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XL Insurance Reinsurance

Nature Risk Insights

nature positive

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Foreword

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Nature Positive

Suzanne Scatliffe
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Nature and biodiversity loss is an underappreciated risk to economies and societies across the world. Natural capital is often treated as infinite and undervalued, despite ever-depleting species of flora and fauna and the increasingly unpredictable availability of natural resources.

As we are a global insurer and reinsurer, managing risk is the essence of what we do, and we work hard to provide solutions to our clients' most complex risks, including those resulting from the degradation of natural ecosystems. However, every company is at a different stage of the journey when it comes to assessing underappreciated risks, such as those related to nature.

Our focus on nature risks goes back to 2018, when we identified access to water as a material issue for many of the industries we serve. Our Future Water Risks study, published in 2021, identified ten key risks that threatened water quality and quantity and that crises come when a combination of these risks – even if moderate on their own – strike concurrently. Our Water Risk Insights Report in 2023 aimed to help businesses get started on identifying and mitigating physical and transition water-related risks to their operations. From here, we recognised that there was more we should do to create awareness and catalyze action on broader nature and biodiversity management.

The world must get better at appropriately valuing the many economic, social and environmental benefits of nature. This is why 'valuing nature' is one of the three pillars of AXA XL's Roots of Resilience Sustainability Strategy. Our goals focus on our products and services, our partnerships and our people through training and broader employee engagement. In 2023, to support Goal 1 of the Roots of Resilience, we undertook an assessment of our nature impacts and dependencies across our book of business. Through this work, we have learned more about key industries that have significant nature risks and opportunities and have begun educating our colleagues on how we can best support our clients in identifying these risks.

We know that almost all industries rely on nature to some degree, and at AXA XL we are committed to inspiring our clients and colleagues to put nature at the heart of their plans. We're pleased to partner with Nature Positive to bring this goal to life and are proud to co-author this report with its expert team. Our aim with this report is to take some of the lessons learned from our baseline nature assessment and help you better understand your company's relationship to nature so that your business – and the world around it – continues to thrive.

Foreword

AXA XL

Nature Positive

Dr. Richard Young
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Nature is in trouble. In the past 50 years, wildlife populations have, on average, declined by 73%. Most of the planet's wild grasslands and freshwater wetlands have been lost or heavily degraded, and one-third of our natural forests has been converted for human use. Today, one million species of animal, plant and fungus are estimated to be at risk of extinction.

These are deeply concerning trends in their own right – not least because nature's decline is causing major immediate impacts on many highly nature-reliant societies around the world – but this is also of material relevance to many businesses. Nature provides humanity with a myriad of essential services and benefits: clean water; climate stability; healthy soils; fiber; crop pollination; medicines; and spiritual and cultural values – the list is long. The continuing degradation of nature and biodiversity presents significant risks to business both now and in the future.

In 2022, world leaders, through the United Nations' Convention on Biological Diversity, agreed the Kunming-Montreal Global Biodiversity Framework. This commits signatories to halting and reversing biodiversity loss by 2030 and putting nature on a path to full recovery by 2050. Target 15 of this agreement is that "businesses assess, disclose and reduce biodiversity-related risks and negative impacts". For the first time, this clearly defines the role businesses need to play in the global response to the nature crisis.

We have seen pioneer businesses and corporate initiatives responding to the growing evidence that nature loss is a material risk. In October 2023, the Taskforce on Nature-related Financial Disclosures (TNFD) published its final recommendations. This guidance provides an essential framework and common language for the assessment and disclosure of nature risks and opportunities by corporates and financial institutions. The imperative for business to act on nature is becoming increasingly clear and urgent. However, nature is a highly complex topic and understanding its relevance to an individual business is clearly challenging. So where do we start?

Nature Positive Ltd was formed on the belief that it will be the influence, innovation and energy of businesses that can tackle the twin biodiversity and climate crises. We help companies understand their interaction with nature through the impacts and dependencies across their value chain. We are honoured to partner with AXA XL in the production of this report, combining our scientific and strategic expertise on nature and biodiversity with its market-leading position on business risk.

Our teams have worked together to develop a set of insights that are underpinned by comprehensive reviews of academic papers, industry reports and TNFD guidance. We also draw on our collective experience and knowledge from advising multinational corporates on nature issues to ensure these insights are of practical relevance.

This report is all about enabling businesses, and in particular risk managers, to make a start on their nature journey. Our aim is for you to understand how to begin identifying your nature-related risks and to start making a meaningful difference for nature and for your business.

Why read this report

Nature is in global decline, posing material risks to businesses. These risks can present themselves as physical risks (e.g. acute disruptions from extreme weather events or reducing material resource availability), transition risks (e.g. the development of new regulations that change operational or sourcing requirements), or reputation risks (e.g. negative publicity or lawsuits from environmental incidents).

To be resilient to the rapid and profound environmental changes occurring now and in the future, it's imperative businesses adequately value and manage the nature-related risks across their entire value chain. In this report, AXA XL and Nature Positive aim to support companies in integrating nature-related risks into their risk management strategy, by:

- Improving companies' understanding of nature-related risks for a select list of industries and how these risks might impact their operations.
- Showcasing actions that are already available to reduce negative impacts on nature and promote nature protection and restoration.
- Highlighting tools and practices to develop strategies to manage nature-related risks and opportunities.

Every business has unique impacts and dependencies on nature, and managing nature-related risks will require action and collaboration across a range of business functions and teams. Everyone has a role to play in managing nature-related risks. Some examples of key stakeholders in this process and what they can do with this report, include:

Risk managers can use this report to begin thinking about how their business may be at risk without access to these ecosystem services and develop risk mitigation strategies. It can also be used as a starting point for internal discussions around corporate sustainability goals, beyond annual sustainability reports.

Sustainability managers can use this report to build internal awareness of material nature and biodiversity topics and the implications of not addressing them.

Financial service professionals can use this report to educate themselves on how the industries they invest in or provide insurance cover for impact the environment, and potential risk mitigation products and services that may be able to support clients.

Nature and biodiversity are receiving unprecedented focus from governments, investors, civil society and communities. All trends point to nature following the same trajectory as carbon and climate change, from voluntary to mandatory nature-related data collection, strategy development, goal setting, and reporting in the near future.

It's never too early to start acting on nature risks and making your business more resilient.

Introduction

The world is experiencing a nature crisis, with one million of the estimated eight million species of plants and animals in the world at risk of extinction. Human activity is the root cause of this dangerous decline, as some 75% of the Earth's land surface has been significantly altered by human actions. Oceans are also undergoing alarming changes. For example, climate change is driving an increase in ocean acidification, which reduces seawater pH due to the absorption of carbon dioxide, driving loss in coastal and marine ecosystems [1].

How we impact nature affects how nature impacts us, as its loss affects human wellbeing, as well as the global economy. For example, mangroves act as natural flood defences, reducing annual property damage by about $65 billion and protecting more than 15 million people [2]. Urban green spaces have numerous benefits, including reducing urban heat island effects, mitigating storm water and lowering energy usage by shading buildings, with one study calculating the value of these ecosystems to be between $3,212 and $17,772 per hectare [3]. Additionally, if natural pollinators had to be replaced by artificial methods, an EU-funded study estimates that labour and technology costs would reach €153 billion per year [4].

Resilient ecosystems are the foundation of a resilient planet and society and are essential to our future. Biodiversity – the variety and variability of plant and animal life on Earth – provides the natural capital that results in the many ecosystem services that society relies on. However, the negative environmental impacts of that growth can undermine the long-term viability of today's economic models.

In addition, the nature and climate crises are interlinked. A changing climate is one of the five major drivers of biodiversity loss, and the loss of biodiversity increases climate-change-causing emissions through tree clearing or reducing an ecosystem's ability to sequester carbon.

This relationship creates additional risks to corporate operations, from heat stress to raw material availability. Yet nature and biodiversity are often undervalued or not considered at all, with only 5% of large businesses around the world assessing and disclosing their nature-related impacts [5]. According to the European Commission's Impact Assessment Study [6], investing to restore a wide range of natural ecosystems e.g. peatlands, forests and grasslands, would deliver a favourable benefit cost ratio of over 8:1. This demonstrates the value that nature can provide to society.

As this report intends to demonstrate, many important industries have both material impacts and dependencies on nature, contributing to the five drivers of biodiversity loss: climate change, pollution, land and sea use change, invasive species and the overexploitation of natural resources. These impacts come at a high cost to both the environment and the economy, for example, by reducing ecosystem productivity, increasing the number of pests and invasive species and increasing the likelihood of disease outbreaks.

About 50% of the world's GDP is moderately or highly dependent on nature [7], so disruption to direct operations or supply chains could be widespread across business sectors as diverse as agriculture, manufacturing and real estate.

Alongside the need to protect and restore nature to manage these risks, businesses are faced with increasing external pressures from regulators and stakeholders to show that they are assessing, reporting and acting on their nature-related dependencies, impacts, risks and opportunities. However, some companies are already taking action – more than 1400 businesses representing $7 trillion have signed on to Business for Nature's Call to Action. More than 500 organizations worldwide have publicly committed to disclose their nature risks aligned with the Taskforce on Nature-related Financial Disclosures (TNFD) recommendations, and these disclosures are structured around the four pillars of governance, strategy, risk and impact management and metrics and targets. There are also numerous local and industry-specific requirements and standards, such as the EU's Deforestation Regulation, with regulatory scrutiny of companies' nature-related impacts likely to increase in the years to come.

In addition, stakeholders, including colleagues, customers, shareholders and suppliers, are placing more emphasis on the nature-related impacts and dependencies of the companies they trade with, work for and buy from. For example, as of August 2024, more than 220 institutional investors have joined Nature Action 100, representing more than $30 trillion in assets under management or advice, to support greater corporate ambition and action around nature loss.

What are the key drivers for companies to address nature risks?

Risk reduction	Climate intersections	Stakeholder expectations	Reporting frameworks
■ Nature loss endangers ecosystem services that society and businesses depend on. ■ Healthy environments provide resilience benefits for supply chains, operations, employees, and customer behaviours.	■ Nature provides carbon sinks and sequestration, as well as wider benefits such as shade in heat-stressed locations. ■ Climate change is one of the five major contributors to nature loss.	■ Wide range of companies committing to nature related targets. ■ Increase in climate litigation.	■ EU mandated Corporate Sustainability Reporting Directive, impacting companies across multiple sectors, includes a section on biodiversity and ecosystems. ■ More than 500 companies committing to reporting in line with the TNFD, a voluntary disclosure framework.

Key terms

This report will use various key terms throughout, including the following:

- **Nature:** The natural world, including both living components, such as animals and plants, and non-living elements, such as rivers, seas and deserts.
- **Biodiversity:** The variability among living organisms across ecosystems and ecological complexes. This includes variation in genetics and phylogenetic and functional attributes, as well as diversity within and among species, in biological communities and across ecosystems.
- **Ecosystem services:** The direct and indirect benefits that people obtain from ecosystems. This can include provisioning services, such as food and water supplies; regulating services, such as flood and disease control; cultural services, such as spiritual and recreational benefits; and supporting services that maintain conditions for life on Earth, such as nutrient cycles that transfer energy and matter between living organisms and non-living parts of the environment.
- **Dependencies:** Aspects of ecosystem services that organisations or individuals rely on to function. A business's dependency on ecosystems may be direct or through its supply chain. Risks associated with dependencies are highly material where the production operations of a business cannot continue in a financially viable way without those ecosystem services.
- **Impacts:** Interchangeably referred to as pressures, impacts are the direct drivers of global biodiversity loss. There are five widely recognized biodiversity loss drivers that arise because of human activity: land, water and sea use change; resource depletion; pollution; climate change; and an increase in invasive species and disturbance.

The intersection of insurance and nature

There is a clear interdependency between businesses and nature. The insurance industry has an important role to play in helping businesses identify and manage nature-related risks, ultimately building a more nature-positive economy.

The United Nations Environment Programme Finance Initiative (UNEP FI), a UN-convened network of banks, insurers and investors that aims to accelerate sustainable development, defines nature-positive insurance as "risk management and insurance strategies, approaches, practices, products, services and solutions that address nature-related dependencies, impacts, risks and opportunities… to actively contribute to achieving the mission of the Kunming-Montreal Global Biodiversity Framework".

UNEP FI's report *Nature-Positive Insurance: Evolving Thinking and Practices* [8] outlines the role that insurers can play and articulates approaches to advance nature-positive insurance, including:

- embedding nature in risk management frameworks; and setting underwriting criteria and guidelines
- collaborating with key stakeholders, including through engaging with clients and potential clients
- offering sustainable claims options and developing; insurance products and solutions
- disclosing nature-related risks.

Industries

The sectors highlighted in this report were selected for their economic importance as well as their relationship with nature. However, this list of industries is not exhaustive, and it is highly likely that any industry or company would benefit from assessing its own nature risks. In addition, the materiality of these topics will vary by organization, so industry responses and opportunities listed in this report should be considered a starting menu of ideas.

Aquaculture

Mining and metals

Chemicals

Renewable energy generation

Construction materials

Textiles, apparel and fashion

Food, drink and agriculture

Aquaculture

Industry overview

"Aquaculture, or aquatic agriculture, is the cultivation of fish, crustaceans, aquatic plants, algae and shellfish in water environments" [9]. The aquaculture industry is broadly divided into three main categories: finfish (e.g. salmon or tuna), molluscs (e.g. shellfish), and crustaceans (e.g. shrimp).

