SECOND-QUARTER 2023 EDITION

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Sustainable1

INTRODUCTION

Introduction

This theme of interconnectedness was on display at the summits that S&P Global Sustainable1 hosted in Paris and Singapore in May, where attendees discussed themes ranging from physical climate risks to net-zero to the energy transition to nature. Throughout these discussions, we heard about the importance of taking a holistic approach to sustainability issues and not treating them in silos.

The research that follows shows how these connections are playing out around the globe and across borders. We look at how rising water stress could have a long-term impact on economic growth in Mexico and how the world's major food and beverage companies are approaching water stress and conservation. We also examine the economic and political environment of Chile and Peru, which will play a key role in supplying commodities needed for the energy transition, and we gauge the risks and opportunities of industrial decarbonization efforts, from the global trade impact of carbon pricing in the EU to the carbon capture, removal and credit solutions.

And underlying it all is the growing understanding of the global economy's reliance on biodiversity and ecosystem services — a topic we explore in research based on a new S&P Global Sustainable1 dataset.

Events like the wildfires now raging in Canada, which blanketed major US cities on the East Coast in smoke for several days, drive home the point that what happens in one part of the world can have knock-on effects for the sustainability of other industries and jurisdictions. ■

Richard Mattison
Vice Chairman,
S&P Global Sustainable1

How the world's largest companies depend on nature and biodiversity

Most of the world's largest companies are significantly dependent on nature in their operations even as the biodiversity and ecosystems underpinning natural resources are declining due to overexploitation and climate change, according to new research from S&P Global Sustainable1.

This research was authored by S&P Global Sustainable1.

Published on May 10, 2023

Key takeaways

- New research from S&P Global Sustainable1 finds that 85% of the world's largest companies that make up the S&P Global 1200 have a significant dependency on nature across their direct operations.
- The analysis also finds that 46% of companies in that universe have at least one asset located in a Key Biodiversity Area that could be exposed to future reputational and regulatory risks.
- S&P Global 1200 companies used an estimated 22 million hectares of land for their direct operations in 2021 to generate $28.9 trillion of revenue. Expressed as an ecosystem footprint, this is equivalent to fully degrading 2.2 million hectares of the most pristine and significant ecosystems globally, such as the most intact and biodiverse parts of the Amazon or Sumatran rainforests.

▶ **Most of the world's largest companies are** significantly dependent on nature in their operations even as the biodiversity and ecosystems underpinning natural resources are declining due to overexploitation and climate change.

S&P Global Sustainable1 data shows that 85% of companies in the S&P Global 1200 — an index that covers the 1,200 largest companies across North America, Europe, Asia, Australia and Latin America — have a significant dependency on nature across their direct operations.

A look at a broader universe of companies in the S&P Global Broad Market Index (BMI) shows similar dependency on nature: 68% of companies in this index have a significant dependency on nature across their direct operations. The S&P Global BMI includes approximately 14,000 companies from across dozens of developed and emerging markets.

Protecting nature is a nascent priority for many companies, despite the fact that nature underpins much of the global economy. About $44 trillion of global economic value generation — over half of global GDP in 2019 — is moderately or highly dependent on natural assets and their ecosystem services, according to the World Economic Forum. A new analysis PwC released in April 2023 updated that figure, finding that 55% of global GDP, equivalent to an estimated $58 trillion, is moderately or highly dependent on nature.

Understanding ecosystem dependency and risk

The economy is reliant on the ecosystem services that nature provides in many ways. For example, ecosystem services provide wood for timber harvest; groundwater or fresh water for drinking, cooling power plants or irrigation; and animal or plant fibers for fabrics or fertilizer.

Nature also provides ecosystem services by modulating the climate and hydrological, ecological and soil processes. Examples of these ecosystem services include pollination, carbon sequestration, erosion control, flood and storm protection, disease control and soil quality.

How does this connect back to business? The global economy is benefiting from nature even as it is driving nature loss, which is reducing nature's ability to sustain those ecosystem services. Pollution, deforestation and other unsustainable land use, paired with climate change and the spread of invasive species, have put about 1 million animal and plant species at risk of extinction, many within decades, according to the UN.

The 2021 Dasgupta Review, a landmark study of the economics of biodiversity, noted that from 1992 to 2014 the world's stock of natural capital assets per person declined by nearly 40% while during that same period the produced capital per person doubled.

Understanding ecosystem dependencies — how much an organization relies on certain ecosystem services to function — can also help the organization understand the risk it would face if that ecosystem service declined or stopped.

Ecosystem dependencies will vary based on location and the services a company provides. For example, a company with operations in a flood-prone area will be more dependent on flood and storm protection.

Healthy and diverse ecosystems also play a key role in absorbing carbon emissions and helping both the natural world and human society adapt to the physical impacts of climate change. But nature's ability to provide those services will diminish with every degree of global warming, the Intergovernmental Panel on Climate Change (IPCC) warned in its recent synthesis report.

Biodiversity and nature are gaining rising attention from companies, investors and governments, but many companies are in the early stages of understanding the risks these issues pose to their business.

To help address this challenge, S&P Global Sustainable1 has launched a new Nature & Biodiversity Risk Dataset that assesses nature-related impacts and dependencies across a company's direct operations including at the asset, company and portfolio levels. The Nature & Biodiversity Risk Dataset covers more than 17,000 companies and more than 1.6 million assets. The dataset applies the Nature Risk Profile Methodology for analyzing companies' impacts and dependencies on nature, launched by S&P Global Sustainable1 and the UN Environment Programme in January 2023.

What ecosystem services do the world's largest companies depend on most?

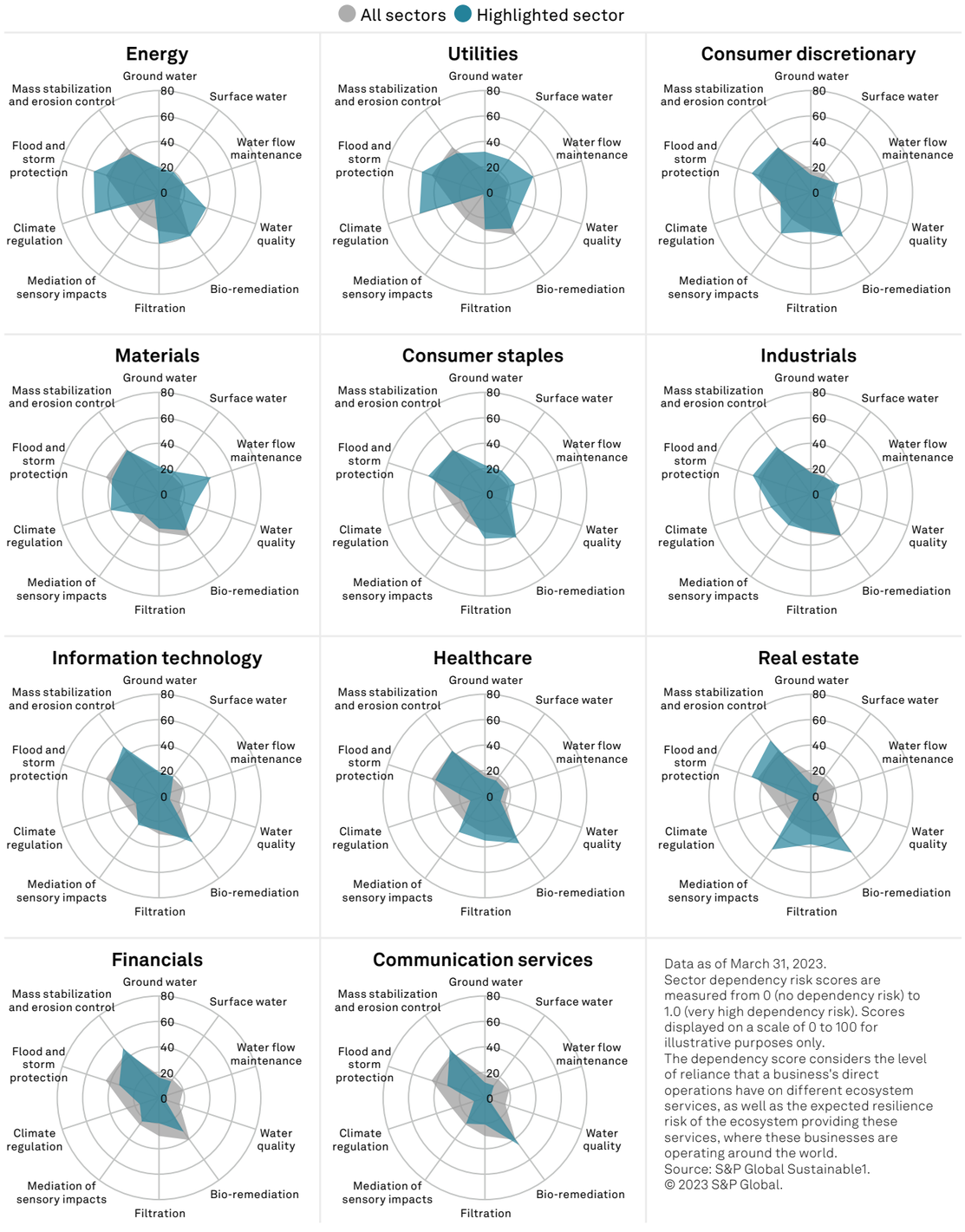
- **Mass stabilization and erosion control:** Many sectors in our analysis are dependent on the ecosystem service known as "mass stabilization and erosion control." This includes things like when vegetation on slopes prevents avalanches and landslides or when mangroves, sea grass and macro-algae provide erosion protection for coasts. This is the top dependency for four sectors in the S&P Global BMI: communication services, financials, information technology and materials.

- **Flood and storm protection:** The ecosystem service "flood and storm protection" is an important dependency across most sectors in the S&P Global BMI, and it is the top dependency for four sectors: consumer discretionary, consumer staples, energy and industrials.

  Flood and storm protection is provided by the sheltering, buffering and attenuating effects of natural and planted vegetation. Mangrove forests that grow along tropical coastal wetlands, for example, reduce waves and storm surges and can be a first line of defense against flooding and erosion. A scientific study in 2020 found that mangroves, which have been in rapid decline in recent decades, reduce property damage by more than $65 billion and protect more than 15 million people from flooding each year.

All sectors rely on ecosystem services, particularly erosion control and flood protection

Dependency risk scores on 10 ecosystem services by sector for S&P Global BMI companies



Data as of March 31, 2023.
Sector dependency risk scores are measured from 0 (no dependency risk) to 1.0 (very high dependency risk). Scores displayed on a scale of 0 to 100 for illustrative purposes only.
The dependency score considers the level of reliance that a business's direct operations have on different ecosystem services, as well as the expected resilience risk of the ecosystem providing these services, where these businesses are operating around the world.
Source: S&P Global Sustainable1.
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- **Bio-remediation:** The ecosystem service "bio-remediation" is another key dependency across sectors and is the top dependency for the healthcare and real estate sectors. Bio-remediation occurs when living organisms such as micro-organisms, plants, algae and some animals degrade, reduce and/or detoxify contaminants from soil and water. The living organisms typically do this by metabolizing the contaminant and converting it into a less toxic form, such as carbon dioxide or water.

  Bio-remediation occurs naturally but is also often harnessed as a relatively inexpensive way to clean up hazardous waste sites and toxic spills. For example, the US Environmental Protection Agency has used bio-remediation to clean up hundreds of contaminated sites.

- **Climate regulation:** "Climate regulation" refers in this paper to the ecosystem service nature provides to regulate or modulate climate. It is the top ecosystem service dependency for the utilities sector in the S&P Global BMI.

  Climate regulation can help companies by acting as a carbon sink to absorb and store carbon emissions from the atmosphere. Climate regulation can also ease the physical impacts of climate change.

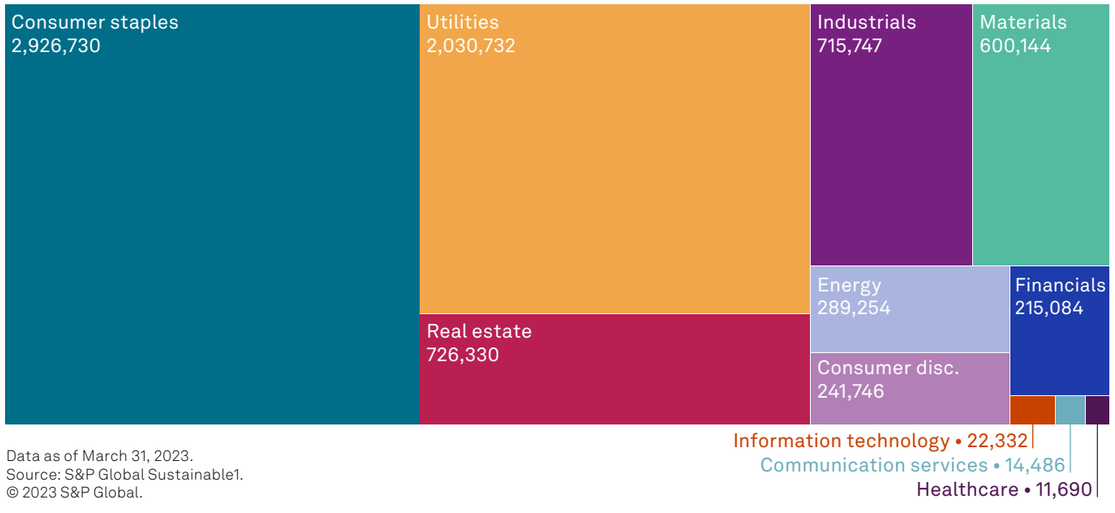
  On a global scale, climate regulation is provided by nature through the long-term storage of carbon dioxide in soils, vegetable biomass and oceans. On a regional level, the climate is regulated by ocean currents and winds. At local and microlevels, vegetation can modify temperatures, humidity and wind speeds.

Quantifying companies' footprint and ecosystem impact

While understanding nature-related dependencies can help a company understand its risk profile, investors, regulators and groups drafting disclosure frameworks are also asking for details about how company operations impact nature. One way to determine impact is by looking at land use. Overall, companies in the S&P Global BMI use an estimated 87.3 million hectares

The consumer staples and utilities sectors have the largest ecosystem footprints

Relative size of ecosystem footprints measured in hectares of Highest Significance Area equivalent by sector for S&P Global BMI companies' direct operations



Data as of March 31, 2023.
Source: S&P Global Sustainable1.
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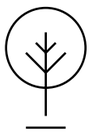


46% of companies in the S&P Global 1200 index and 16% of companies in the S&P Global BMI have at least one asset located in a Key Biodiversity Area

of land for their direct operations, such as for farms, factories, mines, retail stores, hospitals and even office space.

To go a step further and measure the direct operational impact a business has on nature, the Nature & Biodiversity Risk Dataset includes an ecosystem footprint metric. This metric combines three key areas of analysis: the areas of land impacted by the company (land area), the degree to which the location-specific ecosystem integrity is reduced (ecosystem degradation), and the significance of the location-specific ecosystem impacted (ecosystem significance).

Our analysis shows that companies in the S&P Global BMI collectively have an ecosystem footprint of 7.8 million hectares of Highest Significance Area equivalent. Consumer staples companies in this universe, which includes food & beverage activities and agriculture, have the largest total footprint as well as the largest ecosystem footprint, followed by utilities, real estate and industrials companies.

S&P Global 1200 companies used an estimated 22 million hectares of land for their direct operations in 2021 to generate $28.9 trillion in revenue. Expressed as an ecosystem footprint, this is equivalent to fully degrading 2.2 million hectares of the most pristine and significant ecosystems globally, such as the most intact and biodiverse parts of the Amazon or Sumatran rainforests.

Measuring companies' impact-related risk

Another way to measure how a company may be impacting nature is by understanding how much it operates in areas that are important to biodiversity. Businesses may face legal, regulatory, reputational and market risks if their biodiversity-related dependencies are not appropriately identified and managed in connection with their operations. To understand these risks, investors and regulators are increasingly seeking to understand how company operations overlap with biologically significant locations or protected areas.

S&P Global Sustainable1 data shows that 46% of companies in the S&P Global 1200 index and 16% of companies in the S&P Global BMI have at least one asset located in a Key Biodiversity Area (KBA). KBAs are sites contributing significantly to the global persistence of biodiversity. KBAs are identified at the national, subnational or regional level by local stakeholders based on standardized scientific criteria and thresholds.

Utilities in the S&P Global 1200, which include electric, gas and water, had the biggest overlap with KBAs. As providers of electricity and natural gas to customers, utilities' footprints, especially their transmission lines, traverse millions of miles.

Energy companies in the S&P Global 1200, which include oil and gas as well as coal mining companies, had the second-highest percentage of assets that overlap KBAs. Similar to electric utilities, oil and gas companies own and control millions of miles of pipelines around the world.

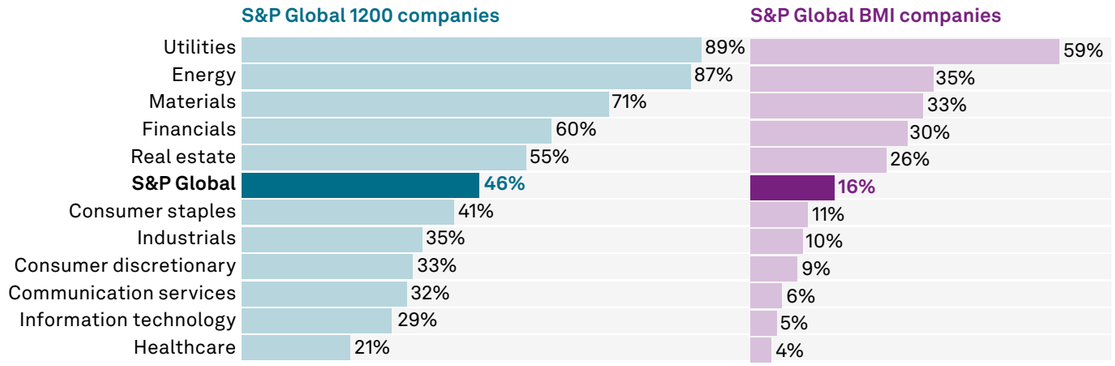
The materials sector, which includes metals and mining companies, has the third-highest percentage of assets in KBAs, at 4.9%.

The percentages of assets per sector covered by S&P Global's database and located in KBAs and protected areas is similar for companies in the S&P Global BMI universe and the S&P Global 1200 sample.

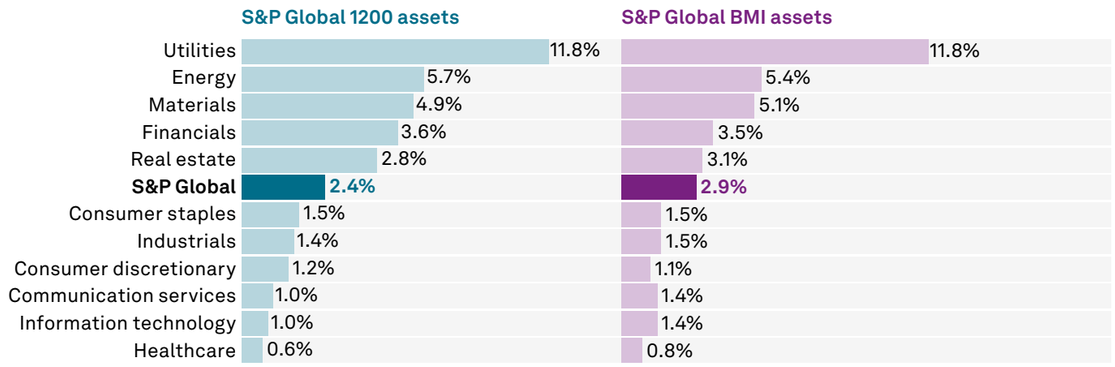
Many companies will face difficult choices in the energy transition as they build out additional infrastructure and increase their risk of overlapping with KBAs or protected areas.

