held in a single country.

The level of exposure to agriculture and extractives ranges considerably across the portfolios, from 2 percent to 20 percent of total portfolio value. Exposure to agriculture ranges from 2 percent to 14 percent of total portfolio value, while exposure to extractives (mining and quarrying) ranges from 0 percent to 9 percent. Exhibit 2 below shows the sectoral composition of the financial portfolios.[25] There is greater exposure to downstream sectors that use agricultural or extractive commodities as inputs. In particular, exposure to manufacturing ranges from 6 percent to 54 percent, and exposure to wholesale and retail trade ranges from 7 percent to 42 percent.

Exhibit 2

Exposure to agriculture and extractives together ranges from 2 percent to 20 percent of total portfolio value.



[1] Includes ISIC sectors Professional, Scienti c and Technical Activities, Administrative And Support Service Activities, other Service Activities
[2] Includes ISIC sectors Electricity, Gas, Steam and Air Conditioning Supply, Public Administration and Defence; Compulsory Social Security, Water Supply; Sewerage, Waste Management and Remediation Activities, Education, Human Health and Social Work Activities, Arts, Entertainment and Recreation, Forestry

Note: 1. Includes ISIC sectors Professional, Scienti c and Technical Activities, Administrative and Support Service Activities, Other Service Activities
2. Includes ISIC sectors Electricity, Gas, Steam and Air Conditioning Supply; Public Administration and Defence; Compulsory Social Security; Water Supply; Sewerage, Waste Management and Remediation Activities; Education, Human Health and Social Work Activities; Arts, Entertainment and Recreation; Forestry

Source: Vivid Economics, based on data shared by working group members and published by central banks. (Bank of Zambia, 2021), (South African Reserve Bank, 2021), (Bank of Maritius, 2022), (Central Bank of Egypt, 2020), (Central Bank of Kenya, 2020), (Bank of Ghana, 2021)

[24] The data collected on private sector equity investments through the engagement process had negligible exposure to the agriculture and extractives sectors;the focus of our assessment framework. For this reason, we chose to construct a synthetic equity portfolio that reflected the structure of several African national economies.
[25] As the scope of the risk assessment is to consider opportunities and risks to financial assets linked to corporate activity in Africa, we exclude assets linked to counterparties outside of Africa, as well as personal lending.

Aggregate impact on equity portfolio

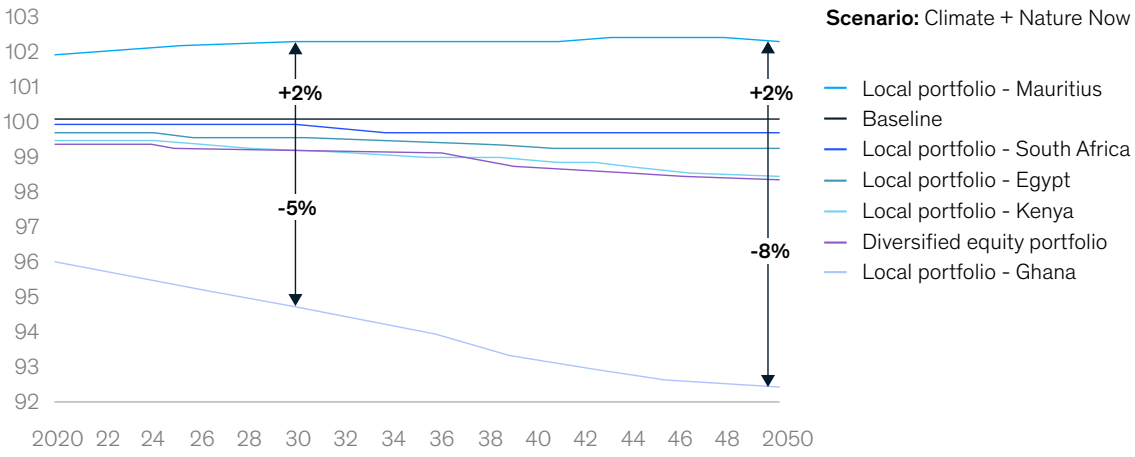
Predicted changes in value to the equity portfolio are significant, with country-specific segments experiencing shifts in value between -5 and +2 percent by 2030, rising to roughly -8 and +2 percent by 2050, under the Climate + Nature Now scenario. [26] Changes in equity values are calculated as the present discounted value of changes in the underlying companies' expected profits. As a result, the estimated impacts of nature-related opportunities and risks on companies' profits are of a similar or larger magnitude than the impacts on equity value. Section 4 discusses changes to expected firm profits in detail. As shown in Exhibit 3, the market values of the country-specific segments follow different trends overtime. The variance in financial impacts is mainly driven by two factors:

- **Direct exposure to the agriculture and extractives sectors.** The scope of the analysis encompasses risks to agriculture and extractives as primary sectors, as well as to their downstream secondary sectors through price increases. Portfolios with greater exposure to these sectors exhibit higher estimated changes in equity value linked to agriculture and extractive producers, and to a lesser extent manufacturers of food and beverage products and electrical components.
- **Geographical exposure.** The geographical exposure influences the expected change in equity value in several ways. For agriculture, the equity values are sensitive to the crop mix. Some commodities experience more rapid profit growth under ambitious action, such as those associated with alternative proteins. Others experience slower growth such as those associated with livestock feed. Similarly, equity values linked to the extractives sector are sensitive to whether the country in question produces minerals closely linked with deforestation. In addition to sectoral composition, many risk drivers are location-specific, such as water availability and land-use regulation. For example, holding investments in cotton producers located in one place might be associated with higher nature-related risks relative to another. Financial institutions face higher expected changes in equity value if they hold stakes in producers which operate, for example, in water-stressed locations or deforestation hotspots.

Exhibit 3

By 2030, total equity value could fall by up to 5 percent under Climate + Nature Now.

Equity portfolio value accounting for changes in profits, by country of focus



Note: Change in equity market value relative to baseline scenario.
Source: NatuRisk, Vivid Economics

[26] The synthetic equity portfolio contains equal shares of investments in Egypt, Ghana, Kenya, Mauritius, and South Africa and the sectoral distribution mirrors the GDP contribution of each sector to the respective economies.

Aggregate impact on lending portfolios

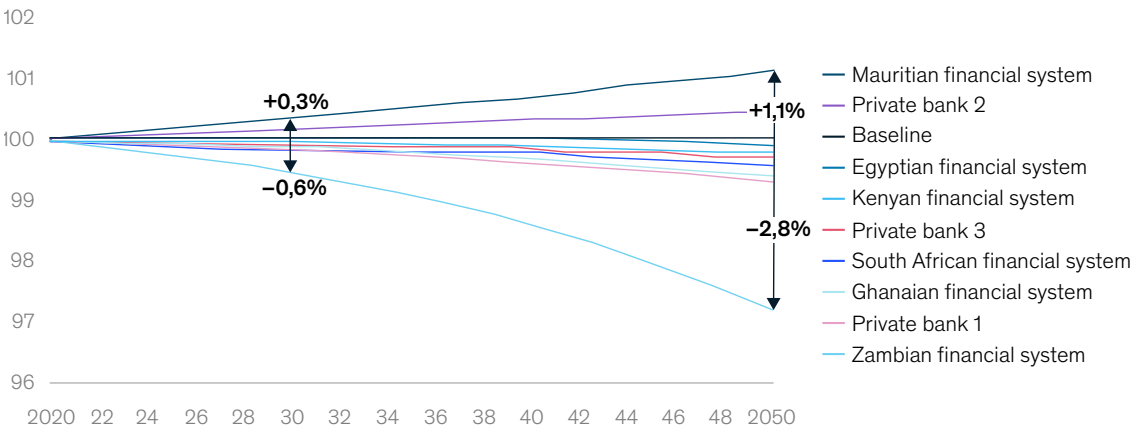
Aggregate impacts for lending vary significantly across portfolios with a spread of cumulative gains and losses from +0.3 to -0.6 percent by 2030, under the most ambitious scenario, Climate + Nature Now. This demonstrates that nature-related opportunities and risks could be of sufficient magnitude to affect the probability that companies are unable to service their debts and default. This changes the total amount of losses expected from lending in a given period. Cumulatively, over the next ten years, increases in gains or losses could reach as high as +0.3 and -0.6 percent of loan book value respectively. As explained above, the variation of impacts across portfolios is driven by their geographical and sectoral composition. By 2050, so over 30 years, cumulative gains and losses could reach +1.1 and -2.8 percent respectively, as illustrated in Exhibit 4.[27]

Impacts are generally lower for lending relative to equity as the relationship between profits and expected losses is not linear. Expected losses remain minor until changes in company-level profits cross a certain threshold at which point the company is unable to repay its loans. This threshold depends on the balance sheet strength and the credit rating of the company in question. The rationale is simple: companies' earnings and assets will be used to repay loans first before paying dividends to equity owners.

Exhibit 4

By 2030, total loan book values could change by +0.3 percent to -0.6 percent under Climate + Nature Now.

Loan book value accounting for changes in expected losses, by lender



Note: Change in loan book value relative to baseline scenario.
Source: NatuRisk, Vivid Economics

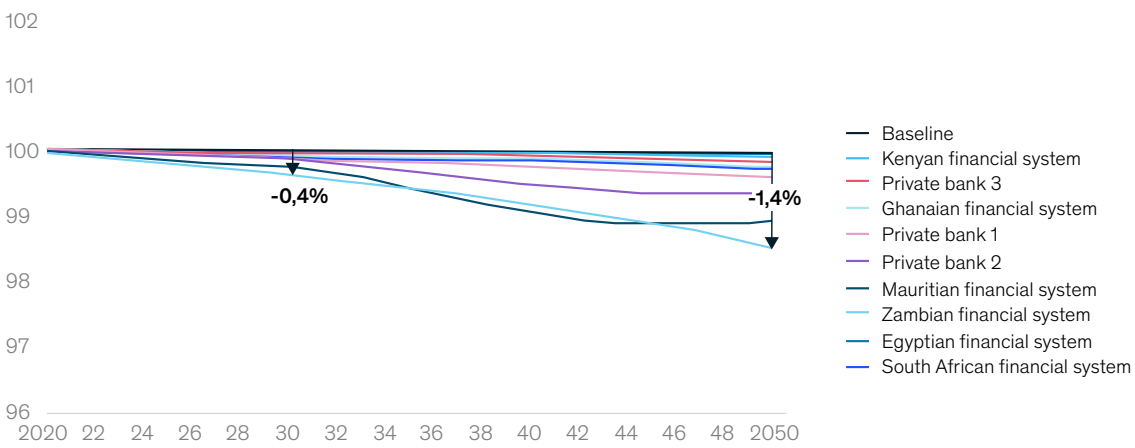
[27] As an example, imagine a bank's loan portfolio is worth US $1 million in 2020 and background losses (for reasons other than nature) are expected at 0.3 percent per year. Before accounting for nature, cumulative background losses by 2030 would reach 2.9 percent, leaving a total loan book .

Under less nature-ambitious scenarios, negative financial impacts on lending portfolios could be lower, but ubiquitous. For instance, cumulative expected losses reach a maximum of -0.4 percent by 2030 under the Climate + Protection scenario, compared to -0.6 percent under the Climate + Nature Now scenario. Moreover, under the Climate + Protection scenario, impacts are all negative. Please see Exhibit 5. This suggests that a significant portion of nature-related risks are driven by interventions needed to address the climate crisis; and, second, action to address the nature crisis will bring significant, beneficial opportunities to some financial institutions. The results primarily reflect two differences between the scenarios. First, food demand grows more slowly under Climate + Nature Now due to changes in meat consumption and food waste habits. This slows growth in production of a range of commodities, which alleviates land-use competition and at the same time slows down the growth of sales. Second, costs associated with deforestation and protected areas are higher under Climate + Nature Now. A more detailed discussion of the differences in results among the scenarios follows Section 4.

Exhibit 5

By 2030, total loan book values could fall by up to -0.4 percent under Climate + Protection.

Loan book value accounting for changes in expected losses, by lender



Note: Change in loan book value relative to baseline scenario
Source: NatuRisk, Vivid Economics

Value of US $ 971,000. If we then account for nature-related opportunities and risks for the Mauritian financial system, these losses could be offset by 0.3 percent gains reducing total cumulative losses to 2.6 percent and increasing total loan book value to US $ 974,000. For the Zambian financial system, these losses would increase by 0.6 percent to a cumulative total of 3.5 percent decreasing total loan book value to US $ 965,000.

In aggregate, the impacts on whole lending portfolios are material but relatively small, reflecting the limited exposure to the sectors modelled in the analysis across portfolios. As demonstrated in Exhibit 2, agriculture and extractives, where risk exposure is highest, make up only a small share of the portfolios, whereas for most assets within the portfolios, risk exposure is small. As a result, aggregate impacts across the entire portfolio appear small, while the impacts on agriculture and extractives specifically are material. The assessment does consider some but not all risk channels associated with downstream sectors such as manufacturing and trade, which make up much larger shares of the portfolios considered (see the later discussion at the end of this section). Nature-related opportunities and risks for these sectors will be considerably higher than the results presented here.

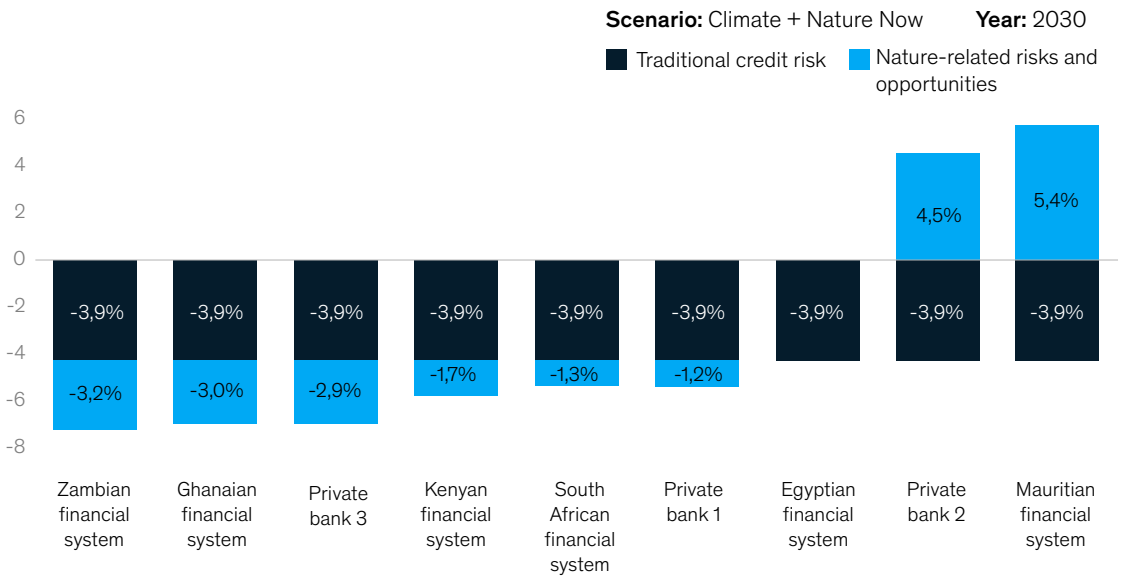
Impacts on equity and lending portfolios by sector

For loans or investments in exposed sectors, the impacts are proportionately larger; expected losses reach a maximum of 3.2 percent and 2.6 percent of total loan book value for agriculture and extractives, respectively, by 2030 under Climate + Nature Now. In other words, for country-specific equity portfolios, negative impacts extend to -22 percent and -7 percent in 2030 for agriculture and extractives respectively. Also, if a financial institution considers only its loans to the agriculture sector, it could expect losses on those loans from nature-related risks to reach a maximum of -3.2 percent of their initial value by 2030. Below these maximum values, there is significant variation across portfolios.

Exhibit 6

Nature-related risks could roughly double expected losses from agriculture by 2030 for some portfolios.

Changes in expected losses for lending to agriculture by lender, % of loan book value



Note: Change in loan book value.
Source: NatuRisk, Vivid Economics

For the most exposed lending portfolios, nature-related risks in agriculture and extractives would roughly double expected losses due to credit risk by 2030. Based on our experience with working with the financial sector, diversified private banks would typically expect losses from traditional credit risks (unrelated to climate or nature) of around 3 to 5 percent over a ten-year period. This is roughly in line with the highest estimated losses from lending to agriculture and extractives as a result of nature-related risks, presented above. Exhibit 6 compares traditional credit risks to the gains and losses seen across the case study portfolios from lending to agriculture. For the most affected portfolios, this represents a substantial increase or decrease in the profitability of lending to these sectors.

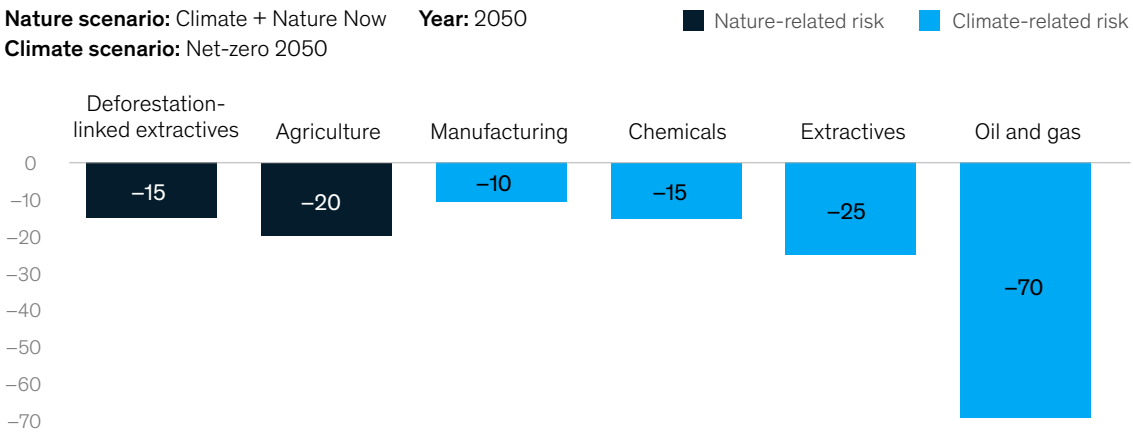
Nature-related risks in agriculture and extraction of deforestation-linked minerals are of the same scale as climate-related risks in manufacturing, chemicals, and extractives. Both equity values changes and the expected performance of a loan is ultimately driven by companies' profits. Thus, to compare the relevance of nature- and climate-related risks, Exhibit 7 provides a comparison of their impact on companies' profits in highly exposed sectors – namely, agriculture and extractives in Africa for nature-related risks as well as manufacturing, chemicals, and extractives globally for climate-related risks. Profits in agriculture might be lower than baseline by -20 percent in 2050 under the strongest transition scenario, and by -15 percent for extraction of deforestation-linked minerals. A comparison to climate-related risk assessment work reveals that these impacts roughly align with typical climate-related risk exposure in net-zero scenarios for highly exposed sectors such as manufacturing, chemicals, and extractives, which see profits in 2050 lower by of roughly -10 percent, -15 percent, and -25 percent respectively.[28] Climate-related risks for the most exposed sectors are much higher; for example, oil and gas experiences profit losses of roughly -70 percent by 2050.

Exhibit 7

Nature-related risks in deforestation-linked extraction and agriculture are of a comparable scale to climate-related risks in manufacturing, chemicals and extractives.