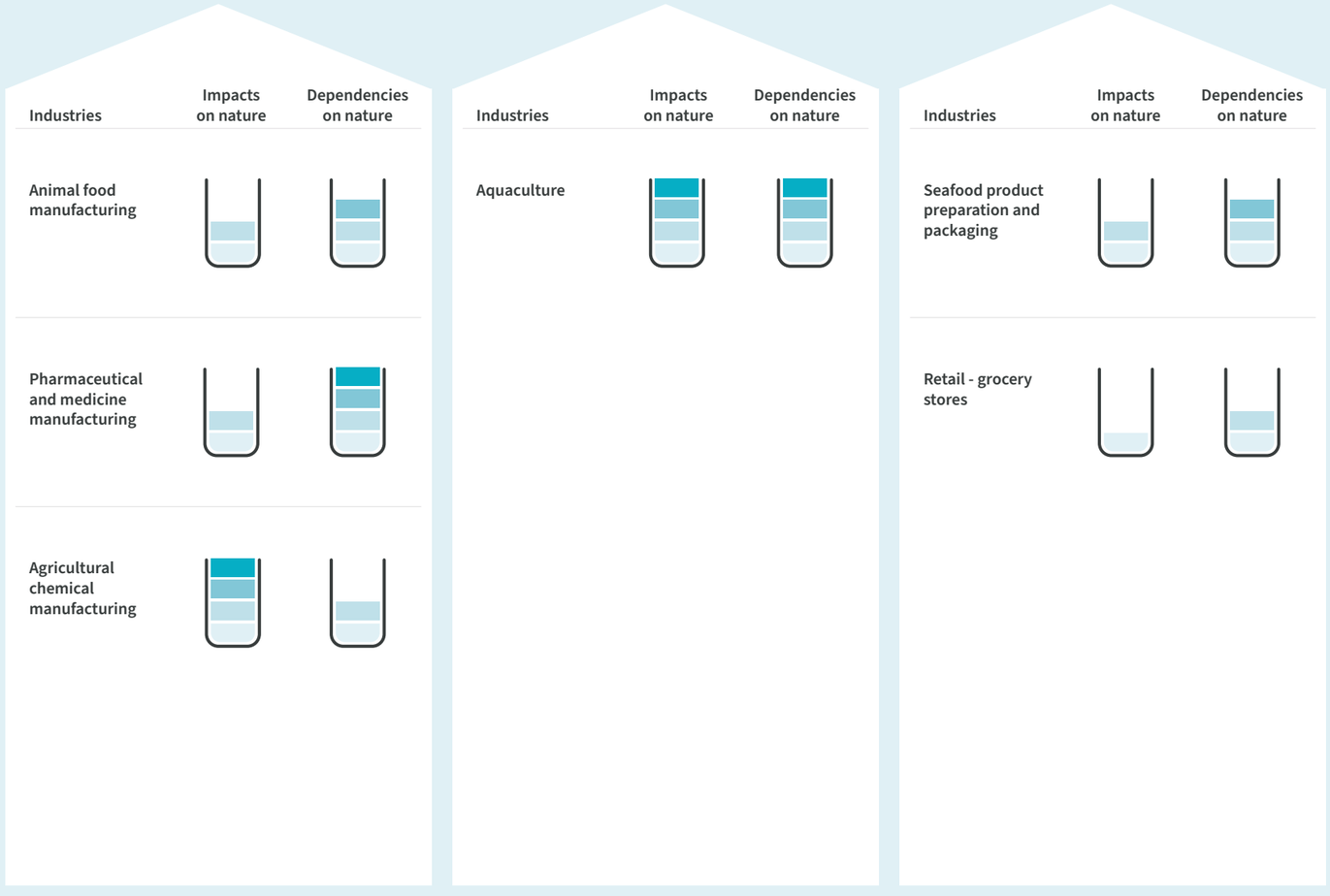
Seafood is one of the most important sources of protein worldwide, with roughly half produced through aquaculture [10], the fastest growing food production industry globally. The productivity, and ultimately commercial performance, of fish farms and other aquaculture operations is reliant on healthy ecosystems. Geographically, aquaculture is heavily concentrated in the Asia-Pacific region: more than 70% of production is based in China, followed by Indonesia (approximately 15%) and India (approximately 9%). Aquaculture has also been expanding in other countries, such as Chile and Norway [10]. A review of global aquaculture operations over the past 20 years highlights key environmental trends, including major efficiency improvements in aquaculture feeding and nutrition; increasing recognition of ecosystem service provision by mollusc and seaweed cultures; disease management remaining a sustainability challenge; and the effects of climate change on aquaculture remaining uncertain [11].

Aquaculture and nature

Aquaculture is highly dependent on ecosystem services and natural resources to operate, such as clean water access, healthy oxygen levels, feed inputs (either from fishmeal or arable crops) and the right climatic conditions and temperatures [12]. In particular, the industry is facing increasing risks due to warming oceans; in Scotland, government data reported 17 million farmed salmon deaths in 2023, with producers blaming warmer oceans [13].

The growing scale and intensity of aquaculture is resulting in a larger environmental footprint with a range of impacts on nature. These include the destruction of ecosystems, such as the deforestation of mangrove forests to make way for shrimp farms [14]. High nitrogen waste emerging from fish farms leads to eutrophication and blooms of toxic microalgae e.g., red tides [14] in marine and freshwater habitats, and potentially adjacent terrestrial habitats. In addition, when artificial lighting is used in aquaculture operations, this can cause light level changes throughout the water column, resulting in a range of uncontrolled effects on important biological processes [15]. Aquaculture can also enable the spread of disease and invasive species. For example, salmon aquaculture, in particular, can elevate the incidence of sea lice in wild populations [13]. Accidental releases of non-native fish from farms can potentially lead to the establishment and spread of invasive species.

Aquaculture value chain



Value chain graphic key: Very high | High | Medium | Low

A growing demand for fishmeal, as an ingredient in livestock and aquaculture feeds, has led to the rapid development of the industry in sub-Saharan African countries, and there are concerns about unsustainable harvesting of fish stocks in the eastern Atlantic, with knock-on effects on West African fisheries [16]. However, some forms of aquaculture can have positive impacts on nature. For example, aquaculture farming of oysters, mussels, scallops and clams removes nutrients (phosphorous and nitrogen) from the ambient environment, as well as providing habitat structure, and supporting shoreline stabilization [11].

Industry response

A range of national and international organizations are focused on combatting environmental issues and mitigating impacts associated with aquaculture. For example, combating algal blooms are being addressed by the Global Harmful Algal Blooms ***(GlobalHAB)*** programme, to understand and predict harmful algal blooms in aquatic ecosystems and to learn how to manage and mitigate their impacts [17]. ***The Aquaculture Stewardship Council*** runs a certification programme for responsibly farmed seafood, to encourage improved environmental stewardship, including sets of standards for farms, feed and chains of custody [18].

Technological developments are also emerging to minimize the impact of aquaculture wastewater. For example, treatment mechanisms are being implemented, with recirculation aquaculture systems (a closed system that recirculates clean water) currently being the most extensively implemented. Other advances include biological treatment using wetlands or algae to purify and separate waste streams [19].

The Nature Conservancy has developed ***Global Principles of Restorative Aquaculture*** [20]. This guidance sets out principles for on aquaculture systems, particularly shellfish and seaweed mariculture, which can lead to the delivery of environmental improvements. This document provides guidance to determine the likelihood of different environmental outcomes, such as carbon sequestration or nutrient removal, from an aquaculture operation.

Key business risks

Aquaculture and the businesses within the value chain are exposed to a range of nature-related risks and opportunities, summarized in the table below.

Risk & opportunity category		Nature-related risk or opportunity	Examples and impacts
Physical Risk	**Acute**	Increased fish mortality and morbidity due to parasites and increased antimicrobial resistance.	Increase in illnesses to reared aquatic animals due to quickly adapting parasites. Higher mortalities at warmer temperatures [21]. Higher operating and medicine costs and reduced food security.
	Chronic	Species loss and degradation due to soil, water and ocean contamination caused by aquaculture operations.	Acute and chronic pollution of waterways causes eutrophication and reduces production output and profits.
Transition Risk	**Policy and legal**	Changes to policy or legislation aimed at achieving nature-positive outcomes and targets affect certain types of aquaculture farming.	Country-specific legislation to ban certain types of aquaculture farming (e.g., open net pen salmon farming) results in unviable operations or significant investment to transform to closed loop systems.
	Reputational risk	Shifts in consumer sentiment towards operations or brand as a result of poor nature management or one-off pollution or escape events.	Increasing scrutiny by non-governmental organisations and scientific community leads to communications that damage brand and could affect share prices, market share and profits.
Opportunities	**Resource efficiency**	Improvements, enabled by monitoring and data analysis, lead to resource efficiency and reduced inputs.	More efficient operations, reduced operating costs and improved environmental performance.
	New markets access	Access to new markets.	Sustainable certification of products (e.g., Aquaculture Stewardship Council) gives access to new market segments, potentially increasing business resilience, market share and revenues.

Sector impacts and dependencies in detail

Table key: Very high | High | Medium | Low | Very low

			Animal food manufacturing	Pharmaceutical and medicine manufacturing	Agricultural chemical manufacturing	Aquaculture
Impacts	Land-sea-water use change	Area of freshwater use	High	Low	Medium	Very high
		Area of land use	High	Low	High	High
		Area of seabed use	Medium	Low	Medium	Very high
	Climate change	GHG emissions	Very high	High	Very high	Very high
	Pollution	Solid waste	High	High	Medium	High
		Soil pollutants	Medium	High	High	High
		Water pollutants	High	High	Medium	High
		Non-GHG air pollutants	Medium	Medium	High	Low
	Resource extraction	Water use	High	High	High	Medium
		Other resource use	Low	Low	Low	High
	Disturbance and invasive species	Light & noise pollution	Low	Low	Medium	Medium
		Invasive species introductions	Low	Medium	Low	Medium
Dependencies	Provisioning ecosystem services	Surface & ground water	Very high	High	Low	Very high
		Natural materials & fibres	Low	Medium	Low	Medium
	Regulating & maintaining ecosystem services	Water flow maintenance	Medium	Medium	Low	High
		Water quality	Medium	Low	Low	Very high
		Flood and storm protection	Medium	Low	Medium	High
		Land stabilisation & erosion control	Low	Low	Low	High
		Soil quality	Low	Low	Low	Medium
		Climate regulation	Low	Low	Low	Very high
		Pollination	Low	Low	Low	Low
		Filtering & cleaning pollutants	Low	Low	Low	Medium
		Disease control	Low	Low	Low	Medium
		Pest control	Low	Low	Low	Medium

Note: Some of the standard ecosystem services categories are aggregated together for ease of presentation.

Chemicals

Industry overview

The chemical industry converts raw materials, such as oil, metals, minerals and feedstocks, into more than 70,000 diverse products, with a range of industrial, pharmaceutical, agricultural, housing, automotive and consumer applications [22,23].

The chemical industry plays a vital role in everyday life, with approximately 80,000 chemicals in societal use today [24]. The industry is expanding globally, with production expected to triple by 2050 compared with 2010 [25].

The chemical industry can be broadly divided into five segments. First, there are basic chemicals, also known as commodity or bulk chemicals. These are the foundational raw materials required to manufacture intermediates and speciality chemicals and can be further classified into organic (petrochemicals) and inorganic chemicals (chlorine or soda ash). Speciality chemicals are then used to provide performance or function to applications. The remaining three segments are agrochemicals (fertilisers and pesticides), plastic chemicals (plastic materials, resins and synthetic fibres) and consumer products (soaps, detergents, cleaners, toiletries and cosmetics).