Almost half of major companies globally operate within Key Biodiversity Areas

Percentage of **companies** in the S&P Global 1200 and S&P Global BMI with at least 1 asset within a Key Biodiversity Area



Percentage of **assets** in the S&P Global 1200 and S&P Global BMI within Key Biodiversity Areas



Data as of March 31, 2023.
Key Biodiversity Areas, as defined by the International Union for Conservation of Nature, are sites contributing significantly to the global persistence of biodiversity. Key Biodiversity Areas are identified at the national, subnational or regional level by local stakeholders based on standardized scientific criteria and thresholds.
Source: S&P Global Sustainable1.
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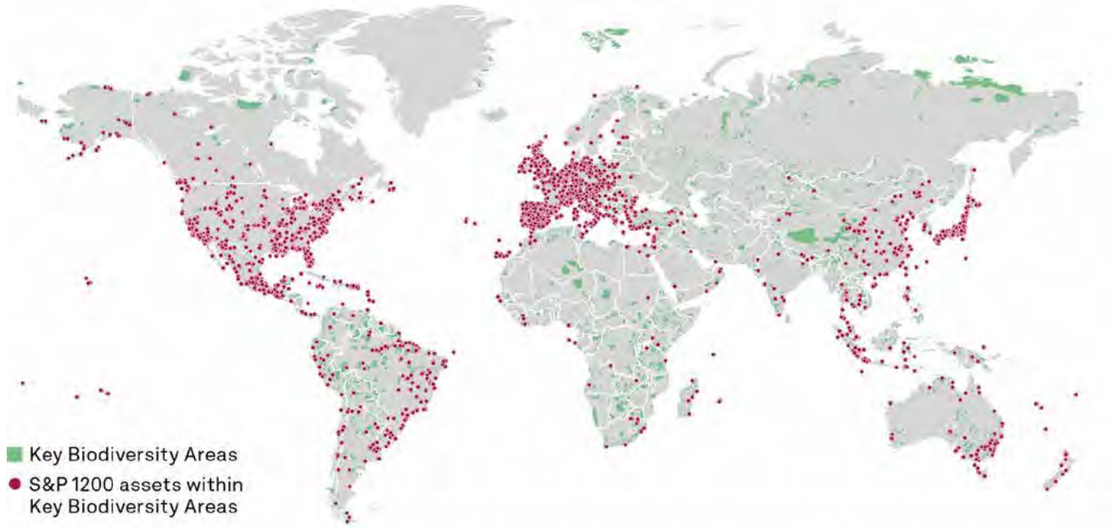
Recent research from S&P Global Sustainable1 found more than 1,200 mining sites that intersect with KBAs, and 29% of those sites are for extracting minerals needed for the low-carbon energy transition.

As KBAs are identified by the scientific community based on biological criteria and thresholds, the designation does not carry legal protections. However, governments have been known to use KBAs as reference points in establishing legally protected areas. Protected areas are geographically defined spaces that are managed through legal or other effective means to achieve the long-term conservation of nature with associated ecosystem services and cultural values.

Protected areas include national parks, wilderness areas and nature reserves managed by local, state or national governments. A protected area can also be an area of land that is owned or managed by a private owner, nongovernmental organization, for-profit organizations or Indigenous peoples.

Major companies around the world have assets overlapping with Key Biodiverstiy Areas

Asset locations operated by companies in the S&P 1200 within Key Biodiversity Areas by sector



Data as of March 31, 2023.
Key Biodiversity Areas (KBAs), as defined by the International Union for Conservation of Nature, are sites contributing significantly to the global persistence of biodiversity. KBAs are identified at the national, sub-national or regional level by local stakeholders based on standardized scientific criteria and thresholds.
Map credit: Ciaralou Agpalo Palicpic
Source: S&P Global Sustainable1

Protected areas and KBAs often overlap. As of 2021, about 61% of KBAs were either partly or completely within protected areas, according to an annual report on the KBA program, which is managed by the International Union for Conservation of Nature and 13 other global organizations.

Globally, about 17% of land and 10% of marine areas are protected. And with the passage of a new global biodiversity framework at the UN's COP15 biodiversity conference in December 2022, governments will be looking to expand existing protected areas or designate new ones.

Under the new biodiversity framework, governments pledged to achieve "effective conservation and management of at least 30% of the world's lands, inland waters, coastal areas and oceans" by 2030. The agreement "prioritizes ecologically-representative, well-connected and equitably-governed systems of protected areas and other effective area-based conservation."

S&P Global Sustainable1 data shows that about 70% of companies in the S&P Global 1200 have at least one asset in a protected area. In this universe of companies, the utilities sector has the largest amount of assets in a protected area (26.4%), followed by the information technology sector (12.7%) and the materials sector (8.9%).

Why KBAs and protected areas matter in company disclosure

Disclosure regulations and voluntary frameworks consider a number of indicators associated with nature dependencies and impacts, including the presence of operations in KBAs and protected areas.

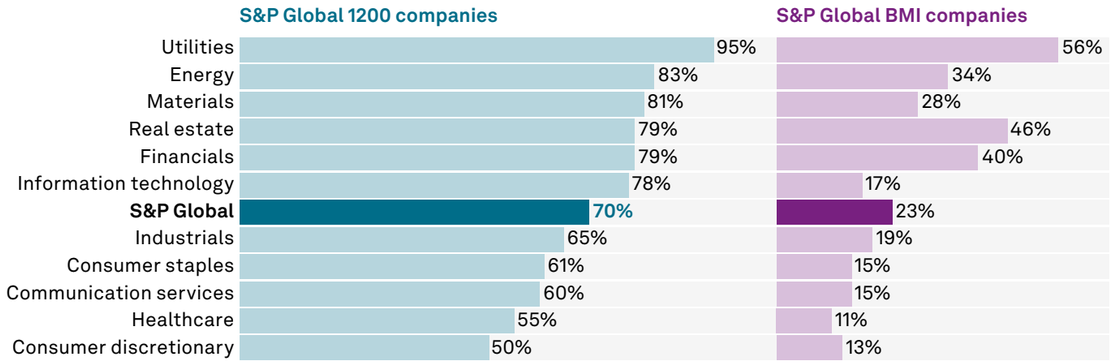
The Taskforce on Nature-related Financial Disclosures (TNFD) in March 2023 released its final beta framework for nature-related risk management and disclosure that proposes to have companies assess and disclose how their operations and supply chains overlap with KBAs and protected areas, as well as potential impacts and dependencies on nature, and ecosystem integrity. The TNFD aims to publish its final recommendations in September 2023.

Similarly, the EU's Sustainable Finance Disclosure Regulation (SFDR) requires financial market participants and financial advisers based in the EU to disclose the share of their investments in companies that have sites or operations in or near "biodiversity-sensitive areas." The SFDR defines biodiversity-sensitive areas as the European Natura 2000 network of protected areas, Unesco World Heritage sites and KBAs.

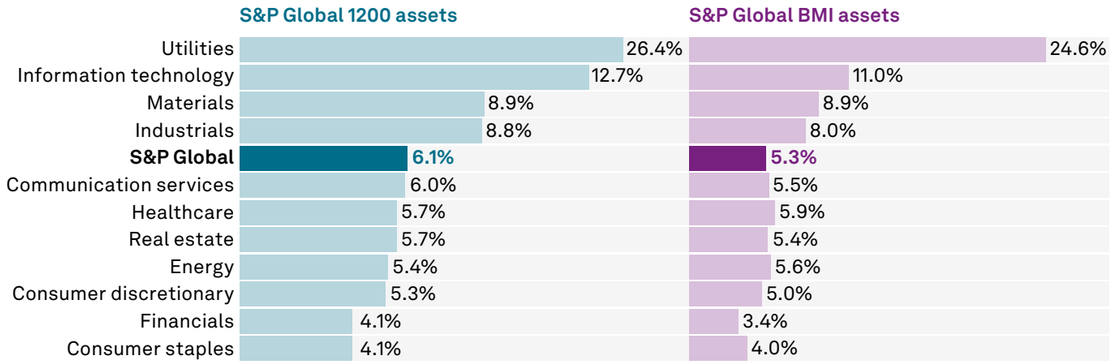
The GRI (Global Reporting Initiative), an independent international voluntary sustainability standards organization, is also developing a biodiversity disclosure standard. Comments on the draft standard closed in February 2023.

A majority of large companies globally operate within protected areas

Percentage of **companies** in the S&P Global 1200 and S&P Global BMI with at least 1 asset within a protected area



Percentage of **assets** in the S&P Global 1200 and S&P Global BMI within protected areas



Data as of March 31, 2023.
Protected areas are geographically defined spaces that are managed through legal or other effective means to achieve the long-term conservation of nature with associated ecosystem services and cultural values.
Source: S&P Global Sustainable1.
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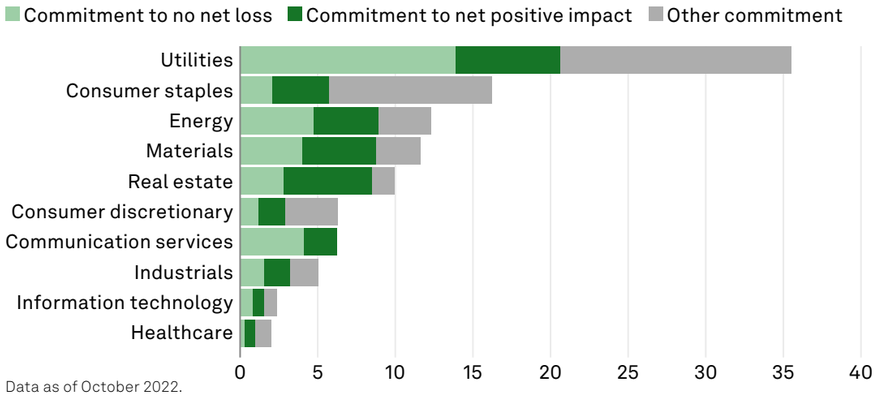
Nature-related commitments are uncommon outside the utilities sector

Percentage of companies by sector making nature-related commitments



Data as of October 2022.
No net loss means that damages linked to business activity are offset by at least equivalent gains, avoiding a net loss of biodiversity and ecosystem services. Net positive impact means that corporate actions on biodiversity, such as habitat protection, are greater than the impact from its business activity. A commitment to net positive typically goes further than one to no net loss. Examples of "other" commitments include: no deforestation, no peat, no exploitation, the use of certified raw materials, etc.
Results based on responses from 3,565 companies assessed in the 2022 S&P Global Corporate Sustainability Assessment.
Source: S&P Global Sustainable1.
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Meanwhile, corporate pledges to protect nature are increasing, but they remain rare. Research by S&P Global Sustainable1 has found wide variations in commitments to protecting biodiversity and ecosystem services. According to the S&P Global Corporate Sustainability Assessment, no assessed industry has a majority of companies making nature-related commitments.

Methodology

Ecosystem footprint: In order to provide a decision-useful metric that enables comparison between business operations, land area, ecosystem integrity degradation and ecosystem significance are brought together to calculate the equivalent impact on the most significant areas globally in terms of biodiversity conservation and ecosystem services provision. This produces an Ecosystem Footprint expressed as the equivalent number of hectares in the most globally significant ecosystems that would be fully degraded by the company's operations.

Dependency score: The dependency score considers the level of reliance that a business has on 21 different ecosystem services as well as the expected resilience risk of the ecosystem providing these services, where these businesses are operating around the world. Significant dependency is signified by companies that have a dependency score over 0.6, where 0 represents no dependency risk and 1.0 represents very high dependency risk. ■

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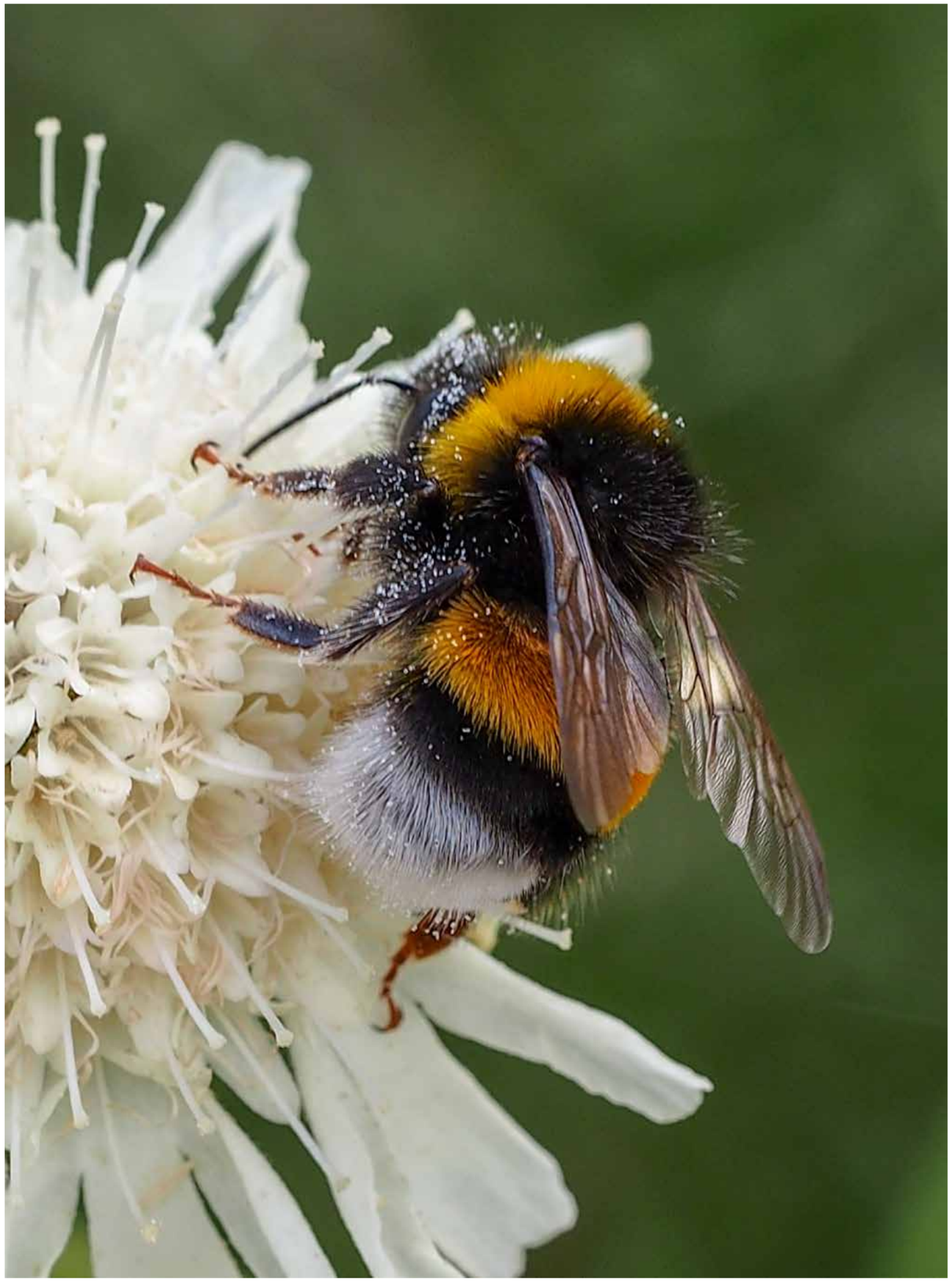
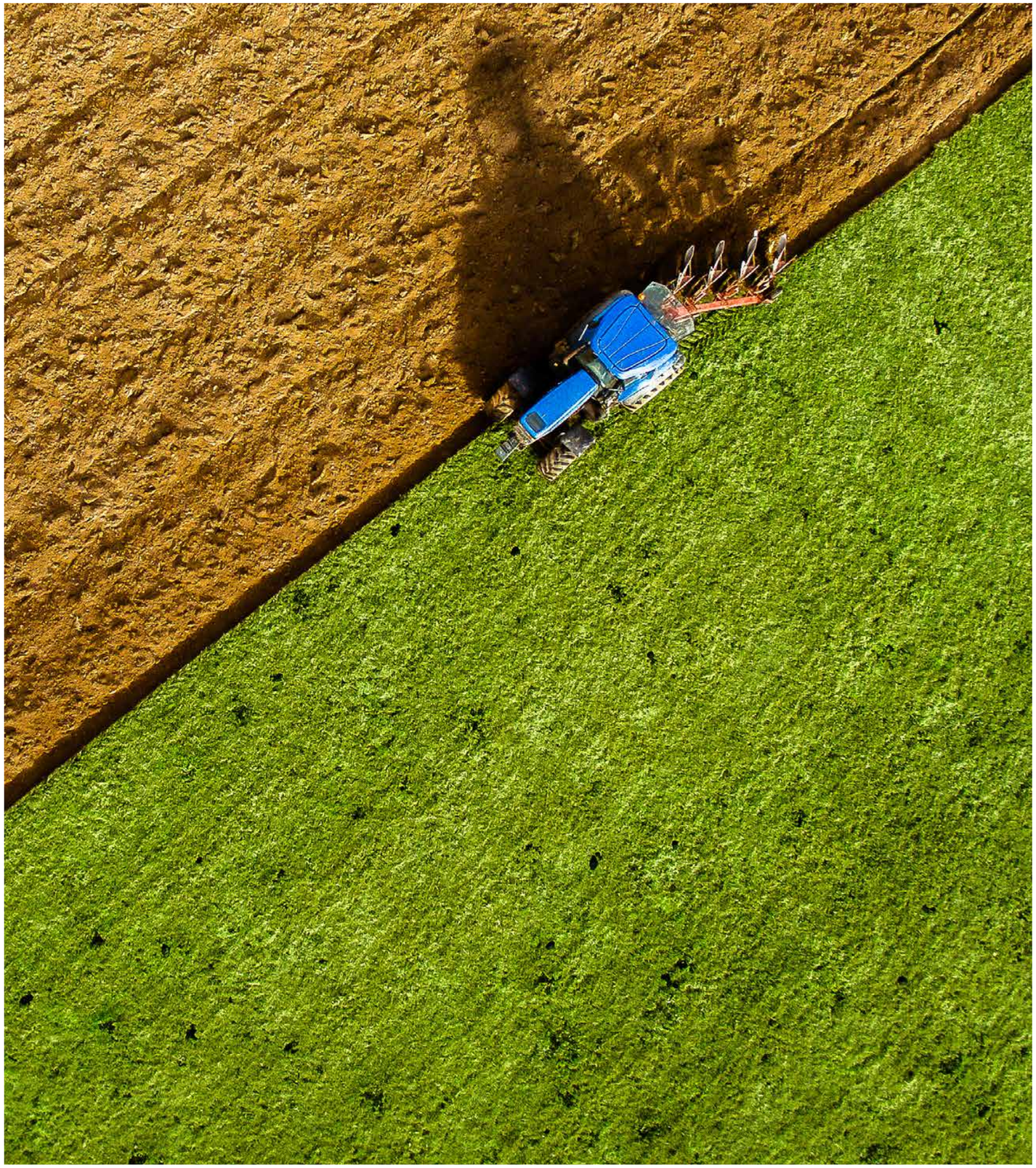


NATURE AND BIODIVERSITY



How global food producers are responding to rising water stress

Water conservation will become increasingly important over the coming decades as cropland in many of the world's largest food-exporting countries faces exposure to water stress. Only about half of major food companies around the world have commitments to sustainable agriculture, which focuses on conserving natural resources such as water.

This research was authored by S&P Global Sustainable1.

Published on March 23, 2023

Key takeaways

- Water conservation will become increasingly important over the coming decades as cropland in many of the world's largest food-exporting countries faces exposure to water stress, S&P Global Sustainable1 physical risk data shows.
- About half of major food- and beverage-producing companies have a publicly available commitment to sustainable agriculture, which focuses on preserving natural resources such as fresh water; not all of those commitments cover the full scope of those companies' supply chains, according to the 2022 S&P Global Corporate Sustainability Assessment.
- Food and beverage companies chose environmental management and climate strategy as two of their top material issues, and reducing water consumption was the most common sustainable agriculture program that companies had in place, according to the assessment.

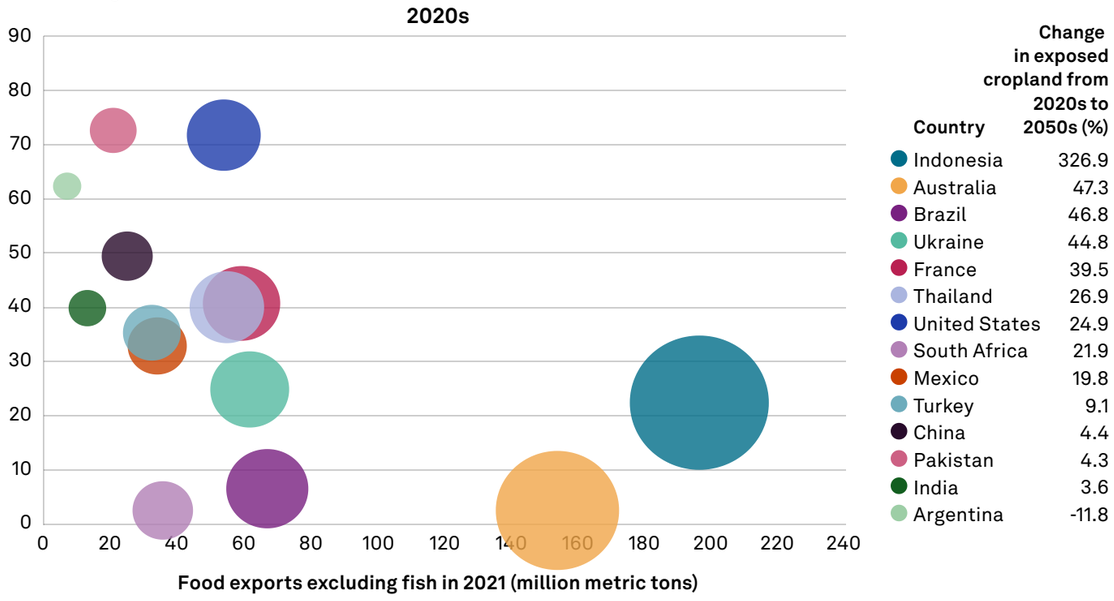
▶ **Food producers face the challenge of** feeding a growing global population while conserving the natural resources agriculture relies on. The UN Food and Agriculture Organization (FAO) estimated in its 2017 report, "The future of food and agriculture – Trends and challenges," that demand for food will rise 50% by 2050 compared to 2012 and undergo structural changes due to population growth, urbanization and evolving consumer trends. Competition for natural resources such as water is likely to increase even more as climate change leads to freshwater scarcity in more parts of the world and intensifies in areas where water is already limited.