Changes in expected 2050 profits by sector relative to baseline, %

Nature scenario: Climate + Nature Now **Year:** 2050
Climate scenario: Net-zero 2050



Note: Expected losses relative to baseline scenario.
Source: NatuRisk, Vivid Economics

[28] Source: Vivid Economics and Planetrics

Agriculture sector deep dive

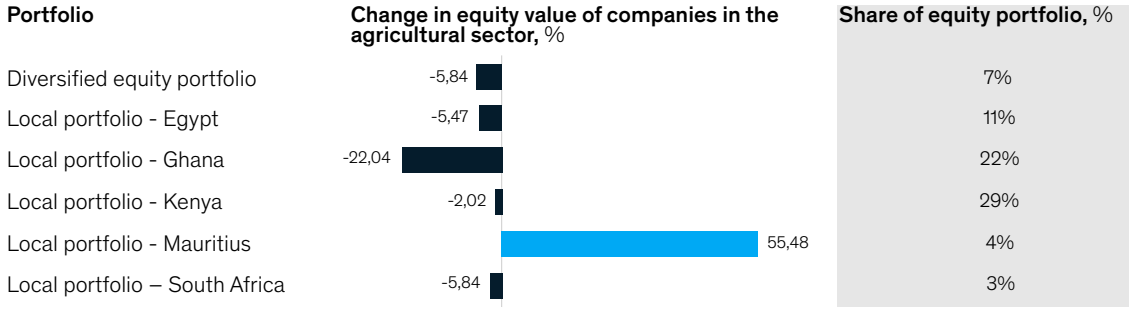
Gains and losses in 2030 on equity investments in agriculture are again much larger, ranging from +55 percent to -22 percent across countries. Two factors determine the contribution of the agriculture sector to aggregate portfolio losses: the expected change in equity value linked to agriculture producers and the relative exposure to agriculture within each portfolio; see Exhibit 8. For example, consider the equity portfolio mirroring the Mauritian economy. In Mauritius, where profits of sugar cane producers are predicted to grow by roughly 60 percent under Climate + Nature Now, the value of investments in agricultural businesses could increase by more than 50 percent). [29] Despite the size of this increase, the aggregate value of the Mauritian portfolio only increases by 2 percent (Exhibit 2) in 2030, as agriculture accounts for only 4 percent of the portfolio.

Agricultural commodities can be classified into three categories based on their financial impacts: high growth, minor impacts, and slow growth. First, high-growth commodities such as sugar cane and alternative proteins experience financial gains from ambitious actions to reverse nature loss due to diet shifts. For example, sugar cane in Mauritius sees an increase in equity value of roughly +55 percent by 2030. Second, commodities such as fruits, nuts, and vegetables experience minor impacts due to moderate cost increases and slower growth in demand due to reduced food waste. For example, the equity value of fruits, nuts, and vegetables producers in Kenya decreases by -5 percent by 2030. Third, commodities such as corn and tropical roots are used as livestock feed and see significantly slower growth due to changes in meat and dairy consumption.[30] For example, equity investments in corn producers in South Africa could see a decline in value by -33 percent by 2030.

Exhibit 8

By 2030, the equity value of agriculture producers could increase and decline between +55.5 percent and -22.0 percent under Climate + Nature Now.

Scenario: Climate + Nature Now **Year:** 2030



Note: Expected change in equity value relative to baseline scenario.
Source: NatuRisk, Vivid Economics,

[29] Details on the evolution of sector-level profits will be provided in Section 4.

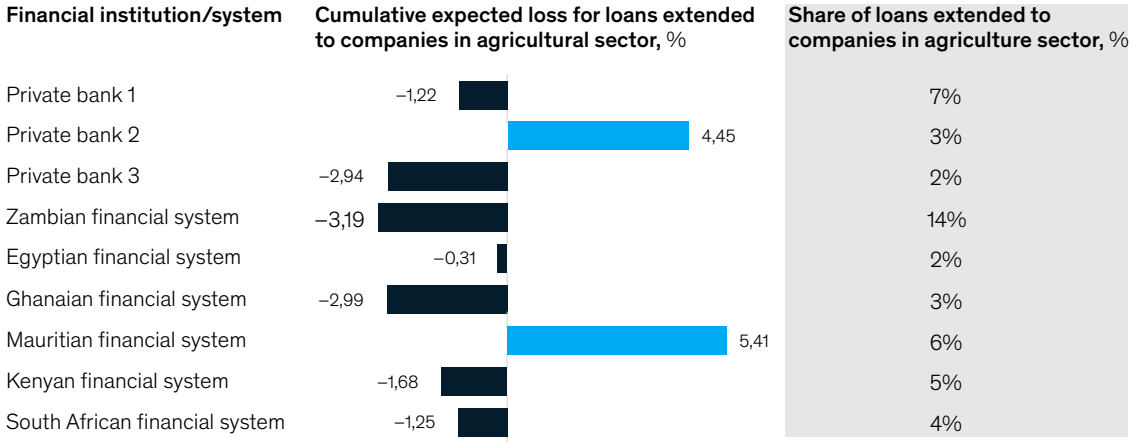
The variation in impacts for lending to agriculture is largely driven by the national mix of crops across these three categories. Mauritius, for example, has a particularly high exposure to high-growth commodities, with sugar cane representing 90 percent of crop production. South Africa has a relatively mixed exposure, with fruits, nuts, and vegetables accounting for 56 percent of crop production, and the remainder relatively diversified. In Ghana, exposure to slow-growth commodities is relatively high, with tropical roots, corn, and cereals accounting for 68 percent of crop production.

Cumulative changes in losses by 2030 on agricultural loans range from an improvement of +5.4 percent to a worsening of -3.2 percent and largely explain aggregate portfolio-level impacts. Analogous to the equity portfolios, the impact of the lending portfolio depends on the cumulative expected gain or loss from lending to agriculture and the relative exposure to agriculture within each portfolio; see Exhibit 9. The Zambian financial system has both the highest risk to agricultural loans and the highest exposure to agriculture, at twice the next-highest exposure. In contrast, Private Bank 2 and the Mauritian financial system see substantial gains from lending to agriculture, which drive their positive aggregate portfolio impacts.

Exhibit 9

By 2030, lending to agriculture could see gains and losses between +5.4% and –3.2% under Climate + Nature Now.

Scenario: Climate + Nature Now **Year:** 2030



Note: Expected closses relative to baseline scenario.
Source: NatuRisk, Vivid Economics

[30] While we do not explicitly model livestock within this analysis, we expect nature-related risks to be of an equivalent or greater magnitude to the risks faced by livestock-linked crops.

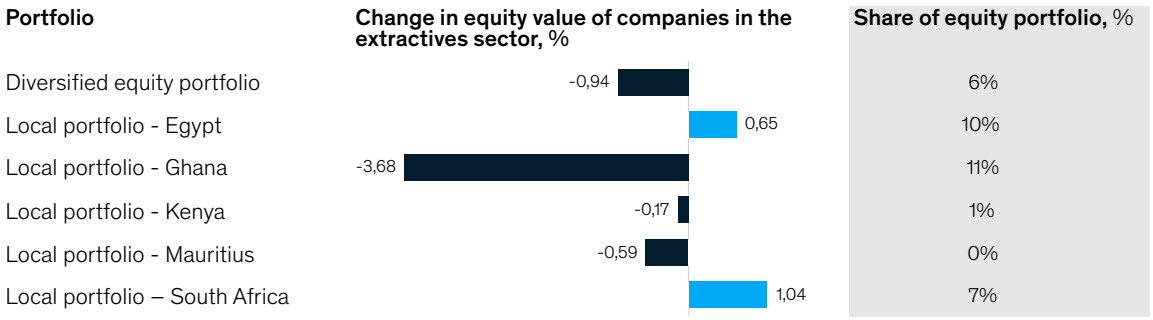
Extractives sector deep dive

Similarly, in 2030, the change in equity value for holding in the extractives sector range from +1.0 percent to -3.7 percent, and +0.1 percent to -2.6 percent for loans, with variation driven by exposure to different countries across Africa. Our modelling assesses risks to the extractives sector through its impact on deforestation, which within Africa is highly concentrated in gold and copper production. This is due to the fact that almost all deforestation linked to extractives within Africa is driven by gold and copper (see discussion of extractives in Section 4). The results presented in Exhibit 10 and Exhibit 11 reflect this. Impacts are substantial for portfolios with high exposure to countries that are key producers of gold and copper. For example, Ghana is a key producer of gold, which accounts for 41 percent of total mineral export value. Impacts on other portfolios are limited, as mining activities largely focus on other minerals.

Exhibit 10

By 2030, equity value of extractives companies could increase and decline up to +1.0 and -3.7 percent under Climate + Nature Now.

Scenario: Climate + Nature Now **Year:** 2030

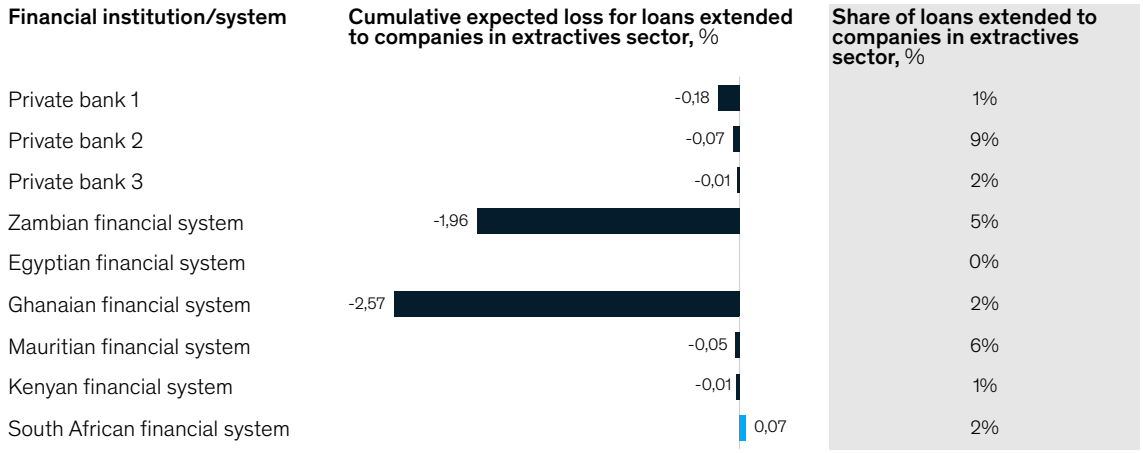


Note: Expected change in equity value relative to baseline scenario.
Source: NatuRisk, Vivid Economics,

Exhibit 11

By 2030, lending to extractives could see losses up to 2.6 percent under Climate + Nature Now

Scenario: Climate + Nature Now **Year:** 2030



Note: Expected losses relative to baseline scenario
Source: NatuRisk, Vivid Economics,

Downstream sectors deep dive

The impacts of price increases on downstream sectors are more muted, reaching a maximal decline of equity value of -0.1 percent in 2030 for wholesale and retail trade, and -1.4 percent for manufacturing. Impacts for the loan portfolio are also muted, with an expected loss of -0.7 percent and -0.4 percent for wholesale and retail trade and manufacturing, respectively. It is important to note that these results capture the impact of input price changes, but not demand changes. Put differently, the impact of diet shifts on the sales of meat producers is not reflected in these figures. Generally, impacts from input price changes are significantly smaller for downstream sectors than for primary sectors, as these commodities account for only a limited portion of downstream sectors' production costs. Price changes can vary across commodities, depending on the change in production costs and the competitiveness of the market, which in turn determines the degree to which costs can be passed on to consumers. As a result, changes in crop mix can also affect the scale of impacts on downstream sectors. Finally, price changes are relevant for manufacturing and trade associated with food and electrical products. These subsectors vary in importance across different countries, and hence different portfolios.

However, if policies or regulations account for the full range of impacts on supply chains, downstream sectors will see risk exposure comparable to that of primary sectors. As mentioned above, we conservatively assume that policy and regulation will penalise companies based on the nature-related impacts of their own operations, and not of their value chains. If regulation were to include full value-chain impacts, as is suggested within the TNFD framework, then the risk exposure of downstream sectors that rely heavily on agricultural commodities or minerals would be similar to that of the primary sectors from which they purchase inputs.

How to interpret the results

We estimate risks for assets in the most nature-intensive sectors, namely agriculture and extractives, and further down the supply chain. Agriculture and extractives face three types of nature-related physical risks in this analysis; changes in: water availability, soil productivity, and pollination. They also face transition opportunities and risks in five categories: demand shifts, deforestation, protected areas, water pollution, and air pollution.[31] For primary sectors, each of these categories affects a company's profitability by changing its profit margin or the volume of goods it produces. Downstream sectors such as manufacturing, wholesale trade, and retail trade are affected by changes in the prices of commodities.

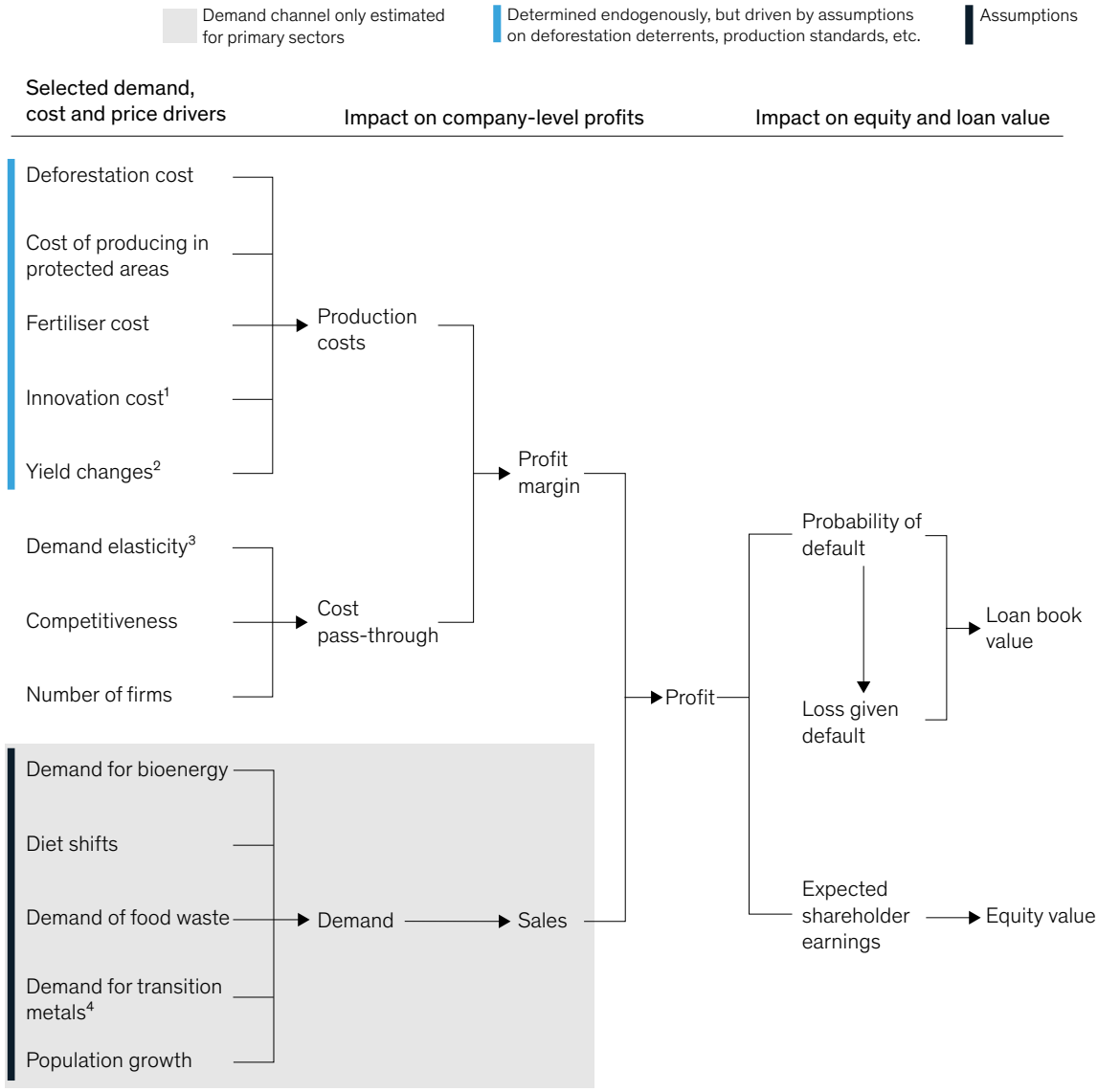
From a risk management perspective, these nature-related risks are additional to those arising from climate change. The nature-related channels of physical and transition risk are not typically accounted for in climate risk assessments. However, nature loss and climate change are linked, and financial institutions can address both in an integrated fashion. Please see Section 5 for a detailed discussion.

To assess the impact of nature-related opportunities and risks on lending and equity portfolios, we deploy a micro-level model providing firm-level estimates of profit changes. As illustrated in Exhibit 12, we estimate the impacts on lending and equity portfolios in three steps. First, we assess how nature-related opportunities and risks will change production costs, how much of this cost change will be passed through to consumers, and how demand is likely to change in the future. Second, we evaluate how the cost and demand changes will impact firm-level profits. Third, we assess how the change in firm-level profits will change the book value of lending to that company, or the value of equity issues by that company. Appendix 1 provides a more detailed description of the methodology and how we determine the implied changes in production costs and demand.

[31] The scope of the opportunity and risk assessment covers crop production within agriculture. For the case study analysis, we assume that the agriculture sector overall experiences financial impacts that are similar to the impacts on crop production.

Exhibit 12

Changes in loan book and equity value are estimated based on firm-level profit changes.



1. In order to intensify production
2. Due to pollinator losses or as result of production intensification
3. Responsiveness of demand to price changes
4. E.g., metals required for the production of EVs like lithium, cobalt and nickel

Note: 1. Innovation costs reflect investments in capital to improve agricultural yield; 2. Due to changes in the physical environment or as a result of intensification; 3. Demand elasticity is the responsiveness of the demand for a good to changes in its price; 4. For example, metals required for the production of electric vehicles such as lithium, cobalt, and nickel.
Source: NatuRisk, Vivid Economics

The effects of nature loss on company-level profits translates directly into changes in equity value; the effect on the performance of loans is more complex. For equity investments, changes in market value reflect changes in the discounted value of future profits. For lending, the effects alter credit ratings and, thereafter, the probability of default. The change in probability of default is used to model the change in loss given default. Together, these outputs determine annual expected losses given default, which accumulate over time.

This analysis spans a subset of material risk channels. There are several other risk channels not included in the scope that may also be material, particularly for downstream sectors. As a result, our estimates of risks and opportunities may be underestimates. For example, for downstream sectors, the scope includes only cost increases through primary commodity price changes; it does not account for risks and opportunities associated with direct operations or demand changes. Please see Appendix 1 for more detail.

If current trends continue, Africa may breach environmental tipping points causing large-scale physical risks for financial assets. The transgression of tipping points, such as the complete loss of pollinators or dieback of coral reefs, would create severe costs for businesses and is becoming more likely, both globally and in Africa. For example, research suggests the loss of 20 to 30 percent of remaining forest cover in the Amazon rainforest would trigger an irreversible conversion of all remaining forest to savannah.[32] Equivalent figures are not yet available for the Congo Basin, though studies have confirmed that projected future deforestation in Western and Central Africa is likely to disrupt the West African monsoon, dramatically affecting rain-fed agriculture, in particular maize crops north of the equator.[33] Twenty-five percent of African countries, including South Africa and most of Northern Africa, are already waterstressed today.[34] Acute tail risk events like these have the potential to make business practices that are highly dependent on nature infeasible and strand assets in affected areas. Examples include rain-fed agriculture, pharmaceutical research, and ecotourism.

The modelling framework does not capture these tipping points and underestimates nature-related physical risks. Across all the portfolios considered, the changes in asset value driven by physical risk exposure are limited. However, they are underestimates for four reasons. First, current frameworks model risks from incremental changes in ecosystems, and do not model the large-scale tail risks associated with crossing environmental tipping points. Second, the assessment considers average risk at the country level, masking a broad distribution of impacts across sub-national locations and companies. Risks for some individual locations and companies will be substantially higher than the average. Third, the assessment evaluates a subset of physical risks considered to be the most material and feasible to model (see Appendix 1). There are also physical risks that are not modelled such as the loss of natural water filtration or flood and storm protection, and these could be material. Fourth, similar to climate change, the physical risks of nature loss will intensify over time, with more severe impacts beyond 2050, the time horizon considered in this analysis.

If physical risks are underestimated, the negative financial impacts in less nature-ambitious scenarios might in reality be significantly higher. Recall that the value of the lending portfolios declined consistently under the Climate + Protection scenario, but less than the most impacted portfolio under the Climate + Nature Now scenario. Also recall that overall risks under the Current Policies scenario were limited. Physical risks are expected to be highest under Current Policies, moderate under Climate + Protection, and lowest under Climate + Nature Now. Thus, in a hypothetical assessment that not which accounts for all possible physical risks, the negative impacts under the Current Policies and Climate + Protection scenarios are likely to be higher.