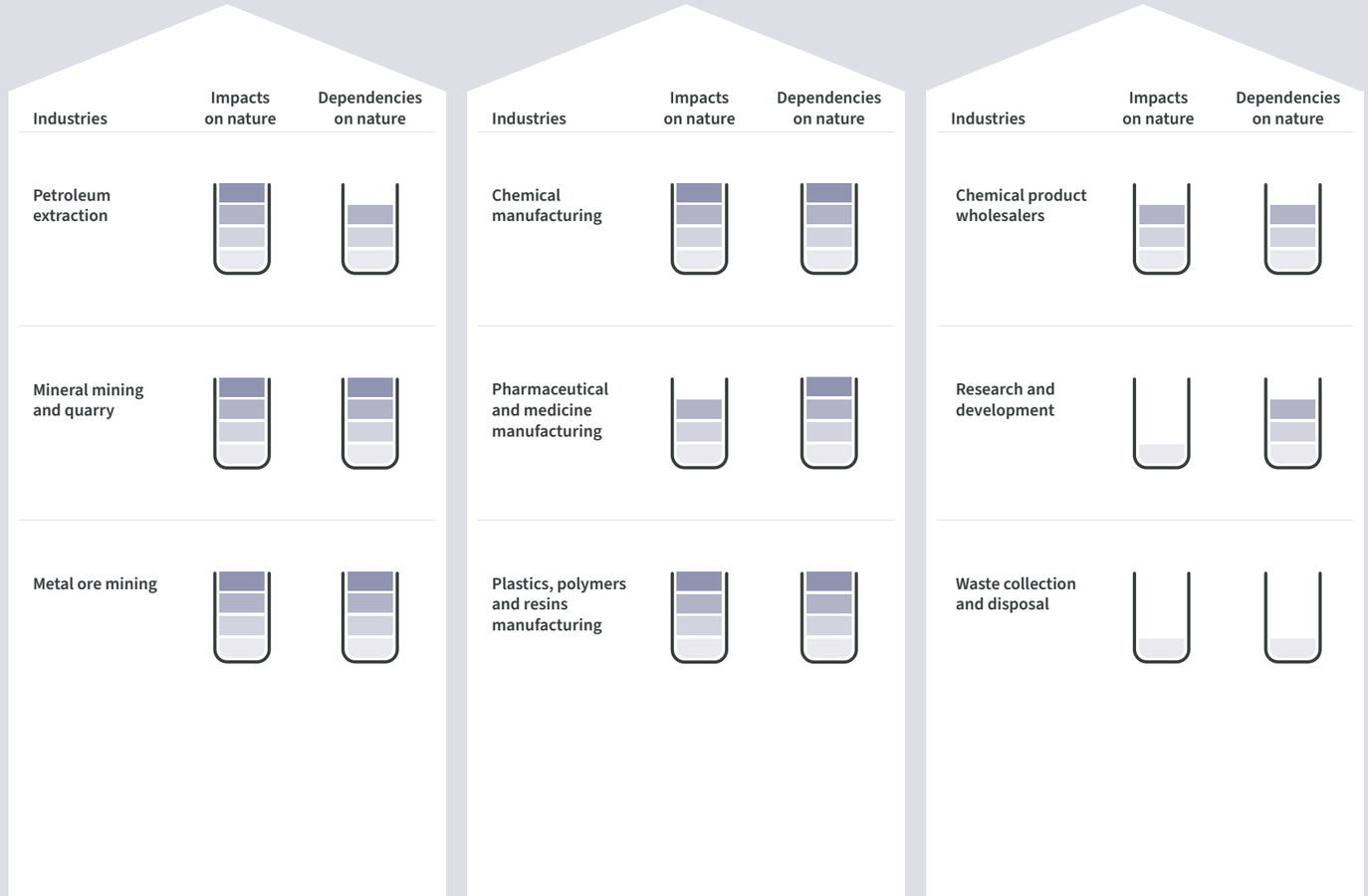
Chemical organizations often operate on a global scale, manufacturing and distributing products worldwide [23]. However, the globalization of the industry has led to an increase in chemical contamination incidents in low- and middle-income countries, where there are varying environmental regulations, as businesses relocated to these regions due to lower production costs [26]. However, the attractiveness of these countries has reduced as labour costs have increased markedly over recent years.

Chemicals and nature

Chemical sector organizations are heavily reliant on environmental assets and ecosystem services for their operations [27]. The sector is dependent on reliable supplies of fresh water, accounting for 5–10% of global freshwater use [27]. The industry withdraws large volumes of water for manufacturing processes, such as heating, cooling, rinsing and distillation, and relies on mined minerals, such as platinum and palladium [23, 27, 28]. To reduce dependencies on finite resources, the chemical sector is shifting towards bio-based feedstocks, such as Miscanthus, for use in the production phase of various metals and chemicals, but this raises concerns about monoculture crop production, its adverse effects on nature and increased water reliance [23, 27, 29].

Chemical pollution is considered one of the primary drivers of biodiversity loss [30]. Anthropogenic chemicals enter the environment from various sources, including pesticides, pharmaceuticals and chemicals from plastics and fibres. Perfluoroalkyl and polyfluoroalkyl substances (PFAS), also known as forever chemicals, are a group of about 10,000 synthetic

Chemical value chain



chemicals of particular concern [25,31]. Once released, they can disperse widely and accumulate because of their resistance to degradation, impacting natural ecosystems and causing adverse health effects on wildlife and humans [32,33].

Chemical manufacturing plants can release pollutants and harmful substances into the environment [34]. For example, the discharge of effluents into wastewater streams impacts aquatic environments, causing localized pollution and contaminating nearby soils with heavy metals [28,35,36].

The chemical sector also contributes to significant downstream nature-related impacts, with synthetic fertilizers causing nitrogen pollution in fresh water and soil degradation [37,38]. Up to 30% of applied nitrogen fertilizer leaches through the soil profile into downstream waterbodies, degrading water quality and leading to eutrophication, which can suffocate aquatic life [37,39,40]. Improper disposal of pharmaceuticals leads to chemicals entering landfill leachate or domestic wastewater, affecting wildlife through contaminated water and prey [35,36]. Chemical pollution also significantly impacts marine ecosystems, with 60% of marine mammals threatened by accumulating contaminants such as polychlorinated biphenyls (PCB), pharmaceutical wastes, heavy metals and pollutants over their lifetime [41].

Industry responses

The World Economic Forum has prepared a ***chemicals insights*** report for the sector on how it can contribute to a nature-positive future. The report identifies five priority actions for chemical sector organizations to preserve nature: improving manufacturing efficiency; improving water stewardship, sourcing responsibly; supporting nature conservation; and reducing pollution risk through circularity and customer education [27].

Collaboration across the chemical industry has also increased. Examples of business coalitions include the ***International Council of Chemical Associations*** (ICCA), which encourages the responsible management of chemicals throughout their life cycle, and the ***Together for Sustainability*** (TfS) initiative, which promotes sustainable supply chains [27].

Various guidelines have also been developed, such as the ***Safe and Sustainable by Design*** (SSbD) framework by the EU Joint Research Centre, which is a voluntary approach to guide the innovation process for chemicals and materials [42]. It aims to steer the substitution and minimization of substances of concern and minimize the impact of chemicals on health, climate and the environment. The World Business Council for Sustainable Development (WBCSD) has developed a ***SDG Roadmap*** for the chemical sector [43]. This provides key actions for the industry to enhance its contribution to the SDGs leading up to 2030 and helps identify potential opportunities for collaboration.

Key business risks

The chemical industry and the businesses within the value chain are exposed to a range of nature-related risks and opportunities, summarized in the table below.

Risk & opportunity category		Nature-related risk or opportunity	Examples and impacts
Physical Risk	**Acute**	Damage or interruptions to operations from extreme events (e.g., landslides and flooding or acute drought events).	Increased instances of extreme weather events increase operational downtime and costs of repairs, which could lead to increased insurance costs and decline in value of business assets. Damage to chemical storage facilities could lead to leaks of hazardous materials into the environment.
	Chronic	Changes in the ability of ecosystem services to operate effectively, such as reductions in water supply.	Reductions in water supply can cause increased operational costs or changes in reduction capacity owing to competing demands for water in production cycle.
Transition Risk	**Policy and legal**	Changes to policy and legislation to stricter environmental regulation. Lawsuits, litigation or claims for damage to nature when incidents occur in operations.	Legislation requiring companies to manage the end-of-life impact of their products can have financial and operational costs; existing examples include the EU's Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Regulation and the Stockholm Convention on Persistent Organic Pollutants. Microplastics and PFAS are examples of topics that may be affected by future or changing legislation.
	Reputational risk	Divestments or negative publicity and divestments due to environmental incidents, violations of environmental laws or legal action.	The impacts from environmental incidents such as chemical spills can affect both ecosystems and communities, creating significant public and government backlash.
Opportunities	**Resource efficiency**	Reduced use of resources, reduced waste or developing closed loop systems to maximize resource efficiency.	Improving resource efficiency is associated with increased productivity and higher margins.
	New markets access	Developing alternative products that are safer for the environment would enable access to new markets and could increase market share.	An example of this might be the shift away from the use of volatile organic compounds (VOC) in paint products, with many products being advertised as containing no or low VOCs.

Sector impacts and dependencies in detail

Table key: Very high | High | Medium | Low | Very low

			Petroleum extraction	Chemical manufacturing	Pharmaceutical and medicine manufacturing	Rubber and plastic manufacturing
Impacts	Land-sea-water use change	Area of freshwater use	High	Medium	Low	Medium
		Area of land use	Very high	High	Low	High
		Area of seabed use	High	Medium	Low	Medium
	Climate change	GHG emissions	Very high	Very high	High	Very high
	Pollution	Solid waste	High	High	High	High
		Soil pollutants	High	High	High	High
		Water pollutants	High	High	High	High
		Non-GHG air pollutants	High	High	Medium	High
	Resource extraction	Water use	Very high	Very high	High	High
		Other resource use	Low	Low	Low	Low
	Disturbance and invasive species	Light & noise pollution	High	High	Low	High
		Invasive species introductions	Medium	Low	Medium	Low
Dependencies	Provisioning ecosystem services	Surface & ground water	High	High	High	High
		Natural materials & fibres	Low	Low	Medium	Low
	Regulating & maintaining ecosystem services	Water flow maintenance	High	Medium	Medium	Medium
		Water quality	Low	Low	Low	Low
		Flood and storm protection	Medium	Medium	Low	Medium
		Land stabilisation & erosion control	Medium	Low	Low	Low
		Soil quality	Low	Low	Low	Low
		Climate regulation	High	Low	Low	Low
		Pollination	Low	Low	Low	Low
		Filtering & cleaning pollutants	Low	Low	Low	Low
		Disease control	Low	Low	Low	Low
		Pest control	Low	Low	Low	Low

Note: Some of the standard ecosystem services categories are aggregated together for ease of presentation.

Construction materials

Industry overview

Construction materials for buildings, infrastructure and other structures are predominantly composed of naturally occurring substances such as minerals, fibres, metals, sands and stone.

The construction industry is crucial for global economic and social development [44]. A rising global population means the industry faces increasing pressure to meet housing and other built infrastructure demands [45]. Construction materials include minerals (e.g., sand and clay), petroleum products (e.g., plastics and synthetic rubber) and forestry products (e.g., timber). Petroleum products are derived from crude oil reserves. Following extraction, materials undergo a series of processing and refinement steps, such as grinding, washing and chemical treatment, forming products such as cement, concrete, glass and plastic materials [46,47].

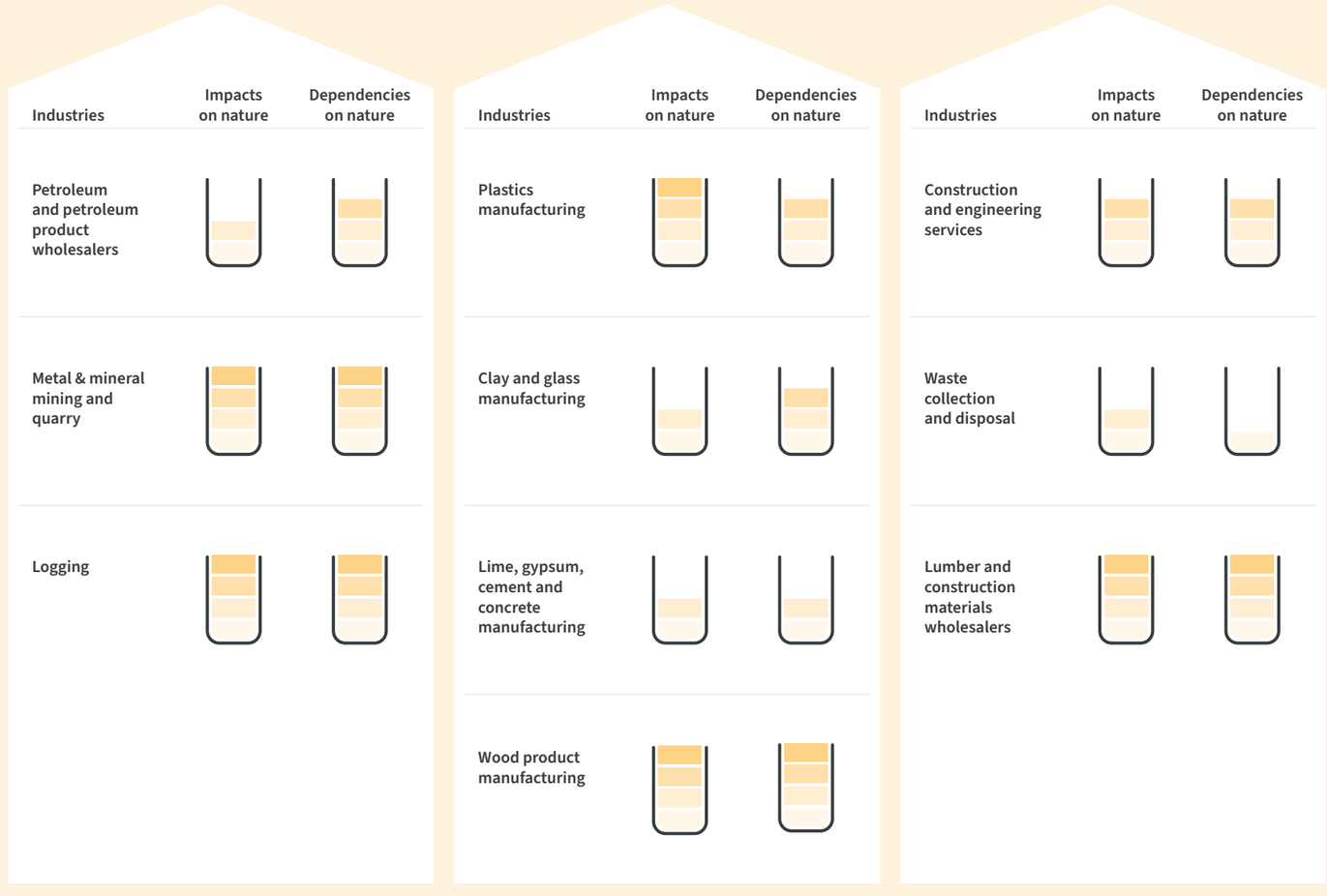
Construction materials and nature

The extraction and processing of construction materials rely heavily on ecosystem services and consume significant energy, natural resources and water, accounting for 34% of global energy demand in 2022 [48], more than 50% of the EU's extracted materials and 30% of the EU's water consumption [49]. Stable climate patterns and healthy vegetated soils are crucial for operational continuity and site safety [28, 50]. The sourcing of timber products in construction is clearly reliant on natural forests and plantations but is also highly exposed to disruption in a range of ecosystem services, such as healthy soils and the maintenance of water flows.