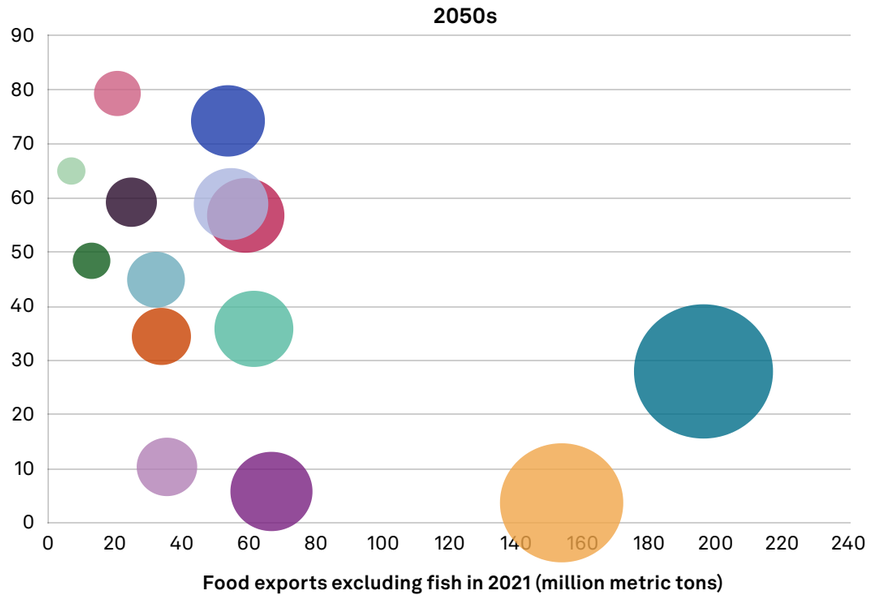
Agricultural practices vary widely around the world, from the large-scale industrial farms in Australia and the western US to smallholder farming systems more common in South and Southeast Asia, but all farming relies to some extent on fresh water. Much of the world's crop production — about 60% — is from farming that is entirely reliant on rainfall, according to the FAO report "The State of Food and Agriculture 2020: Overcoming water challenges in agriculture." The remaining portion draws at least some of its water needs from fresh groundwater, and as climate change disrupts rainfall patterns and increases the frequency of drought in different parts of the world, more demand for groundwater could come from cropland previously supplied by rainwater.

Demand for fresh water for growing crops, alongside domestic demand for drinking water and water's use in many industrial and manufacturing processes, will put increasing strain on water supplies in the coming decades without efforts to adapt. S&P Global Sustainable1 physical risk data shows that cropland in some of the world's largest food-exporting countries, such as Brazil and Ukraine, will face significantly more water stress between the 2020s and the 2050s. While farming systems in these countries face the challenge of water scarcity, support for the sustainable agriculture practices that can conserve natural resources such as fresh water is not yet universal among

Water stress exposure will climb for major food exporters by the 2050s

Percentage of cropland in major food-exporting countries that will face significant water stress exposure under a business-as-usual climate change scenario





Data as of Dec. 23, 2022.
The business-as-usual scenario, also known as SSP3-7.0, is characterized by limited mitigation where total greenhouse gas emissions double by 2100 and global average temperatures rise by 2.8 degrees C to 4.6 degrees C by 2100.
Sources: Food and Agriculture Organization of the United Nations; S&P Global Sustainable1.

FAO. Crops and livestock products. License: CC BY-NC-SA 3.0 IGO. Extracted from: https://www.fao.org/faostat/en/#data/TCL. Date of Access: 14-03-2023.
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major global food and beverage companies, according to data from the 2022 S&P Global Corporate Sustainability Assessment (CSA).

Major food-producing nations face water stress

Efficient water usage is a top priority for food and beverage producers as it is a major input for nearly every agricultural product across their supply chains and is often an input in the production of food products and beverages. Groundwater and irrigation play a part in raising crops even in areas that receive substantial rainfall, and arid regions rely on groundwater even more. Irrigated agriculture accounts for 70% of all freshwater withdrawal globally, according to the 2022 United Nations World Water Development Report.

Access to adequate supplies of fresh groundwater for food production will become more critical over the coming decades as climate change disrupts weather patterns and temperatures become more extreme. S&P Global Sustainable1 data on climate hazards such as water stress shows that the largest food-exporting countries face heightened water stress by the 2050s — a trend that could have significant implications for food and beverage companies, considering their presence in and dependence on exports from these countries.

This analysis measures water stress, in line with the World Resources Institute water risk tool Aqueduct and UN sustainable development goal 6.4, as a ratio of total water withdrawals, including domestic, industrial, irrigation and livestock uses, to available renewable surface water and groundwater supplies. Water stress reflects the level of competition for the supply of fresh water held in surface water basins, such as lakes and streams, and in below-surface aquifers.

The S&P Global Sustainable1 analysis models the percentage of cropland exposed to significant water stress in 14 major food-exporting countries based on metric tons of food exported in 2021 in two decadal periods, the 2020s and the 2050s. The analysis uses a business-as-usual climate change scenario known as SSP3-7.0, in which total greenhouse gas emissions double by 2100 and global average temperatures rise by 2.8 degrees C to 4.6 degrees C by 2100.

The percentage of water-stressed cropland will rise in 13 of these 14 countries from the 2020s to the 2050s across several continents. The largest food exporters in this group, the US and Brazil, will see their share of water-stressed cropland rise 24.9% and 46.8%, respectively, absent adaptation. Other major increases include Ukraine, known as the breadbasket of Europe, which exported 61.8 million metric tons of food in 2021, making it the fourth-largest agricultural exporter in this list. The percentage of water-stressed cropland in Ukraine is projected to rise 44.8% from the 2020s to the 2050s to more than one-third of its farmland by the 2050s.

The most drastic increase is projected for Indonesia, where the percentage of cropland exposed to significant water stress will more than triple. Indonesia exported about 35.8 million metric tons of food in 2021, roughly one-sixth the amount of food as the US.

Other large exporters, including France and Australia, will see the share of cropland facing significant water stress rise by 39% or more. For one of the top exporters, Argentina, the opposite trend is forecast: A smaller share of cropland is projected to face significant water stress by the 2050s compared to the 2020s. Argentina exported roughly one-third the amount of food as the US, and about 5 million more metric tons than Ukraine, in 2021.

A spike in the amount of cropland experiencing water stress in Brazil, Ukraine and other major exporters could have far-reaching consequences for food supply chains that rely on agricultural inputs, from grains such as barley, wheat and maize to sugars and oils. Rising water stress at this origin point of large food and beverage companies' supply chains increases the importance of implementing water conservation programs that extend throughout companies' supply chains beyond Tier 1.

Water stress reflects scarcity due to demand from other industries and activities, not just agriculture. Demand for fresh, clean drinking water will rise as the world's population grows and becomes more urbanized. Water is also a key input or coolant to many industrial and energy processes. CSA data shows that water consumption among the world's largest companies is highest for electric utilities, chemicals companies, and oil and gas companies. The CSA's water consumption data reflects the assessed companies' operations and does not capture water consumed across supply chains, where most of the agricultural water consumption that supplies the food products industry occurs.

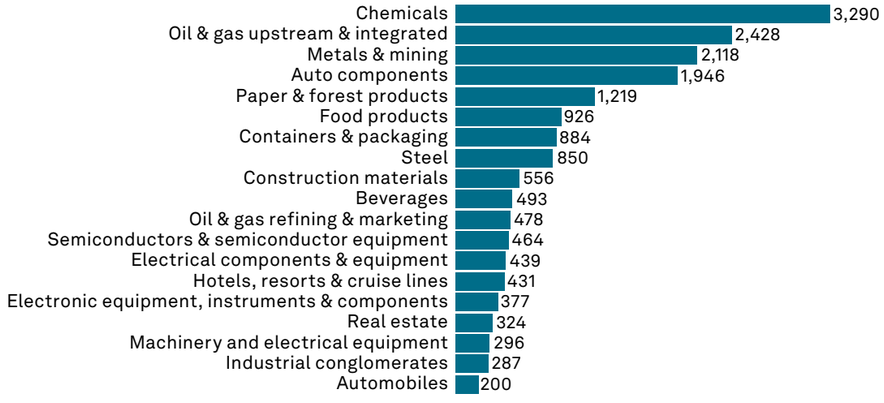
Corporate commitments to sustainable agriculture

Sustainable agriculture refers to a set of practices that can help food producers conserve vital natural resources like fresh water and reform existing practices that cause much of the sector's greenhouse gas emissions contributing to climate change. Because their supply chains source inputs from the farm systems on the front lines of water demand and natural resource use, major food and beverage companies can advance sustainable agriculture by adopting programs and policies that actively seek to make resource use more efficient and avoid environmental damage.

Data from the 2022 CSA shows that about half of the 213 assessed companies in the food products, beverages, and food and

Industrial and energy industries are among the largest consumers of fresh water

Industries with the highest annual net freshwater consumption (Million cubic meters)



Data as of March 6, 2023.
Results based on responses from 582 companies assessed in the 2022 S&P Global Corporate Sustainability Assessment. The Electric Utilities industry has been excluded to improve readability of the other industries. The Electric Utilities industry had the highest water consumption recorded in the 2022 CSA, at 16,125 million cubic meters.
Source: S&P Global Sustainable1.
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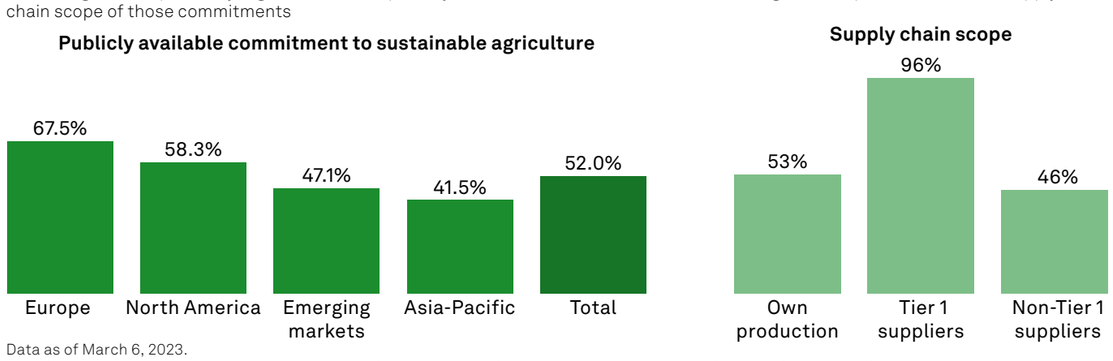
About half of food and beverage companies have publicly committed to sustainable agriculture

Percentage of companies by region that have a publicly available commitment on sustainable agriculture practices, and the supply chain scope of those commitments



Data as of March 6, 2023.
Results based on responses from 213 companies in the Food Products, Beverages, and Food and Staples Retailing industries assessed in the 2022 S&P Global Corporate Sustainability Assessment, of which 97 companies indicated the scope of their sustainable agriculture commitments.
Emerging Markets includes the following: Chile, Mexico, Peru, Thailand, Brazil, China, India, South Turkey, Africa and Saudi Arabia.
Own production refers to all products and services produced or offered by the company. Tier 1 suppliers are those that directly supply goods, materials or services to the company. Non-Tier 1 suppliers are those that provide their products and services to the supplier at the next level of the chain.
Source: S&P Global Sustainable1.
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staples retailing industries have a publicly available commitment to sustainable agriculture. The CSA is a research framework that captures data from thousands of companies annually on relevant sustainability topics.

Sustainable practices were most common in Europe and North America, where 68% and 58% of assessed companies, respectively, provided a publicly available commitment. The commitments generally apply to companies' supply chains.

Nearly every company with a sustainable agriculture commitment showed that its policy applied to Tier 1 suppliers, or companies one step away in the supply chain that provide direct inputs. But only about half of the commitments covered non-Tier 1 suppliers that provide inputs farther up the supply chain. This finding, combined with the fact that only half of companies had a commitment to sustainable agriculture in the first place, shows that some companies are not taking a long-term view on how to preserve the natural resources that agriculture ultimately depends on.

Sustainable agriculture practices

Sustainable agriculture covers a range of practices with the goal of conserving the natural systems that underpin food production, such as protecting soil health, preventing the pollution of fresh groundwater, lowering greenhouse gas emissions to slow climate change, and avoiding the destruction of ecosystems.

About 42% of the 213 assessed companies provided detail on at least one program they have in place. Most of these companies (85%) have a program in place to reduce water consumption, and a similar percentage (84%) have a program in place to reduce environmental pollution. Agriculture is a source of pollution in many countries due to the pesticides, nitrates and phosphates that can leach into the local fresh water, marine ecosystems, air and soil.

Nearly three-quarters of the companies have a program or policy to prevent the destruction of ecosystems. Agriculture is responsible for 80% of deforestation, according to the 2022 FAO study "The future of food and agriculture – Drivers and triggers for transformation." In some countries, particular crops or commodities drive much of the damage. Livestock grazing is a main cause of the shrinking Amazon rainforest, parts of which have become a net carbon source rather than sink. Marine aquaculture — raising fish and other seafood in coastal waters — can be detrimental to important ecosystems such as coastline mangrove forests, which also act as natural buffers against climate hazards like tropical storms and cyclones.

Similarly, 73% of assessed companies are actively seeking to reduce agricultural greenhouse gas emissions, much of which are due to ecosystem destruction. Deforestation removes the natural carbon sinks of expansive old-growth forests. Raising livestock on this cleared land contributes even more to climate change. In a 2021 study, the FAO found that 31% of human-caused greenhouse gas emissions originate from agri-food systems, with more than half of those emissions coming from activities within the farm gate and from land-use change such as clearing forests.

Materiality and innovation

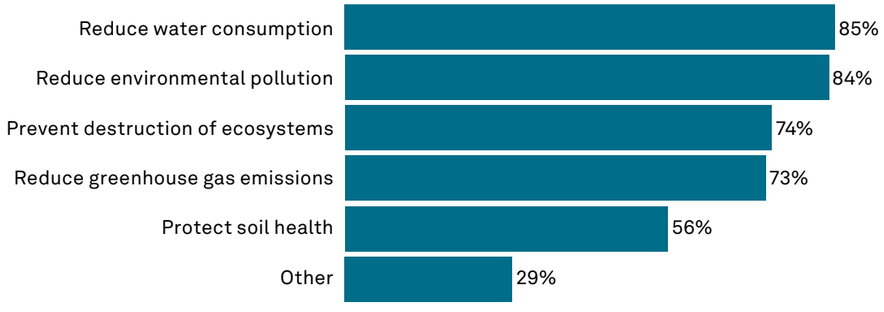
The world's major food producers appear to understand that environmental concerns are key to their success. The 2022 CSA asked companies to list the three issues they consider most material to their business performance, and among the 213 food, beverages and food retailing companies assessed, environment-related topics were among the most chosen.

73% of assessed companies are actively seeking to reduce agricultural greenhouse gas emissions, much of which are due to ecosystem destruction

Companies were able to select up to three issues, resulting in a total sample of 494 responses. The environmental management, climate strategy and long-term environmental trends topics received 36.4% of responses in aggregate.

Reducing water consumption and environmental pollution are the most common sustainable agriculture programs in place

Percentage of companies with sustainable agriculture programs, the percentage that have the following programs in place



Data as of March 6, 2023.
Results based on 358 responses from 213 companies in the Food Products, Beverages, and Food and Staples Retailing industries assessed in the 2022 S&P Global Corporate Sustainability Assessment, of which 89 companies had at least one sustainable agriculture program in place. Companies were able to select multiple programs.
"Other" includes programs such as: water sanitation, wastewater treatment, waste management, traceability, energy reduction, responsible materials for packaging and others.
Source: S&P Global Sustainable1.
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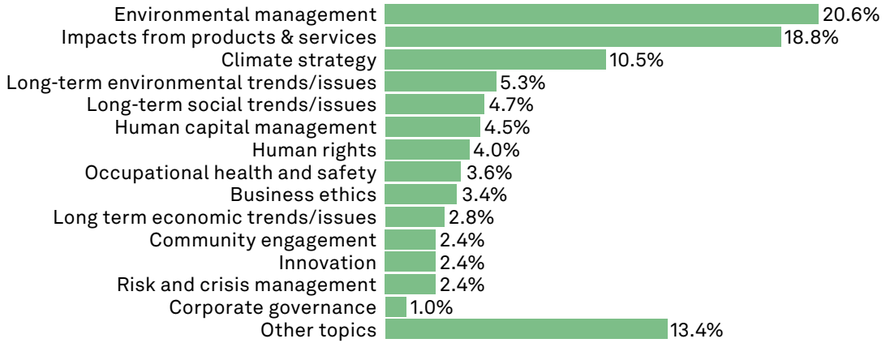
Environmental management and climate strategy are among the top material issues for food and beverage companies

Percentage of company responses selecting following topics as one of the company's top 3 material issues



Data as of March 7, 2023.
Results based on 494 responses from 213 companies in the Food Products, Beverages, and Food and Staples Retailing industries assessed in the 2022 S&P Global Corporate Sustainability Assessment. Each company was able to provide up to three material issues.
Source: S&P Global Sustainable1.
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This focus on the environment as a material concern contrasts with the data showing that only about half of these companies have a publicly available commitment to sustainable agriculture covering their suppliers. Similarly, only about 42% of assessed companies provided detail showing they had at least one sustainable agriculture program in place.

A range of innovative practices exist for farmers to preserve soil health, conserve water resources, and reduce their environmental impact while also increasing their crop yields, according to the FAO. Conservation or minimum tillage, for example, has benefits across the spectrum of sustainability in agriculture, from reducing erosion and runoff to retaining moisture in the soil to improve water conservation.

These practices take place at the origin point of food supply chains, within the farm gate. But major food and beverage companies can help drive higher crop yields and better water conservation across their supply chains by adopting sustainable agriculture programs. Support for on-the-ground innovation at the corporate food production level could help agriculture rise to the dual challenges of water scarcity and population growth. ■

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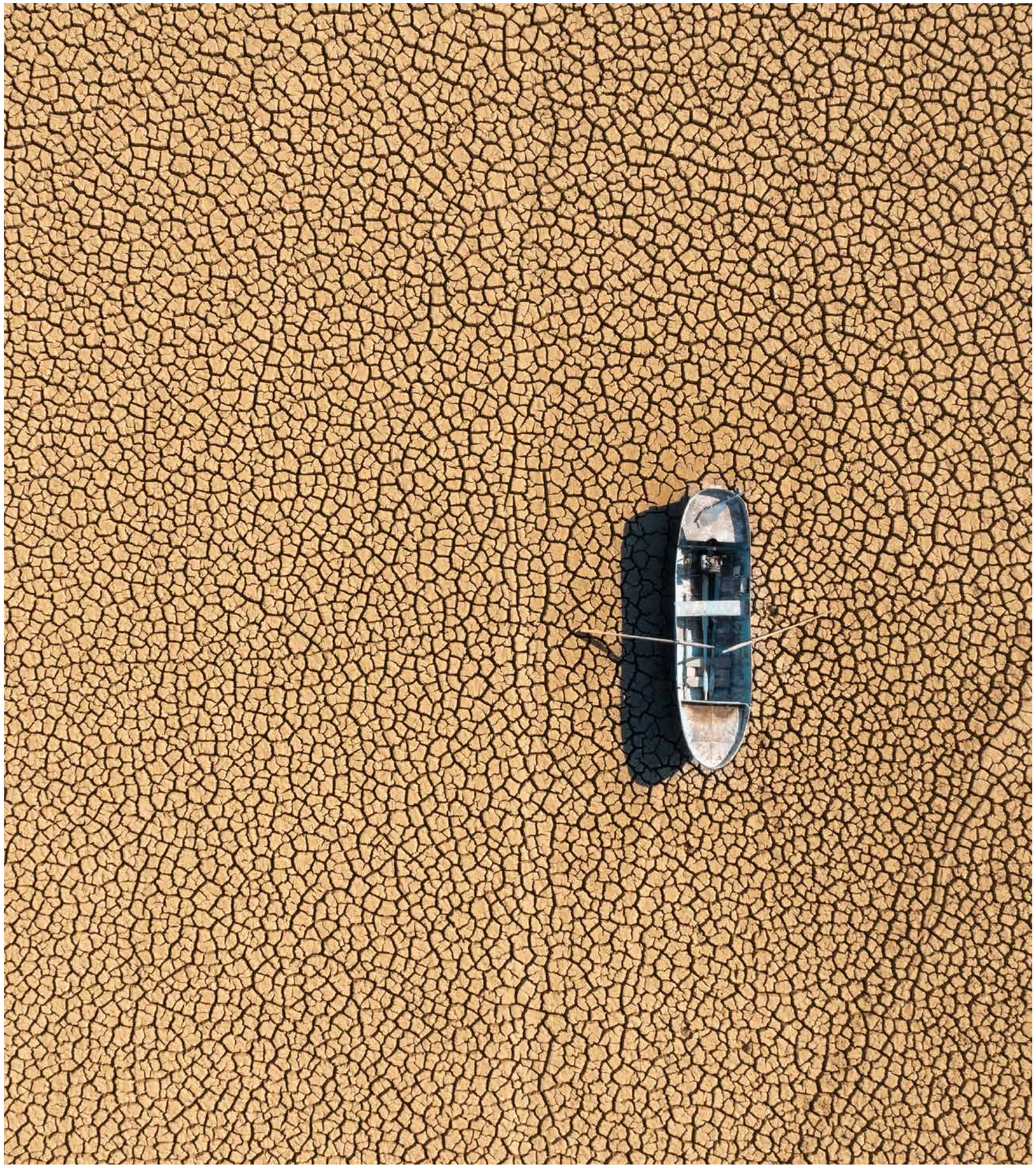
SUSTAINABLE AGRICULTURE



More Mexican states could face water stress by 2050

S&P Global Ratings believes that Mexican states' exposure to high water stress, if left unaddressed, could influence long-term economic growth in the country. In this research paper, we are seeking to better understand the scale of Mexico's potential exposure to this environmental risk and its distribution across the country.