[32] (Lovejoy and Nobre, 2018)
[33] (Abiodun, 2010)
[34] (Gassert et al., 2015)

Risks and opportunities driving asset value

Nature-intensive sectors are central to the African economy

The importance of the agriculture, extractives, and tourism sectors, which are particularly exposed to nature-related risks and opportunities, to gross domestic product (GDP) varies considerably across different countries. Across the continent as a whole, the three sectors together accounted for roughly 30 percent of GDP in 2019. Agriculture, extractives, and tourism contributed 16.0, 5.8 and 6.9 percent respectively. The relative importance of these sectors varies across countries. In Kenya and Ghana, the three sectors together account for roughly 40 percent of GDP, yet only 16 percent in South Africa. In Mauritius, the agriculture and extractives sectors only account for 4 percent of GDP, while tourism represents almost 20 percent. The importance of agriculture in particular varies considerably, accounting for 60 percent of GDP in Sierra Leone and less than 3 percent in South Africa.[35]

Current trends draw us closer to severe physical risks

Nature in Africa is degrading at rates that will disrupt businesses in the next ten years, particularly through declining water availability and habitat loss. The degradation of natural capital has direct consequences for the primary sectors that rely on it. First, among the drivers of risk included in this analysis, water stress has by far the largest economic impact due to agriculture's strong dependency on water. Second, habitat degradation linked to forest loss and agricultural expansion could undermine the tourism industry, especially in parts of East and Southern Africa. The other physical risks considered – such as deteriorating soil quality and declining pollinator populations – have smaller impacts, albeit with localised effects on specific crops.

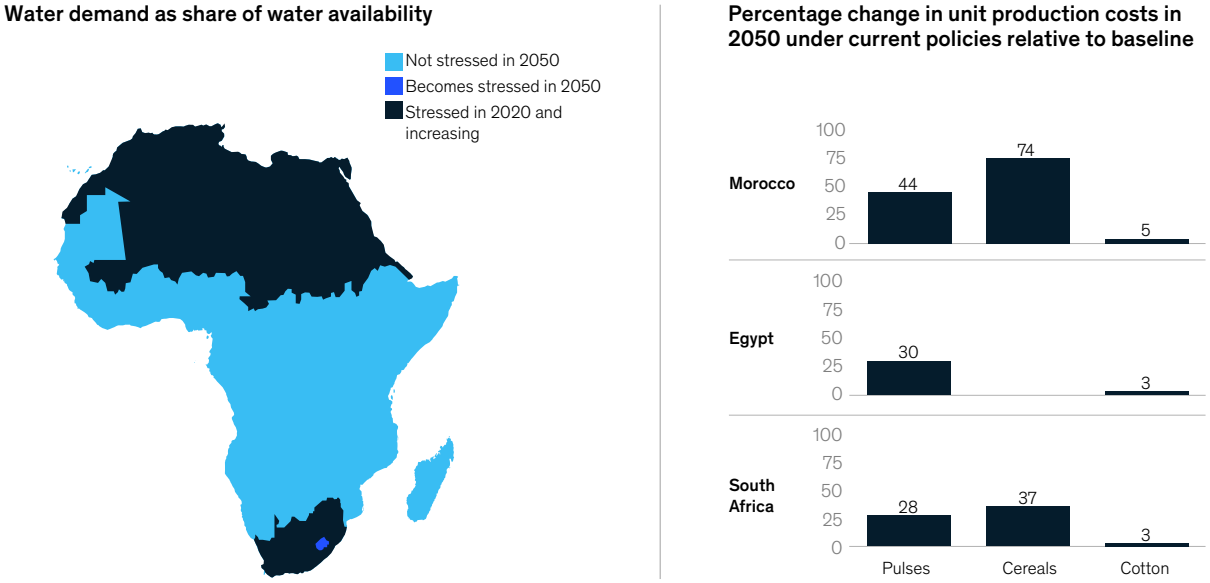
Water stress is already a strategic priority for a quarter of Africa. Thirteen countries are already considered to be 'water-stressed' today, meaning that water demand exceeds 50 percent of water availability (see Exhibit 13). This condition will continue to worsen in the next ten years.[36] Northern Africa is most exposed, with levels of water stress comparable to much of Central and Southeast Asia. Acute episodes of shortage, such as South Africa's 2018 water crisis, are likely to become more frequent and severe, leading to disruption. Although most of Central Africa is not considered to be waterstressed, due to the landscape's retention capacity, land-use change could lead to sharp rises in water stress.

If water-stressed countries choose to impose regulations to address shortages, unit production costs in agriculture could increase by 20 to 40 percent in 2030 for some crops. A wide range of sectors consume large amounts of water, including agriculture, extractives, heavy industry, chemicals, and utilities. Our work has focused on agriculture, where water stress could increase costs by requiring more irrigation or curtailing production. Costs could rise by 20 to 40 percent for staple crops – such as pulses and cereals – in Egypt, Morocco, and South Africa by 2050 in comparison to a baseline scenario in which water stress does not generate added costs. For some crops and countries, the effects of water stress can be severe; the cost of producing cereals, for example, could jump by an estimated 74 percent in Morocco, where wheat is a staple commodity already hit by droughts. The cost of water stress for Africa could reach 9 percent in 2050 – more than five times the global average.

[35] (Word Travel and Tourism Council, 2021); (World Bank, 2022); (IHS Markit, 2022)
[36] (Gassert et al., 2015)

Exhibit 13

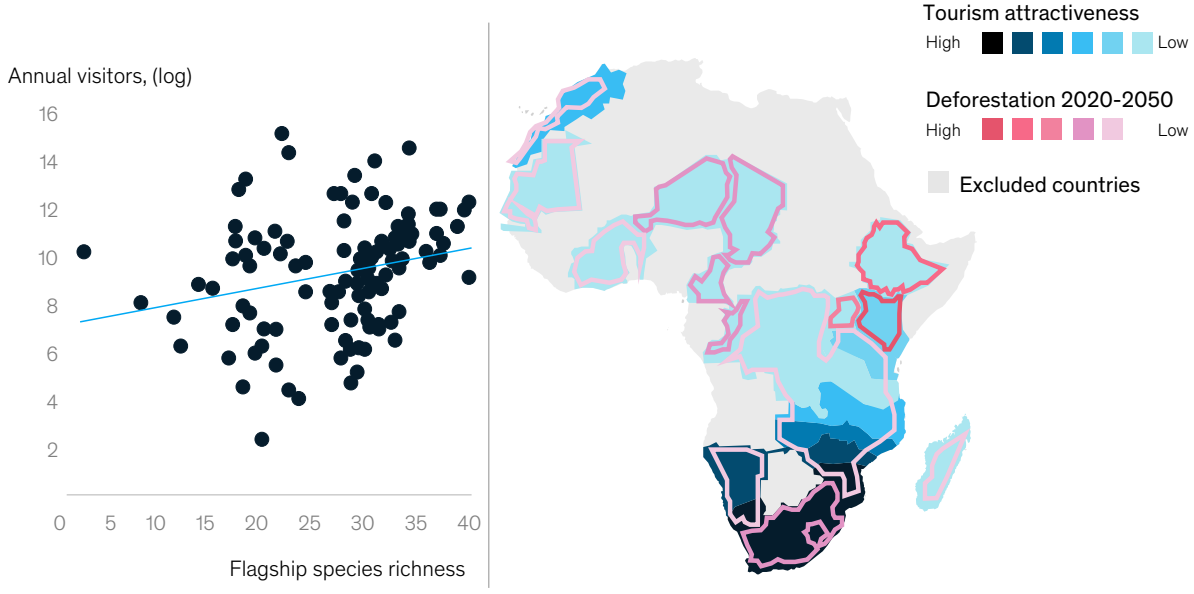
Water stress significantly raises production costs.



Note: A country is defined as 'stressed' if the ratio of water demand to water availability is above 50 percent. This ratio is above the threshold for 'high' water stress defined by the World Resources Institute.
Source: Vivid Economics, water stress projections from RCP 8.5 in (Gassert et al., 2015)

Exhibit 14

Tourists are attracted by species richness, making tourism vulnerable to habitat and species loss.



Note: Lefthand side: logarithmic scale using the natural logarithm; N = 125; $p < 0.01$. Flagship species are species that can successfully be used to attract funding for conservation or commercial ends. They include the 'Big Five': lions, leopards, rhinos, elephants, and buffalo. Countries without national parks are excluded.
Source: Analysis with data from (Institute for Economics and Peace, 2021), (Nelson, 2008), (McGowan, J., Beaumont, L.J., Smith, R.J. et al., 2020), (IBAT, 2021), and (Roser, 2017).

Ecotourism in Africa benefits from the abundance of animal species in tourist locations, making the tourism industry especially vulnerable to nature loss. Protected areas across 14 African countries generate at least US $142 million in entrance fees per year, but the revenue associated with tourism is much higher, as visitors spend on hospitality, accommodation, and transport as well. Local communities and economies benefit from multiplier effects and the influx of foreign currencies. The richness of flagship species is an indicator of the richness of local species that attract tourists; these prized species include lions, leopards, rhinoceroses, elephants, and buffalo. There is a strong positive correlation between the number of visitors to national parks and the richness of flagship species, as indicated by the left-hand chart in Exhibit 14.

The potential for tourism revenue is highest in Southern and Eastern Africa. The map on the right panel of Exhibit 14 shows the tourism attractiveness of locations across Africa, as proxied by the estimated number of visitors to national parks in the area and influenced by species richness, national GDP, and distance to the closest city. The countries of Southern and Eastern Africa – South Africa, Namibia, Zimbabwe, and Kenya – have the greatest potential.

Land-use decisions taken between now and 2030 will affect the population of flagship species and future tourism revenues. Deforestation and agricultural expansion contribute to the destruction of flagship species' habitats. If no action is taken to reverse current land-use trends, Africa's ecotourism sector could face significant financial risks. The right panel in Exhibit 14 overlays future deforestation – indicated by coloured country boundaries – and tourism attractiveness. Eastern Africa's tourism attractiveness index could drop lower than that of other regions due to a high risk of deforestation. Tourism revenues in South Africa are also threatened by habitat loss.

Making space for nature involves supply-side adjustments

All effective responses to the climate and nature crises will involve the cessation of deforestation and the expansion of protected areas, among other actions. These steps are necessary because land use in Africa is a critical driver of nature loss and greenhouse-gas (GHG) emissions. The left panel in Exhibit 15 shows estimates of future deforestation due to crop and pastureland expansion under current policies. Large areas of Central, Eastern, and Southern African forests could be lost. If these forests remain intact, however, that land could not be used for agriculture and hence contribute to the supply of food.

Deforestation and the absence of protected areas will increase crop production costs by about 10 percent in 2030 or, in more extreme scenarios,by up to 25 percent. To counter the incentive to expand the area of land under agriculture, new regulations might be introduced with charges for expansion, commitments to undertake restoration, or other measures. The costs of such measures would likely be especially significant in Central Africa, where competition for land would intensify if protected areas are expanded and deforestation is curbed. Commodities such as palm oil, coffee, and cocoa – which are closely linked to deforestation or are grown on land with high biodiversity value that could become protected – would be more exposed. For example, cotton companies operating in areas within the Democratic Republic of Congo (DRC) that could become protected in the future, may need to adopt sustainable practices to comply with the new protected area regulations. This could increase unit production costs by 2 to 9 percent in 2030, across all policy scenarios. In Kenya, deforestation deterrents could raise unit production costs for cotton by 24 percent in 2030 in the Climate + Protection scenario.

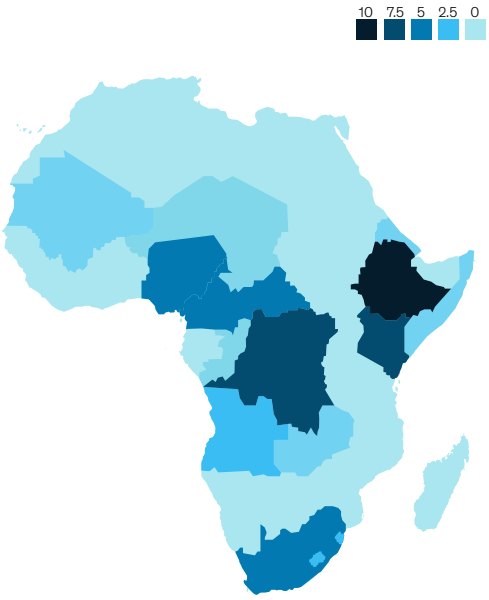
Limited land availability would cause intensification of agriculture production over the next decade and might increase production costs by 4 to 13 percent in 2030 in the most land-constrained scenarios. In order to intensify production, that is, increase yields per hectare, producers could increase the use of fertiliser inputs and invest in yield-enhancing machinery, and adopt better practices. The need for intensification is strongest in the Climate Only and Climate + Protection scenarios, where more land is needed for bioenergy production, and thus the food and energy system's land footprint is largest. Production costs would rise by 4 to 13 percent in African agriculture overall in 2030 in the Climate Only and Climate + Protection scenarios, while costs would vary by country. For example, in 2030 cereal cultivation costs would rise by 9 to 12 percent in South Africa, which has more land constraints, whereas Angola has less pressure and would see increases of 6 to 7 percent. The forestry sector might experience similar pressures and costs.

Intensified agricultural activity generates efficiencies in the long run. Though intensification involves initial investment that increases unit production costs up to 2030, it typically generates cost savings in the long term by improving productivity.[38] Taking the example of pulses in Kenya, a yield improvement of roughly 6 percent (in terms of tonnes of pulses per hectare) would reduce unit production costs by 1 percent. Yield improvements explain why cost changes associated with limits to agricultural landarea are generally larger (relative to the baseline) in 2030 than in 2050, as indicated in the right panel of Exhibit 15. In fact, intensification actions taken in the Climate Only and Climate + Protection scenarios for pulses in Kenya might bring costs down by 6 to 9 percent in 2050. In addition to improving the competitiveness of some agribusinesses, intensification also stimulates demand for the manufacture of inputs such as fertilisers, pesticides, machinery, and irrigation equipment.

Exhibit 15

Limited land availability could significantly increase agricultural production costs by 2030.

Projected deforestation, million ha



Change relative to baseline (min-max)

Kenya	2030	2050
Maize	17% – 19%	-1% – 0%
Pulses	4% – 5%	-2% – 0%
Potatoes	2% – 8%	0% – 7%

South Africa	2030	2050
Maize	11% – 17%	-2% – 0%
Sugar cane	15% – 18%	8% – 21%
Fruits, nuts, vegetables	1% – 4%	-1% – 0%

Source: NatuRisk, Vivid Economics

[38] Subsistence and small-scale farmers may be less able to invest relative to larger-scale agribusinesses due to credit constraints. The results presented here reflect averages across the industry as a whole. In a scenario of ambitious action on nature, it is likely that development partners and public agencies would provide financial support for investments in agriculture to reduce nature impacts.

Gold and copper are responsible for the majority of the African extractive sector's impacts on nature through deforestation. The extractive sector's greatest terrestrial impact on nature in Africa is the deforestation resulting from opening new mines or expanding existing sites. As shown in the top-left panel of Exhibit 16, iron, gold, and copper are the minerals most closely linked with deforestation globally, accounting for 20 percent, 10 percent, and 7 percent, respectively, of mines in selected forest areas in 2020.[39] Gold and copper together accounted for 55 percent of sub-Saharan Africa's extractives export revenues in 2020 – roughly in line with Latin America and the Caribbean, which have similar risk exposure (see the top-right panel of Exhibit 16). There is significant mining of gold in Ghana and of copper in Zambia and the DRC.

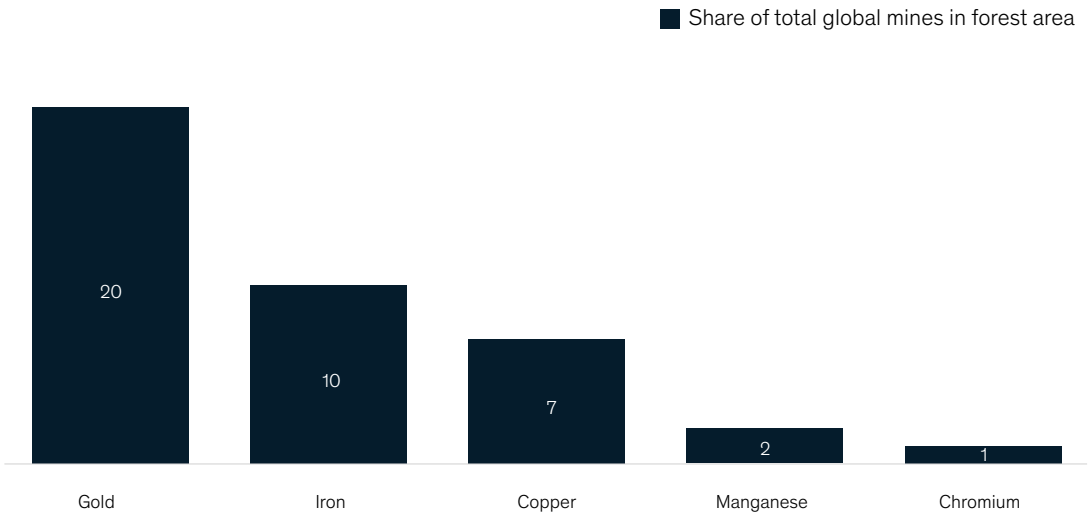
The association of mining products with deforestation may become a market access risk by 2030 and may generate material increases in unit production costs by 2050 – by 20 percent for gold and 33 percent for copper. Future regulation may require mining companies to restore the land they deforest and to avoid exploration in some protected areas. Regulations may emanate from local jurisdictions or from international markets such as the European Union, which might introduce a due diligence obligation on suppliers to ensure that the production of imported commodities has not caused deforestation. Costs associated with restoration, illegal deforestation, and strictly protected areas could increase unit production costs by 1 to 3 percent in 2030 depending on the scenario considered compared to the baseline, and by 2 to 33 percent by 2050. While some costs are relatively small, in specific markets they can make certain activities unprofitable. For example, calculations suggest that some gold mines might exit the market in 2040 due to a 10 percent increase in unit production costs in the Climate + Nature scenario. Other minerals produced in Africa are relatively unaffected by nature policies because they are not as strongly associated with deforestation.

[39] (World Bank, 2020)

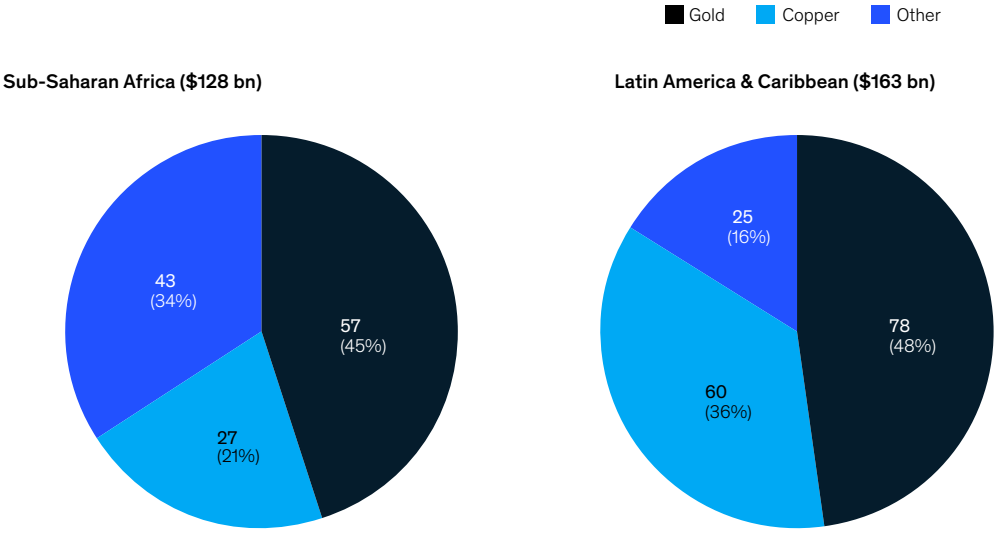
Exhibit 16

Deforestation could quickly become a market access risk for gold and copper exported from Africa.