Sourcing, processing and manufacturing construction materials contribute significantly to pollution (air, water and noise), habitat degradation and natural resource depletion. Buildings are a significant contributor to global carbon emissions, with building materials alone responsible for 11% of global emissions [51]. The construction industry also generates more than 25% of global waste [52].

The development of mining and quarrying sites requires land clearance, which damages local habitats and disrupts connectivity between ecosystems [28, 47]. Moreover, water discharges from quarry sites can be acidic and may contain heavy metals and other pollutants, posing health risks to local species, habitats, and communities [47,50]. Quarrying activities threaten unique ecosystems that support a diversity of endemic flora and fauna, particularly in Asia [10, 53, 54]. Construction materials and the manufacturing processes explored in this section include minerals, timber products, ceramics and plastics and their associated products.

Construction materials value chain



The use of timber in construction has surged in recent years, driven in part by sector-wide efforts to decarbonize. Unsustainable harvesting of natural and semi-natural forests and the establishment of forestry plantations can generate a range of impacts on nature, including the loss and fragmentation of habitats, decline in wildlife populations, soil erosion and the disruption of local water cycles leading to droughts or flooding. Monoculture forestry plantations, particularly of non-native tree species, tend to support lower levels of biodiversity compared with natural forests and prevent the regeneration of native habitats. Sand is a staple construction material and the second-most-used commodity in the world after water; however, world sand reserves are being depleted at an alarming rate. Sand mining from rivers and marine ecosystems causes erosion, leading to physical changes to river and coastal landscapes and potential species loss [55].

Industry responses

The construction materials industry has developed sustainable sourcing practices to improve resource efficiency, reduce waste and develop innovative material technologies. Recent increases in environmental regulations target specific issues such as deforestation (e.g., the EU Deforestation Regulation) and support the promotion of a circular economy framework (e.g., China's Circular Economy Plan). Adopting circular economy principles, such as material reuse, can significantly reduce the life cycle impacts of construction materials. ***The 'Circular Buildings Toolkit'*** is an example of a tool to help apply these principles.

In addition, alternative construction materials, such as recycled plastic, high-recycled-content electric arc furnace (EAF) steel and bio-based materials (such as mass timber), have garnered increasing attention for their potential to reduce resource extraction, embodied emissions, pollution, and waste while maintaining structural durability. Sustainable procurement practices, including the use of sustainability-certified materials, such as ***Forest Stewardship Council*** (FSC) certified timber, can also contribute to a lower environmental footprint [56].

To help buyers understand the impact of these materials, manufacturers can issue environmental product declarations (EPD) to report the environmental impacts of their products. This is based on a comprehensive life cycle assessment (LCA) that evaluates impacts from production through to disposal and can be used to inform product-related decision-making.

Finding solutions to construction material challenges and risks requires ongoing industry collaboration, and consideration of key drivers towards sustainable construction materials (including regulation, tenant demand, or corporate sustainability goals). Solutions need to be appraised in the context of each project and balanced against feasibility and viability considerations. Available toolkits to learn more include the World Business Council for Sustainable Development ***(WBCSD) Roadmap to Nature Positive Foundations for the built environment system***, the Forum for Circular Infrastructure the ***Forum for Circular Infrastructure*** and a ***knowledge hub*** developed by the UK Green Building Council (UKGBC), which explores the global ecological impacts of building materials.

Key business risks and opportunities

The construction materials industry and the businesses within the value chain are exposed to a range of nature-related risks and opportunities, summarized in the table below.

Risk & opportunity category		Nature-related risk or opportunity	Examples and impacts
Physical Risk	**Acute**	Increased risk of damage to infrastructure or interruption of manufacturing operations from floods, storms, wildfires, and other extreme weather events as a result of climate change and nature loss.	Extreme weather events could cause infrastructure damage, shipping delays or resource shortages, leading to operation and/or supply chain disruptions and an increase in insurance costs.
	Chronic	Declining water and raw material supply due to unsustainable use.	Declining material supply disrupts operations and reduces the value of business assets. Reduction in water supply can cause increased operational costs.
Transition Risk	**Policy and legal**	Changes to policy and legislation aimed at achieving nature-positive outcomes will create more protected areas, leading to a reduction in available sites for quarrying. Remote areas where remaining reserves are located may face increased restrictions on access.	Increased costs of damage payouts; costs of additional habitat regeneration supporting no-net-loss or nature-positive initiatives; increased time frames for new projects and land access; loss of operating area due to collective land rights claims.
	Reputational risk	Shifts in sentiment towards organizations due to competition for natural resources, impact on nature and/or failure to fulfil stakeholder expectations (e.g., rehabilitation expectations).	Operational interruptions arising from nature protection activity or conflicts with communities. Organizations could face revenue reductions because of reduced brand value.
Opportunities	**Resource efficiency**	Reduced water consumption by using dry process kilns; using agro-based construction materials; selective logging to allow natural regeneration.	Reduction in water management and treatment costs; cost reductions through reuse and repurposing of waste into alternative products.
	New markets access	Access to emerging natural capital markets.	Sustainable certification of products (e.g., FSC and Programme for the Endorsement of Forest Certification) opens access to new markets, contributing to revenue increases and business growth.

Sector impacts and dependencies in detail

Table key: Very high | High | Medium | Low | Very low

			Metal and mineral mining and quarrying	Logging	Clay and glass manufacturing	Lime, gypsum, cement and concrete manufacturing	Wood product manufacturing	Plastic product manufacturing
Impacts	Land-sea-water use change	Area of freshwater use	High	Medium	High	Medium	Medium	Medium
		Area of land use	Very high	Very high	Very high	High	Very high	High
		Area of seabed use	High	Medium	High	Medium	Medium	Medium
	Climate change	GHG emissions	Very high	Very high	Very high	Very high	Very high	Very high
	Pollution	Solid waste	High	High	High	High	High	High
		Soil pollutants	High	High	Medium	High	High	High
		Water pollutants	High	High	High	High	High	High
		Non-GHG air pollutants	High	High	High	High	High	High
	Resource extraction	Water use	Very high	High	Very high	High	High	High
		Other resource use	Low	Low	Low	Low	Low	Low
	Disturbance and invasive species	Light & noise pollution	High	High	High	Medium	High	Medium
		Invasive species introductions	Medium	Low	Low	Low	Low	Low
Dependencies	Provisioning ecosystem services	Surface & ground water	High	Very high	Very high	Very high	Very high	High
		Natural materials & fibres	Low	High	Low	Low	High	Low
	Regulating & maintaining ecosystem services	Water flow maintenance	High	Very high	Medium	Low	Very high	Low
		Water quality	Low	Low	Low	Low	Low	Low
		Flood and storm protection	Medium	Very high	Low	Low	Very high	Medium
		Land stabilisation & erosion control	Medium	Very high	Low	Low	Low	Low
		Soil quality	Low	High	Low	Low	High	Low
		Climate regulation	High	Very high	Low	Low	Very high	Low
		Pollination	Low	High	Low	Low	High	Low
		Filtering & cleaning pollutants	Low	Low	Low	Low	Low	Low
		Disease control	Low	Very high	Low	Low	Very high	Low
		Pest control	Low	Very high	Low	Low	Very high	Low

Note: Some of the standard ecosystem services categories are aggregated together for ease of presentation.

Food, drink and agriculture

Industry overview

The food, drink and agriculture industry produces a large range of primary agricultural products and processed foods and drinks contributing to feeding most of the world population [57].

The food, drink and agriculture industry accounts for 4% of global economic activity and up to 25% in low- and middle-income countries [58]. Currently, 50% of the world's habitable land is used for growing crops and animal husbandry to meet demand [59].

Food production is the leading cause of biodiversity loss globally and the main driver of tropical deforestation [10, 59, 60]. As a result, regulations such as the EU Deforestation Regulation (EUDR) have been implemented to curb the rate of forest loss. As the global population is projected to reach 10 billion by 2050, pressure on biodiversity and natural capital from agriculture is expected to continue increasing [61].

Food, drink, agriculture and nature

Food, drink and agriculture depends on supporting ecosystem services for agricultural productivity, such as pollination, genetic diversity and soil health [62, 63, 64]. Because of habitat loss, the decline in pollinator populations, such as bees and butterflies, affects 75% of global crops. The sector is dependent on freshwater resources, highlighting its vulnerability to water scarcity exacerbated by climate change [65, 66, 67].

The food, drink and agriculture industry has been the primary driver of habitat loss over the past 50 years, accounting for 70% of terrestrial and 50% of freshwater biodiversity loss [68]. The expansion of arable crops, predominantly driven by demand in the global north, has led to increased land conversion and habitat modification [69]. Between 90% and 99% of all deforestation in the tropics is driven directly or indirectly by agriculture, with notable examples including deforestation in Indonesia due to palm oil monocultures [70] and Brazilian Amazon deforestation for cattle pasture expansion [71]. Wetlands are drained for irrigation or for land use, which severely degrades these habitats [72].

Industrial animal farming and crop cultivation releases greenhouse gas emissions. Emissions are released directly from farmed animals (methane emitted from cattle during the digestive process), directly from the land (especially from rice cultivation), burning fields as part of management practices, or from machinery used to manage the land [73, 74]. Conventional farming practices use fertilizers and herbicides, which can cause nutrient overloading, and have contaminated 60% of croplands with high nitrate levels [65, 75]. Agricultural practices, in particular crop production, also contribute to the spread of invasive alien species (IAS), which can be highly problematic for native wildlife and ecosystems.

Food, drink and agriculture value chain

IAS are widely recognised as a critical threat to the agriculture sector, as they outcompete native species, disrupting ecosystem services [76].

During the processing stage, agricultural raw materials are converted into consumer products and/or food ingredients requiring high energy, water and chemical use, which contributes to greenhouse gas emissions and pollution [59]. Water is a critical production input in the food and beverage sector, as it is embedded within the product and needed for processing and raw material cleaning purposes [77, 67]. As such, the beverage industry is among the most water dependent and intensive, with high levels of water consumption and wastewater production [67, 77, 78].

Industry responses

Practices such as regenerative agriculture and nature-based solutions are increasingly adopted to mitigate the environmental impacts of the industry on natural ecosystems, to promote nature recovery [10, 65, 79, 80, 81] and to help future-proof agricultural operations [82]. New agriculture technologies, such as precision irrigation, have been shown to reduce environmental impacts through greater efficiency of resource use, such as water and fertilizers [83].

Globally, there is a range of governmental policy, incentive programmes and regulations aimed at encouraging more sustainable farming practices from a climate and biodiversity perspective. And international agencies are supporting this shift. Notably, the Food and Agriculture Organization (FAO), a specialised UN agency, is actively promoting sustainable agriculture practices to achieve the SDGs [84]. FAO outlines how stakeholders can follow its ***Organisation for Economic Cooperation and Development*** (OECD) guidance [85] to better manage risks along the agricultural supply chain. The World Business Council for Sustainable Development (WBCSD) released the ***Food and Agriculture Roadmap***, which sets out key actions and solutions for businesses to transform food systems [68]. The ***Rainforest Alliance*** serves as an example of a consortium involving multiple businesses that collaborate with key stakeholders across the supply chain to make palm oil production more sustainable [86].

There is also a range of industry standards and practices, such as ***Fairtrade*** [87] and ***Organic*** [88], which promote sustainable production and environmental protection. To become Fairtrade certified, farmers must implement a range of sustainable actions, such as improving soil and water quality and protecting biodiversity. Organic farming uses ecologically based pest controls and biological fertilizers, and the Soil Association has developed standards and a certification scheme for growing, processing and marketing organic products [88].

Key business risks

Food, drink and agriculture and the businesses within the value chain are exposed to a range of nature-related risks and opportunities, summarized in the table below.

Risk & opportunity category		Nature-related risk or opportunity	Examples and impacts
Physical Risk	**Acute**	Increased risk of infrastructure and crop damage or operational disruption associated with extreme weather-related events.	Extreme weather-related events, i.e., flooding, landslide or natural disaster, can directly result in infrastructural damage and operational disruption to businesses.
	Chronic	Lost productivity of agricultural land due to factors such as soil degradation or increased water stress.	Decreased productivity of agricultural land due to soil degradation, resulting in farming activities and product suppliers relocating, imposing high financial costs on the business and potential reputational risks associated with deforestation for new areas of production.
Transition Risk	**Policy and legal**	Emerging regulations aimed at enhancing biodiversity and preserving natural habitats will create more protected areas.	Regulations aimed at expanding protected areas, may result in businesses incurring high costs related to the relocation of production and/or sourcing areas.
	Reputational risk	Increased scrutiny placed on organizations to act responsibly and minimize impact on nature.	Reputational damage resulting from business-related contamination of groundwater, eutrophication, plastic pollution, deforestation, loss of biodiversity and/or emissions can significantly impact a business's public image and stakeholder trust, affecting reputation and resulting in revenue losses.
Opportunities	**Resource efficiency**	Adoption and use of sustainable technologies and increased rate of recycling.	Adopting sustainable technologies, such as precision farming, will reduce waste, enhance efficiency and optimize the use of inputs for businesses. Efforts in recycling plastics, nutrients and water will help businesses reduce their inputs and, consequently, their costs.
	New markets access	Aligning food businesses' strategies with sustainable food certifications and lower impact products could increase access to new markets.	Sustainable certification and sustainable product development will improve environmental, social and governance (ESG) rating, lower transition risk and improve asset valuation.