This research was authored by S&P Global Ratings.

Published on April 4, 2023

The findings of this research do not currently form part of the base case for our ratings on Mexican local and regional governments.

This report does not constitute a rating action.

Key takeaways

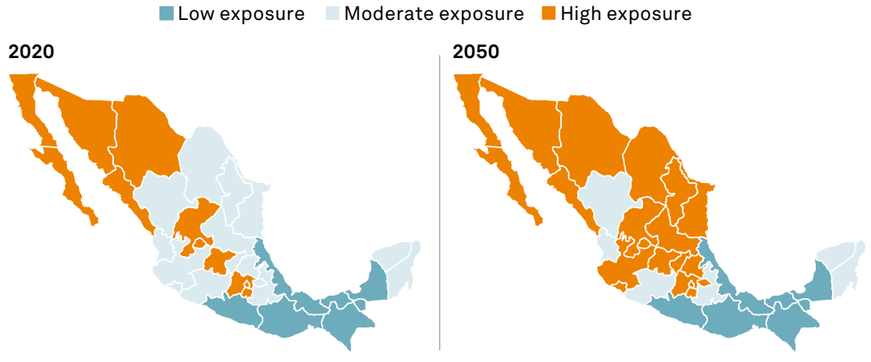
- Without adaptation measures, the number of Mexican states exposed to high water stress will almost double to 20 (about 60% of states) by 2050, from 11 (34%) in 2020, under all scenarios covered in our analysis.
- States facing the greatest risk are already short of water and may experience decreased economic growth as the frequency and intensity of droughts increase.
- An increase in investments in water infrastructure over the long term could weaken some states' and municipalities' budgetary performance and result in higher debt but go some way to building resilience to water scarcity.

▶ **Water stress occurs when demand for** water exceeds available supply or when poor water quality restricts its use, according to the European Environment Agency. S&P Global Ratings believes that Mexican states' exposure to high water stress, if left unaddressed, could influence long-term economic growth in the country. In this research paper, we are seeking to better understand the scale of Mexico's potential exposure to this environmental risk and its distribution across the country. The scenarios presented here provide insight into the potential exposure of Mexican states to the specific physical climate risk represented by water stress.

This research uses S&P Global Sustainable1's Climate Change Physical Risk dataset to explore Mexican local and regional governments' (LRGs) exposure to water stress over the next 30 years. S&P Global Sustainable 1 is separate and distinct from S&P Global Ratings. Certain activities of these business units are kept separate from each other in order to preserve their respective independence and objectivity.

The stress scenarios reflect Shared Socioeconomic Pathways (SSPs) from the Intergovernmental Panel on Climate Change (IPCC) and incorporate broad changes in socioeconomic systems. This paper presents findings as of 2050 through SSP2-4.5 — a moderate emissions scenario —noting often small differences among the SSPs for the midcentury, owing to historical emissions.

The number of Mexican states highly exposed to water stress could almost double by 2050



Estimate based on analysis under a moderate stress scenario (SSP2-4.5).
Source: S&P Global Ratings.
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Drought is a recurring issue in some states

Water stress and drought are not new for many Mexican states, but their impact has intensified. There is no universal definition of drought, and there are many different types. UN-Water defines drought in hydrological terms as deficiencies in surface and subsurface water supplies measured as stream flow, lake, reservoir and groundwater levels. In the past three years, public reports show that low water availability has directly affected the lives of tens of millions of people in Mexico. Comisión Nacional del Agua (CONAGUA), which regulates and administers Mexico's water resources, reported that in July 2022, eight of the country's 32 states were experiencing extreme to moderate drought. S&P Global Ratings believes that this trend could worsen as early as this decade, given the increasing incidence of droughts; inadequate investment in water infrastructure, supply and conservation; and limited water resources.

Mexican states that use more ground or surface water than is available face greater water stress than states with similar consumption levels but a larger supply. Likewise, for states in very dry areas, despite a relatively smaller population, industries that require large amounts of water could put strain on the water supply. For states with abundant water resources, it would take a much larger population and higher economic activity to stress water levels.

According to S&P Global Sustainable1's data, the number of Mexican states exposed to water stress will increase — absent preventive measures — to 20 in the next three decades under a moderate stress climate scenario (SSP2-4.5) from 11

Shared Socioeconomic Pathways Defined

The IPCC established the Shared Socioeconomic Pathways (SSPs) as a set of scenarios for projected greenhouse gas emissions and temperature changes. The SSPs incorporate broad changes in socioeconomic systems, including global population growth, economic growth, resource availability and technological developments:

- **SSP1-2.6** is a low-emissions scenario in which the world shifts gradually, but consistently, toward a more sustainable path. This SSP aligns with the Paris Agreement on climate change's target to limit the average increase in global temperature to well below 2 degrees Celsius by the end of the century. The global temperature is projected to increase by 1.7 degrees (a likely range of 1.3-2.2 degrees) by 2050 or by 1.8 degrees (1.3-2.4 degrees) by the end of the century.
- **SSP2-4.5** is a moderate-emissions scenario, consistent with a future with relatively ambitious emissions reductions but where social, economic and technological trends do not deviate significantly from historical patterns. This scenario falls short of the Paris Agreement on climate change's aim of limiting the global temperature rise to well below 2 degrees, with a projected increase of 2.0 degrees (1.6-2.5 degrees) by 2050 or 2.7 degrees (2.1-3.5 degrees) by the end of the century.
- **SSP3-7.0** is a moderate- to high-emissions scenario, in which countries increasingly focus on domestic or regional issues, with slower economic development and lower population growth. A low international priority for addressing environmental concerns leads to rapid environmental degradation in some regions. This SSP projects a global temperature increase of 2.1 degrees (1.7-2.6 degrees) by 2050 or 3.6 degrees (2.8-4.6 degrees) by the end of the century.
- **SSP5-8.5** is a high-emissions scenario, in which the world places increasing faith in competitive markets, innovation and participatory societies to produce rapid technological progress and development of human capital as a path to sustainable development. This SSP projects the global temperature increase at 2.4 degrees (1.9-3.0 degrees) by 2050 or 4.4 degrees (3.3-5.7 degrees) by the end of the century.

states on average in this decade. The extent of water stress exposure will differ by geography, population density and economic activity.

Water Stress Represents High Physical Risk For Mexico

Using its Climate Change Physical Risk dataset, S&P Global Sustainable1 assigns scores from 1 (the lowest risk) to 100 (the highest risk) to assess the exposure of a given location to different climate hazards, including water stress. Scores greater than 70 indicate high exposure to the climate hazard. The data shows that in this decade (2020-2030), 11 of Mexico's 32 states face high water stress (with scores of 70 or higher). Of these 11, the states with the greatest exposure are Baja California and Baja California Sur in the north, Aguascalientes in the Bajío region in the central part of the country, and Mexico City. The remaining seven states are in the north, Bajío, and the Mexico City metropolitan area: Mexico, Morelos, Sonora, Chihuahua, Sinaloa, Zacatecas and Guanajuato.

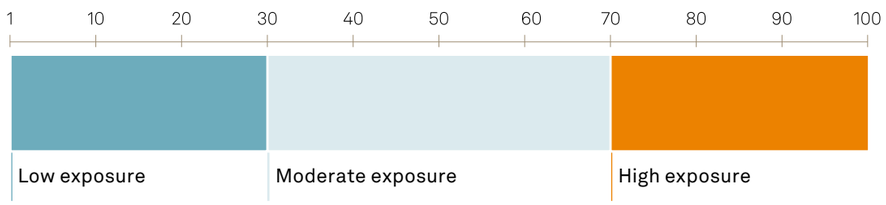
By 2050, under a moderate emission climate scenario (SSP2-4.5 — which implies a 2 degrees C rise in the global mean temperature by 2050 compared with the preindustrial period), the number of states exposed to high water stress (with scores of 70 or greater on the 1-100 scale) will rise by nine without measures to adapt. These nine additional states are Nuevo León, Tamaulipas, Coahuila and San Luis Potosí in the north; Querétaro in the Bajío region; Tlaxcala and Hidalgo in the center; and Colima and Jalisco on the Pacific coast.

In contrast, S&P Global Sustainable1 identified only six states that have low exposure to water stress (with scores of 1-30) in this decade, and that will likely remain the case until 2050, absent adaptation: Chiapas, Oaxaca, Guerrero, Campeche, Veracruz and Tabasco. Southern Mexico, where these six states are located, has fewer arid ecosystems and lower industrial activity than in other regions. S&P Global Ratings therefore expects these states' exposure to water stress to remain low. However, the SSP scenarios do not account for potential changes in the six states' social and economic structures, such as rising prosperity, that may increase the use of water.

Demand from industries and populations increases water stress risk

Factors such as population growth or water-sensitive economic activities amplify states' vulnerability to water stress. Population and the economic structure are therefore key elements determining exposure to water stress. Water-sensitive industries include agriculture, food/beverage production, textile manufacturing, chemicals, construction, auto manufacturing, power generation and tourism.

The three levels of exposure to water stress



Source: S&P Global Sustainable1, which defines water stress as the projected future ratio of water withdrawals to total renewable water supply in a given area.
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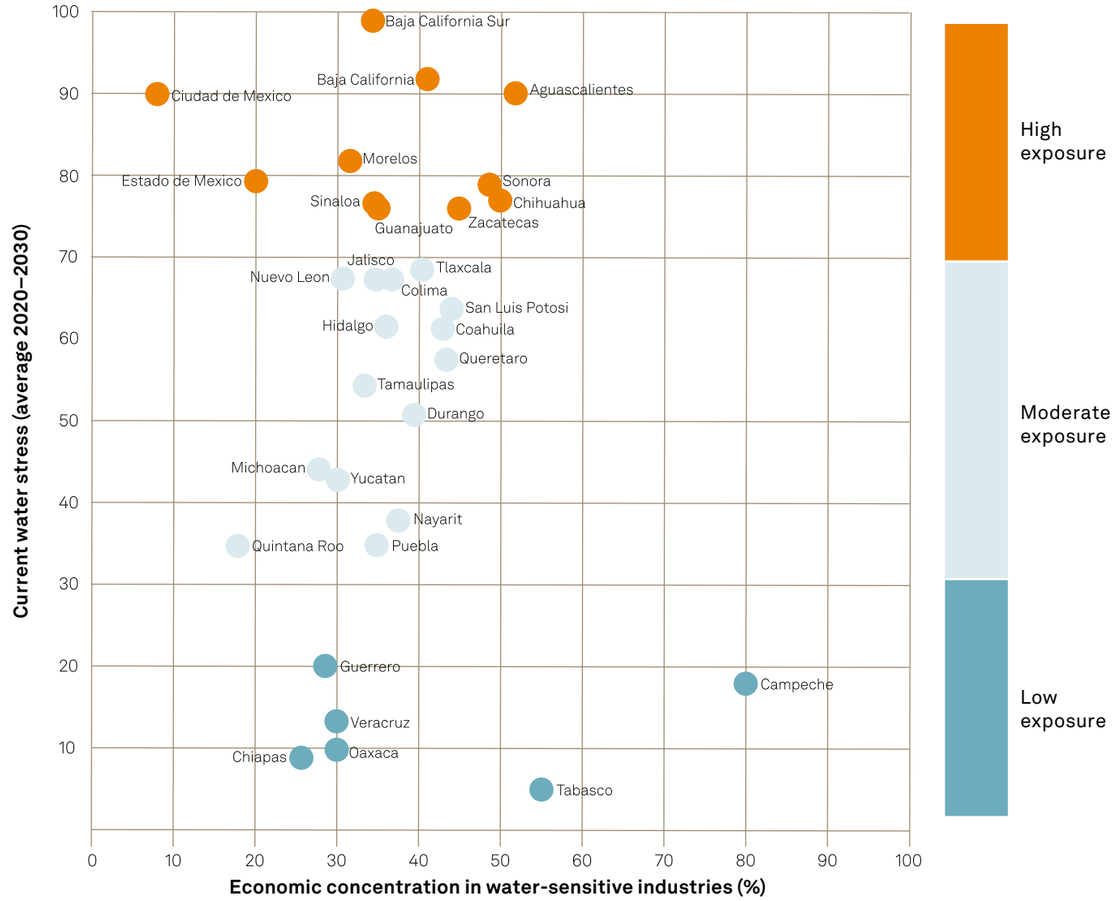
S&P Global Sustainable1 and S&P Global Ratings consider water intensity — that is, direct and purchased water consumption as a function of a company's revenue — to be an indicator of sensitivity since companies with high water demands are more likely to be adversely affected by water supply shortages or increased water costs. An economy that is dependent on water-sensitive sectors, particularly in parched regions, could face higher costs related to ensuring the availability of water resources to support those sectors' growth and, at the same time, address potential declines in economic activity.

Mexican states whose economies already rely heavily (more than 40% of activity) on water-sensitive industries include Baja California, Sonora, Chihuahua and Zacatecas in the north and Aguascalientes in Bajio (see graphic 3). These states are already exposed to high water stress under the moderate scenario (SSP2-4.5) in this decade. On the other hand, S&P Global Sustainable1 expects the water-stress exposure of states such as Campeche and Tabasco, with water-sensitive economic sectors — for example, oil extraction — to remain low until 2050 owing to abundant local water sources.

Exposure to water stress is already high in 11 states



Source: S&P Global Sustainable1.
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Various levels of exposure to water stress may influence Mexico's long-term economic growth because without measures to build resilience to the threat, high water stress may result in water scarcity. The UN defines water scarcity as scarcity of available water due to physical shortage, or scarcity of access due to the failure of institutions to ensure a regular supply or a lack of adequate infrastructure. Since water is a critical input for certain manufacturing processes, frequent water disruptions may increasingly affect investment decisions and prompt relocation of water-sensitive industries to less exposed states. This could constrain the economic growth prospects of states with high exposure to water stress.

Other causes of water stress include scarce water resources due to low rainfall, sometimes exacerbated by La Niña conditions, and an arid climate. All these factors are present across much of northern Mexico but also in the Bajío region and the densely populated states in the Mexico City metropolitan area. From both a credit and community welfare perspective, many Mexican states' vulnerability to water stress is compounded by what we view as chronic underinvestment in water and other critical infrastructure compared with peers. This underinvestment, in turn, affects supply.

Climate risk and our ratings on Mexican states

The scenarios in this research provide insight into the potential exposure of Mexican states to the specific physical climate risk represented by water stress. Climate risk accounts for just one set of risks that may influence our credit rating analysis. States will have differing levels of financial buffers to absorb the impact of physical climate risks, including water stress. There is also uncertainty about state governments' future policy responses to manage and adapt to such climate hazards as well as uncertainty regarding the actual path of climate change under the different scenarios presented here. Given these uncertainties, the findings of this research do not currently form part of the base case for our Mexican LRG ratings. Furthermore, no credit ratings have changed to date as a result of water stress, despite some budgetary and debt impact.

Each state's water stress is determined not only by water scarcity or drought frequency but also by the type of industries, water demand and measures taken or planned to address water risk. In this sense, water stress is a useful metric for understanding states' exposure to water risks.

Nevertheless, when assessing the creditworthiness of LRGs, we incorporate the adverse physical effects of climate change, where material and visible, into our analysis. As such, changes affecting climate risk can influence our LRG ratings and outlooks and may directly affect the main credit factors — economic, budgetary performance, financial management and debt assessments — and indirectly affect other credit rating factors (see "Methodology For Rating Local And Regional Governments Outside Of The US," published July 15, 2019).

As the financial impact of high water stress on Mexican states becomes clear — for example, if significant capital outlays for water infrastructure begin to squeeze budgets — we incorporate those risks into our credit analysis. We already do so and will continue to do so in the future. As strains on water resources increase, risks to LRGs include deterioration of economic growth and public finances as well as disruptions in the water supply to the population that could lead to social unrest or emigration. These factors could push federal and local governments to implement costly emergency measures, weakening their financial performance.

Mexico's water problems could hurt states' credit profiles

Key drivers are a physical shortage of water sources or inadequate infrastructure

67%
of Mexico's territory is in arid or semi-arid areas.

76%
of water supply in Mexico is used in agriculture.

Water stress has a potential negative impact on ratings through

Economic assessment
Constrained economic development

Public finances
Stressed budgetary performance
Larger funding needs

Financial management
Ability to address infrastructure needs
Handling of debt and liquidity

Source: S&P Global Ratings.
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Water stress can curb growth and increase debt

As exposure to water stress increases, it could constrain economic growth among vulnerable states, such as those in Mexico's northern region, Bajío and Mexico City metropolitan area. At the same time, exposure to high water stress may amplify political and economic pressures to increase water-related spending. Given that many Mexican LRGs rated by S&P Global Ratings have very weak liquidity compared with global peers, such spending could dent their budgetary performance by reducing fiscal buffers, increasing the need for extraordinary transfers to water utilities, or raising the share of capital expenditure on water infrastructure.

We assess the budgetary performance of many Mexican LRGs as weak or very weak (87% of rated states and 29% of municipalities), while we assess the economy as weak or very weak for more than 90% of rated LRGs. In addition, some have limited fiscal flexibility, or their budgetary performance does not reflect the full picture due to chronic underinvestment in infrastructure. If water-related investments rise, they could squeeze LRGs' liquidity and push up debt.

Government response can influence water risk

Global water demand for agricultural and industrial uses is projected to increase by up to 30% by 2050, according to UN-Water. Governments have enacted measures to build resilience to the threat of water stress. These range from regulations and policies to improve water conservation, to building infrastructure, such as desalination plants. Other examples include measures to curb water use by charging users according to the level of consumption.

Given Mexican states' close financial ties with the central government, we expect increased spending on water infrastructure to come from a combination of direct federal

WATER STRESS

Desalination capacity in Mexico has increased 2.4x since 2013 but remains low at nearly 750,000 cubic meters per day in 2022, compared with 11.9 million cubic meters per day in the US.

funding from CONAGUA, federal transfers to states and the states' own revenue. LRGs may also incur additional debt to finance investments or guarantee water utilities' debt, increasing their debt burdens.

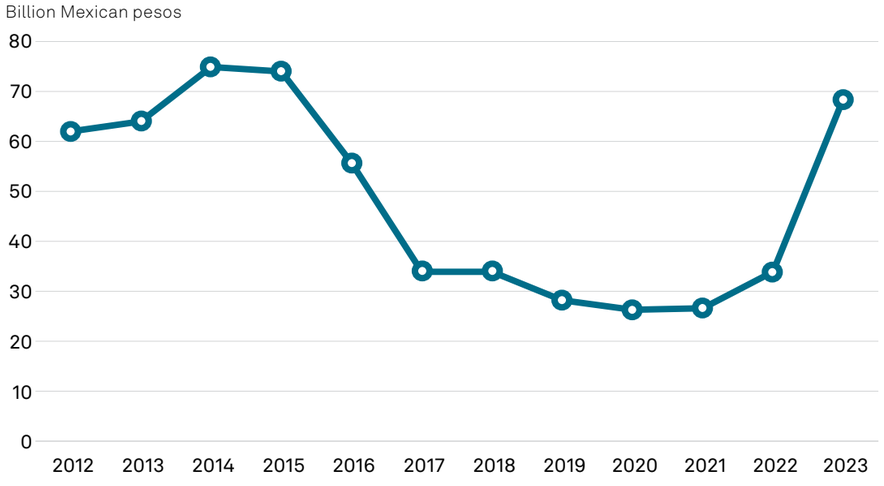
Other water-stressed countries, including South Africa, Chile and Saudi Arabia, are using a combination of measures to ease the worst impact. For example, they use regulations and policies for water conservation, supporting improvements in water quality and quantity through nationwide water management strategies.