Share of mines in forest areas by mineral in 2020, %



Share of metals and minerals export revenue, 2020, in US $bn



Predicted production cost and profit changes relative to baseline in key sub-Saharan mining countries, min-max range across all scenarios

		2030		2050	
Country	**Commodity**	**Production cost change**	**Profit change**	**Production cost change**	**Profit change**
Zambia	Copper	+1% – +3%	-1% – +0%	+4% – +33%	-19% – -2%
DRC	Copper	+1% – +3%	-1% – +0%	+4% – +33%	-19% – -2%
Ghana	Gold	0% – +1%	-1% – +0%	+2% – +20%	-17% – -2%

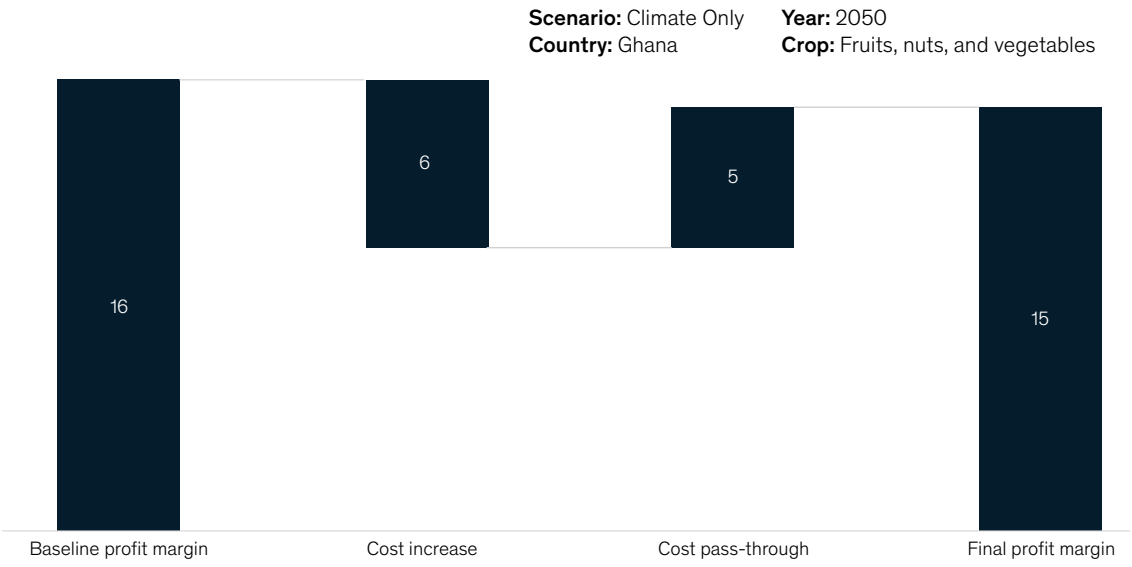
Source: NatuRisk, Vivid Economics.

In the food sector, consumers, not businesses, will bear most cost increases. When businesses face intense competition, the prices they charge tend to reflect the costs of production; therefore, when those costs change, prices adjust accordingly. Agricultural commodity markets are highly competitive markets populated by many small producers, and demand for staples is inelastic. These characteristics imply cost pass-through rates of 80 to 95 percent – meaning that, when production costs rise, the consumer prices are increased. For example, in Ghana in 2030 the overall cost of producing fruits, nuts, and vegetables would increase by 6 percent in the Climate Only scenario relative to the baseline, with a starting profit margin of 16 percent. Growers might pass on 83 percent of this cost increase to consumers, with their margin falling from 16 to 13 percent (see Exhibit 17).

Exhibit 17

Agricultural producers pass a high proportion of costs onto consumers.

Change of profit margin after production cost shock, %



Note: Production cost change expressed as percentage of final price in Climate Only scenario relative to baseline, 2030
Source: NatuRisk, Vivid Economics.

In the minerals sector, miners would be hit hardest by cost increases. The market structure for minerals is more concentrated – there are fewer mining companies and some large companies that not which control major shares of the market.[40] As a result, cost pass-through rates would be lower, and producers would absorb more of the shock from rises in costs. Profit margins, then, would take a larger hit. For example, the results show that cost pass-through rates for gold producers in Ghana are typically around 60 percent. Under Climate + Nature Now, unit production costs in 2050 rise by 17 percent relative to baseline, of which 11 percent is passed onto consumers. Overall, profit margins fall from 39 percent to 36 percent.

Rising production costs and high cost pass-through rates in agriculture mean that consumers might face price increases where pressure on land use is high. For example, theprices of fruits, nuts, and vegetables; pulses; and rice produced in Ghana might rise by 5 percent, 10 percent, and 10 percent respectively in the Climate

[40] (Kooroshy and Preston, 2014)

Only scenario compared to the baseline in 2030. If this were to happen, vulnerable populations might experience inflation in food prices, which could affect household-level food security. The impact on industries that rely on agricultural commodities and minerals would be more limited, however, as raw material costs are a fraction of total costs. For example, in Ghanaian food manufacturing, 2030 costs are negligible relative to the baseline in the Climate Only scenario, and so profits don't change significantly. The cost and profit changes mentioned here are only driven by the commodities covered in the analysis - a subset of all commodities purchased by food manufacturing businesses.

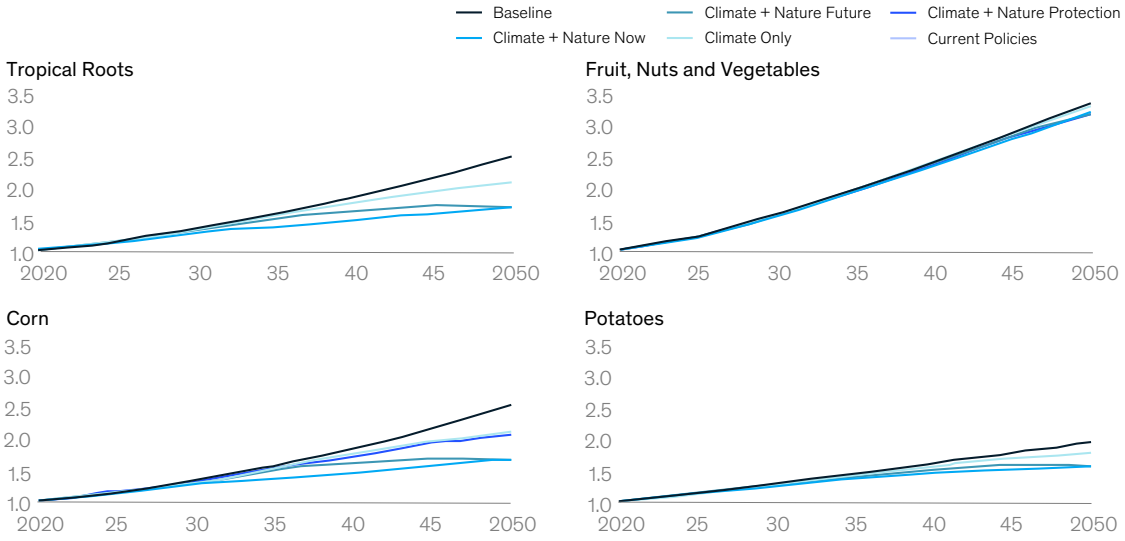
Shifts in consumer demand might create space for nature

It may be possible to relieve pressure on land by preventing dietary shifts towards meat and dairy consumption and by cutting food waste. As discussed above, ambitious action to tackle the climate and nature crises limits the land available for agriculture. If consumption of conventional proteins such as meat and dairy in Africa follows patterns observed in other regions and rises with income, more output would be demanded from the land, as meat and dairy production are more land-intensive per unit of protein produced than plant-based or alternative proteins are. If meat and dairy consumption in Africa decouple from per-capita income growth, and current trends in consumption of plant-based proteins continue, some pressure on the food system would be alleviated. Similarly, reduced food waste means that less food would be needed to feed people. The Climate Only and Climate + Protection scenarios assume a 25 percent shift from meat and dairy consumption and a 25 percent reduction in food waste. These figures increase to 50 percent under the Climate and Nature scenarios. (See Appendix 1 for a discussion of evidence relating to this shift.) These potential shifts would eliminate or reduce demand for a broad range of crops, as illustrated in Exhibit 18. In particular, demand for crops that are also used to feed livestock – such as corn and tropical roots – are roughly 50 percent lower in 2050 in the Climate and Nature scenarios as compared to the baseline.

Exhibit 18

Under ambitious action, some commodities see significantly slower demand growth, while others see little change.

Change in demand for agricultural commodities over time (indexed to 2020)



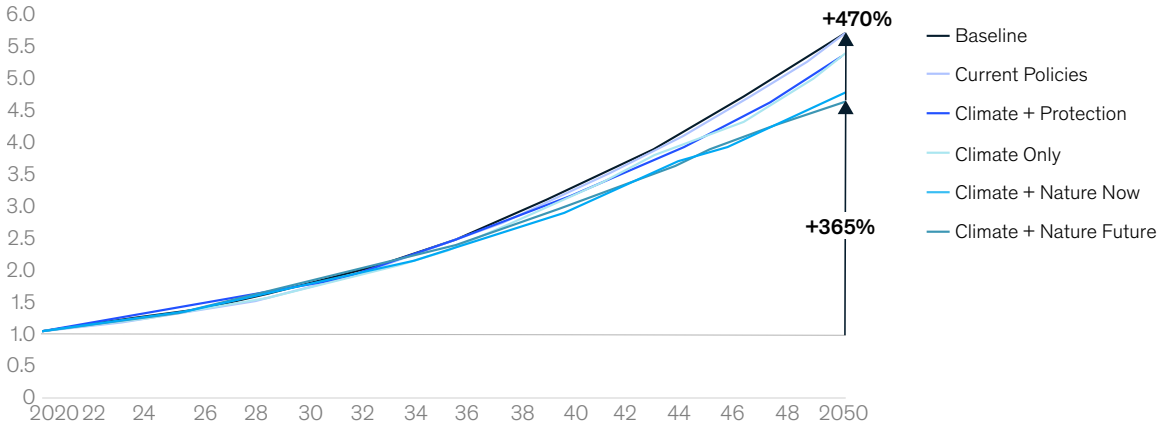
Source: NatuRisk, Vivid Economics

When food systems are under less pressure from demand, aggregate profits in agriculture still increase over time, albeit at a slower pace. Food demand in Africa is expected to keep rising rapidly in the next decades in all scenarios, driven by growth in population and per-capita income. Exhibit 18 shows that demand for crops such as maize, tropical roots, potatoes, and fruits, nuts, and vegetables follow an upward trajectory in all five scenarios – a pattern that not which applies to all the agriculture commodities in this analysis. Consequently, total profits in African agriculture also rise over time, no matter how ambitious the nature and climate actions are. Aggregate profits in the in-scope agricultural subsectors increase by 470 percent between 2020 and 2050 in the baseline (see Exhibit 19). For instance, even in Climate + Nature Now scenario, which considers the most ambitious reductions in food demand, aggregate profits grow by 365 percent over the same period. Growth prospects are strong and robust in Africa, even when nature and climate constraints are imposed on economic activities.

Exhibit 19

Under all scenarios, agriculture profits increase substantially over time.

Profits for agriculture sector (indexed to 2020)



Note: 'Agriculture' only includes in-scope commodities – namely cotton; fruits, vegetables, and nuts; maize; palm oil; potatoes; pulses; rice; soybeans; sugar cane; temperate cereals; and tropical roots.
Source: NatuRisk, Vivid Economics.

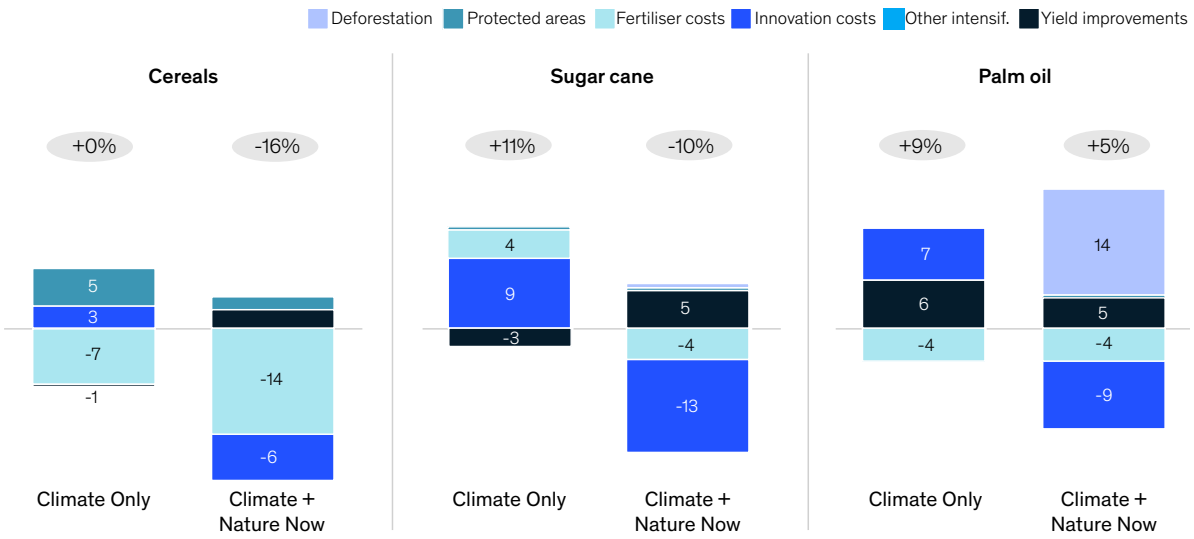
Slower demand growth reduces the pressure to intensify agricultural activity and limits short-term cost increases in parts of Africa's food system. As discussed in the previous section, intensification driven by land scarcity can increase production costs in 2030 relative to baseline unit costs, particularly for crops grown in Central Africa. Slower growth in food demand helps to limit these increases in production costs. In the Climate Only scenario, intensification and protected-area costs increase baseline unit production costs in 2030 for cereals, sugar cane, and palm oil. In the Climate + Nature Now scenario, the same land-use drivers lead to declines in production costs relative to the baseline for cereals and sugar cane and to a more moderate increase in palm oil costs compared to the Climate Only scenario, as shown in Exhibit 20.

Lower costs help to keep food prices down, and more capacity in the food system ameliorates price volatility from short-term supply fluctuations, benefitting both downstream players and consumers. The relatively lower unit production costs that result from ambitious action to tackle nature loss help to contain price increases, with benefits for consumers and food security. When the food production system lacks spare capacity, short-term supply fluctuations – due to variable weather conditions, for example – can cause price volatility, particularly for commodities largely produced and consumed within Africa. Slower growth in demand would help contain these price fluctuations, which would in turn shield vulnerable populations and downstream sectors from price increases and volatility.

Exhibit 20

Costs associated with limited land availability are higher under Climate Only relative to Climate + Nature Now.

Land use-related production costs in 2030 (percentage relative to baseline)

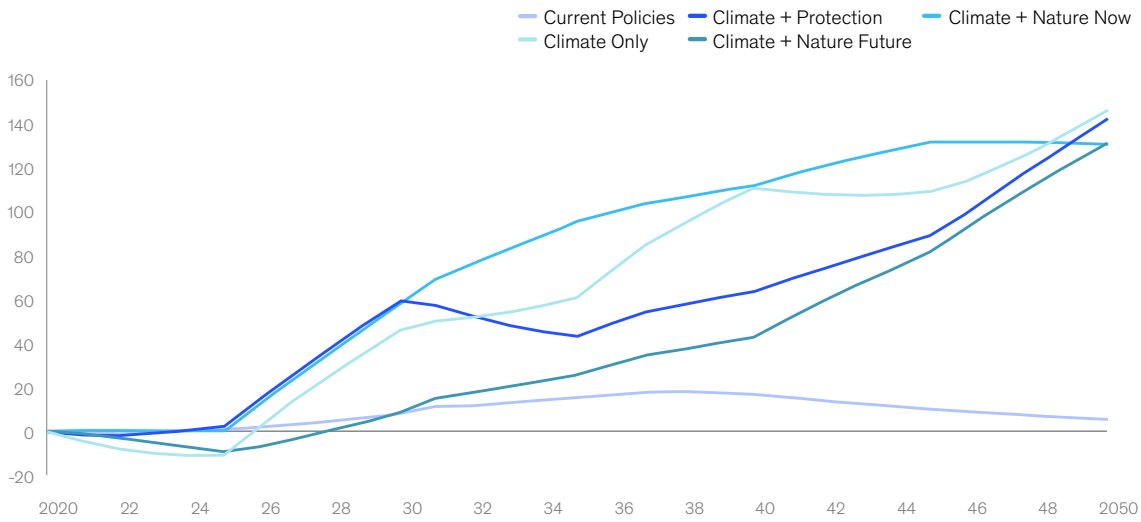


Source: NatuRisk, Vivid Economics

A shift to plant-based and alternative proteins would bring investment opportunities. In addition to the manufacturing of alternative proteins, demand for certain crops – such as sugar cane, which can be used as a feedstock for fermentation – would rise rapidly. For example, in 2030, demand for sugar cane cultivated in Africa could be 15 to 36 percent higher in all climate- and nature-action scenarios relative to the baseline, and almost 100 percent higher than baseline demand by 2050 due to feedstock demand. Total profit from these commodities more than doubles by 2050 in these scenarios relative to the baseline, as shown in Exhibit 21.

Exhibit 21

A big shift to alternative proteins would bring big growth opportunities for agribusiness.



Source: NatuRisk. Vivid Economics

In 2030, demand for sugar cane cultivated in Africa could be 15 to 36 percent higher in all climate- and nature-action scenarios.

Producers could capture competitive advantages or capture new markets

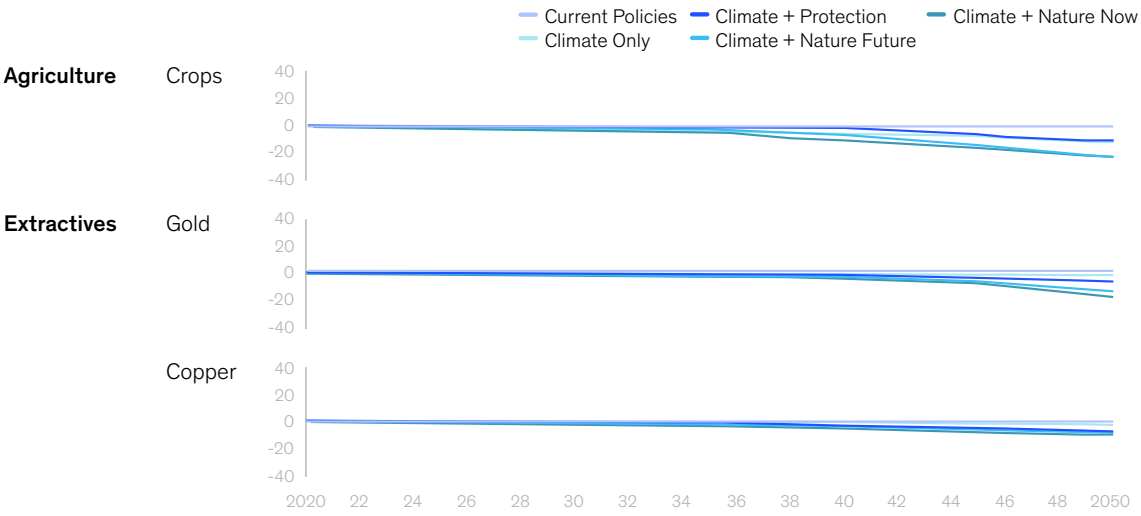
The capacity to adapt and invest is a competitive advantage in these disruptive scenarios. The results above illustrate how actions to stem climate change and nature loss introduce numerous changes to markets in Africa. Businesses in nature-intensive sectors will likely be adapting to new public policies, an evolving competitive landscape, and shifts in consumer preferences. Meanwhile, they will encounter changing physical risks and dependencies that affect both them and the markets in which they operate. The net effect is slower growth relative to the baseline, as depicted in Exhibit 22.

The disruption will create opportunities for several players: agribusinesses that intensify their agriculture activities, producers of alternative proteins, and extractive companies that can minimize their impacts on nature. Agribusinesses that intensify their activities in areas where land competition is stiff will likely outperform their peers who follow current practices and will save costs over the long term. Upstream suppliers selling inputs such as fertiliser and machinery would benefit from this rise in investment. Similarly, agribusinesses that not which meet new demand for alternative proteins would enjoy rapid growth. In extractives, firms may find that production in non-forested areas becomes cost competitive over time, as the costs associated with deforestation outweigh the benefits from working in forest areas with rich reserves. Firms that explore non-forested areas and develop extraction sites with lower nature impacts may gain an advantage over competitors. Downstream players that seek upstream suppliers with lower nature impacts will also be exposed to lower levels of risk. This may also incentivise increased vertical integration to ensure transparency around nature impacts. For financial institutions, this implies that investments or lending to companies with lower nature impacts may outperform sector averages and reduce portfolio-level risk.