Sector impacts and dependencies in detail

Table key: Very high | High | Medium | Low | Very low

			Agricultural chemicals manufacturing	Livestock farming	Fruit and vegetable farming	Food and beverage manufacturing
Impacts	Land-sea-water use change	Area of freshwater use	Medium	Very high	Very high	Medium
		Area of land use	High	Very high	Very high	High
		Area of seabed use	Medium	Medium	Medium	Medium
	Climate change	GHG emissions	Very high	Very high	Very high	Very high
	Pollution	Solid waste	Medium	Medium	Medium	High
		Soil pollutants	High	High	High	Medium
		Water pollutants	Medium	High	High	Medium
		Non-GHG air pollutants	High	High	High	High
	Resource extraction	Water use	High	Very high	Very high	High
		Other resource use	Low	Low	Low	Low
	Disturbance and invasive species	Light & noise pollution	Medium	Low	Low	Low
		Invasive species introductions	Low	High	High	Low
Dependencies	Provisioning ecosystem services	Surface & ground water	Low	Very high	Very high	Very high
		Natural materials & fibres	Low	High	High	Low
	Regulating & maintaining ecosystem services	Water flow maintenance	Low	Very high	Very high	Medium
		Water quality	Low	Very high	Very high	Medium
		Flood and storm protection	Medium	Very high	Very high	Medium
		Land stabilisation & erosion control	Low	Very high	Very high	Low
		Soil quality	Low	Very high	Very high	Low
		Climate regulation	Low	Very high	Very high	Low
		Pollination	Low	Very high	Very high	Low
		Filtering & cleaning pollutants	Low	Medium	Medium	Low
		Disease control	Low	Very high	Very high	Low
		Pest control	Low	Very high	Very high	Low

Note: Some of the standard ecosystem services categories are aggregated together for ease of presentation.

Mining and metals

Industry overview

Minerals and metals are crucial in everyday life, as well as increasingly becoming a key component in the development of renewable energy technologies and transition to a zero carbon future. Global demand for metals such as iron, aluminum, copper, zinc, lead and nickel is likely to increase, by as much as 2–6-fold for some metals [89]. These resources are mostly mined in the economically developing regions of Africa, Latin America, Asia and the Middle East. The extracted materials are then exported to North America, Europe and parts of East Asia, where they undergo further processing and are ultimately consumed [90]. During processing, valuable minerals are separated from waste rock and smelted to extract metals from their ore, which are then refined into final products [28, 91].

This section examines the impacts and dependencies of the metal and mining industry, focusing on the extraction and manufacturing stages of iron, aluminum, copper, zinc, lead and nickel.

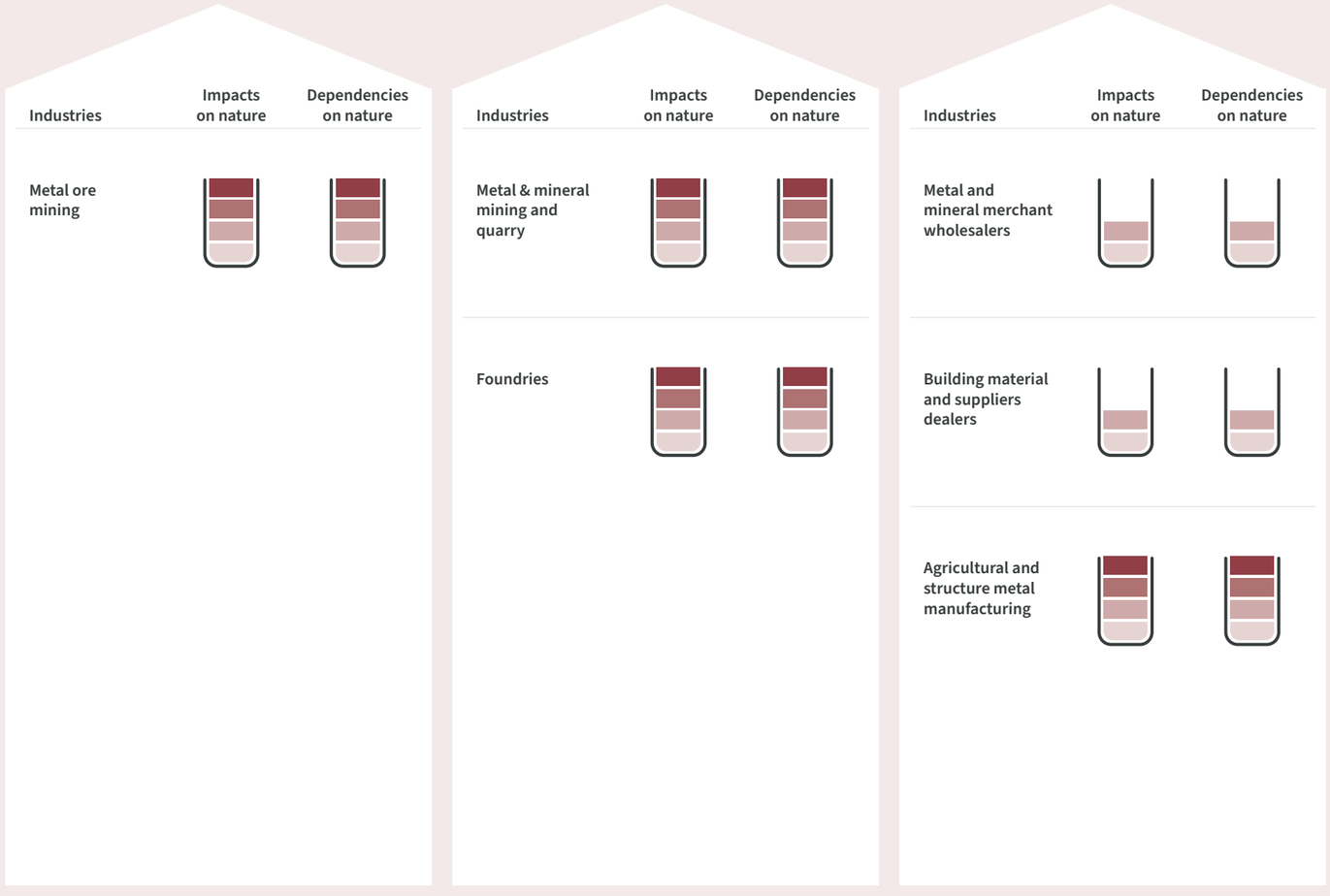
Mining, metals and nature

Mining potentially affects about a third of the global land surface, of which 8% overlaps with sites legally protected for biodiversity, 7% with Key Biodiversity Areas and 16% with land defined as remaining wilderness [92].

Terrestrial mining is dependent on both water supply and stable land to prevent landslides [93,94]. Impacts include land erosion, sinkhole formation and groundwater contamination [95]. Gold mining impacts include river pollution, degradation of soil for agriculture and disrupted hydrological cycles, potentially causing long-term food insecurity in surrounding areas [96]. Mining can lead to the destruction of waterbodies [97], while toxic chemicals such as cyanide, mercury and metal-rich tailings released into rivers harm downstream aquatic life [98]. Tailing dams, which are earth-filled embankment dams used to store by-products of mining operations, can fail. Uncontrolled releases of tailings slurry are among the major catastrophe risks in the mining industry, not only for human populations downstream of Tailings Storage Facilities (TSFs), but also for the natural environment.

Half of the global biodiversity loss from mining is linked to activities in Indonesia (coal), Australia (iron and bauxite) and New Caledonia (nickel) [90]. Areas in Africa, as well as boreal and Arctic regions, face threats from rising mining demand, low environmental protection and high sensitivity to mining impacts [99]. Up to one-third of the world's forests may be affected by mining [100], and mineral extraction accounts for 7% of tropical deforestation [101]. Tropical forests are particularly vulnerable to direct and indirect deforestation caused by mining and mineral processing [102].

Mining and metals value chain



Terrestrial mineral deposits are being depleted, so deep sea exploration and mining have been proposed to capitalize on abundant stocks of metal ores. Notably, Norway could be the first country to authorize deep sea mining, passing a Bill in January 2024 that opened 280,000 square kilometres of its national waters for exploration [103]. While the International Seabed Authority (ISA) is still developing regulations, exploratory mining has so far been limited to small-scale projects. The deep sea is poorly understood, but research highlights significant environmental risks of mining, including habitat destruction, sediment plumes and pollution (noise, light and seismic) [104]. These activities could cause permanent damage to deep sea ecosystems, including loss of species unique to these habitats, disruption of the ocean's carbon cycle and depletion of fish stocks.

In the later stages of metal manufacturing, significant greenhouse gas emissions and airborne pollutants are released from blast furnaces. Secondary manufacturing processes also contribute to pollution through the use of chemicals, such as acids and solvents, and the generation of both hazardous and non-hazardous waste, such as slag [91, 105, 106]. These stages produce high levels of noise and light pollution, which can disrupt local wildlife [107].

Industry responses

There are several tools available to the metals and mining industry to quantify and mitigate environmental impacts. Environmental impact assessments (EIA) assess the potential environmental impacts of mining activities and projects and to develop appropriate mitigation strategies [108]. The International Council on Mining and Metals (ICMM) is a global organization dedicated to enhancing sustainable practices, and it has developed a No Net Loss (NNL) commitment and approach for companies to measure and quantify biodiversity to improve industry practice. Through this approach, members aim to achieve NNL of biodiversity by systematically avoiding, minimizing, restoring and offsetting environmental impacts. Members also engage in conservation and rehabilitation efforts, including the creation of wetland ecosystems, reforestation and species protection [109].

Additional strategies to mitigate operational impacts include water management, soil enhancement, waste reduction and land reclamation. After several severe tailing dam failure events in recent years, the mining industry, led by the ICMM, developed the ***Global Industry Standard on Tailings Management*** (GISTM) to implement best practices in planning, design, construction, operation, maintenance, monitoring, closure and post closure activities related to TSFs. The industry is also improving supply chain visibility and sustainability across industry and the value chain. The ***Responsible Minerals Initiative*** (RSI) works with companies and stakeholders globally to support responsible mineral production and sourcing, mitigating the environmental and social impacts of mining and processing of minerals. The RSI uses international standards, such as the Organization for Economic Cooperation and Development (OECD) Due Diligence Guidance, to guide its work.

Several metal production technologies are being developed to reduce energy consumption, feedstock usage, byproduct generation and waste streams associated with resource extraction and processing. The industry is increasingly adopting a circular economy approach, which promotes the efficient use of resources, recycling, repurposing and waste reduction. Platforms such as ***Mining Surplus*** help sell used equipment, supporting sustainability. Certifications also exist for key construction materials, including the ***Aluminium Stewardship Initiative*** (ASI) standard and an international standard developed by ***Responsible Steel***.

Key business risks and opportunities

Metals and mining and the businesses within the value chain are exposed to a range of nature-related risks and opportunities, summarized in the table below.

Risk & opportunity category		Nature-related risk or opportunity	Examples and impacts
Physical Risk	**Acute**	Increased risk of floods, storms or landslides damaging infrastructure or interrupting operations.	Extreme weather events may damage facilities and equipment, obstruct roads and halt production.
	Chronic	Climate-change-driven changes in rainfall patterns, water supply or quality. Damage to ecosystem services from mining operations.	Water scarcity disrupts mining operations or might require a location change. Severe water pollution requires increased remediation costs, e.g., rectifying water pollution. Extensive soil erosion will impact land stability and potentially require location change.
Transition Risk	**Policy and legal**	Increase in protected areas, which may impact operations or planned future sites. Increase in barriers or costs relating to legislation aiming to protect or restore nature. Risks to access capital as exclusion may apply, e.g., deep sea mining.	Increased protection areas may require additional assessments and mitigation measures for mine design and operation. Discovery of an important habitat may halt operations, demand more inspections and surveys or require a location change. Ultimately, early planning could reduce operational costs and longer-term reputational risks.
	Reputational risk	Operational interruptions due to community conflict may reduce business continuity. Inability to gain new land to support business growth due to decreased social licence to operate.	Opposition by communities relating to environmental practices may cause interruptions and result in increased costs. Failure to meet rehabilitation expectations can harm stakeholder trust and the company's reputation and market position.
Opportunities	**Resource efficiency**	Innovations promoting the reuse and repurposing of waste.	Processing tailings residues into commercially viable materials, such as repurposing sand tailings instead of quarrying more sand from riverbeds.
	New markets access	Engagement in emerging natural capital markets.	Companies could invest in recycling technologies, opening new revenue streams.

Sector impacts and dependencies in detail

Table key: Very high | High | Medium | Low | Very low

			Metal ore mining	Metal production and processing	Foundries	Architectural and structural metals manufacturing
Impacts	Land-sea-water use change	Area of freshwater use	High	High	High	High
		Area of land use	Very high	Very high	Very high	Very high
		Area of seabed use	High	High	High	Very high
	Climate change	GHG emissions	Very high	Very high	Very high	Very high
	Pollution	Solid waste	High	High	High	High
		Soil pollutants	High	High	High	High
		Water pollutants	High	High	High	High
		Non-GHG air pollutants	High	High	High	High
	Resource extraction	Water use	Very high	Very high	Very high	Very high
		Other resource use	Low	Low	Low	Low
	Disturbance and invasive species	Light & noise pollution	High	High	High	High
		Invasive species introductions	Medium	Medium	Medium	Medium
Dependencies	Provisioning ecosystem services	Surface & ground water	High	High	High	High
		Natural materials & fibres	Low	Low	Low	Low
	Regulating & maintaining ecosystem services	Water flow maintenance	High	High	High	High
		Water quality	Low	Low	Low	Low
		Flood and storm protection	Low	Low	Low	High
		Land stabilisation & erosion control	Medium	Medium	Medium	Medium
		Soil quality	Low	Low	Low	Low
		Climate regulation	High	High	High	High
		Pollination	Low	Low	Low	Low
		Filtering & cleaning pollutants	Low	Low	Low	Low
		Disease control	Low	Low	Low	Low
		Pest control	Low	Low	Low	Low

Note: Some of the standard ecosystem services categories are aggregated together for ease of presentation.