We have observed that governments are also increasingly shifting toward desalination. Since 2010, the annual increase in the capacity and installation of desalination plants globally has been about 7% on average but was up by about 19% between 2020 and 2022 alone, to 20,956 plants, according to "State of the Art of Desalination in Mexico" (2022, Juan Rios-Arriola et al). Saudi Arabia, the U.S. and the United Arab Emirates have the largest installed water desalination capacity in the world. Desalination capacity in Mexico, meanwhile, has increased 2.4x since 2013 but remains low at nearly 750,000 cubic meters per day in 2022, compared with 11.9 million cubic meters per day in the US.

Funding for water infrastructure has risen

In Mexico, water provision services and fee collection occur at the municipal level, but water management follows the guidelines of higher levels of government. CONAGUA is the federal body that oversees the country's hydro assets, as stated in the National Water Law. It is the main body responsible for the administration, control and protection of water infrastructure. Although federal funding for water infrastructure has decreased over the past 10 years, the increasing frequency and intensity of water shortages, along with social unrest stemming from extreme drought in northern Mexico, prompted policymakers to take action in 2022–2023.

Mexico's water budget has increased but remains below 2014 and 2015 levels



Values reflect the approved budget allocations for each fiscal year. Source: Secretaría de Hacienda y Crédito Público (SHCP PEF, 2012- 2023).
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The 2023 federal budget almost tripled the funding for water infrastructure from 15.3 billion Mexican pesos (about $0.8 billion) to 44.5 billion pesos (about $2.4 billion) and roughly doubled CONAGUA's funding from 33.0 billion pesos to 68.5 billion pesos. We expect the federal government, through CONAGUA, to continue funding key infrastructure projects around the country and address, to some extent, the water-related vulnerability of certain regions.

Mexico's national water law established 13 basin agencies across the country, organized around the country's 757 hydro basins. These basin agencies have representatives from the state, municipal and federal levels to plan and administer local water resources. Water utilities provide water, sewage and drainage services. In some cases, water utilities belong to a municipality, such as Guanajuato, which owns Sistema de Agua Potable y Alcantarillado de León. They may also be state-owned, self-supporting entities that provide services to metropolitan areas, such as Servicios de Agua y Drenaje de Monterrey in Nuevo León and Sistema Intermunicipal de los Servicios de Agua Potable y Alcantarillado in Jalisco.

Water is key to Mexico's economic development

Based on the observations presented in this research paper, we believe that the need for Mexico to invest in water infrastructure will rise as water risks increase. The cost of such investments and inability to provide the population with reliable access to water could constrain the country's economic growth potential. As freshwater sources shrink and populations increase, water scarcity will, in our view, influence economic development, migration and public infrastructure investment in Mexico. According to CONAGUA, nearly two-thirds of the country's land area is arid or semi-arid, and water scarcity is becoming an increasingly urgent issue as well as a potential threat to local governments' economic and financial vitality.

Some companies in water-sensitive industries are beginning to move operations away from Mexico's industrialized and highly drought-prone northern region. In 2022, severe drought in that region diminished the water supply for the population and industries, revealing the limits of the water infrastructure and states' preparedness to address it. We expect economic and fiscal risks stemming from exposure to high water stress in Mexico will continue to rise and could ultimately weigh on LRGs' credit quality over the medium to long term.

We anticipate that Mexico's approach to mitigating water stress will include investments in existing infrastructure; construction of new reservoirs, wells and desalination plants; and measures that encourage water conservation, such as volumetric charges, with users paying according to the level of consumption. One of the main challenges to increasing desalination capacity is the high investment cost, which has risen to nearly $500 million per project, depending on the installed capacity and technology, along with high operating costs. Desalination also has substantial environmental costs, including high energy requirements, discharge of brine, and wastewater generation.

Looking ahead

Our base-case scenarios for our Mexican LRG ratings are not founded on the climate scenarios presented in this research report. Rather, S&P Global Ratings considers the current and potential pressure on an LRG's finances stemming from water scarcity and underinvestment in infrastructure where it has sufficient visibility to do so. Assessing the impact of physical climate risks can improve our understanding of an LRG's potential exposure and level of

preparedness and the potential future influence of climate risks on credit quality over the years to come.

The impact of water stress on our LRG ratings will depend in large part on the cooperation between various levels of government in planning and investing to ease water stress. We will continue to assess how Mexico approaches sustainable water management, economic growth, and planning and funding for water and related infrastructure. Strategies to secure sustainable economic growth come with costs and trade-offs that will confront communities and policymakers as they strive to address water stress exposure. ■

Related research and criteria

Related Research

- Crunch Time: Can Adaptation Finance Protect Against the Worst Impacts From Physical Climate Risks?, Jan. 13, 2023
- Weather Warning: Assessing Countries' Vulnerability To Economic Losses From Physical Climate Risks, April 27, 2022
- Model Behavior: How Enhanced Climate Risk Analytics Can Better Serve Financial Market Participants, June 24, 2021

External Research

- State of the Art of Desalination in Mexico, MDPI, 2022, Juan Rios-Arriola, Nicolas Velazquez, Jesus Armando Aguilar-Jiminez, et. al.
- World Resources Institute (working paper: https://www.wri.org/research/aqueduct-country- and-river-basin-rankings)

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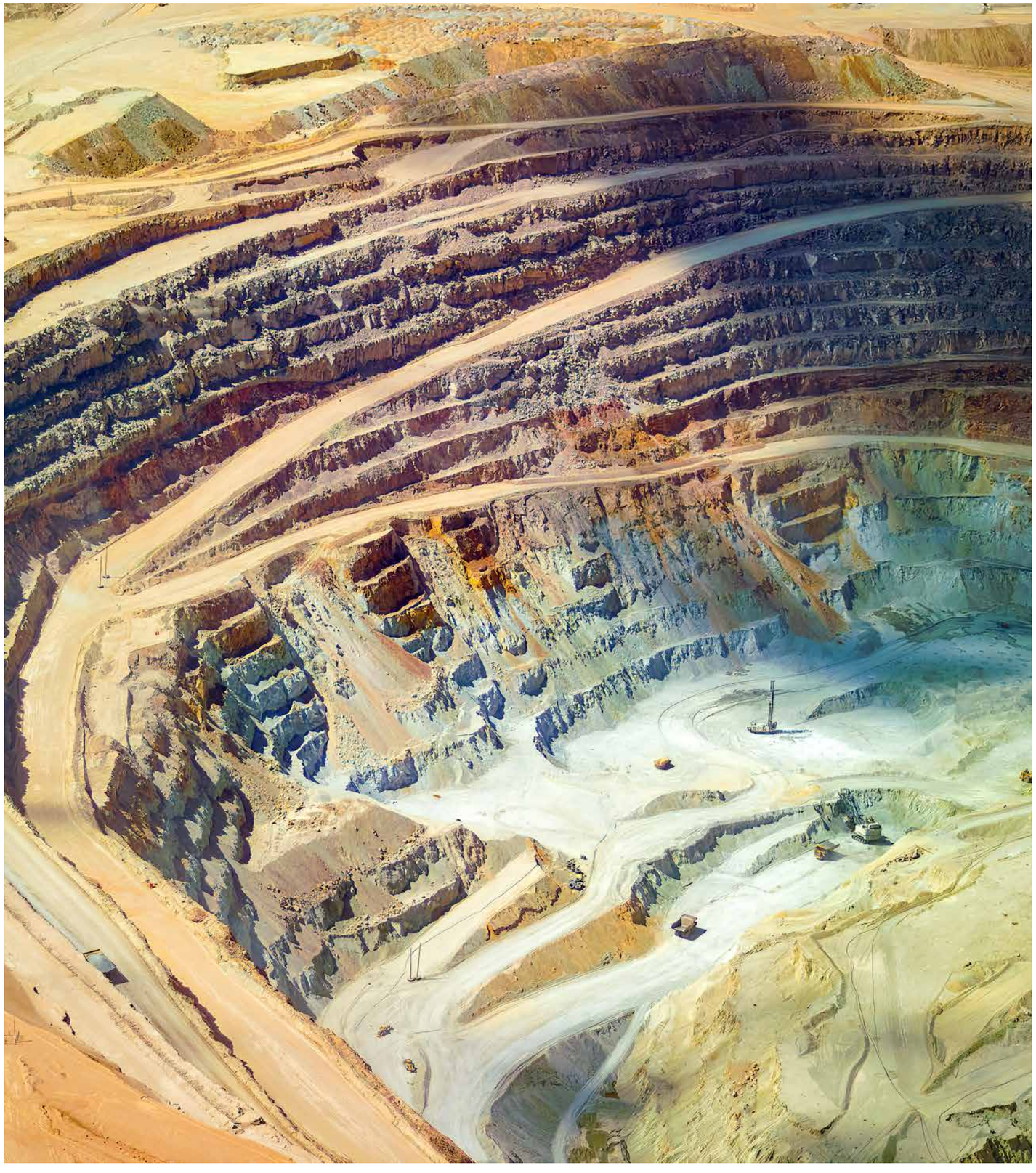


Chile and Peru's copper for energy transition

Chile and Peru are likely to play an important role in adjusting commodity supply chains, given the increased demand for minerals for the energy transition. Despite their well-established mining industries, Chile and Peru face the challenge of rapidly expanding their output capacity. New investors in Chile are likely to struggle to access concession land, while in Peru, they face lengthy procedures to obtain permits.

This research was authored by S&P Global Market Intelligence.

Published on April 5, 2023

Note: This report includes input from the Price and Purchasing team of S&P Global.

Key takeaways

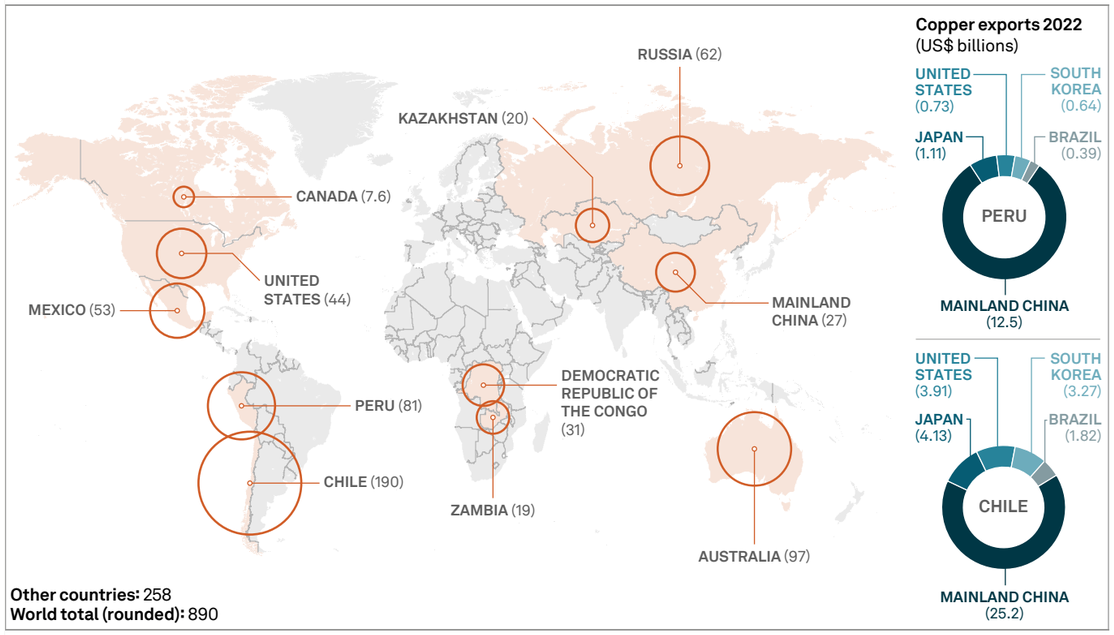
- Chile and Peru are likely to play an important role in adjusting commodity supply chains, given the increased demand for minerals for the energy transition alongside the US and European countries seeking to diversify mineral sources.
- Despite their well-established mining industries, Chile and Peru face the challenge of rapidly expanding their output capacity. Apart from regulatory and political uncertainty, new investors in Chile are likely to struggle to access concession land, while in Peru, they face lengthy procedures to obtain permits.
- A new constitution being prepared in Chile is likely to slightly increase the state's role in the development of natural resources, but it would continue to allow private sector involvement, although with tighter environmental scrutiny and higher taxes, including a new royalty. However, business-friendly conservative parties' dominance of the constitutional council, the body in charge of the re-draft, will limit a stronger state role under a new constitution.
- Peru's government is likely to focus on simplifying procedures and maintaining current tax rates and incentives for the mining sector to increase private investment, but it will maintain tight environmental requirements for exploration.
- Increased enforcement of environmental, social and governance standards is likely to make it more difficult to obtain the social license to operate in Chile and Peru while encouraging more protests or lengthy court challenges affecting mining projects.

▶ **As the world moves away from fossil fuels** with the goal of reaching net-zero carbon emissions by 2050, the demand for minerals needed for clean energy technologies, such as wind and solar power, battery storage, and electric vehicles will significantly increase in the coming decades. S&P Global Market Intelligence concluded in "The Future of Copper" that demand for copper will double by 2035, which would require new mine capacity in order to be met. This special report examines the preparedness of Chile and Peru — the world's largest copper producers with significant unexploited potential — to expand their production capacity to meet increased demand.

Copper will play a key role in the energy transition, being needed to expand power grids and transmission lines to bring renewable energy, such as solar and wind power, from sources to urban centers. Our copper study estimates that global demand will increase from 25 million metric tons in 2022 to 50 MMt in 2035 and to 53 MMt by 2050. Existing mines and projects in the pipeline are insufficient to meet this demand.

Chile and Peru produce 40% of the world's copper output and have significant unexploited potential to help reduce the shortfall between supply and projected demand. According to the United States Geological Survey (USGS), Chile — the world's largest copper producer — produced 5.39 MMt in 2022 and has the largest reserves, estimated at 190 MMt, or 21.3% of the world's total. Peru, the second-largest producer, at 2.2 MMt in 2022, has the third-largest reserves behind Australia, with 81 MMt, or 9% globally. The USGS estimated that both countries, alongside Ecuador, could contain approximately 750 MMt of undiscovered copper resources.

Copper world reserves (millions of metric tonnes), 2022



Data compiled June 2, 2023.
Source: United States Geological Survey (USGS), January 2023; S&P Global Market Intelligence (Global Trade Atlas): 2009699.

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Reframing global supply chains

Chile and Peru are likely to play a key role in reframing commodity supply chains as the US and European countries intensify their efforts to secure critical minerals and diversify sources. The US Inflation Reduction Act of August 2022 increases requirements for critical minerals to be sourced from countries with a free trade agreement with the US. Although the Inflation Reduction Act does not class copper as a "critical mineral" — the definition varies across jurisdictions — Chile and Peru have free trade agreements with the US, increasing the likelihood of them being favored by US investors. Latin America also has huge lithium potential, with 60% of global reserves; see "Critical minerals: Illuminating the path to an electric future."

Despite the increased need for copper and the two countries' well-established mining industries, there are multiple challenges to expanding output in Chile and Peru.

Challenge 1: Regulatory uncertainty in Chile

Planned changes to Chile's constitution are likely to slightly increase the state's role in the development of natural resources, although conservative dominance will guarantee property rights and limit state intervention. A new process to write a new constitution started March 6 with the installation of a 24-member expert committee, after a previous draft was rejected in 2022 in a referendum. The committee is preparing a blueprint for use by an elected 50-member constitutional council, which will write a final draft. Elections for the council members took place May 7 ahead of the council's installation June 7. A final draft will be submitted to a referendum Dec. 17. The conservative

Republican Party (Partido Republicano) obtained 23 seats in the council while the government block Unity for Chile (Unidad para Chile) got 16. As conservative parties will dominate the council, they will be able to pass policy, enshrining property rights and private investment in the mining sector under a potential new constitution. However, the council will be bound by set principles, including respecting nature and establishing a "social" state that is likely to slightly expand the state's role in the economy, including in natural resources.

Companies investing in Chile's copper will face higher taxes, including a new royalty. After Congress rejected in March a tax package proposed by President Gabriel Boric's administration, the government is preparing a new proposal, which is likely to remove tax exemptions and raise the overall tax burden. In the meantime, to fill the fiscal gap, the government made concessions to the opposition, which led to the legislative approval of a mining royalty bill May 17. The government accepted further reductions to the proposed tax cap for the royalty to 45.5%-46.5%, down from the original proposal of 50%, and will integrate a flat tax on sales (ad valorem tax) of 1% on production above 50,000 metric tons per year.

Pending changes to Chile's mining code are likely to free land for new concessions from 2024, but they will increase demands for minerals development. The structure of Chile's concession system has hindered the expansion of the mining sector, blocking the entrance of new companies, particularly junior and small miners. To date, concession holders have not been obliged to develop copper or make investments. Moreover, concession holders can maintain concessions indefinitely, subject to paying an almost symbolic annual fee amounting to less than US$10 per hectare for exploration and exploitation. This leads to permit holders hoarding and speculating with mining concessions; Chile's mining ministry estimated that while 36% of the country is covered by concessions, less than 10% is exploited. Law 21,240, promulgated by former President Sebastián Piñera in February 2022, increases the cost of acquiring mining concessions and introduces penalties for holders that fail to develop resources, while removing some mining-sector tax breaks, effectively opening the sector to new concessions. The law's implementation has been postponed from February 2023 to January 2024 because of inconsistencies related to land delimitations. Despite the delay, changes to the mining concession system are highly likely to be implemented from 2024, increasing the likelihood of investment targets being established and concessions being revoked if holders fail to develop them. Chile's economy is highly dependent on copper exports, which contribute approximately 10% to the GDP, and Boric and future governments are likely to prioritize freeing land for new projects.

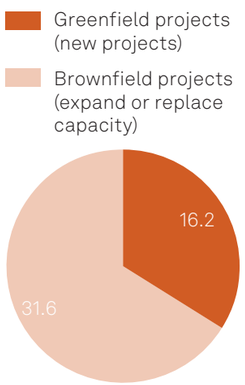
Challenge 2: Political instability in Peru

The Peruvian president's reliance on center-right legislative support will prevent passage of structural changes to mining law. The likelihood of an early election in 2023 has declined significantly as Congress has repeatedly failed, after the impeachment of President Pedro Castillo, to pass legislation to bring the election forward from April 2026. As nationwide protests against President Dina Boluarte have receded, Congress is unlikely to quickly pass enabling legislation for an early poll, reducing scope for a general election in 2023 or even 2024, given the extensive timetable needed to organize a poll. Although Boluarte had originally formed part of Castillo's liberal Free Peru party (Perú Libre), she now relies on the support of center and conservative parties to pass policy and avoid impeachment, having left the Perú Libre party and lacking backing from a formal coalition. The Perú Libre party and other liberal parties are demanding her resignation and will try to impeach her. However, as in April with the first impeachment motion against Boluarte, the parties are unlikely to gather the required 87 votes in Congress, out of 130, to do so. To avoid alienating her fragile center-right support base in Congress, Boluarte is unlikely to seek structural changes. These include a new constitution demanded by the Perú Libre party or amendments to the mining law to strengthen prior consultation with local communities, as demanded by governors of the southern regions of Tacna, Moquegua, Cusco and Arequipa, which hold 35.5% of mining exploration and are hotspots for anti-mining protests.