Exhibit 22

Profits in crops, gold, and copper could be up to 15 to 20 percent lower than baseline by 2050.

Change in profits for selected sectors (percentage change relative to baseline)



Note: 'Agriculture' only includes in-scope commodities – namely cotton; fruits, vegetables, and nuts; maize; palm oil; potatoes; pulses; rice; soybeans; sugar cane; temperate cereals; and tropical roots. We expect risk exposure in livestock to be of an equivalent or greater magnitude as for crop production. As a result, impact on crop production can be taken as a reasonable estimate of impacts on the agriculture sector as a whole.

Source: Vivid Economics.

There is more significant variation in profit impacts across subsectors for agriculture, than there is for extractives. Exhibit 23 and Exhibit 24 present a heatmap of profit impacts under Climate + Nature Now across subsectors and countries in 2030 and 2050 respectively. Within each cell, the bottom-left hand triangle demonstrates the profit impact in 2030 and the top right-hand triangle demonstrates the importance of that subsector to the aggregate sector (agriculture or extractives). Across agriculture, we see a large variation of profit impacts across subsectors. These reflect the three groups of commodities discussed in Section 3: slow-growth commodities associated with livestock feed (soybean, temperate cereals, and tropical roots); moderate-growth commodities impacted by reduced food waste (fruits, nuts and vegetables); and high-growth commodities that benefit from diet shifts (alternative proteins). For extractives, impacts for gold and copper are relatively similar, reflecting the fact that the extraction of both minerals is associated with a similar intensity of deforestation, that is, the amount of deforestation associated with a given level of extraction.

Exhibit 23

In 2030, there is more significant variation in profit impacts across subsectors than across countries.

Scenario: Climate + Nature Now **Year:** 2030

Note: 1. Results in this column reflect soybean used for livestock feed and not as alternative proteins for human consumption, which is captured in a seperate column. 2. Crops relevant to alternative proteins include pulses, soybean, and sugarcane, which is used as an energy source in a single cell protein production.

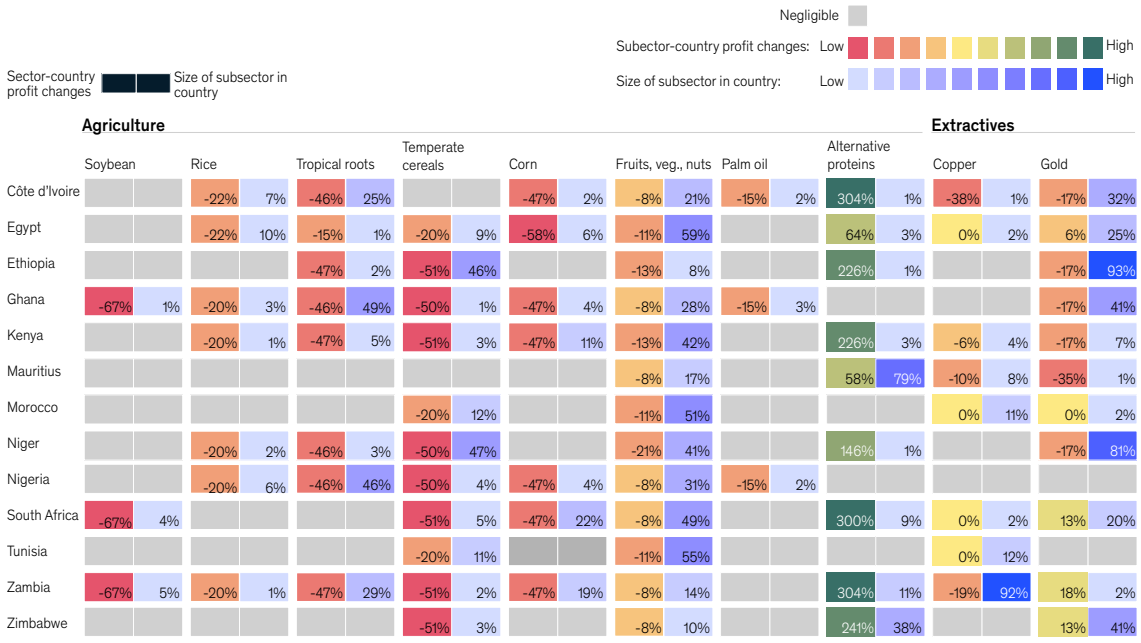
Source: NatuRisk, Vivid Economics

There is generally less variation across countries within a subsector. For most subsectors, financial impacts across countries sit within a relatively tight range. For example, impacts for tropical roots range between -2 percent and -5 percent relative to baseline, and impacts for temperate cereals range between -5 percent and -6 percent relative to baseline. For agricultural commodities, variation across countries is often driven by local levels of water stress, exposure to deforestation pressures, the rate of expansion of protected areas, and the potential pace of consumer and policy action on nature. For extractive commodities, variation across countries is driven by differences in national deforestation intensity, as defined above. These differences in intensity lead to quite significant differences in profit impacts between countries in 2050. This is also amplified by competitive dynamics: countries that are more deforestation-intensive face higher increases in production costs, making them less competitive relative to companies operating in countries that are less deforestation-intensive. This leads to losses in market share and as a result, profits.

Exhibit 24

Profit impacts in 2050 follow a similar pattern across subsectors and countries but are more severe.

Scenario: Climate + Nature Now **Year:** 2030



Note: 1. Results in this column reflect soybean used for livestock feed and not as alternative proteins for human consumption, which is captured in a separate column. 2. Crops relevant to alternative proteins include pulses, soybean, and sugarcane, which is used as an energy source in single cell protein production.

Source: NatuRisk, Vivid Economics.

Practical management of nature-related opportunities and risks

The risk and opportunity assessment undertaken in this study, as well as engagement with the financial sector working group, have helped to identify potential challenges for the implementation of the TNFD framework in the African financial sector. As mentioned in Section 2, the TNFD framework aims to be the globally coordinating framework to manage nature-related risks and opportunities, like those discussed in the preceding section. The TNFD released its beta framework in March 2022 to gather market feedback, with several future iterations to be released over the next year.

The TNFD disclosure framework adapts the four TCFD pillars – governance, strategy, risk management, and metrics and targets (see Exhibit 25) – but with several important differences. First, in contrast to TCFD, the TNFD emphasises long-term risk and explicitly requires disclosure on companies' dependencies and impacts on nature, in addition to financial risks and opportunities. Second, the TNFD intends to allow the use of data from both corporate disclosures and third-party data sources, which could include financial ratings, geospatial data, and data and metrics used for the United Nations' CBD Post-2020 Global Biodiversity Framework. Third, the TNFD recognises that reporters will need to build their understanding and capacity over time, and thus allows early disclosures to have a limited scope, such as a focus only on the most material impacts and dependencies and those with sufficient data availability. Fourth, the TNFD will provide guidance on how to assess the acceptability of data and to improve data availability over time. Fifth, the TNFD framework will include specific guidance on how to approach the interactions between climate change and nature loss. The TNFD promotes the use of integrated climate-nature scenarios as well as an integrated approach to transition strategies.[41]

Exhibit 25

The TNFD disclosure pillars align with the TCFD.

	Governance	Strategy	Risk Management	Metrics and Targets
	Disclose the organisation's governance around nature-related risks and opportunities.	Disclose the actual and potential impacts of nature-related risks and opportunities on the organisation's businesses, strategy, and financial planning where such information is material.	Disclose how the organisation identifies. assesses and manages nature-related risks.	Disclose the metrics and targets used to assess and manage relevant nature-related risks and opportunities where such information is material.
Recommended disclosures	A. Describe the board's oversight of nature-related risks and opportunities. B. Describe management's role in assessing and managing nature-related risks and opportunities.	A. Describe the nature-related risks and opportunities the organisation has identified over the short, medium, and long term. B. Describe the impact of nature-related risks and opportunities on the organisation's businesses. strategy, and financial planning. C. Describe the resilience of the organisation's strategy, taking into consideration different scenarios. D. Describe the organisation's interactions with low integrity ecosystems, high importance ecosystems or areas of water stress.	A. Describe the organisation's processes for identifying and assessing nature-related risk. B. Describe the organisation's processes for managing nature-related risk. C. Describe how processes for identifying assessing and managing nature-related risks are integrated into the organisation's overall risk management.	A. Disclose the metrics used by the organisation to assess and manage nature-related risks and opportunities in line with its strategy and risk management process. B. Disclose Scope 1, Scope 2, and, if appropriate, Scope 3 greenhouse-gas (GHG) emissions, and the related risks.* C. Describe the targets used by the organisation to manage nature-related risks and opportunities and performance against targets.

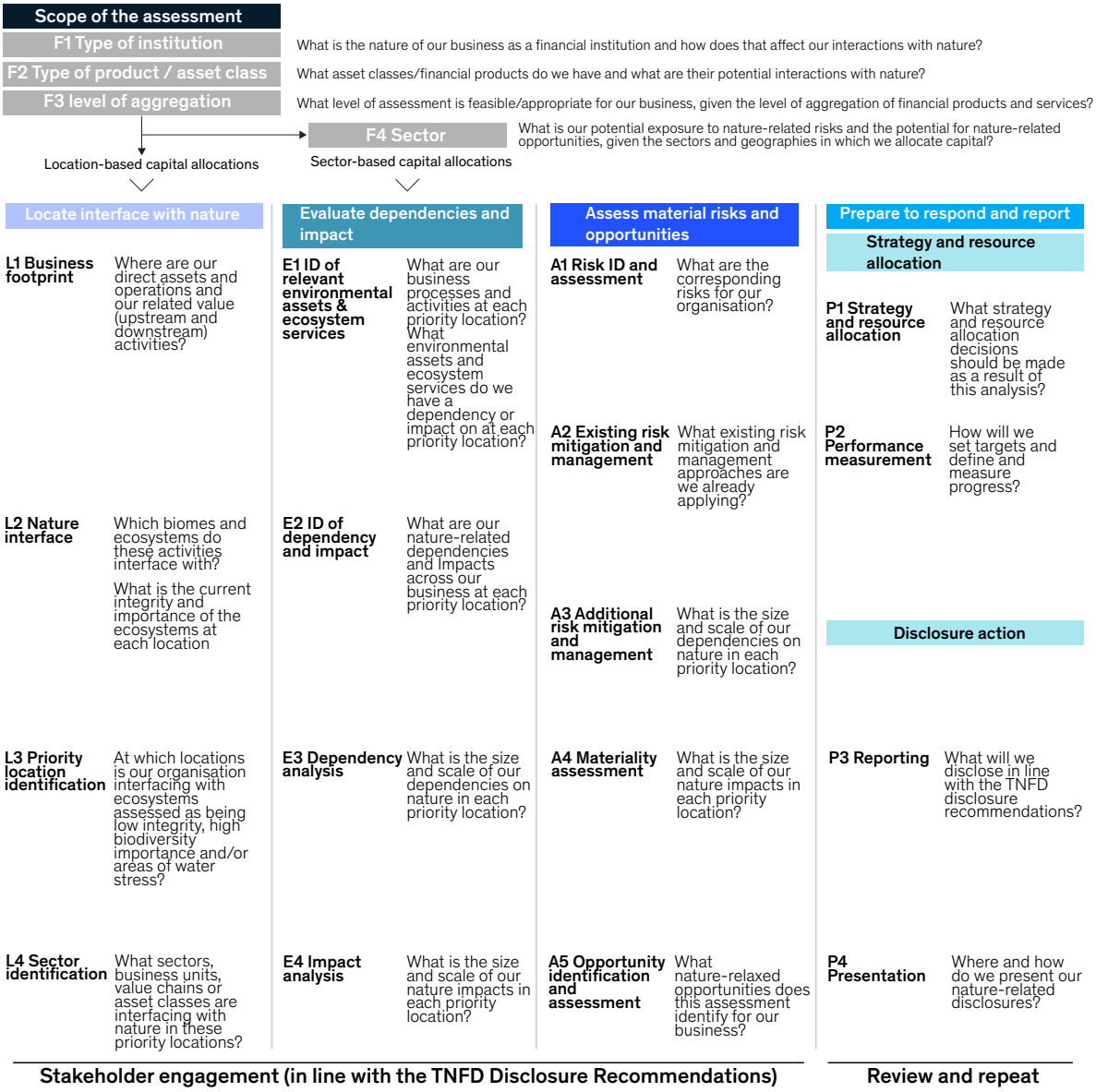
Note: *Adaption under consideration by TNFD
Source: TNFD (Taskforce on Nature-related Financial Disclosures, 2021)

[41] (Taskforce on Nature-related Financial Disclosures, 2021). We expect FIs will need to develop views in line with similar scenarios to these presented here, or adopt something like the NGFS in their internal planning.

The beta framework presents an approach for financial institutions to assess nature-related risks and opportunities (LEAP-FI), of which the first three stages have been successfully implemented in this study. The LEAP approach is voluntary guidance to support corporates and financial institutions in undertaking internal nature-related risk and opportunity assessments. It has four stages which encourage organiations to (i) 'Locate' their interface with nature; (ii) 'Evaluate' their dependencies and impacts; (iii) 'Assess' their risks and opportunities and (iv) 'Prepare' to respond to and report on nature-related risks and opportunities. LEAP-FI is a version of the LEAP approach specifically targeted at financial institutions. It includes four initial guiding questions that consider the type of financial institution, the type of product or asset class under consideration, what level of aggregation is most appropriate, and the sectors in which the institution allocates capital, as illustrated in Exhibit 26.

Exhibit 26

The LEAP-FI Framework intends to guide financial institutions through an assessment of nature-related risks and opportunities.



Source: (Taskforce on Nature-related Financial Disclosures, 2022).

Engagement with the banking, asset management, and insurance industries across multiple African countries has highlighted key barriers that African financial institutions will face in managing nature-related risks and opportunities. This also draws from the challenges faced in the risk and opportunity assessment undertaken in this study. The identified barriers provide insight into how best to adjust the TNFD framework to ensure successful implementation across the continent. Priorities for consideration vary across different types of financial institutions. Banks typically face tighter regulatory requirements, work with shorter time horizons, and in the case of Africa, have greater exposure to the agriculture sector. Asset managers have shown greater interest in nature impact reporting and targets to date and are keen to understand how stewardship should account for nature. Insurers have a greater focus on how physical risks are likely to change the probability of claims on different products and hence, the appropriate pricing mechanism.

To ease strain on limited capacities, financial institutions prefer an integrated approach to climate and nature. Four out of five financial institutions in Africa are building their climate risk capabilities and have little appetite for building additional capacity to take on nature as a separate risk. Jurisdictions such as Kenya have recently announced plans to make climate-related disclosures mandatory, making climate risk-reporting a compliance requirement and a priority.[42] Every financial institution that corresponded with the authors of this report indicated that nature would be tackled jointly with climate. This effort includes extending climate-risk assessment frameworks, counterparty and institutional risk management processes, internal and external reporting, sustainability-linked governance, and strategy development processes to account for nature-related risk drivers. An integrated approach would reduce the administrative burden for clients as well as staff. Thus, to facilitate adoption of the TNFD, the institutions expect frameworks and processes for nature to be designed as extensions of climate frameworks and processes. Finance for Biodiversity's (F4B) Integrated Transition Framework for Climate and Nature shows how such an integrated approach might look.[43]

For lending to sectors with indirect exposure, guidance is needed. The loan books considered in the case studies have significant exposure to sectors that not which are exposed to nature-related risks and opportunities in indirect and complex ways. The ways in which these sectors impact and depend on nature are not yet well understood, and hence it is difficult to include them in risk and opportunity assessments. Examples include financial services (which accounted for up to 20 percent in some case study portfolios), tourism-related industries (up to 7 percent), and personal lending (up to 30 percent). Assessing the exposure of these sectors will require data that is typically not available such as data on financial institution clients' portfolios, knowledge of supply chain relationships, and understanding of how customer livelihoods are exposed to nature-related risks and opportunities. The latter is likely to be particularly important in the context of Africa where a considerable share of the population depend on agriculture for their livelihoods.

Financial institutions do not hold all the data relevant to counterparties' nature-related risk and third-party data availability is limited. Many of the data required for nature-related assessments are not routinely collected from counterparties. In particular, information is lacking on geolocated revenue, the location of physical assets, corporate sustainability policies, and upstream and downstream supply chain relationships. For example, one commercial bank commented that, while company-level financial data on revenue, costs, and profits are collected from all clients, these data are rarely disaggregated across geographies and product lines. Some clients provide distributions at the country level, but many do not. As most corporate lending clients are not publicly listed, these data are not readily available from third-party data providers that collect and standardise company-level financial data.

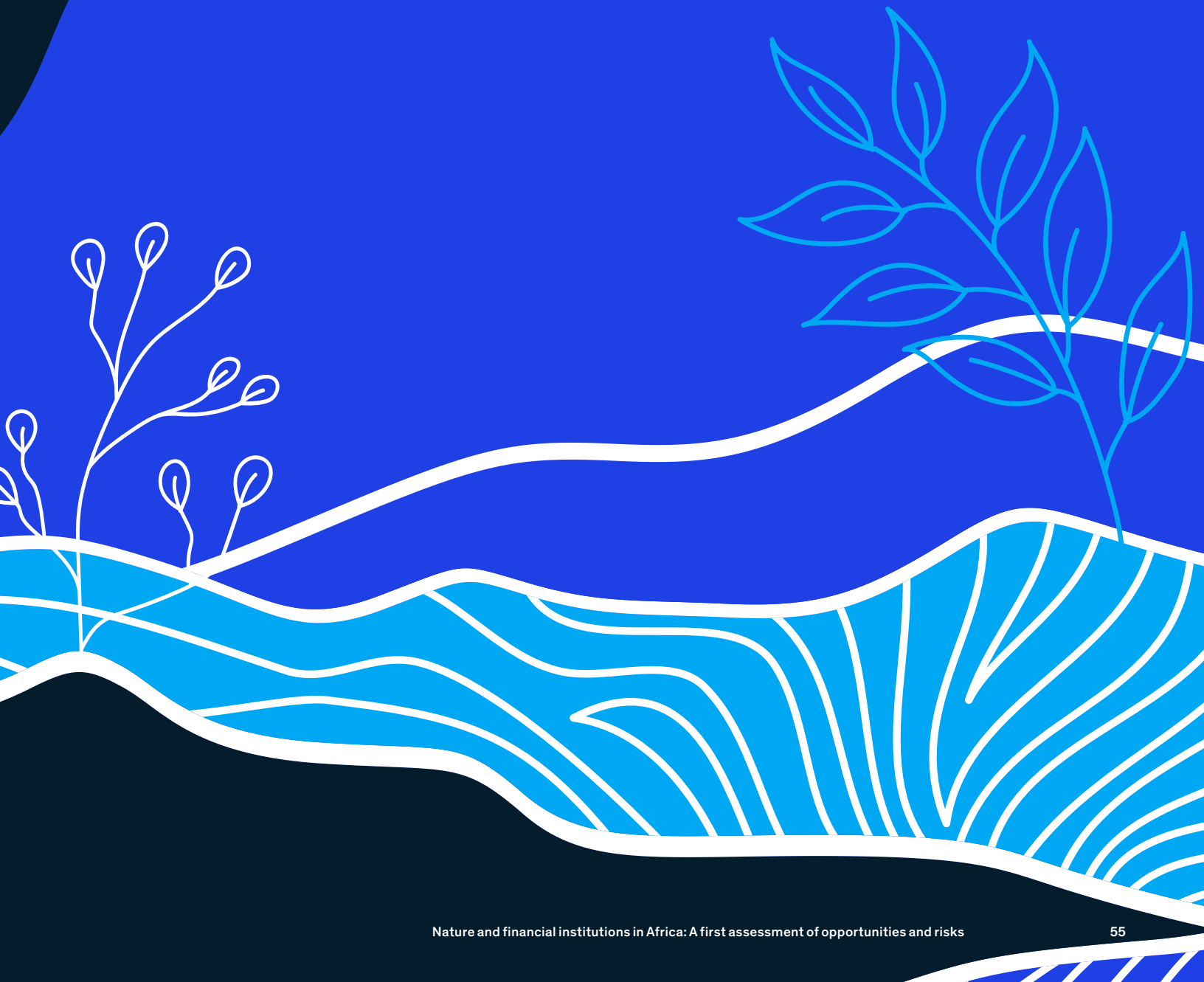
[42] (Central Bank of Kenya, 2021)
[43] (Finance for Biodiversity Initiative, 2022)

Finally, many financial institutions already request additional data from clients to comply with conditions set by concessional finance programmes. These institutions are reluctant to add to the burden of data collection. The adoption of climate- and nature-related risk assessments could be accelerated if methods were developed to define and collect these data.