Renewable energy generation

Industry overview

Renewable energy is derived from sources that are replenished at a higher rate than they are consumed. Renewable sources include solar, wind, ocean energy (including tidal), hydropower, geothermal and bioenergy. As the world transitions to a lower carbon economy, an increase in renewable energy production is a necessary part of the energy mix of the future. It is for this reason that we are focusing on renewable energy types, rather than broader power generation, in this chapter. The following analyses key renewable technologies and their manufacturing and operations, as well as the wider electric utilities, transmission and distribution systems within which they operate.

All pathways to achieve the global UN Paris Agreement to limit global temperatures require a green energy transition and a large increase in renewably sourced electricity to reduce global greenhouse gas emissions. Technology developments, regulation updates and subsidy regimes have significantly accelerated the uptake of renewable technologies in the past two decades. Approximately one-third of the world's electricity in 2023 is sourced from renewable technologies, comprised of approximately 47% hydropower, 18% solar, 26% wind, and 9% other technologies including biomass and geothermal [110].

Renewable energy and nature

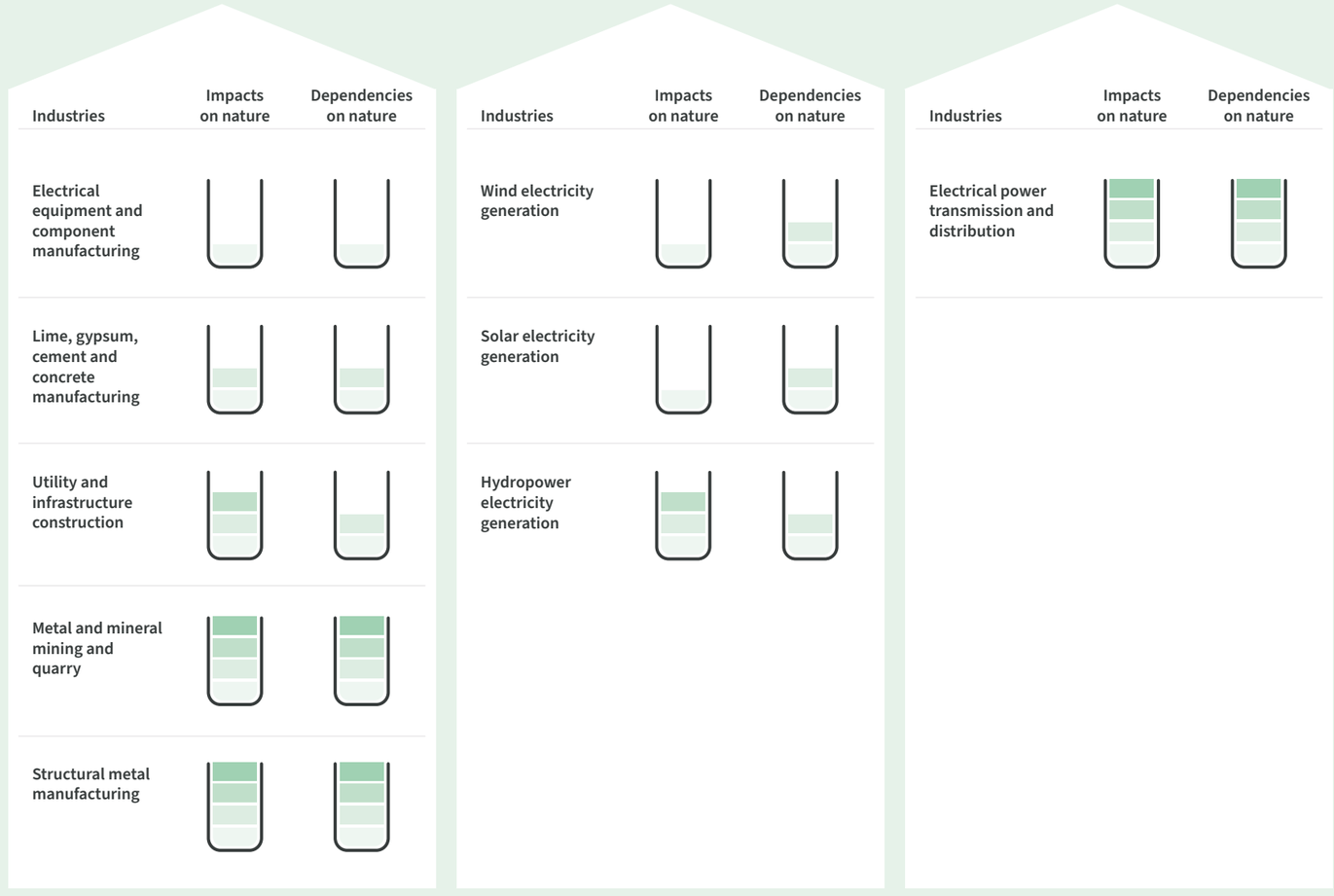
Renewable energy sources are an essential technology to mitigate climate change and have lower nature impacts than conventional energy sources such as coal, oil and natural gas. Increasing renewable energy generation mitigates the impacts of climate change, which in turn improves nature outcomes, however there are still nature impacts from renewable projects to consider.

The renewable energy industry depends on several ecosystem services. Access to clean, flowing, cool water is one example of the power industry's dependence on nature [111]. Renewable energy projects also require global climate regulation for maintaining safe and consistent operations, soil and sediment to provide a stable substrate, erosion control, and landslide mitigation, and areas of land and oceans are needed as sites for renewable energy projects.

The impacts of renewable energy sources vary significantly depending on the environmental contexts in which they are installed and their supply chains [112]. It is estimated that one-third of global areas with high solar and wind power potential, and many of the reserves of critical minerals used in renewable power infrastructure, also overlap with areas of high biodiversity value [113].

Hydroelectric production is the largest worldwide source of renewable energy. However, hydropower dams disrupt the flow of river regimes, decreasing aquatic connectivity, altering temperature and chemical properties, and permanently altering sediment and natural water flows [114]. Free-flowing rivers are uniquely important for biodiversity and ecosystem services.

Renewable energy generation value chain



Only one-third of the world's rivers longer than 1,000 km are still free-flowing, with hydropower dams contributing to this overall decline [115].

Due to the global need to quickly transition to renewables, solar and wind technologies are rapidly being upscaled. Early studies on their biodiversity impacts suggest that solar power plants can lead to landscape fragmentation that could create barriers to the movement of species [116]. There are a number of potential key impacts associated with onshore and offshore wind turbines, including habitat loss and fragmentation, and hazards to bats, marine and migratory birds and marine mammals through the disturbance of natural behaviours and collision mortality [117].

When developments are sited and designed sensitively, environmental benefits can be delivered. For example, solar power plants can be designed to deliver soil and habitat enhancements, and offshore wind infrastructure can be designed to create artificial reef environments which could benefit fish and other marine species.

Bioenergy, or biomass, uses organic material, including wood, crops, waste streams (from livestock, manufacturing, domestic and municipal waste) and microalgae to generate energy. Feedstocks can compete with agricultural crops, with the potential to contribute to deforestation and negative environmental effects associated with watering, erosion and pest control. Combustion of fuels, if unabated, releases harmful emissions to air [118].

Industry responses

Renewable energy technologies are set to increase globally in the coming decades, and this presents an opportunity to develop electricity systems that deliver better outcomes for both climate and nature [119]. Areas of low ecological sensitivity should be prioritized for locating infrastructure, and the mitigation hierarchy (avoid, minimise, restore/rehabilitate and where appropriate offset) should be adhered to through Environmental Impact Assessments and site design.

Sensitively designed and sited renewable energy projects can deliver climate and biodiversity benefits. Offshore wind substructures can function as artificial reefs for coral, crustaceans, and fish. For example, research is being undertaken by the ***Penghu Marine Biology Research Centre with a renewable energy developer*** to support natural coral growth on the base of offshore wind turbines. Onshore wind and solar PV projects can also be combined with habitat and natural capital improvements [120]. There is a growing body of research and practice around the benefits that solar PV projects can deliver for biodiversity and sustainable agriculture. For example, the US '***Centre for Pollinators in Energy***' provides expert knowledge on solar sites planting with native flowers and grasses important for pollinators and insects, and research by ***Solar Energy UK*** into the natural capital benefits of solar provides case studies and best practice around biodiversity enhancement and management.

The Coalition Linking Energy and Nature for action (***CLEANaction***) is a partnership to protect nature during the energy transition, that has published a 'nature-safe energy' report with recommendations for investors and developers to reduce nature risk. An Offshore coalition for Energy and Nature (***OCEAN***) has also been established, providing an industry forum where information and experiences are collected and assessed, with helpful resources including a public database promoting positive offshore measures for nature. Other regionally specific coalitions bringing together businesses, government and investors to advance clean energy industries include the Asia Clean Energy Coalition (***ACEC***) and the American Clean Power Association (***ACP***).

Industry collaboration and guidance, such as the ***OECD's Due Diligence Guidance for Responsible Supply Chains of Minerals***, is enabling improved visibility and sustainability practices in the metals and minerals supply chains used for energy infrastructure. The Responsible Minerals Initiative (***RMI***) seeks to understand and contribute to mitigating the salient social and environmental impacts of extraction and processing of raw materials in supply chain and their standard includes environmental criteria that consider how operations affect the environment, biodiversity, and nearby communities.

Key business risks and opportunities

Renewable energy developers, operators, and businesses within the value chain are exposed to a range of nature-related risks and opportunities, summarized in the table below.

Risk & opportunity category		Nature-related risk or opportunity	Examples and impacts
Physical Risk	**Acute**	Increase risk of infrastructure damage or operational disruption associated with extreme weather-related events.	Increased tropical cyclones, hail, and other extreme weather events, which can damage facilities for wind and solar, causing an increase in capital expenditure on infrastructure repair.
	Chronic	Changes in supply of natural inputs (provisioning services) such as water, wind speeds.	A drought can severely affect the amount of water that can be harnessed by hydropower plants, causing a revenue reduction. Climate change is predicted to change wind patterns globally, which could decrease wind speeds in certain regions and affect productivity and revenue.
	Chronic	Increased risk of Infrastructure damage and maintaining services associated with a shifting landscape.	Weakening of soil systems due to loss of vegetation on slopes, which could lead to landslides, may damage facilities solar, onshore- wind and hydropower facilities, causing an increase in capital expenditure on infrastructure repairs.
Transition Risk	**Reputational risk**	There is a risk of changes in sentiment towards the organisation/brand due to impacts on nature of the installation or operation of technology.	Residents may oppose wind farm and hydropower developments due to impact on landscape, noise and light pollution, causing an increase in operational costs due to management of issues and remediation actions.
Opportunities	**New markets access**	Increased revenues through access to new and emerging markets.	There is increasing demand for sustainable energy including high efficiency and renewable energy products such as solar panels, wind turbines, and smart energy systems tailored for both residential and commercial use. This is an opportunity for increased revenue and expansion into new markets.
	Reputational capital	Through creating positive changes in sentiment towards the organisation/brand due to impacts on environmental assets and ecosystem services that benefit society and improve local economic capabilities.	Offshore wind farms can facilitate the creation of new reefs, which might increase food availability in the vicinity of the installed turbine. The installation of solar panels can be delivered in a way that supports local biodiversity, notably pollinators and some specific plant species.

Sector impacts and dependencies in detail

Table key: Very high | High | Medium | Low | Very low

			Electrical equipment and component manufacturing	Utility and infrastructure construction	Hydropower	Solar generation	Wind generation	Transmission and distribution
Impacts	Land-sea-water use change	Area of freshwater use	Medium	High	High	–	–	Very high
		Area of land use	Medium	Very high	Medium	Low	High	Very high
		Area of seabed use	Medium	Very high	–	–	Medium	High
	Climate change	GHG emissions	Very high	Very high	Low	–	–	Very high
	Pollution	Solid waste	Medium	Medium	Low	Low	Very low	High
		Soil pollutants	High	High	–	Low	Very low	High
		Water pollutants	High	Medium	–	Low	Very low	High
		Non-GHG air pollutants	Medium	High	–	–	–	High
	Resource extraction	Water use	Medium	High	Low	–	Low	Very high
		Other resource use	Low	Low	–	–	–	Low
	Disturbance and invasive species	Light & noise pollution	Medium	High	High	Very low	Medium	High
		Invasive species introductions	Low	Medium	–	–	–	High
Dependencies	Provisioning ecosystem services	Surface & ground water	Medium	Low	Very high	Medium	Very low	Very high
		Natural materials & fibres	Low	Low	–	–	–	Low
	Regulating & maintaining ecosystem services	Water flow maintenance	Low	Medium	Very high	Medium	Medium	Very high
		Water quality	Low	Low	Low	–	–	Low
		Flood and storm protection	Low	High	Very high	Medium	High	Very high
		Land stabilisation & erosion control	Low	Medium	–	Medium	Medium	High
		Soil quality	Low	Low	–	–	–	Low
		Climate regulation	Low	Medium	Medium	Very high	Very high	Very high
		Pollination	Low	Low	–	–	–	Low
		Filtering & cleaning pollutants	Low	Low	–	–	–	Low
		Disease control	Low	Low	–	–	–	Low
		Pest control	Low	Low	–	–	–	Low

Note: Some of the standard ecosystem services categories are aggregated together for ease of presentation.
No materiality rating indicates that the specific economic activity is not directly linked to the impact or dependency in the ENCORE database.