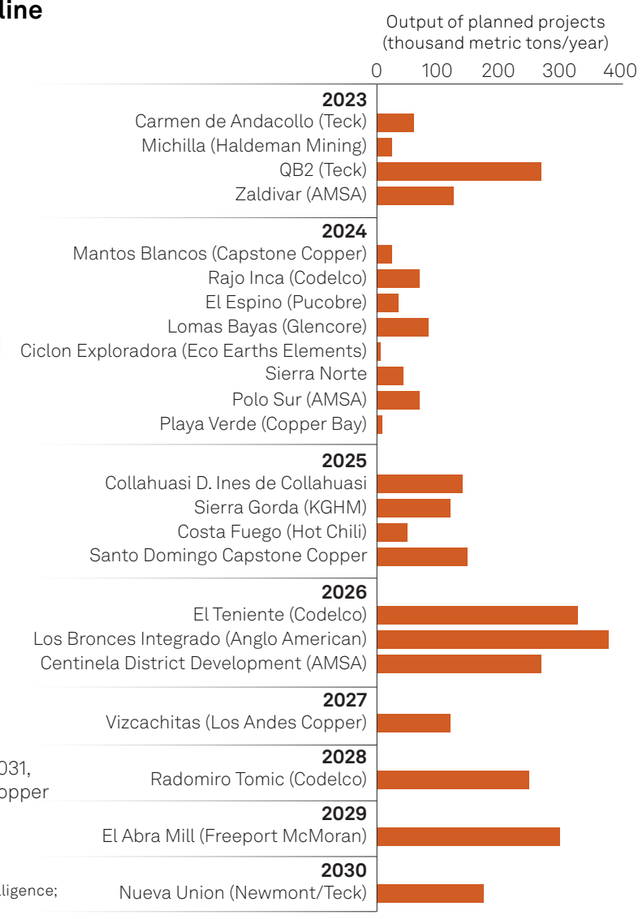
Peru's government will focus on streamlining procedures to initiate mining investment, but it is unlikely to loosen environmental requirements for exploration permits. Boluarte will focus on simplifying procedures to start extractive activities, which require an estimated 400 steps. Changes can be made either by decree or through measures that obtain the required support from center and conservative parties in Congress. The government will maintain corporate tax rates at 29.5% and incentives for the mining sector but is unlikely to revert or loosen a 2017 Supreme Decree for Environmental Protection Regulation, which tightened environmental requirements for

Chile's copper pipeline

Projects in development (billion metric tons)



There is a portfolio of 31 copper projects worth **US$65.2 billion** to be developed through 2031, according to the Chilean Copper Commission (COCHILCO).



As of March 31, 2023.
Sources: S&P Global Market Intelligence; COCHILCO.
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exploration permits and gave greater oversight to the Ministry of the Environment. Changing the decree would trigger further opposition by local communities — which are already demanding Boluarte's resignation — particularly in the south, where many mining operations are based. If future elections result in a left-of-center government with a majority in Congress, which Castillo lacked, regulatory changes such as more oversight powers for local authorities, more exhaustive community consultation and a higher share of the mining canon are likely.

Challenge 3: Stricter application of sustainability standards

Increased awareness of sustainability standards and criteria in both countries will make it harder to obtain the social license to operate. Mining projects that are perceived to cause environmental damage, not conduct proper prior consultation with local communities or Indigenous groups, or breach labor and human rights face reputational risks, delays in obtaining permits, protests and/or lengthy court challenges. The projects are also likely to face growing difficulties in accessing financing as financial institutions are tightening their sustainability exclusion criteria.

Environmental concerns, biodiversity protection and labor disputes are likely to hinder project development through delays, suspensions or unrest. Chile's President Boric is promoting changes to the environmental impact assessment system (Sistema de Evaluación de Impacto Ambiental), which would tighten the requirements to obtain environmental permits and raise fines in cases of noncompliance with the threat of project cancellation in cases of significant environmental damage.

In March, Congress approved the closure of the Ventanas smelter, reflecting Boric's pledge to end "sacrifice zones," which are areas with heavy pollution due to economic activities. This signals that Boric will be rigorous regarding compliance with environmental standards; Boric's compliance with environmental standards is likely to lead to more extensive inspections and regulatory assessments of plants or projects involved in environmental conflicts, which increases the likelihood that projects that severely damage the environment will be closed.

Contaminating industries, such as smelters and refineries located in sacrifice zones — which include Coronel, Huasco, Mejillones and Tocopilla — are likely to face higher threats of closure because of excess pollution. Smelters and refineries are needed in Chile and Peru to obtain the value-added benefits from the countries' domestic resources and to avoid exporting unprocessed raw materials.

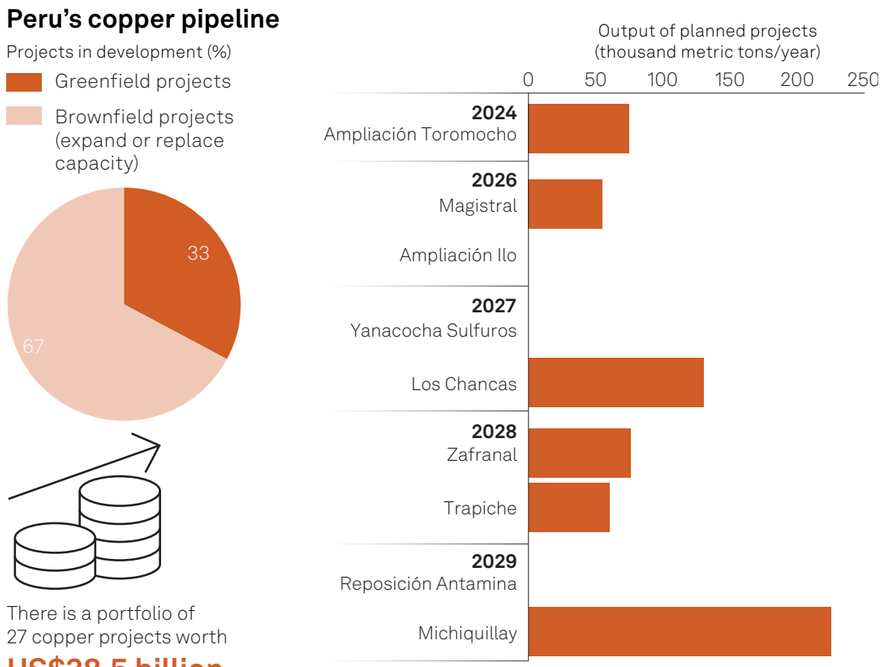
In Peru, anti-mining protests over environmental issues are particularly disruptive in the southern mining corridor, which connects the regions of Cusco, Apurimac and Arequipa with the Matarani port, where about 30% of Peru's copper production is shipped. Mines in the area are a particular target of anti-mining protests, with supply chain disruption lasting for months at time. In Chile, disruptive unrest comes from labor issues, with influential mining unions demanding pay increases and bonuses, particularly during collective negotiations. Protests generally include roadblocks and blocking entrances to the premises and tend to last approximately two weeks, but sometimes longer.

Biodiversity protection will also restrict areas for mining activity. In Peru, mining companies are banned by law from operating on or adjacent to protected areas or nature reserves, with provinces and regions entitled to establish ecological and economic zoning within their jurisdiction. The protection of nature is already included in Chile's new constitution as it is one of the agreed basic principles, while a bill to create a Biodiversity and Protected Areas Service is being debated in the Legislature.

Water scarcity threatens increased restrictions for mining companies. The long-running drought in northern and central Chile has become an increasingly critical hurdle for mining projects; see "Water scarcity in Latin America: Operational challenges." The government is prioritizing the use of water for human consumption, sanitation and preservation of ecosystems over economic activity.

To counterbalance this, almost all new mining projects are designed to use desalinated seawater by operating their own plants or outsourcing the process. Desalination plants have faced little resistance from local residents but are likely to become a focus of opposition from local communities if they see the plants as threatening their livelihoods by affecting activities such as fishing or damaging the landscape or because of demands to access the water for community use rather than to serve mining projects. A glacier protection bill in Congress would ban operations at glaciers and severely restrict them in permafrost areas.

In Peru, violent protests over water can cause indefinite suspension of operations. A Water Users Organizations Law was approved by Congress in January 2023, giving greater oversight to civil society groups, namely the Board of Water Users (Juntas de Usuarios del Agua), over major water infrastructure, potentially restricting mining companies' access to water. However, the government opposes the new legislation and is likely to attempt to amend it to exclude nonagricultural users,



As of March 31, 2023.
Other planned projects have not been included as no date has been determined by the MINEM.
Sources: S&P Global Market Intelligence; MINEM.
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such as mines, from Juntas de Usuarios del Agua oversight.

Requirements for prior consultation are likely to expand, with enforcement to be strengthened. Carrying out prior consultation with Indigenous communities is obligatory and binding in Peru. Failure to do so threatens permit cancellations. In Chile, government officials have suggested starting consultation with communities prior to an environmental impact assessment, as it is now.

Rights of Indigenous groups are also likely to be strengthened as the recognition of Indigenous peoples is a basic principle of the constitutional rewrite, but the change is unlikely to give the groups veto powers over projects, as was the case with the rejected draft. Failure to follow the appropriate consultation process or not respecting its results, even if nonbinding, is likely to trigger legal challenges and protests against projects, causing operational disruption and delays, sometimes even if environmental approvals are obtained successfully.

With local communities and nongovernmental organizations becoming increasingly aware of the legal and political instruments and mechanisms available to hinder project development, these groups are likely to demand stronger consultation, expanding consultation to a wider range of affected parties, not only Indigenous groups, and are likely to demand that the outcomes of these consultations be binding.

Regional political dynamics are likely to exacerbate anti-mining activism and decisions over land use. Anti-mining activism is likely to increase because of political instability in Peru. Many regional governors are demanding Boluarte's resignation and an early election. Thus, they are likely to support

Infrastructure and cargo challenges

Inadequate infrastructure at ports, roads and railways remains a long-term challenge for mining exporters. Governments in Peru and Chile have frequently promised infrastructure improvements, but red tape, lack of financing, contract risks and corruption constrain progress.

In Peru, the lack of road capacity causes supply chain disruption for mining projects and increases costs for new projects. Several tranches of the mining corridor are unpaved, notably at Chumbivilcas, which leads to one of the major mining projects in Peru. The Boluarte government is unlikely to progress a US$9.2 billion plan to build a railway to transport minerals favored by her predecessor. She is more likely to focus on the completion of the Southern Gas Pipeline to meet a key demand of the region to lower energy prices while supporting an area recently at the center of anti-government protests.

Chile's road infrastructure is good by regional standards, but ground cargo faces ongoing risk of 24-48 hour strikes by the influential truckers union, delaying mining cargo one or more times each year. Disruption from natural disasters, mainly earthquakes, in mining areas is another vulnerability. Chile's limited port capacity is also likely to become a bottleneck for smaller mining projects, particularly in the Atacama and Coquimbo regions, where port capacity is limited. However, large mining operations have their own dedicated port facilities.

Source: S&P Global Market Intelligence © 2023 S&P Global

Other critical minerals in Latin America: Nickel, cobalt and rare earths

Latin America is also a source of smaller, less exploited reserves of critical minerals, including nickel, cobalt and rare earths; see "Critical Minerals and Geopolitical Risks."

Nickel will play an important role in the energy transition, largely because of its use in batteries and clean energy technologies, such as geothermal power and green hydrogen. According to the International Energy Agency, global nickel demand will triple between 2020 and 2040, driven by the energy transition. About one-quarter of global nickel reserves are in Latin America, the largest in Brazil, at 16 million metric tons. However, the country's production costs are far less competitive than Indonesia, the world's largest nickel producer. Other countries with nickel deposits, although on a much smaller scale, include Colombia, Cuba, the Dominican Republic, Guatemala and Venezuela.

Cobalt's role in the energy transition is largely driven by its use in batteries for electric vehicles and energy storage. The only major producer of cobalt in Latin America is Cuba, which produces the metal as a byproduct of nickel and has the fourth-largest proven reserves globally, at approximately 500,000 metric tons; it produced 3,900 metric tons in 2022. There is also production in Brazil and Mexico and resources in Chile.

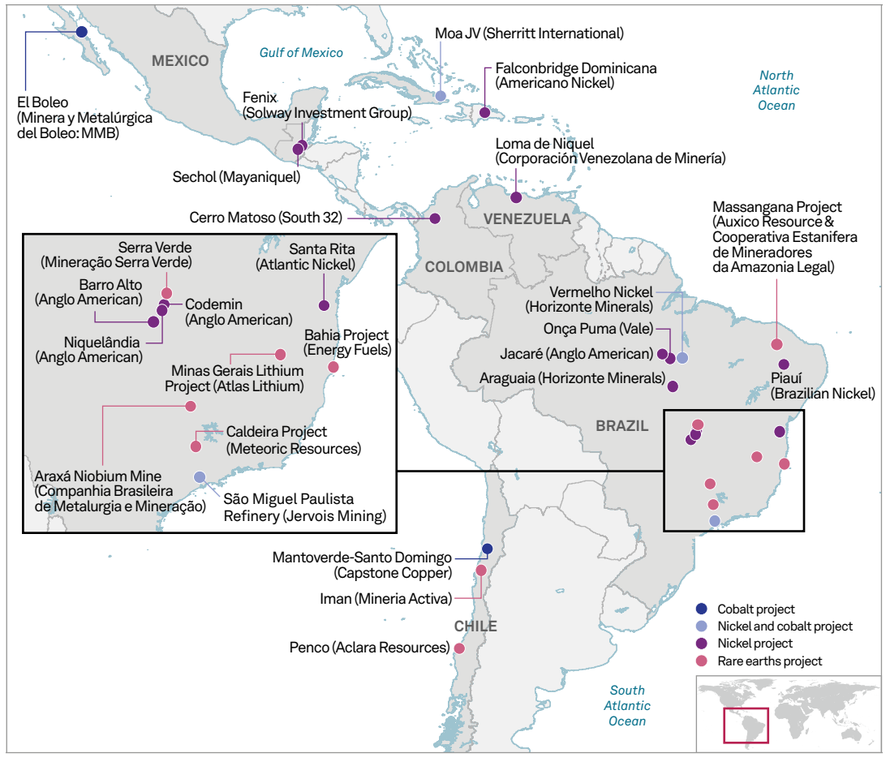
Rare earth elements are 17 soft heavy metals frequently found together, which have numerous applications in electrical components, electronics, lasers, magnetic materials and industrial processes. Rare earths are used in electric vehicles and wind turbines. Brazil is the only significant producer in Latin America. Its reserves of 21 MMt are the fourth largest in the world, behind those of Australia, mainland China and Russia. Rare earth deposits have also been discovered in Chile, with one project at an early stage.

Latin American governments have scope to encourage the exploration, extraction and export of these smaller critical minerals, alongside copper and lithium. This is particularly the case for countries with free trade agreements with the US, which are Chile, Colombia, the Dominican Republic, Mexico, Peru and all of Central America.

However, development will require more clearly defined regulatory and legal frameworks and a policy stance favoring increased private and foreign investment in the mining sector. As shown with lithium, some governments are trending toward greater state control over strategic natural resources, which has included restrictions on private participation in projects — for example in Bolivia, Chile and Mexico — while others, such as Chile, Columbia and Peru, are seeking to increase taxes on mineral exports to maximize public revenues while commodity prices are high. In all the countries, governments will have to balance local community, Indigenous and environmental concerns with the economic benefits of mineral production, while defining and passing sector-specific legislation and regulation is likely to prove an extended process, taking months or even years.

Source: S&P Global Market Intelligence © 2023 S&P Global

Nickel, cobalt and rare earths in Latin America



Data compiled June 2, 2023.
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anti-government protests to pressure the national government, particularly protests affecting mining operations in the southern regions. Some regional governors appear likely to encourage anti-mining protests directly.

Local-level corruption is a further operational challenge for mining projects in Peru. In Chile, regional governors were elected for the first time in mid-2021, and their power has been diluted by the ongoing presence of delegates appointed by the president. S&P Global Market Intelligence assesses that after the next regional elections, scheduled for 2025, governors will gain greater authority over the presidential delegates. Although governors will not be able to review contracts or cancel or grant concessions, their territorial planning responsibility would give them power to ban mining activity in certain areas. ■

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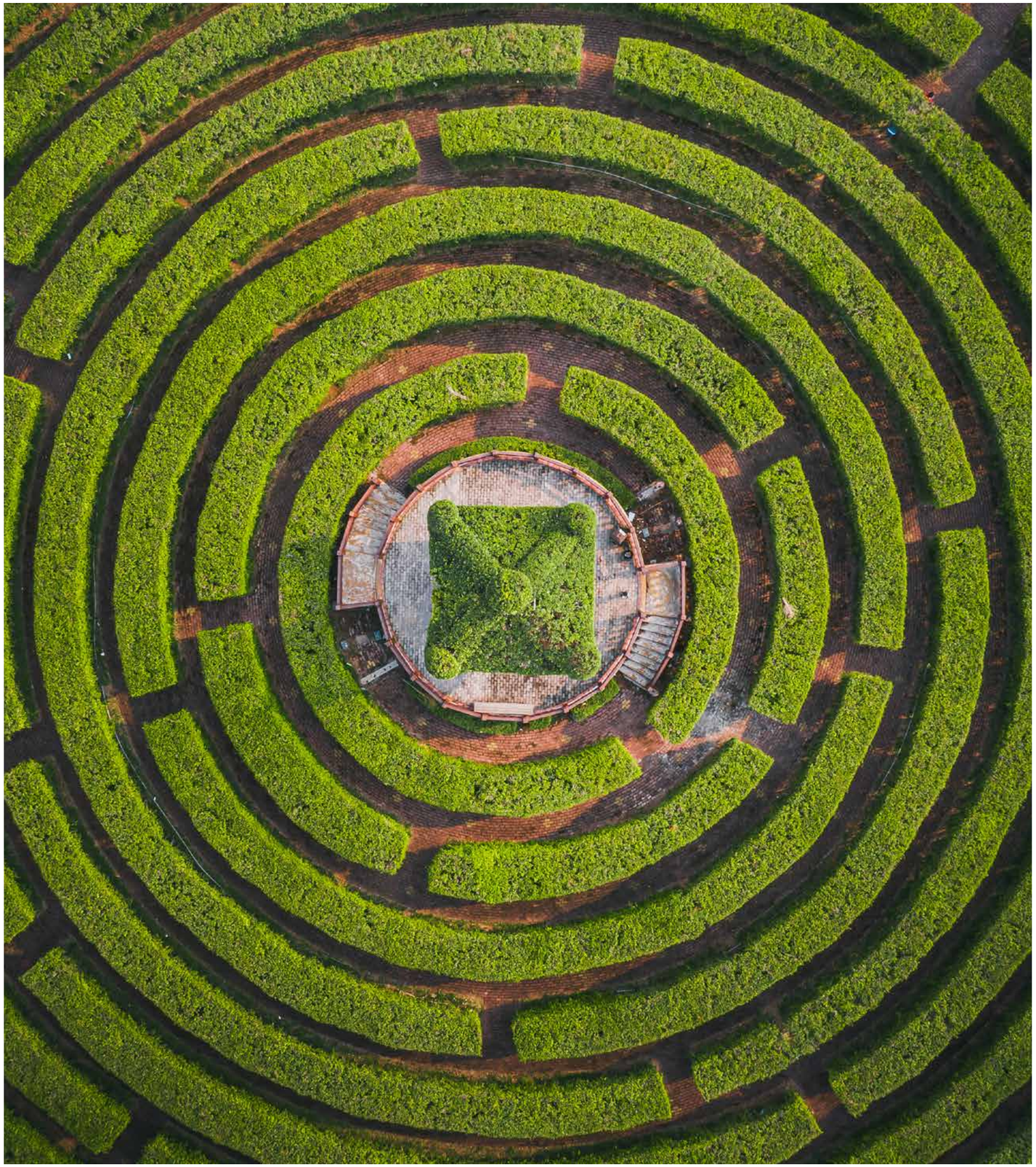


Carbon capture, removal and credits pose challenges for companies

Companies that have made ambitious decarbonization commitments may need to rely on technologies such as carbon capture and storage, carbon dioxide removal and the use of carbon credits. Studies generally recognize that these solutions have a role to play in decarbonizing the economy, but they also carry technological, financial, policy and stakeholder perception risks.

This research was authored by S&P Global Ratings.

Published on June 8, 2023

Note: This research paper was authored by members of the Sustainability Research and credit ratings teams within S&P Global Ratings. It does not comment on current or future credit ratings or credit rating methodologies.

This report does not constitute a rating action.

Key takeaways

- Each potential solution carries its own risks, and companies that pursue carbon capture and storage, carbon dioxide removal or carbon credits could face considerable uncertainties about financial costs as well as evolving regulations and voluntary guidance.
- Using the oil and gas sector as a case study, we find a mix of strategies under consideration. Overall, we see limited consideration or disclosure of the potential risks associated with carbon capture and storage, carbon dioxide removal or carbon credits, and the quality of disclosure varies, which restricts comparison of plans across our sample.
- We believe that disclosure and transparency by companies about their chosen emissions-reduction solutions, and how they are planning for the associated risks, will better enable analysis of how companies might meet their decarbonization commitments.
- As solutions continue to evolve, companies that can understand and manage potential technical challenges are likely to be better placed to deliver the most efficient solutions, limiting financial costs and reputation risks.

▶ **Companies that have made ambitious** decarbonization commitments may need to rely on technologies such as carbon capture and storage (CCS), carbon dioxide removal (CDR) and the use of carbon credits. Studies by global stakeholders generally recognize that these solutions have a role to play in decarbonizing the economy. Such solutions also carry technological, financial, policy and stakeholder perception risks.