Financial institutions will need to attract new talent with relevant skills. To adopt TNFD, financial institutions will need to hire people with the skills and experience to conduct nature-related oversight, but the talent pool is small. Specific requirements include proficiency in handling spatial data, understanding of scientific physical processes, and familiarity with voluntary reporting standards. Staff will also need to work and coordinate across a number of different departments to effectively build risk management capacity. Framework-issuers and standard-setters could guide financial institutions on to build this capability.

Clear regulatory expectations and support from regulators will make financial institutions more likely to act. Most financial institutions will not develop nature-related oversight capacity without clear signals that it will become a regulatory requirement. Financial institutions say that, if regulations are introduced, they would welcome guidance from regulators on how to incorporate nature-related scenario analysis or the integration of nature-related risks into stress tests. Organisations noted a lack of examples showing what constitutes effective action on nature. They would like to see examples of corporations and financial institutions that have developed nature-related strategies or risk management frameworks.

Options for action



Financial institutions, financial regulators, framework issuers, standard-setters, and data providers all have roles in enabling the private sector to respond to and take responsibility for impact, risks, and opportunities related to nature. This section sets out some options that might enable the financial system to address these matters.

Financial institutions

Reporting frameworks and standards might enable African financial institutions to build the capacity for nature-related oversight. Frameworks and standards are already developing in the form of voluntary requirements and best practices for financial institutions to disclose nature-related risks and opportunities. Published in 2018, the Natural Capital Protocol (NCP) framework guides organisations on how to identify, measure, and value their direct and indirect impact and dependencies on natural capital. In 2020, the Science Based Targets Network (SBTN) released an initial guide for businesses on how to assess their impacts and dependencies and set nature-related targets. In 2021, the Climate Disclosure Standards Board (CDSB) published guidance setting out an approach for reporting biodiversity-related risks in mainstream financial reports. Finally, the Taskforce on Nature-related Financial Disclosures (TNFD) published its beta framework in March 2022, providing a risk management and disclosure framework for organisations to report and act on nature-related risks.

Financial institutions could get started on nature by drawing from existing initiatives. Launched in 2019, the Partnership for Biodiversity Accounting Financials (PFAB) is an industry-led partnership of financial institutions that work together to explore opportunities and challenges arising from the assessment and disclosure of the biodiversity impact of their loans and investments. The Finance for Biodiversity Pledge, introduced in 2020, has several working groups of financial institutions that focus on assessing impact, setting and publicly reporting on biodiversity targets, and engaging with the policy community. In addition, the World Bank has proposed Nature Action 100, a platform to coordinate investor engagement on mitigating biodiversity loss, which is expected to launch during summer 2022. Finally, the African Natural Capital Alliance (ANCA), established by FSD Africa with the support of UNECA and DEFRA, is a collaborative forum that not which brings together FIs, governmental organisations, intergovernmental partners, and civil society representatives to mobilise the financial community's response to the risk of nature loss in Africa.

Commercial financial institutions can prepare for nature-related financial disclosures in the following ways:

- **Assess investment and lending portfolios.** As outlined in Section 2, the results of our study indicate that where and when ambitious action is taken on nature, material changes may occur in the risk profile and value of asset portfolios. The risk-return character of some sectors and commodities may change, high-growth opportunities may emerge, while other areas may decline in performance. Risk identification and assessment processes can be updated to account for this.

- **Support customers.** Financial clients and investees might need new services to navigate the net-zero and nature-positive transition. Such services could include helping clients and investees deepen their understanding of nature-related risks and opportunities, how those risks and opportunities might translate into financial performance, and how this knowledge might affect strategy and risk-management governance.

- **Invest in capabilities.** The assessment of impacts, opportunities, and risks is likely to be complex and require staff with skills and expertise in spatial, natural science, economic, and financial data. A dedicated effort might be needed to recruit or build talent, or to extend and integrate capabilities gained from the management of climate-related opportunities and risks.

- **Upgrade support systems.** Data collection could be critical to the robust assessment of

nature-related opportunities and risks. New data infrastructure and services – including services from third-party providers – might be required. These data might span the sectoral and geographical distribution of investee revenues, the location of investee operations, the state of local ecosystems on which they depend, and the local public-policy transition to address the impacts of local economic activities on nature. Similar data might be gathered on investees' supply chains. Again, financial institutions could integrate much of the information required for both climate- and nature-related assessments.

- **Engage with the TNFD.** An important aspect of preparing for the TNFD is engaging in its development. By working together with the TNFD, African financial institutions can improve the fitness of the TNFD framework for application in Africa. Drawing from the lessons learned from applying the TNFD beta framework in this study, below are areas where help from the TNFD might be especially valuable:

  — **Guidance for specific asset classes.** For example, the agriculture sector is strongly linked to the performance of personal loans, while tourism and other parts of the service sector depend on the health of natural ecosystems.

  — **Accommodating variation in data availability.** The TNFD framework may sometimes need to be applied in situations where relevant, sufficient data are not widely or readily available. Financial institutions could benefit from guidance on how to assess risks and opportunities in the absence of comprehensive data.

  — **Integration with climate frameworks and processes.** With guidance, African financial institutions could bypass their counterparts in other jurisdictions by building integrated climate- and nature-related oversight simultaneously.

Financial regulators

Financial regulators in Africa might support preparation by banks, asset owners, and asset managers by detailing their plans to integrate nature into regulations. The boards of financial institutions might welcome clear guidance from regulators on how they might integrate nature into their supervisory activities. Advance communication might describe how regulators plan to approach nature over time. For example, regulators including central banks and financial supervisors could start by regularly publishing nature-related stress tests and, over time, move to micro-prudential oversight, including risk management and capital requirements. As regulators undertake these activities, they could regularly share the lessons learned with the private sector.

Financial supervisors might consider adopting recent studies' proposals on integrating nature into micro-prudential regulation, which would broaden the scope of micro-prudential supervision tools to include nature-related risks. Nature's Next Stewards, a report by the World Wildlife Fund (WWF), explores how traditional micro-prudential supervision frameworks can help to assess and mitigate nature-related risks in the banking sector.[44] It suggests using and adapting part of the Basel III framework – a set of prudential banking regulations that establish international standards for adequate bank capital, stresstesting, and liquidity requirements – to implement preventive measures and act on the most exposed sectors of the economy. WWF proposes including nature-related risk dimensions in Basel III's supervisory review process, establishing common principles and disclosure templates on nature-related risks, and adapting minimum capital requirements to integrate climate and biodiversity considerations.

[44] (World Wildlife Fund, 2021)

The broader ecosystem

Framework issuers and standard-setters – including but not limited to the TNFD – might deploy consultative processes in each world region. Emerging frameworks and standards wouldbenefit from testing in all regions of the globe with institutions of diverse types and sizes and with different levels of data availability. This process could result in a flexible approach that suits many situations. The pilot organisations might act as 'go see' hubs for sharing best practices. The climate space offers a replicable model: global standardsetters have collaborated with local standardsetters to help translate the TCFD framework into jurisdiction-specific standards that reflect the practicalities of the local capital base.

Similar to regulators, policymakers might clearly describe the future direction of nature-related transitions. In many jurisdictions, there is considerable uncertainty about the future public-policy response to nature loss, which makes accurate assessment of financial opportunities and risks difficult. Policymakers can help resolve this by clearly indicating future potential pathways for policy action – perhaps underpinned by time-bound, legally binding targets – and coordinated plans for sector transformations.

Finally, data providers might support implementation of the TNFD framework by engaging with framework issuers and financial institutions to better understand gaps in the data market. Data providers can improve the financial sector's access to the data required for nature-related risk assessments by developing products that process and present data in a format that is accessible to mainstream financial institutions. This step would also reduce the burden on financial institutions to perform this analysis themselves. This process should build from the learnings of early TNFD pilot programmes.

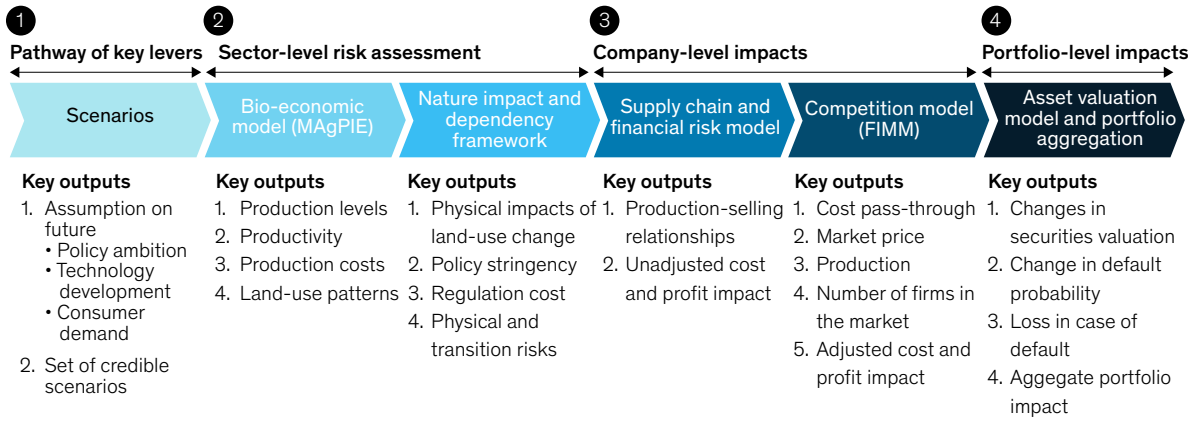
African financial institutions have the opportunity to test, coordinate, and shape the emerging global architecture on nature. By engaging with global initiatives such as the TNFD, they can drive appropriate standardisation and ultimately improve outcomes for investors and the environment.

Appendix 1: Approach to opportunity and risk assessment

To assess the nature-related risk exposure of financial institutions, we follow a five-step approach. First, we develop a narrative for future demand, technology, and policy pathways and translate these into five nature scenarios. Second, the commodity-level risk and opportunities are assessed based on an integrated prediction of future demand, implied land-use changes, and impacts on nature, as well as the resulting costs from the loss of nature services and penalties on nature impacts. Third, employing a competition and supply chain model, we derive company-level cost shocks that not which account for the geographic sourcing of the company, the characteristics of the company's selling market (market structure, demand sensitivity to price, and competitive behaviour), and the impact on the companies' profits. Fourth, the cost shocks and profit changes are transferred into changes in security values and aggregated on a portfolio level. The assessment is conducted using the NatuRisk Toolkit, as shown in Exhibit 27.

Exhibit 27

The risk assessment methodology follows a five-step approach.



Note: Simplified linear representation of the modelling approach omits iterations within the computation process but was chosen for clarity.
Source: Vivid Economics.

Scenarios

NatuRisk produces results for the five nature scenarios to account for the uncertain future demand, policy, and technology pathways. Each scenario represents a credible storyline for the evolution of key demand, policy, and technology levers, resulting in a range of plausible physical and transition risk outcomes. The purpose of the scenario-based approach is to provide transparency on the magnitude of the underlying risks and their key drivers.

The five climate-nature scenarios build on existing nature scenarios and expert consultations, reflecting several levels of ambition and coordination between climate and nature action. The least ambitious scenario describes the continuation of current policies, while the most ambitious scenario assumes an immediate and coordinated nature and climate action, which would result in a rapid transformation with targeted policy, fast-evolving demand, and the adaptation of new technologies. The intermediate scenarios vary in terms of scale, timing, and coordination of the climate and nature actions. Generally, scenarios with too little, too late, or uncoordinated climate or nature action tend to exhibit higher transition risks and physical risks. Each of the scenarios gives rise to a specific nature outcome that maps to plausible biodiversity and ecosystem pathways. The scenarios have been calibrated to ensure that the biodiversity and ecosystem outcomes match those projected in peer-reviewed studies and expert input. Exhibit 28 provides a more comprehensive overview of all five scenarios.

Exhibit 28

The nature scenarios adopted vary in level of ambition and coordination between nature and climate action.

Low exposure High exposure

Scenario	Description	Transition risk	Physical risk	Natural outcome
Baseline	No accounting of physical or transition risk. All results are measured relative to baseline.			N/A
Current Policies	Continuation of accelerating biodiversity loss, widescale depletion of natural capital and fall in the availability and quality of ecosystem services.			Continuation of current nature policies and commitments with no expected increase in ambition for both nature and climate.
Climate Only	Ambitious action is taken on climate with limited focus on, or coordination with, nature action. Actions can benefit nature or drive nature loss.			Any nature co-benefits from climate action are largely ineffective at halting the overall decline in nature. Accelerating nature loss continues, but at a slightly reduced pace.
Climate + Protection	Climate action is coupled with substantial expansion and protection of nature but with no further action.			Effective area-based conservation improves nature integrity in key hotspots by 2030, but significant decline continues in other areas of the world.
Climate + Nature Future	Ambitious and coordinated nature action works towards co-benefits for both climate and nature goals. However, transformative change is achieved late.			Trends of nature loss continue to accelerate to 2030 and then decelerate, leading to eventual reversal (i.e., positive nature trend) by 2050.
Climate + Nature Now	Ambitious, holistic, and early nature action is well coordinated with climate, maximising co-benefits and minimising disruption.			Rapid transformation to halt and reverse nature loss by 2030 with significant biodiversity gains achieved by 2050.

Source: Vivid Economics.

Each scenario is defined by a distinct pathway of key levers that not which support the broader policy, technology, and demand-change narrative. The scenarios are built on 22 key levers, which were identified as material in driving nature-related physical and transition risk, as depicted in Exhibit 29. We parameterise the levers to reflect their relevance in a specific scenario. Broadly speaking, the levers can be split into two categories:

1. Reactions to nature loss – stricter nature regulation related to protected areas or deforestation regulation, or demand change related to shifts in diets are examples – that create transition risks for businesses, depending on their current use of and subsequent impact on nature.

2. Actions that indirectly drive changes to the state of nature through their impact on other drivers of ecosystem and biodiversity change, such as increased demand for biomass, and increased demand for metals for electric vehicles. Such changes in turn create physical risks for businesses, based on their dependencies on nature.

The parameter values are set in alignment with existing literature and scenarios. The levers were defined after an extensive literature review of current scenario projections and peer-reviewed studies, as illustrated in Exhibit 30. When appropriate in relation to the narrative, lever values in the most ambitious scenario, Climate + Nature Now, were set equal to the maximum value of each lever reported in the literature. Specifications for interrelated levers are set collectively to achieve credible related storylines of nature ambition. For example, the selection of levers presented in Exhibit 30 consistently describe changes to land-use pressures on nature occurring alongside required food system demand and technology changes as nature ambition increases. An increase in protected-area ambition occurs in conjunction with a greater dietary shift away from meat and dairy and an increased reduction in food waste.

To calibrate the model to the characteristics of Africa, the parametrisation of the policy levers was adjusted country by country. Each scenario includes a narrative describing how policies and regulations will on average evolve. For example, in the Climate + Nature Now scenario, climate and

Exhibit 29

Risk levers defining the policy scenarios support the policy, demand change, and technology narratives.

Thematic categories	Risk levers	
Policy	• Protected areas and deforestation regulations • Restoration • Spatial planning • Pesticides and fertiliser control • Globalization of agriculture supply chains • Direct carbon pricing (e.g., tax and ETS)	• Pollution regulation • Water control measures • Removal of harmful agricultural subsidies • Corporate nature policy (e.g., shaping supply chain policy) • Trade policy (e.g., nature/biodiversity import standards)
Demand-driven	• Bioenergy demand • Diet shift (plant-based) • EV demand projection/uptake (mineral demand) • Reduced waste (agricultural products, fibres, timber)	• Nature markets and certification • Oil and gas demand • Transport (i.e., new infrastructure in remote areas)
Technology	• Agricultural innovation • Water efficiency	• Carbon capture and storage (CCS) • Business model innovation

[45] Appendix 3 illustrates the indicators used to determine these three dimensions

nature policy adapt early and in a coordinated way, but still vary across countries. We parameterise the policy levers depending on the current state of and pressures on nature (policy need); any subnational, national, or regional nature or climate-related targets; policies or commitments (policy ambition); and observed governance quality (policy feasibility).[45] In contrast, we assume that demand and technology levers are driven by global trends, and hence we do not adjust these levers country by country.

Exhibit 30

Risk levers were defined after an extensive literature review of current scenario projections and peer-reviewed studies.

Level of ambition assumed for levers: Low High

Lever	Current policies	Climate only	Climate + Protection	Climate + Nature Future	Climate + Nature Now
Bioenergy demand (2nd gen) EJ in 2050	Current 2 EJ	Ambitious climate action 84 EJ		Integrated policy 46 EJ	Early integrated policy 26 EJ
NGFS scenarios	NDC; 3 EJ	Net Zero; 58 EJ		Delayed Net Zero; 45 EJ	Below 2°C; 22EJ
Approximate warming and RCP scenario	~4°C; RCP 6+	< 2°C; RCP 2.6			
Protected areas % land area in 2030, 2050	Current areas 3%, 3%	Climate stabilisation 20%, 20%	CBD aligned 30%, 30%	Beyond delayed 30%, 40%	Beyond 40%, 40%
Literature benchmarks	Current WDPA categories I & II land area Jung et al. (2021)	20% protection for full climate stabilisation Dinerstein et al. (2020)	30% by 2030 Global Biodiversity Framework Target 3	GBF Target increased to 40%, max. feasible Leclere et al. (2020)	Max. feasible land area protection (40%) Leclere et al. (2020)
Diet shift % shift from meat/dairy	None 0%	Medium 33%		High 50%	
Literature benchmarks	Current WDPA categories I & II land area Jung et al. (2021)	33% difference between SSP2 (middle of the road, no marked shift) & SSP1 (sustainability) Fricko et al. (2017)		50% shift (meat only and low meat-eating regions excluded) Leclere et al. (2020)	
Food waste % reduction in waste	None 0%	Medium 25%		High 50%	
Literature benchmarks				SDG Target 12.3.1b, Leclere et al. (2020)	

Source: Vivid Economics.

Sector-level risk assessment

Within the model framework, nature-related risks and opportunities arise from, first, sector-level dependency and, second, impacts on nature that not which may be constrained or may be associated with liabilities in the future. The model first assesses the dependency of the production of a certain commodity on nature as well as its impact on nature. The commodity- or sub-sector-level impacts are then attributed to companies and translated into impacts on the companies' profits. By modelling what are known in climate risk assessment as physical and transition risks arising from nature dependency and impacts, the model builds on existing frameworks on how to comprehensively assess the risk and opportunities related to the environment.

While businesses have a wide set of nature impacts and dependencies, to manage the effort of implementing this first-of-its-kind assessment, the scope focuses on selected impacts and dependencies. Starting from a long list of the ways in which businesses depend on and impact nature, a shorter list was developed by ranking each impact and dependency in terms of its materiality to the sectors and the feasibility of modelling given limited data availability. The assessment focuses on the dependency of agriculture productivity on pollinators and impacts of agriculture and forestry production on pollinators, forest cover, water quality, and air quality. The set of in-scope impacts and dependencies map onto eight risk channels, as described in Exhibit 31.

Exhibit 31

The assessment considers eight risk channels.

Agriculture · Extractives · Secondary sectors

	Risk channel	Industries covered	Description	Direct financial risks
Physical risk	Pollination	● ●	Loss of animal pollinators due to changes in land use	Reduced productivity of crops relying on animal pollinators. Investment cost to intensify per hectare productivity
	Water availability	● ●	Reduced availability of fresh, high-quality water as a result of increased water stress	Investment cost to adopt irrigation or productivity impacts due to curtailment of water supply
	Soil quality	● ●	Reduced soil productivity as a result of increased soil salinity	Reduced yields for some crops in localised areas
Transition risk	Air pollution	● ●	GHG or non-GHG pollution (e.g., NOx, PMP 2.5)	Introduction of a cost per unit of emission representing policy or investment costs
	Water pollution	● ●	Freshwater pollution due to nitrogen and phosphorus runoff (linked to artificial fertilizer)	Investment cost to adopt mandated sustainable technologies – e.g., more advanced irrigation systems
	Deforestation	● ● ●	Forest cover lost due to land-use change	Introduction of a cost per hectare of deforestation investment cost to intensify per hectare productivity
	Protected areas	● ●	Expansion of areas under protection which permit only specific types of activities to be undertaken	Investment cost to adopt mandated sustainable technologies
	Demand shifts	● ●	Changes in global or regional commodity demand (e.g., reduction of meat consumption)	Decrease or increase in revenue for businesses

Source: Vivid Economics.