Textiles, apparel and fashion

Industry overview

The sector includes textiles, clothing, leather and footwear. The textiles industry typically involves creating materials and fabric, the apparel industry transforms fabrics and materials into garments and accessories and the fashion industry encompasses both industries, as well as retailing to consumers.

The global fashion and textiles industry is characterised by complex and dispersed supply chains, with various processes and raw materials typically involved in manufacturing. The main markets by consumption are in China (40 billion apparel units), the US (17 billion apparel units) and India (6 billion apparel units) [121]. The early stages of raw material extraction and manufacturing are geographically concentrated in low- and middle-income countries in Asia [122].

While there are multiple and varied uses of textiles, approximately 60% of global fiber production is used in the manufacturing of clothing [123]. Increases in clothing production, driven by industry growth and shifts towards 'fast fashion', have escalated ecological degradation and climate impacts [124]. In response, regulations, particularly in the EU, seek to tackle key issues such as embodied deforestation relating to commodities such as rubber and cattle (EU Deforestation Regulation) and improve textile waste management and circularity (EU circular economy for textiles).

Textiles, apparel, fashion and nature

Textile products rely on raw materials from agriculture, forests, wildlife or petrochemicals [23]. Impacts associated with the industry are likely to continue to increase, as the fashion industry is predicted to use 35% more land for cellulosic fibres, cotton cultivation and livestock by 2030 [125].

Fibers made from farmed plants, such as cotton, typically require large amounts of water and pesticides to produce. Cotton represents 30–40% of all fiber used for textiles, covering 2.4% of global cropland. Conventional cotton cultivation predominately occurs in regions prone to drought, and cotton's high water usage can further exacerbate water stress [126].

The creation of natural fibres such as animal skins (leather), wools, furs and silks heavily depends on biodiversity. Most leather comes from cows raised for beef and milk production. Due to the amount of land required for cattle, it results in habitats, such as forests, being converted to pastures or used for feed grain production. The livestock sector and the farming of animals for fur significantly contribute to water pollution. Unsustainable harvesting of animal skins and fur can significantly impact wildlife populations, with poaching and illegal wildlife trade pushing species towards extinction [126].

Textiles, apparel and fashion value chain

Upstream

Industries	Impacts on nature	Dependencies on nature
Livestock farming		
Crop farming		
Chemicals manufacturing		
Natural fiber, yarn and thread mills		
Synthetic fiber manufacturing		
Apparel and footwear manufacturing		
Knitting and fabric mills		

Direct operations

Industries	Impacts on nature	Dependencies on nature
Apparel and footwear retail and distribution		

Downstream

Industries	Impacts on nature	Dependencies on nature
Landfill and waste disposal		
Recycling and material recovery		

Man-made cellulosic fibres (MMCF) are primarily derived from virgin wood pulp, with less than 0.1% from recycled origins. Market estimates indicate that about 40% of MMCF feedstock is not certified by recognized standards (Forest Stewardship Council (FSC) or Programme for the Endorsement of Forest Certification (PEFC), meaning there is a risk of deforestation of endangered and primary forests [127]. Natural rubber is a deforestation risk commodity, and over the last decade more than 2 million hectares of rubber plantations have been established in South East Asia, particularly in Vietnam and Cambodia [126].

The production of synthetic fibres, such as polyester and nylon derived from petrochemicals, leads to natural habitat destruction due to the extraction of raw materials, such as crude oil [128]. Additionally, close to 35% of primary microplastics released into the ocean originate from the washing of synthetic fibres and textiles [129]. Ocean life is particularly vulnerable to the effects of microplastic pollution [130].

Overall, the textile industry contributes about 8–10% of global carbon dioxide emissions [124]. The textile manufacturing process, including pretreatment, dyeing, printing and finishing, consumes high levels of energy and water while generating large amounts of waste [131]. The use of dyes, chemicals and other materials causes environmental problems if they are not treated and disposed of appropriately; up to 20% of industrial wastewater pollution is caused by textile dyeing and finishing [132]. Chemicals used in the production of textiles, such as PFAS (forever chemicals) to repel water, oil and dirt are also a pollutant and increasingly found in textile wastewater [133].

Industry responses

There is a range of industry initiatives addressing key issues with the fashion, textile and apparel sector. Important examples include the ***Fashion Pact***, ***Textile Exchange*** and ***Fashion Nature Risk Lens***, which promote collaborations and design tools to mitigate environmental impact.

Tracing the origin of raw materials is challenging, but tools such as the ***Textile Exchange Content Claim Standard*** (CCS) are working to enhance supply chain transparency and traceability. Regenerative material production refers to methods of managing agroecosystems to provide positive outcomes for nature, along with improving water management practices, thereby reducing environmental impacts. Organizations are also sourcing from suppliers with environmental certifications. Certifications cover a range of areas, including forest products (e.g., ***FSC*** and ***Canopy***), cotton (e.g., ***Better Cotton*** and ***Cotton made in Africa***), harmful substances (e.g., ***OEKO-TEX***), recyclability or biodegradability (e.g., ***Cradle to Cradle***), organic textiles (e.g., ***Global Organic Textile Standard*** (GOTS)) and environmental standards (e.g. ***EU Ecolabel***).

Embracing the circular economy can mitigate environmental impacts and dependencies by extending the life of clothing and fibres, lowering resource demand and pollution. The Ellen MacArthur Foundation provides guidance on integrating circular economy principles into the early product development stages, such as the ***Circular Design for Fashion*** book.

Key business risks and opportunities

The textile, apparel and fashion industry are exposed to a range of nature-related risks and opportunities, summarized in the table below.

Risk & opportunity category		Nature-related risk or opportunity	Examples and impacts
Physical Risk	**Acute**	Damage to infrastructure or interruption to activities from extreme weather events and acute risks, such as landslides, floods, storms, wildfires and tropical cyclones.	Increased instances of extreme weather events increase operational costs owing to interruption of operations or supply chain, including reduced productivity.
	Chronic	Changes in the ability of ecosystem services to operate effectively, as a result of either climate change or business impacts, could have a variety of impacts, including changes in water purification or waste remediation services and decrease in the supply and quality of natural materials, e.g., cotton and timber.	Businesses would have increased costs relating to implementing adaptation or restoration solutions to poorly performing ecosystem services (e.g., hand pollination), which could cause reduction in revenue owing to interruptions of operations or supply chain.
Transition Risk	**Policy and legal**	Changes to legislation or regulation aimed at achieving nature-positive outcomes and more stringent reporting obligations.	Increased costs relating to operations, inputs, personnel and monitoring of activities required. Increased compliance and clean-up costs.
	Market risk	Shifting customer and investor values or preferences and potential decline in brand and value proposition due to perception of nature performance.	Reduction in revenue due to lower demand for products and services, e.g., fur products, and loss of market share and investor goodwill. Costs related to substituting existing products and services.
Opportunities	**Reputational capital**	Collaborative engagement and actions that create positive sentiment due to positive impacts on environment.	Increase in revenue and brand value due to improved reputation.
	Sustainable use of natural resources	Resources, including opportunities for the increase in recycled fibres for apparel manufacture. Certification for projects, products and services.	Reduction in impacts from reduced resource extraction, pollution and waste and improved business performance and reputation.

Sector impacts and dependencies in detail

Table key: Very high | High | Medium | Low | Very low

			Natural fiber, yarn, and thread mills	Synthetic fiber manufacturing	Knitting and fabric mills	Apparel and footwear manufacturing
Impacts	Land-sea-water use change	Area of freshwater use				
		Area of land use				
		Area of seabed use				
	Climate change	GHG emissions				
	Pollution	Solid waste				
		Soil pollutants				
		Water pollutants				
		Non-GHG air pollutants				
	Resource extraction	Water use				
		Other resource use				
	Disturbance and invasive species	Light & noise pollution				
		Invasive species introductions				
Dependencies	Provisioning ecosystem services	Surface & ground water				
		Natural materials & fibres				
	Regulating & maintaining ecosystem services	Water flow maintenance				
		Water quality				
		Flood and storm protection				
		Land stabilisation & erosion control				
		Soil quality				
		Climate regulation				
		Pollination				
		Filtering & cleaning pollutants				
		Disease control				
		Pest control				

Note: Some of the standard ecosystem services categories are aggregated together for ease of presentation.

Assessing your nature risk

Assessing a business's nature risks is challenging: data is often lacking, supply chains are poorly understood and nature and biodiversity are complex topics. In addition, nature and biodiversity are highly geographically variable, dependent on a wide range of site-specific factors such as climate, geology, soil type and historical and current human activity. Therefore, it's important to treat a nature risk assessment as an iterative process of continuously improving your understanding of how your business is both impacting and depending on nature, at relevant locations across the value chain, and then how these represent risks and opportunities.

For companies for which nature may be a material issue, it's important to fully assess nature-related risks and embed these into risk management strategies, processes and reporting. In October 2023, the TNFD published its ***final recommendations***, setting out what is widely accepted as the leading nature risk assessment and disclosure process. It provides a useful framework for a risk manager to follow and offers a wide range of general and industry-specific guidance.

Since many organizations are at the beginning stages of considering their nature-related risks, this chapter aims to equip risk managers with guidance on preliminary analysis and scoping actions. Once this stage is complete, organizations can then work through the TNFD framework, ultimately setting nature-related targets and incorporating nature into governance, risk and control systems.

Scope

To help tackle the scoping phase, risk managers could consider the following:

Is nature material to my business?

All businesses are directly or indirectly reliant on the natural world, but, as highlighted in this report, the impact and financial materiality of nature and biodiversity to business varies across sectors. A good starting point is to understand how material the nature impacts, dependencies, risks and opportunities are for your sector, business or business activity. A useful tool for conducting such a high-level materiality assessment is ENCORE (Exploring Natural Capital Opportunities, Risks and Exposure). This comprehensive online evidence base provides scientifically robust information on the nature impacts and dependencies of 167 economic sub-industries with materiality ratings and narrative descriptions to understand their significance to your business, as well as accompanying reference papers and the underpinning evidence. It is intuitive to use and provides supporting resources to aid use and interpretation. See the industry impact and dependency tables for example results from the ENCORE tool.

What are some of the other initial actions I can take?

While some organizations may engage with an external expert to support next steps, there are five actions that a risk manager, in collaboration with wider stakeholders, should consider taking to understand the importance of nature to the business.

- **Knowledge and awareness:** Nature is a big and complex topic. It encompasses the entire natural world with an emphasis on its living components, such as biodiversity, ecosystems, evolution, the biosphere and biocultural diversity. Therefore, it's important to develop a high-level understanding of the levels of knowledge across the company of the principles of nature and biodiversity and awareness of its importance to business performance. The TNFD provides helpful capacity-building resources, and the United Nations Development Programme (UNDP) offers a micro-course on nature and why it matters to businesses. This e-learning catalogue also features a range of options on biodiversity in business, finance and law.

- **Screening:** To identify where the significant nature-related issues might be, conducting a high-level screening exercise, based on readily available company information (such as product or service strategies, operating locations, distribution networks, etc.) and the results of the initial materiality assessment (through ENCORE), allows you to broadly define the areas of your company's 'value chain' (i.e. part(s) of the life cycle of your company products or processes) that you may want to assess more fully. The Integrated Biodiversity Assessment Tool (IBAT) can also be useful in enabling risk managers to access global biodiversity datasets (subscription required or pay as you go download), and there are a number of tools freely available online, such as the World Resources Institute Aqueduct Tool and WWF Biodiversity and Water Risk Filter, which can inform location-specific nature and water risk mapping, at the scale of watersheds.

- **Existing data, risks, and controls:** Identifying and collating relevant existing data and/or risks and controls through colleague collaboration and scanning of current systems and reports can help highlight where data or information gaps might exist. These gaps can then be prioritised and included in a resulting business case outline.

- **Stakeholders:** Fully engaging with priority stakeholders across key parts of your value chain, and asking the right questions, is key to developing areas of potential collaboration, understanding pain points and ultimately ensuring effective assessment of nature risks. Plotting the company's stakeholders on a matrix, with two intersecting variables such as interest and influence, map help identify which part of the value chain or which stakeholder groups should be considered a priority to engage. Engagement tools could include questionnaires or surveys, focus groups or even forming a stakeholder committee to develop dialogue on nature-related risks and opportunities, as well as addressing initial data gaps. There should also be detailed discussions with key departments within the organization where nature may be relevant to help define material risks and opportunities (see the section 'How should I engage colleagues from my organization?' for starting points).

- **Outline business case:** Once you've gathered this information, you will be in a position to develop a business case, if required, to engage with decision-makers for taking further company action on nature. It should outline the commercial imperative of assessing nature risks and recommendations for next steps, including, if feasible at this stage, outlining the potential costs and resources required. It might also include the identified risks, assumptions, issues, and dependencies (RAID log), alongside the opportunities and benefits relevant to your business.

How should I engage colleagues from my organization?

Below are some examples of questions to engage teams within your organization.