In this research, we explore the risks of a variety of approaches for managing carbon emissions, including those that are more difficult to address — often referred to as hard to abate or residual. As part of this research, we include a case study on the oil and gas sector using publicly available information from a sample of 25 companies from across the globe with combined revenue of US$3.8 trillion and capital expenditure of US$279 billion in their latest fiscal year. We also examine a range of reports and guidance from industry stakeholders.

Decarbonization calls for a broad range of solutions

More companies are setting decarbonization targets, but not all emissions will be easy to tackle. To avoid the most severe effects of climate change — as most recently set out in the Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Report — global economic actors will need to take significant mitigating action (IPCC, 2021; 2023).

Whether driven by policy, financial risks, reputation risks or stakeholders' concerns, more companies are taking steps to decarbonize each year. Those committing to the Science Based Targets initiative (SBTi) have roughly doubled in each of the past four years (SBTi, 2022). Companies looking to align with the Paris Agreement on climate change — to reduce the average global temperature rise to "well below" 2 degrees Celsius compared with pre-industrial levels — have set specific targets for decarbonization, and many are investing in new technologies and facilities and/or different business models to operate in a future net-zero environment. Some companies have aspirational net-zero-by-2050 targets.

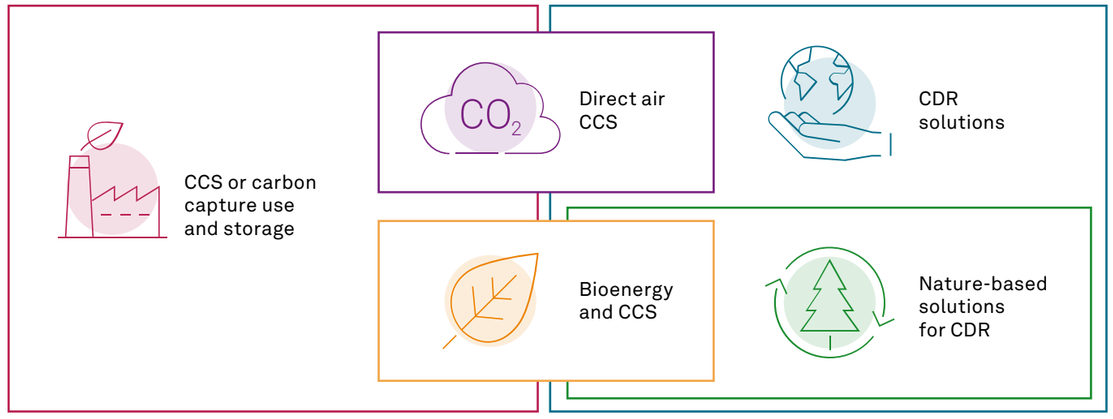
Some companies that have set ambitious decarbonization targets, such as net-zero commitments, face significant challenges to reduce all their emissions. While parts of many companies' emission footprints might have an identifiable pathway to decarbonization — for example, switching to renewables or hydrogen from fossil fuel-based electricity — others face greater challenges, for example, emissions resulting from calcination during cement production. These are often referred to as hard-to-abate or residual emissions and will require their own solutions if such companies are to completely decarbonize.

CDR and CCS may play a role in efforts to reach decarbonization goals

A large body of research now shows ways to decarbonize. However, some climate scenarios suggest that CCS and CDR will be required to limit warming to 1.5 degrees C or 2 degrees C, including those of the IPCC (2021), the International Energy Agency (IEA, 2020; 2021; 2022), and the Network for Greening the Financial System (NGFS, 2022). These studies have differing views about the importance of each solution, but the message is consistent: Although significant emissions reductions come first, CDR and CCS are likely to play a role in efforts to achieve the most ambitious decarbonization scenarios, and the two approaches have some overlaps.

CDR is a group of both nature-based and technological solutions that remove carbon dioxide from the atmosphere and permanently store it in terrestrial, geological or ocean reservoirs. The most prominent examples of nature-based solutions are afforestation and reforestation, but other approaches include improving soil quality, enhanced weathering and the production of biochar (see table 1). Technological options include direct air carbon capture and storage (DACCS), which removes and stores carbon from ambient air, and bioenergy combined with CCS (BECCS). In most cases, CDR approaches are decoupled from actual

Understanding the interaction between carbon capture and removal technologies can be challenging



CCS = carbon capture and storage; CDR = carbon dioxide removal.
Source: S&P Global Ratings.
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CARBON CAPTURE

Nature-based soutions could be constrained by available land but also could deliver a wider range of benefits to stakeholders if well planned.

emissions sources or industrial processes, meaning their potential benefits are net in nature and do not directly reduce emissions. For technological CDR options, CCS forms a key part of solutions. The vast majority of the 2 gigatons per year of CDR achieved today comes from land management, with only a small amount from technological solutions, according to the State of Carbon Dioxide Removal (2023). The IPCC, however, concludes that CDR use — both natural and technological — will need to increase significantly to support all scenarios that limit warming to 2 degrees C.

CCS is a group of technologies that separate carbon dioxide from other gases then capture and store it in a permanent facility. CCS can be deployed in power generation and industry to capture carbon dioxide directly from processes and transport the gas in pipelines to long-term geological storage sites. Captured and stored carbon can be used in the energy sector, for example for extracting oil and gas in depleted reservoirs. The Global CCS Institute (2022) reported that the operating capacity of CCS in 2021 was 37 million metric tons per annum with a pipeline of projects that could develop around 150 million metric tons per annum of capacity. This is a small fraction of the total that the IPCC, IEA and NGFS anticipate would be needed (between 3 gigatons and 8 gigatons per year) in more ambitious decarbonization scenarios. The IPCC (2022) notes that deployment is already behind where the panel would expect it to be to meet a 2 degree C scenario.

While CCS and CDR are expected to play a key role in decarbonization, the limitations of both have been documented in global studies. There are also technical, economic and political barriers to overcome. Approaches using CCS are seen as having stronger permanence characteristics than nature-based solutions (NbS), meaning they are considered less vulnerable to the accidental release of carbon dioxide, provided they are well managed. With a CCS-based approach, it can also be easier to monitor and determine the amount of carbon stored compared to NbS. The technological readiness of CCS is, however, generally behind that of afforestation or reforestation, and costs are less certain, although there are some facilities operating in certain sectors such as oil and gas. Storage capacity is a major consideration; studies estimate that there is enough total storage capacity for CCS to cope with decades of emissions, whereas NbS could be constrained by available land but also could deliver a wider range of benefits to stakeholders if well planned. Technological CDR solutions, especially DACCS, are at much earlier stages of development, with technical and economic challenges still to be overcome.

Carbon credits carry their own risks but could provide flexibility

Carbon credits are certificates that represent the reduction, avoidance or removal of 1 metric ton of carbon by a specific activity. For example, a party develops an afforestation project that removes a ton of carbon from the atmosphere, generating a carbon credit, which the party can either use for itself to support a decarbonization claim or trade to another party like any other commodity.

Some stakeholders have expressed concerns about the role of carbon credits and whether they can deliver real reductions. Carbon credits are complex, with multiple actors involved (see "Voluntary carbon markets: how they work, how they're priced and who's involved," June 10, 2021). The World Resources Institute (2010) and the U.K. Climate Change Committee (2022) are among those that have identified specific considerations for companies when selecting projects that could offset emissions. The credibility of the underlying projects is crucial; potential issues can arise for carbon credits that are based on perceived benefits that can be difficult to substantiate or can simply lead to adverse effects elsewhere. For example, credits based on avoided deforestation in one area would need to show that deforestation did not simply occur somewhere else, which can be difficult to prove. Crediting schemes also require that the creation of carbon credits be limited to reduction or removal projects that would not otherwise be economically viable without the additional source of revenue the credits provide. Transparent and credible verification and data are therefore key for increasing stakeholders' confidence that any given carbon credit represents a real benefit. Meanwhile, some companies' interest in carbon credits might only be to trade them, not necessarily to use them to support their own decarbonization goals.

Despite this, momentum is growing for voluntary carbon markets (VCM), which could indicate some stakeholders believe that carbon credits can support decarbonization claims. For example, the IEA's net-zero scenario notes that offsetting mechanisms could provide

Table 1: **Overview of the most prominent CCS and CDR solutions**

Solution	Description	Examples
CCS or carbon capture use and storage	Used in conjunction with industrial production to capture carbon dioxide emissions generated from a particular activity. The captured emissions can either be stored or used for another purpose.	Capture systems as part of power generation, cement production and other industrial processes, placed in geological storage locations. Capture systems that subsequently use carbon dioxide for enhanced oil recovery, chemical products or food production.
Carbon dioxide removal solutions		
Nature-based CDR (or nature-based solutions)	Interventions that use natural processes to remove carbon dioxide directly from the atmosphere and store it as carbon in organic materials.	Afforestation (or reforestation) where new vegetation absorbs and stores carbon. Efforts that improve soil quality and increase organic carbon, including peatland and wetland restoration. Production of biochar, a charcoal-like product made from biomass, which can then be used to improve soil quality. Enhanced weathering, the spreading of finely ground silicate rocks, which promotes fast carbonation.
Technology-based CDR	Using a chemical and mechanical process to remove carbon dioxide from ambient air and geologically store it, commonly referred to as direct air capture.	Systems that use a chemical solution to cause a reaction with carbon dioxide. Systems that use filters to absorb carbon dioxide, then store carbon in geological storage locations.
Special case: bioenergy and CCS	Where crops are grown to produce bioenergy (thereby absorbing carbon dioxide from the atmosphere) and then, when combusted, the emissions are captured through CCS and geologically stored.	Biomass or biofueled thermal power generation with integrated CCS facilities.

Sources: S&P Global Ratings; IPCC (2021); S&P Commodity Insights. CCS = carbon capture and storage. CDR = carbon dioxide removal.
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cost-efficient support to mitigate emissions. There are several existing schemes that promote VCM, managing the creation, offering and retirement of carbon credits for buyers and sellers alike. Some sectors, such as the International Civil Aviation Organization's Carbon Offsetting and Reduction Scheme for International Aviation, allow participating companies to use carbon credits as a key part of their decarbonization approach.

The voluntary market could also support the development of new technologies. For example, methodologies are being increasingly developed that would allow DACCS projects to generate carbon credits, potentially making those projects more financially viable. The World Bank (2023) reported on a significant increase in VCM activity in the last five years, with 275 million voluntary credits issued in 2022. Ecosystem Marketplace (2021) estimated the market value of VCM at US$2 billion. Although this represents only a fraction of current global emissions, demand is expected to increase substantially

Companies face a complex set of challenges

While global studies recognize the potential role for CDR, CCS and carbon credits, not all companies have identified the potential risks that could limit their effectiveness. Here, we use the oil and gas sector as a case study to illustrate how companies are approaching the available solutions.

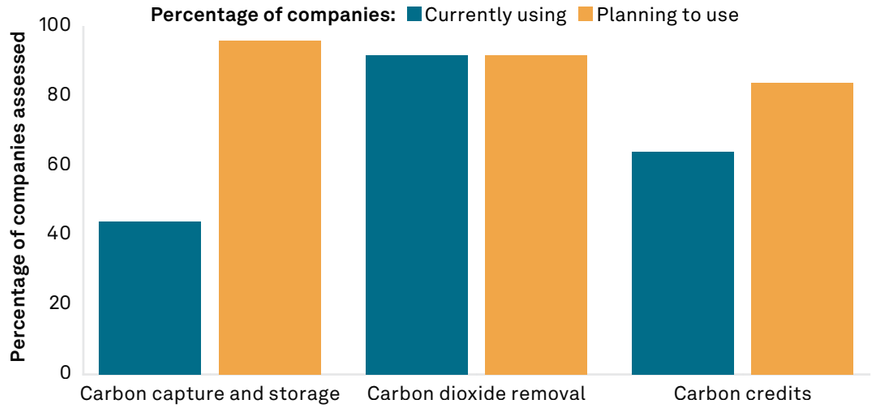
Oil and gas companies show a wide range of starting points and approaches to meeting emissions-reduction targets

Not all companies in our sample have set net-zero targets (see chart 1); this also applies to other sectors, but all have set targets to reduce emissions to some extent between 2030 and 2050. Of our sample, 76% are targeting net-zero for Scopes 1 and 2 emissions by 2050. Additionally, 64% of the companies have set a methane reduction target and 80% are signatories to the World Bank's Zero Routine Flaring by 2030 initiative. While 32% of companies

Our oil and gas sector case study approach

- From across the globe, we selected a sample of 25 of the highest-revenue oil and gas companies, with combined revenue of US$3.8 trillion and aggregate capital expenditure of US$279 billion in their latest fiscal year. We see the sector as clearly exposed to climate transition risks, given the significant emissions that are generated through the use of oil and gas, and we think that our sample offers a representative view of how a key sector is approaching CCS, CDR and carbon credits.
- We reviewed the companies' publicly available sustainability and financial disclosures for 2022 and their positions on using CDR, CCS or carbon crediting schemes to achieve stated carbon targets. We also assessed how investment, as well as the understanding of technology and other sustainability risks, informs their plans.
- Our sample represents Scopes 1 and 2 emissions of 687 million metric tons of carbon dioxide covering about 31% of emissions from listed oil and gas companies, based on the universe of companies in our S&P Global Market Intelligence dataset. We note that the majority of oil and gas sector emissions are Scope 3 because fuels are burned by users; in our sample, Scope 3 accounted for 93% of total emissions.

Chart 1: **All oil and gas companies in our sample plan to use CCS, CDR or carbon credits to achieve their decarbonization goals**



CCS = carbon capture and storage; CDR = carbon dioxide removal.
Source: S&P Global Ratings.
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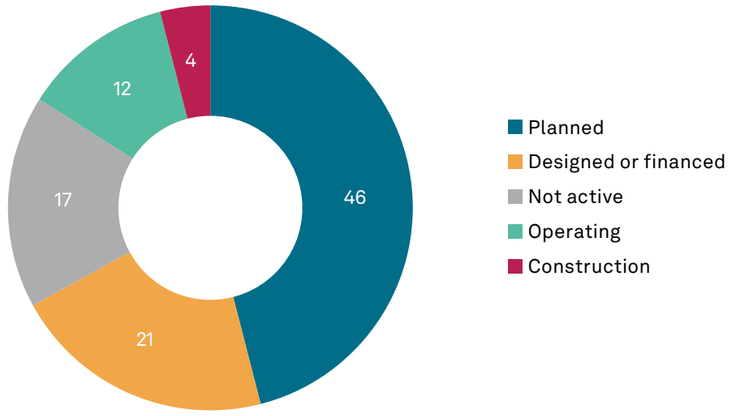
have set targets to reach net-zero, including Scope 3 emissions, this only covers 20% of the Scope 3 emissions in our sample. To put these figures into context, the IPCC (2021) suggests that emissions from the combustion of fossil fuels — the main Scope 3 emissions of oil companies — would need to decline by around 85% by 2050, compared to today, to meet the below 2 degree C scenario.

All the companies in our sample plan to use at least one of either CCS, CDR or carbon credits to meet their decarbonization goals, although strategies vary in the level of detail. Current CCS capacity in our sample in 2022 represented only 7% of the companies' reported Scopes 1 and 2 emissions, with most activity from the US- and Europe-based global majors. Plans for future deployment reported by companies in our sample would see capacity increase substantially, to around 325 million metric tons by 2030 from 50 million metric tons today. These CCS and carbon capture use and storage (CCUS) capacities include plans for enhanced oil recovery and solutions to capture emissions from other companies. However, only 60% disclose their expected future capacity and only 56% identify the specific investment costs required, either explicitly or as part of a wider package of measures. When we looked at companies' aims, 24% mentioned they would use captured carbon for enhanced oil recovery, but often these aims are expressed in vague terms, which is important because emissions that result from the oil produced in this way could nullify the possible benefits of the captured carbon, potentially introducing reputation risks.

In our sample, 92% of companies intend to use CDR, mainly through NbS, but implementation plans are not always clear. We have observed that the most common approach is to partner with others, although a high proportion of companies' disclosures lack details. Most companies in our sample described projects that contribute to biodiversity initiatives, but they do not identify CDR as a potential additional benefit. In our analysis, companies' strategies focused on afforestation or reforestation solutions; none disclosed any involvement with other types of NbS. Reference to the use of DACCS (40%) and BECCS (28%) in our sample was also limited.

Chart 2: **6 times more CCS projects are planned globally than already operational**



CCS = carbon capture and storage.
Of the projects monitored by S&P Global Market Intelligence, only 12% are in operation as of 2023.
Source: S&P Global Market Intellegence.
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Our finding is supported by the Global CCS Institute (2022) status report that found limited developments and by an estimate by S&P Global Market Intelligence that DACCS and BECCS represent only 2% of planned CCS deployment to 2030.

From our sample, 40% of companies have disclosed that carbon credits are part of their low-carbon solutions for customers

Among the oil and gas companies in our sample, 64% are already participating in the voluntary carbon credit market, but 84% suggest this will be part of their future strategy. Current total purchases were disclosed as 3% of 2022 Scopes 1 and 2 emissions across our sample, including both removal- and reduction-based credits. From our sample, only five companies disclosed plans to limit the use of carbon credits to offset on average 10% of total greenhouse gas emissions by 2030. We note, however, an emphasis on coupling credits to sold fuel, for example marketing the fuel as carbon neutral or net-zero to emphasize relevance for Scope 3 emissions, as opposed to balancing Scopes 1 and 2 emissions. Meanwhile, some oil and gas companies treat trading carbon credits as a business line, not exclusively as a way to support their own decarbonization claims.

From our sample, 40% of companies have disclosed that carbon credits are part of their low-carbon solutions for customers. Understanding how companies will use credits is difficult without a standardized reporting framework (Rosales et al., 2022).

All options will add to costs and carry considerable technical uncertainty

Some solutions are still evolving and are yet to be proven at commercial scale (see chart 2), making it difficult to gauge the potential impact on investment needs and costs. The IPCC (2021) notes that while afforestation and reforestation are well understood, technological approaches, such as DACCS and BECCS, are less mature.

In addition, some already-delivered CCS projects have not met their full potential, having experienced technical issues with both capture and storage as well as economic challenges in some geographies (Institute for Energy Economics and Financial Analysis, 2022). All options involve both capital and operating expenditure, where current estimates fall into wide ranges (see table 2).

Table 2: **Estimated cost ranges for CCS and CDR solutions**

Type	Solution	Cost range (US$/metric ton)
Technology-based solutions	Carbon capture and storage	15-130
	Direct air carbon capture and storage	100-345
	Bioenergy combined with carbon capture and storage	15-400
Nature-based solutions	Afforestation and reforestation	5-240
	Soil carbon sequestration	45-100
	Biochar	10-345
	Enhanced weathering	50-200

Costs are expressed as life-cycle costs.
Source: S&P Global Ratings; Based on a range of estimates from IPCC (2021), IEA (2020, 2021).
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The wide variation in estimates for life-cycle costs shows the state of technological readiness, the specific application and the uncertainty involved in all the solutions. For example, the cost of CCS is related to the concentration of the carbon dioxide being captured. Where concentrations are high, for instance in some industrial processes, costs are likely to be lower compared to DACCS, where the carbon dioxide in ambient air is very diluted. However, geographic considerations are also relevant, such as the distance to storage sites. This can make estimating the potential financial costs of hypothetical developments difficult. In our sample, disclosure about investment in CCS, CDR or carbon credits is mixed. In some cases, specific investment amounts are identified, but in many cases, they are not stated or set out clearly, or are expressed only as a future ambition. To illustrate the range of uncertainty, a company in our sample with median carbon emissions could expect costs of US$1.5 billion-US$2.5 billion per year to balance current Scopes 1 and 2 emissions of 21 million metric tons through CCS or afforestation, assuming a future policy requirement for oil and gas companies to operate with net-zero emissions, and CCS and afforestation or reforestation costs of US$72-US$118 per metric ton. In this illustrative example, these costs would likely represent at least 10% of operating profit. Using only DACCS, which is still in early development, would cost considerably more because of higher expected operating costs.

Those that choose to rely on carbon credits could also face cost risks, particularly for higher-quality removal-based projects. There is considerable uncertainty about how the voluntary market for carbon credits will evolve. While prices appear lower for now on average across all carbon credit types — and therefore potentially more attractive than other options — Trove (2021) estimated that carbon credit prices could be between US$25/metric ton CO_2 and US$100/t CO_2 by 2030. There could also be variations in cost between credit types. For example, in

2022, nature-based removal credits traded at a daily average price that was more than twice as high as that of avoidance-based credits, according to S&P Global Commodity Insights data. This wide range of costs introduces uncertainty for companies that might plan to use carbon credits as part of a long-term decarbonization strategy.