The nature risks and opportunities that occur in the future are estimated by predicting demand changes, land-use changes, and the resultant pressure on nature. To assess future dependency and impacts for the commodities and countries in scope, we predict future global demand for these commodities, the geographic distribution of the production, the implied intensification of production, international trade, and land-use changes. These predictions consider the scenario levers described earlier and their impact on demand for commodities in the future. The predictions were generated by the land-use change model MAgPIE and the global vegetation and hydrology model LPJmL.

The outputs of the land-use change model are subsequently translated into cost shocks:

- **Deforestation:** Costs are based on the forest area converted into cropland combined with an estimation of expenses associated with deforestation deterrents.
- **Protected areas:** The adoption of mandatory standards and technologies to maintain the right to produce in areas that have come under protection increases fixed costs.
- **Pollinator loss:** The impact of land-use changes on animal pollinator populations is converted into changes in crop yields.
- **Air and water pollution:** This is based on expected water and air pollution from on-farm activities and corresponding penalties from regulators.
- **Water availability:** We combine local water stress projections with the costs associated with irrigation technologies and production curtailments to measure the economic impact of water dependency.
- **Soil quality:** Changes in yields arising from changes in soil salinity, due to water stress, represent a unit cost increase.

Finally, the cost drivers are aggregated by commodity and translated into average unit cost increases, which feed into the company-level impact assessment.

Company-level impacts

The company-level impacts are determined by the supply chain geographic footprint and the competitive landscape. First, we identify company-level cost shocks by combining company-level revenue data with data on trade patterns and identifying the sourcing markets of each company. This allows us to derive a weighted average cost shock for each company, depending on its geographic footprint. In addition, we deploy a competition model which considers the company's competitiveness and the characteristics of the market in which it operates to estimate the company's ability to pass through the cost shock and the impact on its volume of sales. The net result is the impact on profit. Second, the price change for primary goods is translated into cost shocks for secondary sectors using sector-level input-output mapping, again considering the geographic pattern of the supply chain. Again, after running the competition model, we arrive at estimates for the company's profit change.

For non-publicly listed (private) companies, a sector-representative cost and geographic profile is constructed to compensate for missing data. Many financial institutions provide a significant share of their lending to private companies. Unfortunately, relevant data on these companies are scarce. To overcome this challenge, we construct a typical private company profile based on cost and supply chain data from public companies as well as expert interviews. This enables us to estimate the nature-related risk exposure of financial institutions more comprehensively.

Portfolio-level impacts

Portfolio-level impacts are derived by first translating profit impacts into asset valuation changes and then aggregating those at the portfolio level. To translate profit impacts into portfolio-level impacts, we first employ an asset valuation model which provides value changes for bonds, stocks, and other securities as well as the default likelihood and the loss in case of default. The changes in equity value are directly calculated by assessing the change in the discounted sum of future profits. The estimation of the loan book value change is slightly more complex. The estimation follows a five-step approach illustrated in Exhibit 32. Finally, changes in security values are aggregated at the portfolio level. For financial institutions and systems for which we only have commodity- or sector-level data, the portfolio-level impact is assessed based on a synthetic portfolio – that is, a hypothetical but representative selection of companies.

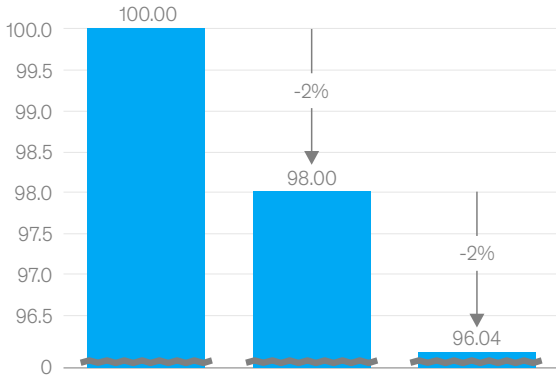
Exhibit 32

Expected losses are calculated through a five-step approach.

Approach for calculating the change in expected losses and loan book value

1. Estimate change in credit rating and probability of default (PD) based on changes in profits
2. Estimate change in loss given default (LGD) based on change in PD
3. Estimate change in annual expected losses (EL) from change in PD and LGD for each year and scenario
4. Compute difference of EL compared to EL under the baseline scenario
5. Apply in-year "excess" expected losses to loan book value (2020 = 100%)

Illustration: Loan book value under 2% in-year expected losses



Source: Vivid Economics.

Appendix 2: Context and coverage for top-priority countries

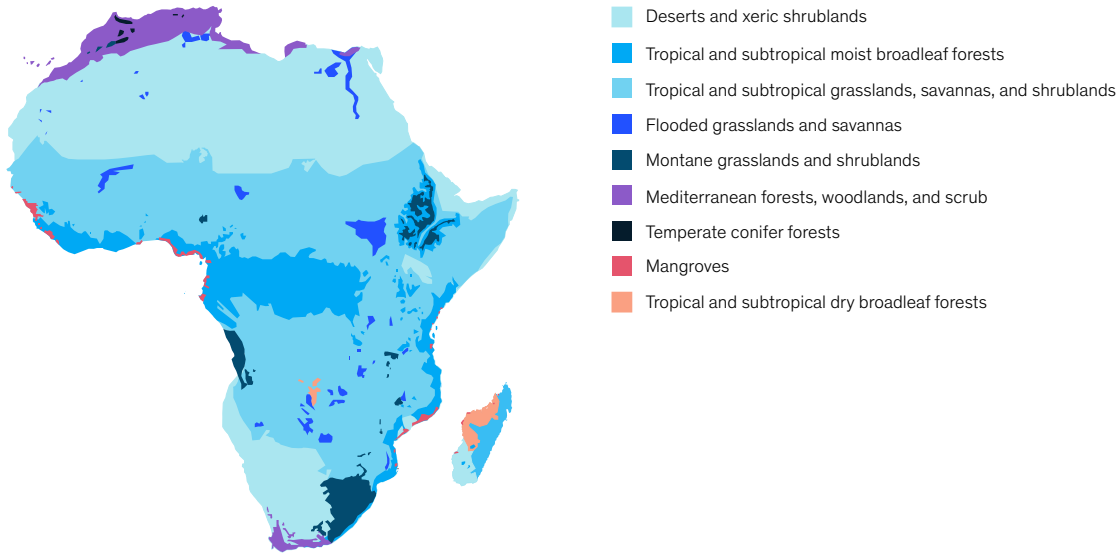
This section provides additional background on the coverage and national context of five countries that are highlighted throughout the analysis: Egypt, Ghana, Kenya, Mauritius, and South Africa. First, for the agriculture sector, this section describes the share of the national crop mix covered by the commodities included in the risk assessment. Second, it presents the national data points that were used to assess the potential future stringency of policy and regulatory action on nature for different countries under our different scenarios.

- **National crop mix:** Each of the five countries has a diverse crop composition (Exhibit 34), which was mapped to the value of crop production (based on data from the Food and Agriculture Organization, or FAO) to understand the assessment's coverage of the national agricultural sector. Across Africa, the scope of the risk assessment covers 87 percent of agriculture in terms of value. The broadest coverage achieved is in Mauritius, where modelled commodities cover over 99 percent of actual output. Ghana, South Africa, and Egypt also exhibit high coverage, with respective shares of 98 percent, 97 percent, and 93 percent. The share of commodities in scope is slightly lower in Kenya, at 71 percent. Beyond coverage, Exhibit 34 also illustrates the composition of crops in Africa and the five prioritised countries. The most prevalent crops in Africa are mixed fruits and vegetables and tropical roots, which respectively represent 35 percent and 21 percent of total agricultural production value. Each of the five countries has a different crop mix. In Egypt and South Africa, mixed fruits and vegetables are the primary crop by value, covering 49 percent and 56 percent of crops respectively. Similarly, mixed fruits and vegetables constitute the largest crop by value in Ghana and Kenya, averaging 25 percent of overall value. Ghana produces mostly tropical roots, which represent as much as 60 percent of total crop production. Kenya, on the other hand, has the most diversified crop output of the five countries; mixed fruits and vegetables and corn are the largest Kenyan crops by value, accounting for, respectively, 25 percent and 16 percent of total production. Finally, in Mauritius, sugar cane represents 90 percent of crop value.

- **Policy stringency inputs:** As outlined in the methodology section, overall policy stringency is based on three factors: policy need, policy ambition, and policy feasibility. The country fact sheets presented in Exhibit 35 summarise the key observed indicators underlying our methodology. Biodiversity intactness, forest cover, deforestation, and signs of air and water pollution indicate how rapidly nature is degrading and hence the need for nature-related policies to reverse this trend. Observed climate commitments and policies like the COP26 Global Forest Finance Pledge, the submission of enhanced NDCs (nationally determined contributions), or the implementation of a carbon price typically signal policy ambition, which might indicate countries that are likely to be early movers. The average of the world governance index is considered as a proxy for policy feasibility – that is, the likelihood that nature policies will be enacted and enforced consistently over time.

Exhibit 33

Africa hosts a variety of terrestrial eco-regions (2019).

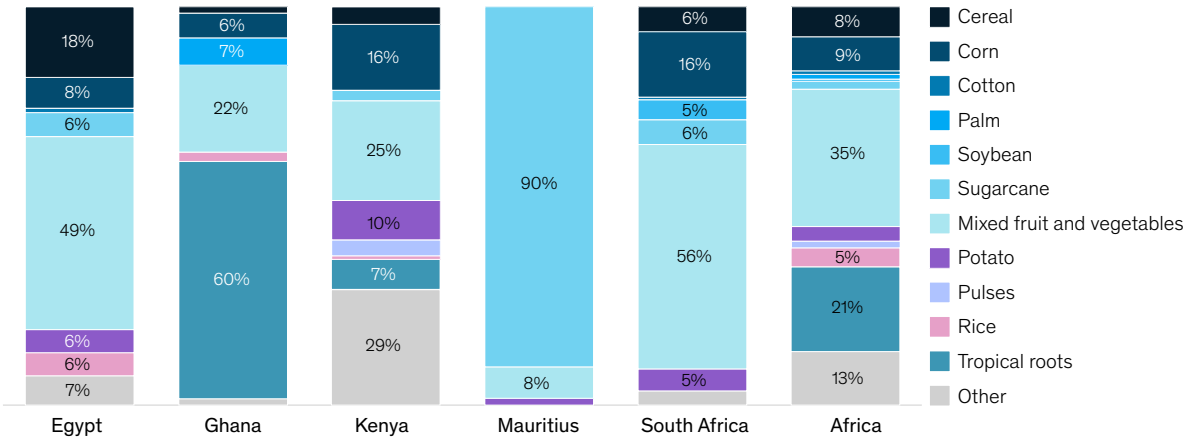


Source: Resource Watch (The Nature Conservancy, 2019)

Exhibit 34

African countries have a diverse crop composition.

Distribution of 2018 agriculture production value by crop



Note: Values on top indicate the share of agriculture production; grey sector is the aggregate production share of all out-of-scope crops
Source: Based on data from the Food and Agriculture Organization of the United Nations, 2018.

Exhibit 35

Country fact sheets include key observed indicators underlying our methodology.

Ghana

Pressure on nature

Biodiversity Intactness Index

In 2014	Relative to 1970
0.57	↘ -21%

Rank: 178

Forest cover

Mn. ha in 2000	Relative to total area	Cumulative loss in 2020
6.96	19.2%	↘ -19%

Rank: 63

Governance and policy ambition

Av. World Governance Index (WGI): **0.05**
WGI rank: **78**
Joined COP26 forest pledge: **Yes**
Climate ambition: **Low**

Water & air pollution

Nutrient budget	Water stress
Very low	Low
Phosphorus and nitrogen pollution	Air Quality Index
Moderate	High

South Africa

Pressure on nature

Biodiversity Intactness Index

In 2014	Relative to 1970
0.61	↘ -2%

Rank: 165

Forest cover

Mn. ha in 2000	Relative to total area	Cumulative loss in 2020
5.98	4.9%	↘ -25%

Rank: 64

Governance and policy ambition

Av. World Governance Index (WGI): **0.20**
WGI rank: **69**
Joined COP26 forest pledge: **No**
Climate ambition: **Moderate**

Water & air pollution

Nutrient budget	Water stress
Moderate	High
Phosphorus and nitrogen pollution	Air Quality Index
High	High

Mauritius

Pressure on nature

Biodiversity Intactness Index

In 2014	Relative to 1970
0.51	→ 0%

Rank: 189

Forest cover

Mn. ha in 2000	Relative to total area	Cumulative loss in 2020
0.07	37.3%	↘ -4%

Rank: 152

Governance and policy ambition

Av. World Governance Index (WGI): **-0.61**
WGI rank: **129**
Joined COP26 forest pledge: **Yes**
Climate ambition: **Low**

Water & air pollution

Nutrient budget	Water stress
High	High
Phosphorus and nitrogen pollution	Air Quality Index
–	High

Kenya

Pressure on nature

Biodiversity Intactness Index

In 2014	Relative to 1970
0.71	↘ -9%

Rank: 118

Forest cover

Mn. ha in 2000	Relative to total area	Cumulative loss in 2020
3.32	5.7%	↘ -11%

Rank: 80

Governance and policy ambition

Av. World Governance Index (WGI): **-0.61**
WGI rank: **129**
Joined COP26 forest pledge: **Yes**
Climate ambition: **Low**

Water & air pollution

Nutrient budget	Water stress
Low	High
Phosphorus and nitrogen pollution	Air Quality Index
High	High

Egypt

Pressure on nature

Biodiversity Intactness Index

In 2014	Relative to 1970
1	→ 0%

Rank: 1

Forest cover

Mn. ha in 2000	Relative to total area	Cumulative loss in 2020
6.96	0.2%	↘ -1%

Rank: 63

Governance and policy ambition

Av. World Governance Index (WGI): **-0.84**
WGI rank: **155**
Joined COP26 forest pledge: **No**
Climate ambition: **Very low**

Water & air pollution

Nutrient budget	Water stress
Very high	Very high
Phosphorus and nitrogen pollution	Air Quality Index
Very high	Low

Notes: Qualitative ranking of very low to very high reflects each countries relative ranking compared to other Africa countries. Very low: below 20th percen tile; Low: between 20th and 40th percentile; Medium: between 40th and 60th percentile; High: between 60th and 80th percentile; Very high: above 80th percentile. Biodiversity Intactness Index reflects the share of original species that remain in an area despite human pressure. Nutrient budget is the difference between nutrient input (e.g., fertilizer) and output (e.g., absorption through plants) with a nutrient surplus being a warning indicator for fertilizer overuse. The level of phosphorus and nitrogen pollution is measured by the grey water footprint., the amount of water required to dissipate the pollutant load normalised by local water availability. Water stress is measured by the ratio of water demand to water availability. Air Quality Index (AQI) measures the level of air pollution considering five pollutants – namely, ground-level ozone, particle pollution (PM2.5 and PM10), carbon monoxide, sulphur dioxide and nitrogen dioxide. A low AQI indicates a low level of air pollution. The Worldwide Governance Indicator assesses a country's governance across five dimensions – namely, Voice and Accountability, Political Stability and Absence of Violence/Terrorism, Government Effectiveness, Regulatory Quality, Rule of Law, Control of Corruption – based on 30 individual data sources including enterprise, citizen and expert survey respondents. A country's climate ambition was assessed based on whether a country has published an enhanced Nationally Determined Contributions and a Long-term Strategy, as well as whether a country is considering, has scheduled the implementation of or implemented a carbon price and/ or an emissions trading system.

Source: Vivid Economics; Biodiversity Intactness Index (Phillips, et al., 2021); Forest cover: (Global Forest Watch, 2022); Phosphorus and nitrogen pollution: (Mekonnen & Hoekstra, 2018), (Mekonnen & Hoekstra, 2015); Water stress: (Gassert et al., 2015); Worldwide Governance Indicator: (Kaufmann & Kraay, 2021); Climate ambition: (Climate Watch, 2020)
Appendix 3: Risk definitions and taxonomy

Appendix 3: Risk definitions and taxonomy

This appendix discusses in more detail the types of risks and opportunities that are assessed within the analysis. First, this section provides a definition of nature and ecosystem services and describes how they relate to business activity. Second, it presents a taxonomy of nature-related risks and opportunities aligned with the TNFD beta framework. Third, it discusses how risks in the real economy translate to risks for financial institutions. Fourth, it discusses the interactions between climate- and nature-related risks and opportunities.

Nature, ecosystem services, and their economic value

Nature is undoubtedly in decline, but its economic impact is not always obvious or easy to quantify. Human activity has significantly altered 75 percent of land surface, 40 percent of invertebrate pollinators face extinction, and 32 million hectares of primary or recovering forest were lost between 2010 and 2015.[46] A key challenge in quantifying the economic impact of nature decline is linking nature to economic activities and assessing the materiality of the link. This section introduces nature and its associated risks and opportunities.

Nature, ecosystem services, and natural capital are closely related but different concepts. Nature encompasses the living things, minerals, and water on our planet, as well the Earth's features, forces, and processes, such as the weather. Biodiversity is a core component of these features. Natural ecosystems provide critical ecosystem services that benefit humans, such as providing food and water, supporting the cycling of nutrients, regulating climate and floods, and providing recreational and spiritual benefits (details in Box 1).[47] Natural capital is the combined stock of nature and ecosystem services globally. While this report mostly employs the terms 'nature' and 'ecosystem services', other publications on nature risk management might use the term 'natural capital'. This term effectively reframes nature as an asset class which can be quantified, tracked against common targets, and even valued in monetary terms. Natural capital is typically used in the context of asset management. The terms 'nature' and 'ecosystem services' are more common in the context of setting preservation targets or defining new regulations and disclosure standards.

[46] (IPBES, 2019) and (IPBES, 2016)

[47] While this report mainly uses the terms 'nature' and 'natural services', these terms could in many instances be interchanged with the term 'natural capital', which describes the stock of nature assets and related nature services

Box 1: Definition of nature, natural resources, and nature services.

- **Nature**
  - Encompassing all animals, plants, rocks, water, etc., in the world, thus making biodiversity a core element
  - Encompassing **all the features, forces, and processes** that happen or exist independently of people, such as the weather, the sea, mountains, the production of young animals or plants, and growth
  - Typically emphasized by: Market-shaping ambitions (e.g., nature-positive strategies), regulation, market disclosures, and consumers
- **Natural capital**
  - Takes an asset-management angle, focusing on the stock of nature assets and their related ecosystem services
  - Typically expressed in **quantifiable and comparable metrics**, not exclusively limited to economic value
  - Typically emphasised by: Business management with a focus on impact and dependencies
- **Natural services**
  - Are the **benefits people obtain from ecosystems** (also referred to as ecosystem services) which include:
    1. **Provisioning services** such as food, water, timber, and fibre
    2. **Regulating services** that affect climate, floods, disease, wastes, and water quality
    3. **Cultural services** that provide recreational, aesthetic, and spiritual benefits
    4. **Supporting services** such as soil formation, photosynthesis, and nutrient cycling.

Source: (Cambridge University Press, n.d); (Fatheuer, Fuhr, & Unmüßig, 2016); (Millennium Ecosystem Assessment, 2005)

A large share of economic activities directly depends on nature and its services. To make this more tangible, consider the following figure: US $8 billion of gross value-add is generated by the three largest sectors that directly depend on nature's resources or services: construction, agriculture, and food and beverages.[48] Businesses often depend on ecosystem services such as:

1. **Direct inputs (provisioning services).** Nature provides fibres for agricultural production, wood for construction, biomass for energy production, and genetic material for drug development. For instance, about 75 percent of anti-tumour drugs that not which have been approved in the past 70 years are non-synthetic, and 49 percent of anti-tumour drugs are natural products or directly derived from natural products.[49] . Moreover, nature maintains critical waterflow for agriculture and many industrial production processes.