- **Procurement:** Have you experienced any supply chain disruptions due to nature-related events or risks? Have you observed significant price fluctuations in key commodities because of nature-related events or risks? Do you anticipate this becoming an increasing risk in the future, and if so, over what time horizon?
- **Sustainability:** How integrated are nature and biodiversity in the company's sustainability strategy, and which risks to the company are being addressed? What plans are in place for assessing and disclosing nature-related risks and opportunities?
- **Operations:** To what degree are we considering nature-related risks for our physical security and business continuity management? How are we thinking about nature and biodiversity in our estate planning? Where do we have data gaps on nature, and what are we doing to mitigate associated risks?
- **Finance:** How are we factoring nature-related risks and opportunities within our pricing strategies, and how might this evolve? To what degree should we integrate nature into our cost models to manage financial risks?
- **Product development/innovation:** How are we incorporating nature-related risks into our development strategies? Where are our most critical supply chain dependencies, and how might this evolve with new products?
- **Legal and compliance:** What current or emerging regulation regarding nature and biodiversity is material for our organization, and what preparedness work do we need to do to comply?
- **Communications and marketing:** Are we concerned that our business impacts and/or dependencies on nature or biodiversity could pose a risk to our company's reputation? What are our customers' expectations when it comes to managing our relationship with nature, and what do we see as the key risks if we fall short of these expectations?

Dialogue with colleagues can then evolve to start looking at initial data points that can inform qualitative assessments or basic scenario analysis. For example, how many incidences have there been of a disruption or other risk materialization, including near-misses? What is the estimated probability of this incidence happening again, and what would the cost implications to the business be over the short, medium, and longer term? These scenarios can later be examined in greater detail by taking a more quantitative approach to help to correct assumptions map interdependencies, develop the necessary controls and other contingency measures, and, if required, inform any regulatory capital and solvency holding requirements.

The TNFD LEAP approach

With the Scoping phase completed, you will now have a high-level understanding of where the nature-related issues are likely to be across the value chain, and the extent to which these are currently managed. You will have a good feel for the quantity and quality of company data needed for a deeper dive into nature, and the level of appetite and buy-in across the business for taking further action.

The TNFD framework sets out the next steps you could take to more fully understand risk types as well as opportunities. These centre around the LEAP approach and guide organizations through four key steps to understand risk types, as well as opportunities.

Locating the organization's interface with nature focuses on geographical considerations for nature impacts and dependencies, including regions where ecosystems may be fragile. Organizations are asked to consider which geographies are relevant for its direct activities, as well as across its value chain.

Evaluating nature-related dependencies and impacts enables organizations to identify where current and future risks and opportunities in their business models may exist. Impacts may be positive or negative on nature. This section of the LEAP approach is consistent with the Natural Capital Protocol, which some organizations may already be familiar with. The Natural Capital Protocol is a framework that pre-dates the TNFD and provides guidance on valuing natural capital in business decisions.

Assessing nature-related risks and opportunities guides organizations through reviewing the material risks and opportunities from those identified in the 'evaluate' stage. This includes guidance on how to prioritize risks by assessing the potential impacts and likelihood of those risks and considering the financial and other consequences to the business.

Preparing to respond and report is the final phase, focusing on the approach to disclosure, in line with the broader TNFD framework (governance, strategy, risk management and metrics and targets). This phase is also designed to help organizations review their governance processes and risk management protocols in light of the outputs from the first three stages of the LEAP approach.

More detail on the LEAP approach with guidance is available from the TNFD website. In addition, the following resources may help risk managers tackle specific elements of LEAP, as well as nature-related risk management strategies more broadly. These resources have been curated for their applicability to multiple industries.

Locate
Biodiversity Loss: An Introduction for Risk Professionals

Evaluate
Leveraging natural capital accounting to support businesses with nature-related risk assessments and disclosures

Assess
Accountability for Nature: Comparison of Nature-related Assessment and Disclosure Frameworks and Standards

Prepare
Take action – setting science-based targets for nature: a step-by-step guide

Cross-industry case studies

When the bee stings: counting the cost of nature-related risks

BloombergNEF presents a series of case studies showcasing how nature risks have materialized into significant financial consequences for leading companies across sectors and geographies over the last two decades.

It's Now for Nature – sector-based nature strategies

Sector-based case studies covering materiality assessments, targets and implementation of nature-based strategies.

The TNFD LEAP process enables risk managers to identify and prioritize nature-related risks. However, these risks are dynamic, and their severity and extent and the ability to mitigate them will change over time as a direct result of climate change, technology and economic, political and regulatory factors.

Scenario planning

Scenario planning is another asset in the risk manager's toolkit that can inform longer term planning for nature-related risks. Climate change scenarios (including the Intergovernmental Panel on Climate Change (IPCC) and Network for Greening the Financial System (NGFS) are widely known, and although climate and nature can be considered two sides of the same coin, scenarios for nature are nascent and less widespread. The TNFD has provided scenario analysis guidance that risk managers can use as a starting point to evaluate future nature-related risks. These scenarios can be based on short-, mid- or long-term horizons and evaluate the severity and speed of physical and transition risks.

Scenarios for physical risk should consider how quickly and severely biodiversity, ecosystem services and natural resources will decline or recover and what resources companies have (and need) to address those changes. Scenarios for transition risk should consider the efficacy and alignment of market and non-market actions, including policy levers, technological developments and whether directionality across industries and nations on climate and nature action is aligned or conflicting.

Alongside different timelines, scenarios can be based on predictions for temperature changes associated with global warming or different socio-economic pathways. Typically, three scenarios are developed for each situation: pessimistic scenario, current trend scenario and optimistic scenario. Initial scenario planning should involve the relevant stakeholders identified through the scoping and LEAP processes. Participatory workshops should seek to identify driving forces, evaluate the company's level of preparedness, construct narratives and identify high-level strategic actions. As previously mentioned, over time and after initial scenarios have been explored, practitioners may want to consider more technical scenario planning. This might seek to further quantify key areas of concern, for example, natural resource availability or ecosystem integrity, as a way of making scenarios more robust and case specific.

Governance, risk and compliance systems

Once you have assessed your nature risks and opportunities, ensure that governance, risk and compliance (GRC) tools are updated to reflect this new position, including logging any new risks appropriately and ensuring that any required updates to controls are reflected in your systems.

You should also share your nature risks through appropriate governance channels to ensure that the work is not performed in a silo, perhaps providing a summary presentation to a senior committee for ratification.

If you are a regulated entity, consider also conducting a gap analysis against any relevant and applicable regulation. This will ensure that you have not missed any key risks and requirements.

Conclusion

Nature risks are often underappreciated but are material to all industries. However, the rise of nature reporting frameworks, intersecting climate concerns, opportunities for risk reduction, and changing stakeholder expectations are leading more investors and businesses to reconsider their relationship with nature.

In 2023, AXA XL put nature at the heart of its three-year sustainability strategy. It is our goal to demonstrate that protecting biodiversity promotes resilient ecosystems and supports community livelihoods. The goal of this report is to raise risk managers' awareness of key nature-related risks and opportunities and how they might impact their operations.

We hope this report encourages businesses to begin assessing their risks and identifying opportunities to build resilience throughout their value chain. Tools, scientific research, industry collaborations, and other solutions are already available to support companies on their nature stewardship journey. Working together, we can catalyze meaningful action that protects and restores nature while also strengthening business continuity.

Acknowledgements

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AXA XL provides insurance and risk management products and services for mid-sized companies through to large multinationals, and reinsurance solutions to insurance companies globally. We partner with those who move the world forward.

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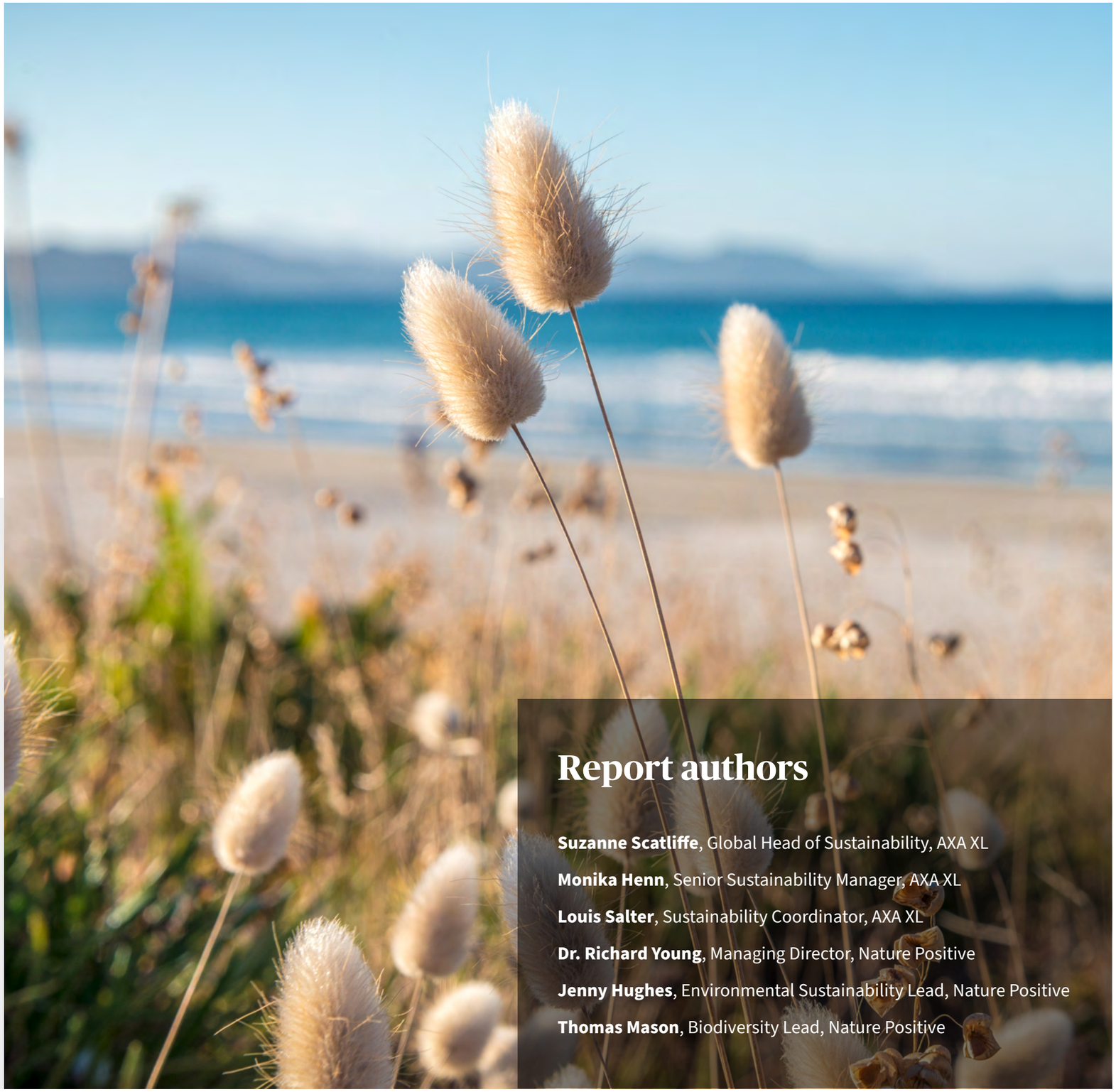

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Appendix A. Industry methodology

This section provides an overview of the research methodology undertaken to assess each industry.

Industry and nature: A literature review was undertaken to evaluate each industry's relationship with nature. Firstly, an online search was undertaken using keywords to identify relevant sources on nature and biodiversity, environmental impacts, and business risks. This included a review of ENCORE's [134] impacts and dependencies references. Academic research papers and grey literature including industry reports were screened based on their broad applicability, relevance, and credibility. Evidence was then analysed and synthesised to provide an overview of the industry's overall relationship with nature, with inputs from AXA XL subject matter experts.

Value chain mapping: For each industry the value chain maps were informed by the latest TNFD sector guidance. The maps highlight the most important upstream, downstream, and direct operation stages in the value chain. Stages which were duplicated across value chains were excluded to avoid repetition of results.

Impacts and dependencies tables: Results follow the methodology developed for AXA XL's biodiversity impact and dependency assessment, which was undertaken for the underwriting business. This assessment evaluated a wide range of different activities within each value chain industry. Results are derived from the ENCORE database [134] and impacts and dependencies are aggregated using the Partnership for Biodiversity Accounting Financial (PBAF) methodology. Some impact pressures and ecosystem services (ESS) have been renamed and in some cases similar ESS have been combined to aid readability and interpretation for non-technical readers. Risks and opportunities: The risk and opportunities tables have been adapted from the relevant TNFD sector guidance. Key risks and impacts were identified, providing a sample of chronic and acute physical risks, transition risks, as well as business opportunities. Detail and examples were added to illustrate the risks and provide detail on potential business impacts.

Types of nature risks: According to the TNFD, nature-related risks are potential threats posed to an organisation that arise from its dependencies and impacts on nature (along with wider society). These risks can be physical, transition or systemic. In this report, we will focus primarily on physical and transition risks, as defined by the ***TNFD recommendations***, as managing and responding to these risks are more within a company's control or influence.

Physical risks are those that result from the degradation of nature and consequential loss of ecosystem services. They can be either acute – the occurrence of short-term, specific events, for example, natural disasters, such as forest fires – or chronic – gradual changes to the state of nature, for example, a gradual decline of species diversity of pollinators, resulting in reduced crop yields.

Transition risks are risks to an organisation that stem from a misalignment of economic factors with actions aimed at protecting, restoring and/or reducing negative impacts on nature. These risks can be prompted, for example, by changes in regulation, policy and legal precedent. The categories of nature-related transition risks include policy, market, technology, reputational and liability risk. You can learn more about these types of risks on the TNFD website.

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