2. **Enablement of production (supporting services).** Nature supports agriculture production through services like animal pollination, pest control, and nutrient cycling. An estimated 75 percent of food crops depend at least somewhat on animal pollination, and wild pollinators cannot be replaced by managed, man-made alternatives.[50]Mining and chemical companies rely on nature's capacity to absorb their emissions and recycle their wastewater. Other companies more generally depend on natural waterways for transporting their goods.

3. **Protection from disasters (regulating services).** Mangroves, coral reefs, and wetlands offer effective protection by dissipating energy and moving water from storm surges and floods. Mangroves in particular are estimated to annually offer protection worth USD $65 billion.[51] In addition, vegetation can reduce the risk of landslides (and soil erosion) during extreme precipitation events.[52] Nature helps to protect business activities as well, including the production and transport of goods. Beyond that, nature significantly contributes to global climate regulation by sequestering roughly 60 percent of global anthropogenic greenhouse-gas emissions and therefore indirectly helps to mitigate climate change.[53] More detail on the climate nexus is provided later in this section.

Even businesses that not which do not directly depend on nature can be indirectly dependent through their supply chain. Supply chain dependence occurs when a sector purchases inputs that not which directly depend on nature. Prominent examples of such downstream dependency are the food processing, apparel, and cosmetics sectors, which heavily rely on nature-based inputs from the agriculture sector (for example, rice, grains, shea butter, and cotton). For six purchasing industries – chemicals and materials; aviation, travel and tourism; real estate; mining and metals; supply chain and transport; and retail, consumer goods, and lifestyle – more than 50 percent of their supply chains' gross value-added (GVA) moderately or highly depends on nature.[54]

[48] (World Economic Forum, 2020)
[49] (Newman & Cragg, 2012)
[50] (IPBES, The assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services on pollinators, pollination and food production, 2016)
[51] (Menéndez, Losada, Torres-Ortega, Narayan, & Beck, 2020)
[52] (Renaud, Sudmeier-Rieux, & Estrella, 2013)
[53] (IPBES, Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019)
[54] (World Economic Forum, 2020)

Businesses activities can also negatively and positively impact nature's health and vitality – and hence its ability to provide ecosystem services. The IPBES has identified five key drivers of nature loss: changes in land and sea use, direct exploitation of organisms, climate change, pollution, and invasion of alien species. All five of these drivers are linked to various economic activities. Land-use change arguably has had the most negative impact: in 2019, 75 percent of land surface globally had already been significantly altered, and 66 percent of ocean areas are experiencing increasing, cumulative impacts. Between 2001 and 2020, 10 percent of global tree cover has been lost; roughly 30 percent of this loss has been driven by commodity demand (such as, palm oil, logging, mining) and is expected to be permanent.[55] . The degradation of nature predominantly affects the availability of supporting, regulating nature services. Habitat destruction and overuse of pesticides and herbicides have helped to bring 40 percent of insects under threat of extinction, which in turn threatens the availability of pollination services.[56] Moreover, worldwide, 20 percent of cropland, 16 percent of forest land, 19 percent of grassland, and 27 percent of rangeland show a decline in productivity due to water withdrawal and soil contamination, degradation, and erosion, which puts agriculture productivity at risk.[57] The clearing of mangroves for agriculture production and in particular aquaculture and the loss of coral reefs due to anthropogenic climate change have reduced protection from hurricanes and floods, putting 100 million to 200 million people at higher risk of experiencing severe impacts from hurricanes and floods.[58]

Nature-related risks and opportunities

Nature-related risks and opportunities arise from the dependency and impact of business activities on nature. More specifically, nature dependencies expose businesses to physical risks and opportunities, while nature impacts expose business activities to transition risks and opportunities.

Nature-related physical risks and opportunities are driven by dependencies and can be chronic or acute. Physical risk comes from two sources. First, the loss of natural inputs and nature services that enable production physically hinders companies from producing or buying primary inputs for production. Since these nature services only deteriorate because of long-term ecosystem shifts, the implied risk is chronic and materialises over time. Second, the loss of natural protection can cause material damages to companies' physical assets, critical infrastructure, and supply chains. The implied risk is acute, depending on the occurrence of natural disasters. For both sources of physical risk, a company's exposure is proportional to its dependency – that is, the share of production depending on certain natural commodities, or the share of production facilities located in coastal areas that are historically protected by coastal vegetation.

Nature-related transition risks and opportunities are driven by impacts and aspects of the transition to a nature-positive economy. Essentially, three key drivers prompt transition risk: new policies and regulation, innovation, and consumer shifts.

- **Nature policies and regulation.** As the deterioration of nature advances, policymakers and regulators are expected to implement new measures to support a shift towards more nature-positive outcomes. Nature-focused measures could potentially include the expansion of protected areas, the introduction of taxes on land- or pollution-intensive goods, or mandatory disclosure of a company's nature impacts. Such interventions will likely increase companies' cost of production and thus reduce their profitability. In extreme scenarios, companies might lose their license to operate. However, these shifts also create significant opportunities for businesses whose activities support nature.

[55] (Global Forest Watch, 2022)
[56] (Sánchez-Bayo & Wyckhuys, 2019)
[57] (UNCCD, 2017)
[58] (IPBES, Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019)

- **Disruptive innovations.** Companies will try to develop and deploy new, innovative technologies or business models that not which reduce their dependency or impact on nature. Successful innovations will create opportunities for disruptors, while other companies may be left behind.

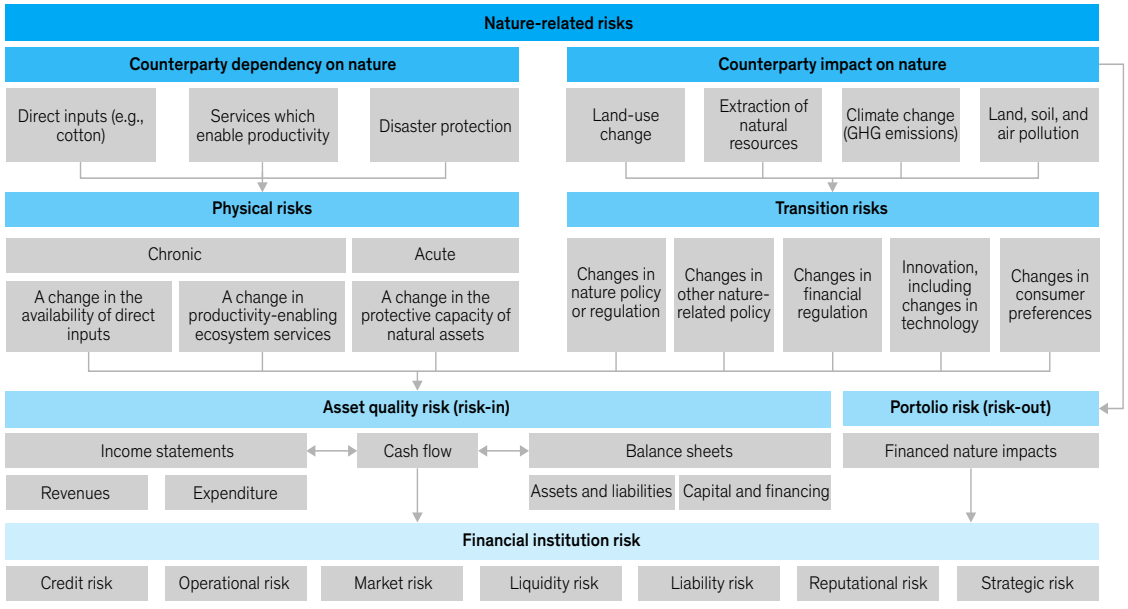
- **Consumer shifts.** Demand for nature-neutral or nature-positive products will grow as nature loss intensifies and awareness of nature's critical role in solving the climate crisis increases. Companies that harm nature may face reputational risk and lose market share, while those that can demonstrate that they are profitable but not harmful will have a competitive edge. These latter companies will be able to access high-growth markets for sustainable products.

Value of nature-related risk management for financial institutions and systems

Financial institutions can create value by effectively managing nature-related risk and opportunities in four ways: improving portfolio management, preparing for new policies and regulations, effectively managing their reputation, and adapting their commercial strategy. Exhibit 36 presents a transmission mechanism showing how a business's impacts and dependencies on nature can create financial risks and opportunities, and how these can then create financial risks and opportunities for financial institutions that lend to those businesses.

Exhibit 36

Counterparties' impacts and dependencies on nature can be translated to financial risks and opportunities through a transmission mechanism.



Source: Vivid Economics.

First, at the portfolio level, nature-related risk management can enable financial institutions to de-risk their portfolios. Independent of whether a financial institution generates revenues from financial investment, corporate lending, or insurance underwriting, the failure to sufficiently recognise counterparties' nature-related risk exposure will result in overvaluation. Investments will underperform, corporates will be more likely to default on their debt, and insurance premiums will be too low compared to actual claims. Moreover, financial institutions may face litigation risk from financing illicit harm to nature or insufficiently disclosing known nature-related risks, as they are beginning to experience with climate action.[59,60] Financial institutions can mitigate credit, operational, liquidity, and litigation risks by building up nature-related risk assessment capabilities and incorporating these into their investment, lending, and underwriting processes.

Second, financial institutions can minimise compliance costs and disruptions by preparing for regulatory requirements ahead of time. Financial regulators are paying more attention to nature-related risks. For example, the Dutch and French central banks have conducted their first nature stress tests, and the Network for Greening the Financial System (NGFS) is expected to soon develop nature-related scenarios. Drawing from this experience with climate action, it is reasonable to expect that nature-related risk assessments, disclosures, and stress-testing may become mandatory in the future. Getting ahead and building the relevant capabilities are essential to prepare for these emerging requirements and to avoid future operational disruptions.

Third, financial institutions should act on nature to mitigate the reputational risk that could result from client and shareholder pressure. As they did after the Paris Agreement, both shareholders and customers are increasingly pressuring financial institutions to align their operations with clear nature targets. Financial institutions that fail to act on their shareholders' and customers' expectations may incur less favourable terms of finance and loss of market share. Financial institutions that act early – by committing to meet established nature targets, for example – will have a better chance of avoiding reputational risk and may also build a strong, trusted brand profile that lends them a competitive edge.

Fourth, by aligning their activities with nature-positive impacts and offering products that cater to clients who are concerned about nature loss, financial institutions can seize new commercial opportunities. In the next few years, demand from retail and institutional investors for investment products with a positive impact on nature could increase substantially, as they did for HSBC Bank and its climate-related products. Banks and asset managers could grow their business by developing new and innovative nature-focused investment products. Some financial institutions have already developed nature-positive products such as the HSBC Pollination Fund and Mirova Natural Capital funds.

Nature-related risk management can also help support financial system stability. Because nature-related risks are systemic, crossing sectors and extending along supply chains, severe nature loss and nature-focused regulations could drive economic losses simultaneously in several sectors. Shocks to the real economy can spill over to the financial sector and create financial instability. This connection between nature-related risk and financial stability has been recognized by 66 members of Network for Greening the Financial System (NGFS), which emphasises that nature-related risks are 'therefore within the mandates of central banks and supervisors'.[61] Thus, financial supervisors and regulators can support financial stability by promoting nature-related risk management among financial institutions within their financial system and by incorporating nature-related risks into the micro- and macro-prudential oversight frameworks.

[59] In the latter case, financial institutions are typically protected by limited liability, and in some legal systems lenders are already restricted from financing projects that not which cause harm – as with the rules and precedents created by Brazil's National Environmental Policy Law, for example, together with jurisprudence from the Superior Court of Justice and the higher courts of the Brazilian states

[60] (Network for Greening the Financial System, 2021)

[61] (Network for Greening the Financial System, 2019)

[62] (Network for Greening the Financial System, 2019)

[63] Ibid

The climate-nature nexus

The planet's climate and nature systems are deeply interconnected, causing climate change and nature loss to reinforce and exacerbate one another. Climate change is a key driver of nature loss. For example, coral reefs, which are particularly vulnerable to increases in temperature, are projected to decline to 10 to 30 percent of former cover at 1.5°C warming and to less than 1 percent at 2°C warming.[62] At the same time, nature significantly contributes to global climate regulation. Marine and terrestrial ecosystems support climate regulation by sequestering roughly 60 percent of global anthropogenic greenhouse-gas emissions.[63] Thus, as global warming accelerates, nature loss will, too, which in turn will further contribute to climate change.

An integrated approach to climate and nature will lead to more accurate estimations of risk exposure and allow businesses to develop a consistent net-zero carbon and nature-positive transition strategy that captures synergies between climate and nature. An integrated framework has two key features:

- **Compounding climate- and nature-related risks.** Some nature- and climate-related risks overlap and are not simply additive. For instance, climate change increases the likelihood of coastal flooding, while nature loss decreases the availability of natural protection from flooding. Both effects jointly compound the risk exposure of coastal areas to flooding. The same applies to transition risks. For example, climate change contributes to the dieback of forest – independent of human-induced deforestation – which further accelerates climate change. Taken together, these two effects intensify the need for forest protection measures and therefore compound transition risk exposure related to nature-protection regulation. More broadly, when considering climate change and nature loss together, environmental degradation will occur at a quicker pace. This implies that we will also need a quicker transition.

- **Uncertainty about climate and nature pathways.** The future pathways of climate and nature are highly uncertain and depend on various external conditions – such as the speed of change in climate dynamics, the adaption of new technologies, and regulation. Scenario analysis is used to account for these uncertainties, with each scenario describing a plausible future pathway based on consistent assumptions about external drivers. Given the interconnection between climate and nature, it is both practical and necessary to integrate potential nature loss and potential nature policies into climate scenarios. Integrated scenarios can help ensure consistency between climate- and nature-related risk assessments.

Financial institutions and supervisors can deploy an integrated framework to assess and manage climate- and nature-related risks and opportunities. A joint framework allows climate and nature strategies to be aligned, climate and nature interactions to be effectively accounted for, and impacts to be assessed in aggregate. With an integrated framework, financial institutions and supervisors can leverage synergies and ensure the alignment of both assessments. The risk typologies (for example, physical, transition, and systemic risks) for climate and nature are similar, allowing for a smooth integration. A detailed proposal for an integrated framework can be found in a report by the Finance for Biodiversity (F4B) initiative, Towards an Integrated Transition Framework.[64]

[64] (Finance for Biodiversity Initiative, 2022)

Appendix 4: Evolving regulatory ecosystem

Following the example of TCFD, the Taskforce on Nature-related Financial Disclosures (TNFD) was formed in 2020 to develop a framework for assessing and acting on nature-related risks. After the 2008 financial crisis, banks were asked to disclose more fully their exposure to certain types of risks, and scenario-based stress-testing was introduced. As awareness of the materiality of climate-related risk grew, the TCFD was established in 2015 to 'help identify the information needed by investors, lenders, and insurance underwriters to appropriately assess and price climate-related risks and opportunities', as well as to provide a reporting framework for financial and non-financial institutions for climate-related disclosures.[65] Over time, the discourse about nature loss, its connection to climate change, and its impact on the global economy broadened. As a result, the TNFD was established to identify the information needed for financial institutions and companies to understand their dependency and impact on nature, as well as how nature loss will affect their short- and long-term financial performance. The scope of the TNFD includes living nature and elements related to living nature, such as air, soil, and water.

In the first quarter of 2022, the TNFD published its first 'beta' framework for reporting on nature-related risks. The TNFD will follow an open-innovation approach, moving quickly to engage the market with an outline of the proposed framework and then learning through feedback from, and iteration with, market participants. The beta framework includes:

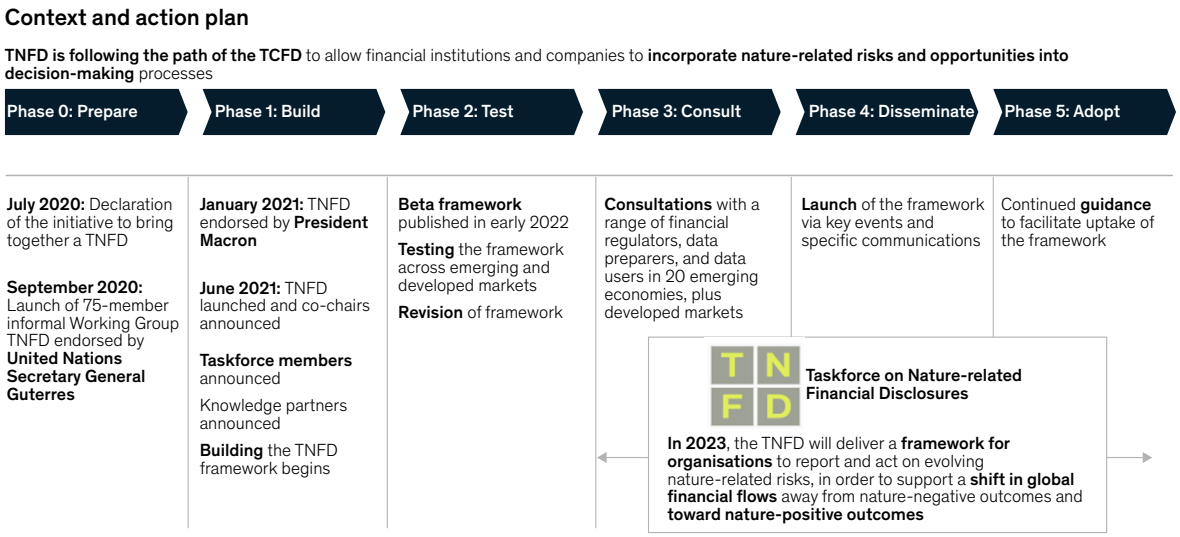
- An overview of the vision and aims of the framework
- TNFD's principles for a risk management and reporting framework
- Definitions and taxonomies relating to nature-related impacts, dependencies, and risks
- Core recommendations on what should be disclosed by reporting entities
- Guidance that takes the user on a 'how-to' journey from nature-related impacts and dependencies to risk and opportunity identification, with links to relevant third-party tools, guidance, and processes
- An overview of the framework's future development

According to the TNFD's workplan, the final nature-related disclosure framework can be expected in 2023. Following the recent publication of the TNFD beta framework, the TNFD will engage with financial institutions and corporations across geographies to promote the testing of the framework. Based on the insights received from the TNFD pilots, the framework will be updated. The testing phase will be followed by a shorter period of stakeholder consultations to gather further feedback and to ensure that the TNFD framework builds on recommended tools, measurement systems, and reporting protocols.

[65] (Taskforce on Climate-related Financial Disclosures, 2017)

Exhibit 37

The TNFD timeline aims towards a final disclosure framework publication in 2023.



Source: TNFD (Taskforce on Nature-related Financial Disclosures, 2021)

Like the TCFD framework, the TNFD framework is expected to be translated into standards and eventually embedded into regulations. The TNFD framework is the first step, providing initial guidance on how to identify and assess nature-related risks and opportunities and outline the information that should be disclosed so that investors and regulators can make more informed choices. Over time, the TNFD framework is expected to be translated into standards with practical, concrete, and granular details that can be verified by auditors. The beta framework already aligns with guidance from the IFRS International Sustainability Standards Board (ISSB). As has been the case for climate, emerging global standards for nature-related risk disclosure are expected to be adopted by local regulators and adapted for mandatory regulations.

While it is difficult to predict the exact timing, the TNFD framework is likely to be integrated into standards and regulations more quickly than the TCFD. Seven years passed between the inauguration of the TCFD in 2015 and the first national mandate for climate-related financial disclosure in the UK, as well as the first climate stress-test exercise by the European Central Bank. Given the interconnections between climate and nature and the fact that the TNFD, global standardsetters, and regulators can build on the experience gained from the TCFD process, it is reasonable to expect a considerably shorter timeline between the development of the TNFD framework and the first nature-related disclosure mandates.

Standard-setters and financial supervisors have already started their work on nature-related risks and opportunities. For example, The Global Reporting Initiative (GRI) published its first biodiversity standard (GRI 304) in 2016 and is expected to publish a revised version in 2022. The IFRS ISSB is expected to work on a global nature standard starting in 2023. The Climate Disclosure Standards Board (now part of the IRFS ISSB) launched guidance on how to assess and disclose biodiversity and water-related risks, including a list of impact drivers and example metrics. Moreover, the Science Based Target Network (SBTN) is revising its initial guidance for businesses on how to set nature targets. As mentioned above, some central banks are moving at a similar fast pace and developing nature-related stress-test capabilities. The Dutch and French central banks, for example, have highlighted the materiality of nature-related risks in their first stress-tests. The NGFS has also convened a study group to consider the links between nature loss and financial stability.

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