Nature-based solutions might also be susceptible to permanence risks such as climate hazards, like wildfires or drought, in the long term

The total cost and return for companies can vary. Assessments of potential future carbon pricing obligations, regulatory incentives, and whether there is an ability to pass on costs to customers may be used as tools to estimate cost scenarios. For example, in the US, where there is no federal carbon tax, there is a current tax incentive of US$85 per metric ton from the Inflation Reduction Act that would partially offset costs associated with construction and operation for CSS. But that could change in the future. In regions with carbon taxes or emissions trading schemes, for example in the EU, companies may have more of an incentive to consider CCS or CDR to minimize regulatory costs, albeit costs and returns may again be uncertain and highly variable. For example, the price for allowances under the EU Emissions Trading System could reach €128/tCO_2 by 2030 (see "Carbon Pricing, In Various Forms, Is Likely to Spread In The Move To Net Zero," Aug. 9, 2022).

CCS and CDR could have other environmental consequences

NbS and the deployment of carbon capture technologies could add pressure to ecosystems. The IPCC (2020) and UNEP/ICUN (2021) have assessed the potential wider effects, both positive and negative, of NbS. For example, low-diversity tree plantations on naturally low-cover habitats, such as savannas, can increase water demand and nutrients, which in turn can put pressure on other forms of life that inhabit the ecosystem. NbS might also be susceptible to permanence risks such as climate hazards, like wildfires or drought, in the long term (Badgley et al., 2022). Meanwhile, CCS assets typically have high water requirements and could add pressure to water-scarce areas. In our sample, companies that plan to deploy NbS were generally better at disclosing environmental risks but lacked detail about how they would manage permanence risk, for example.

Aside from the potential cost of implementing NbS, companies face obstacles to securing enough land to manage it successfully. Given the scale of some companies' emissions, such as those in our sample, the requirements for land could be significant. Although we have found good examples that provided specific locations and timelines for such projects, details are broadly lacking. As an example of the potential scale, if we assume the median company in our sample (current Scopes 1 and 2 emissions of 21 million metric tons of carbon dioxide equivalent in 2022) chooses to use NbS alone to balance its emissions, around 18,000 square kilometers of land could be required. The amount of land required would depend on the type of solution, and over time, this area would need to be increased as habitats reach maturity and to protect them from potential damage. While this is just an illustration, it highlights the challenges of implementing such a solution, implying that companies would either need to use a mix of options or go further in their actual emissions reductions if they were to meet such a target.

Table 3: **Potential impact of CCS and CDR on other environmental factors**

Approach	Land use competition	Increase in energy use	Air pollution	Water use	Water quality	Biodiversity	Vulnerability to climate hazards	High risk of reversibility
CCS and DACCS		•		•				•
BECCS	•		•	•		•		
Afforestation/ reforestation	•			•		•	•	•
Biochar	•		•			•		
Soil carbon sequestration					•		•	•
Enhanced weathering	•		•			•		
Peatland restoration	•						•	•

The actual impact will depend on factors such as implementation and location. Reversibility refers to the potential re-emission of carbon that has previously been captured. In the case of situations where captured carbon is used to make new products, such as hydrogen, rather than being stored, the risk of reversibility is considerably greater. Some risks may be upstream, for example enhanced weathering being potentially dependent on mining. In some cases, benefits could also be delivered where carefully managed, for example those related to biodiversity. DACCS = Direct air carbon capture and storage. BECCS = Bioenergy combined with carbon capture and storage. Sources: IPCC AR6 (2021); Royal Society (2018).
Source: S&P Global Rating.
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Increased transparency from companies could help communicate risks

The policy landscape for CDR, CCS and carbon credits will likely keep evolving

The economics of some solutions have given rise to incentives from governments to support companies' research and development or offer financial help to deploy technologies such as CSS and CDR. Some authorities have already implemented policies supporting CCS and CDR research and development. For example, the US Inflation Reduction Act of 2022 provides further incentives to develop CCS projects, which could strengthen deployment rates in the medium term. In the UK, government support has been given to developers of new industrial hubs that have CCS as an integrated element. Similarly, the European Green Deal, the EU Innovation Fund, and Net Zero Industry Act increase support for CCS. We found examples in our sample of oil and gas companies of investments that are looking to take advantage of such financial support. Given that these solutions always represent some additional cost to the business activity involved, incentives are likely to drive deployment faster than in jurisdictions with more limited or different policy objectives.

The role of policy is a common theme in the energy transition, and there are still some complex stakeholder issues to resolve. Article 6 of the Paris Agreement paves the way for potential international trading of mitigating actions to support national commitments, but the relationship between national budgets and companies is less clear. As of COP27, there are still many methodological and technical issues to resolve about the treatment of removals and who owns the right to use them to support their decarbonization claims, avoiding double-counting issues. Monitoring frameworks

are also likely to develop. For example, in 2022, the European Commission published its draft regulation for the establishment of a centralized EU-wide CDR certification framework to support the EU in meeting its 2030 targets. The regulation aims to build trust in CDR and encourage finance by introducing a set of harmonized criteria covering quantification, additionality, permanence, and impact on other sustainability factors. Zhang et al. (2022) have also noted the need for more consistency in how CCS capacities are reported. Increased consistency as to how CDR, CCS and carbon credits are measured and reported by companies will likely increase stakeholder confidence. Notwithstanding this, there may be some short-term risk as companies develop their strategies within evolving regulatory frameworks.

Guidance is varied and voluntary about the use of CDR, CCS and carbon credits to support companies' decarbonization plans

Few specific regulations govern what requirements companies should or should not meet in order to make decarbonization claims. As a result, a wide range of voluntary guidance has emerged. It is not always aligned, however, and can be fragmented or complex to navigate (see table 4). Some of the guidance and frameworks have made efforts to define the role of CDR, CCS and carbon credits in decarbonization to drive consistency (for example, the UN [2022], SBTi [2021]), and investors and other stakeholders often refer to some of these as standards.

Concerns about quality have led to the development of third-party review services that aim to assure the veracity of carbon credits. Separately, sector initiatives, such as the Integrity Council for the Voluntary Carbon Market, aim to harmonize rules for voluntary carbon credits by providing assurance about the veracity of carbon credits in response to criticisms of some standards, methodologies and projects. There is growing consensus — such as by SBTi (2021) and The Oxford Principles for Net Zero Aligned Carbon Offsetting (2020) — that generally views removal-based carbon credits as more robust than reduction or avoided-emission credits.

However, claims about climate performance are increasingly attracting the attention of advertising regulators on the back of stakeholder concerns. Specific attention has been given to the use of carbon credits; for example, the US Federal Trade Commission's Guides for the Use of Environmental Marketing Claims includes a section specifically on carbon offsets. The UK's Advertising Standards Agency also provides guidance on how companies should describe the role carbon credits might play in environmental claims and provides guidance on the broader use of terms such as carbon neutral or net-zero.

Disclosure proposals are likely to increase the onus on companies to provide more comprehensive information about their decarbonization strategies. The International Sustainability Standards Board and the EU's Corporate Sustainability Reporting Directive are among those developing reporting standards on climate-related issues, which could go some way to increasing visibility on how companies plan to deliver on their commitments.

Limited disclosure makes stakeholder scrutiny more difficult

Disclosure of CCS and CDR risks within our sample of oil of gas companies was limited. Most of the companies in our sample included a Task Force on Climate-related Financial Disclosures (TCFD) section, or similar, within their annual report or sustainability report, but the level of detail about CCS and CDR varied. For example, we found only eight instances (from 25 companies) of specific disclosures related to risks associated with CCS and CDR, such as technology readiness, cost and access to storage locations. Most discussions framed risks around achieving specific targets, but we also found that in

Table 4: **Summary of a sample of views from industry standards and guidelines on CDR, CCS and carbon credits**

Framework or guidance	Approach to CDR, CCS and carbon credits
Global Reporting Initiative	Requires reporting and disclosure on the use of offsets, including the type of scheme, number of credits involved and reductions due to direct removals.
Greenhouse Gas Protocol Corporate Standard	Includes guidance about how to treat removals as part of a greenhouse gas inventory. Enhanced draft guidance published in September 2022 provides clarity about how removals and carbon credits should be treated and reported. Guidance is expected to be published in 2023.
International Capital Market Association (ICMA) Principles	Does not consider carbon offsetting within the Green Bond Principles' guidance because the ICMA does not consider it to represent carbon reduction.
Climate Bond Initiative	Allows for the use of CCS in certain sectors, such as cement and oil and gas, following specific criteria and for carbon sequestration through its forestry criteria. Self-generated or purchased offsets (with exceptions) should not be taken into consideration.
MDB-IDFC (Principles for climate mitigation financing)	CCUS for enhanced oil recovery and carbon credits are not eligible mitigation approaches.
SBTi's latest Net Zero Standard (October 2021, version 1.0)	Requires companies to reduce actual emissions by 90%, with the remainder being balanced by removals ("neutralized" according to its definition). Market-based carbon credits in science-based targets are defined as activity that happens beyond the value chain of the company, meaning that companies can finance offset schemes but cannot use them to abate their emissions on their science-based target pathway.
Climate Action 100+	Stresses that both offsetting and removal should not be used in lieu of actual emissions reductions. The Benchmark 2.0 framework update in 2023 expanded Disclosure Indicator 5 to include new metrics on offsets, negative emissions technologies, and abatement measures. With this expansion, it is not endorsing or promoting the use of offsets or negative emissions technologies in decarbonization strategies. Rather, it evaluates how comprehensive and robust companies are in terms of disclosure.
IIGCC Net Zero Standard for Oil and Gas	Requires the disclosure of the contribution of CCUS, BECCS and DACCS as part of emissions targets and requires companies to publish studies on the technological measures and investments planned to support the deployment of such solutions. It also requires companies to publish strategies regarding the use of carbon credits, including details on types, cost, storage and providers.
Transition Plan Taskforce	Within the Transition Plan Taskforce Disclosure Framework draft, entities should state specifically whether they rely on the use of carbon credits to achieve their targets. It also suggests disclosing details of carbon credits, including the quality and their contribution to transition plans.
UN High-Level Expert Group on Net Zero Emissions Commitments of Non-State Entities	Nonstate actors should prioritize emission reductions across their value chain. High-integrity carbon credits can be used for beyond-value-chain mitigation, but they should not be counted toward interim carbon targets. Residual emissions can be balanced with permanent greenhouse gas removals with independent verification.

Some of the sources cited above use the term "offsets" interchangeably with carbon credits or to represent the action of using carbon credits to make decarbonization claims.
Source: S&P Global Ratings.
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CARBON CAPTURE

We found only eight instances (from 25 companies) of specific disclosures related to risks associated with CCS and CDR, such as technology readiness, cost, and access to storage locations.

cautionary notes in annual reports, there were more statements about limitations. Half the companies in our sample specifically mentioned risks relating to policy support, performance or technology maturity, albeit in few words. This could reflect the current state of companies' TCFD reporting but nonetheless makes it difficult for stakeholders to form a clear view about the deliverability of solutions in decarbonization plans.

The disclosure of risks about the use of carbon credits in our sample was also limited, with only five companies noting particular risks. Some of the companies have developed, or are in the process of developing, a carbon credit policy — mainly those that also act as brokers to others. We see this as a critical step in managing risks associated with stakeholder concerns about issues such as additionality and whether the credits are to be used by companies themselves or sold to another party. Companies that plan to build up a significant portfolio of credits now to use or trade in the future could also be exposed to risks since views about the quality of different carbon credit types might differ among stakeholders and could change over time. Our finding is similar to that of the Transition Pathway Initiative (2021), which found that oil and gas companies did not disclose sufficient detail about the contribution from offsets to their overall targets.

CCS, CDR and carbon credits in our credit analysis of oil and gas companies

Oil and gas companies are adopting different strategic responses to the energy transition; reducing, capturing or offsetting emissions are a part of these responses. Companies with depleted hydrocarbon reservoirs may have a key asset for carbon dioxide storage activities, but this is not the only requirement for technical and commercial success. As shown in our sample and across the sector in general, large oil and gas companies are exploring different business models for carbon capture, which may include sequestering emissions from other companies' activities, not necessarily capturing their own emissions. Production of blue hydrogen — capturing the carbon dioxide formed by steam methane reforming and a water-gas shift reaction — is another use of carbon storage.

We view CCS investments as both prudent and affordable for large companies but not transformational. Announced plans across the sector to date appear to be comfortably within most companies' capital investment guidance and financial frameworks. This moderate level of investment also signals that companies do not see CCS as a panacea, nor is it typically a mandatory requirement imposed by licenses or regulations. Our ratings do not assume any requirement for producers to offset their emissions, still less Scope 3 emissions. This is just one area where a conceivable, disruptive change in regulations could increase costs and affect operations. S&P Global Ratings factored in the potential for these changes and other increasing challenges and uncertainties when it changed its industry risk assessment to moderately high, from intermediate, for oil and gas producers on Jan. 25, 2021. We note that net-zero targets set by companies are long-dated, typically for 2050 as shown in our sample.

As the energy transition proceeds, particularly for smaller producers, we may see some differentiation by investors and lenders between energy companies that produce fossil fuels but do so on a more sustainable basis and with credible operating metrics and companies that have not meaningfully addressed their Scopes 1 and 2 emissions and are not demonstrably willing or able to do so. As shown in our sample, disclosure of potential risks varies across the sector, and investors may increasingly expect more transparency on companies' strategic approaches to CCS, CDR and carbon credits. In the first instance, if more investors were to differentiate these risks, this could affect the cost of funding rather than access to funding. Nevertheless, particularly in a weak oil price environment, it could represent another potential hurdle for companies seeking funding or refinancing of debt.

Looking ahead: All options add complexity to decarbonization strategies

The global decarbonization pathways from the IPCC, IEA and NGFS agree that solutions to manage hard-to-abate emissions will have to play a key part in limiting rising global temperatures. While these solutions might support the management of transition risks associated with broader decarbonization strategies, all of them carry risks and present significant hurdles to overcome. The options will take companies time to develop, plan, implement and scale up and will require investment of some kind even as relative costs change.

Over the coming decade, we expect to see more discussion and disclosure from major emitters across the economy about their decarbonization plans, including how they plan to tackle their hard-to-abate emissions. Along with other risks in the energy transition, companies that can understand and manage these risks are likely to be better placed to deliver the most efficient and effective solutions. National policies and financial support will evolve and could provide more clarity to companies about dealing with emissions.

For now, there is considerable uncertainty about the potential costs associated with all of these options for those that want to meet their own decarbonization targets or those that look to reduce their potential exposure to carbon taxes or costs associated with emissions trading schemes. However, as the policy landscape changes, we expect to see companies pursue a wide range of solutions. Given all these factors, we believe that improved disclosure could enhance stakeholders' analysis of companies' strategies toward reaching their decarbonization goals. ■

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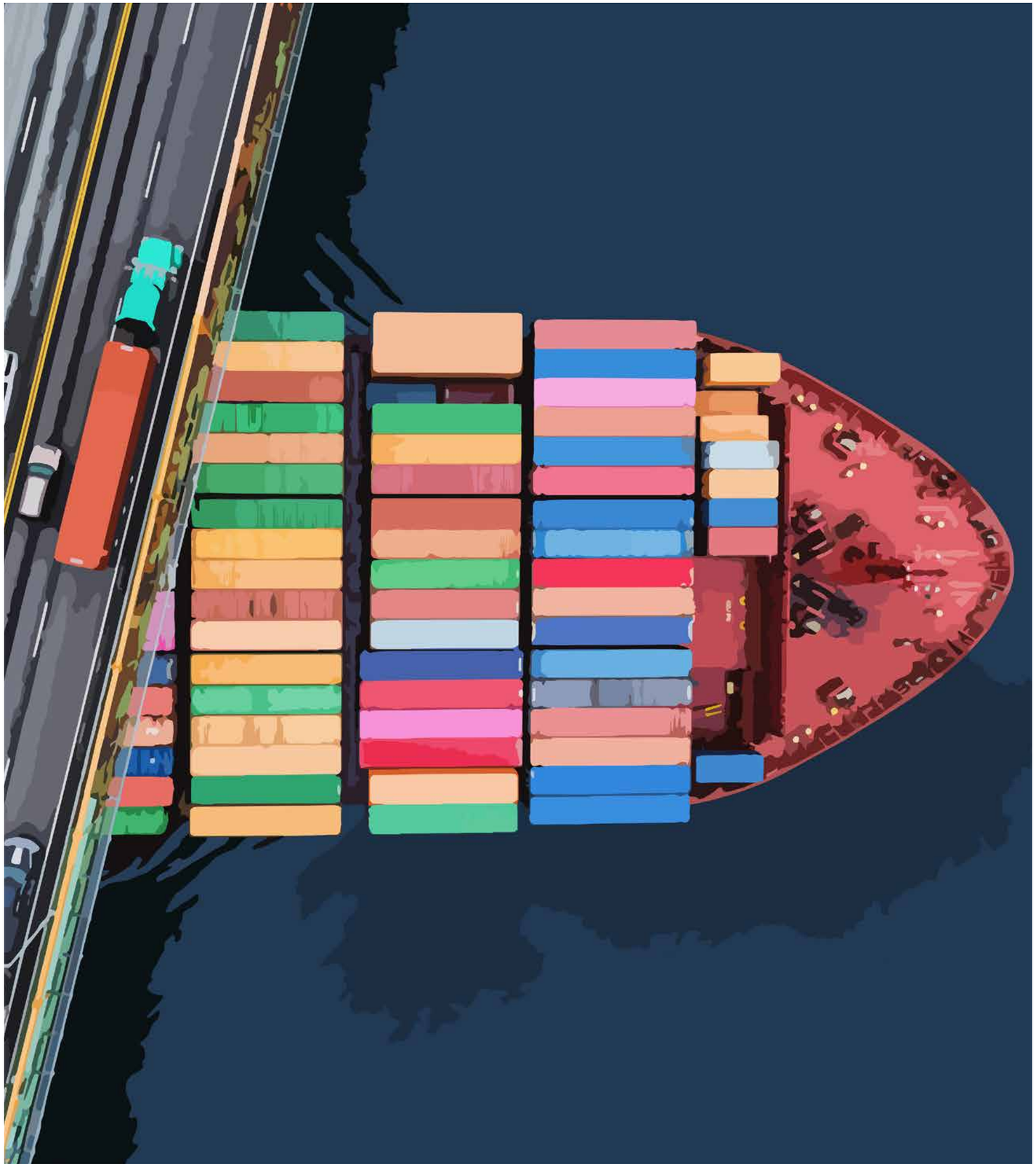

EU Carbon Border Adjustment Mechanism to raise $80B per year by 2040

The EU's Carbon Border Adjustment Mechanism aims to prompt industries to decarbonize without being undercut by imports from geographies with no carbon cost. This report provides a view of the potential impact of the mechanism on the EU's key trading partners and participating sectors as well as estimating the resulting revenues.

This research was authored by S&P Global Commodity Insights.

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Key takeaways

- The EU has agreed to implement a new Carbon Border Adjustment Mechanism (CBAM) as a long-term alternative to the issuance of EU Emissions Trading System free allocations to covered entities.
- Europe's aim is to prompt its industry to decarbonize without being undercut by imports facing no carbon cost.
- From 2026, EU importers of power, iron and steel, cement, fertilizer, aluminum, hydrogen and some polymers will be required to surrender CBAM certificates (equivalent to the prevailing EU carbon price) to match emissions associated with their production. Discounts may be provided where carbon prices in host jurisdictions are already paid.
- Using S&P Global Trade Atlas data and carbon price outlooks from our Energy and Climate Scenario service, we calculate the EU CBAM could rase more than US$80 billion per year by 2040. We expect this will prompt jurisdictions to consider domestic carbon pricing policies to mitigate their exposure in the long term.

▸ EU policymakers agree on final design of EU CBAM; monitoring report and verification of emissions to commence from Oct. 1, 2023

The EU has agreed on the design of a new Carbon Border Adjustment Mechanism (CBAM) as a long-term replacement to EU Emissions Trading System (ETS) free allocations to industrial entities covered under that cap-and-trade program. Importers of energy-intensive materials or products to the EU will need to surrender certificates to match emissions from their production. Producers from countries where there is a carbon price will pay only the difference between the EU's and the producers' countries. Importers of power, iron and steel, cement, fertilizer, aluminum, hydrogen, some polymers, and a few sub-products of iron and steel will need to buy certificates to match their emissions. CBAM certificates will be required for direct emissions and indirect emissions; however, clarity over how the latter will apply to selected products remains subject to further technical details to be provided by the European Commission.

Negotiators have agreed that the CBAM will initially cover iron and steel, cement, aluminum, fertilizers and some chemicals, and electricity, as originally proposed by the Commission, and will also be extended to hydrogen, indirect emissions (under certain conditions), and selected downstream products, such as screws and bolts and similar products of iron or steel, following negotiations with the European Parliament from the start. Refined products, such as oil/petroleum products and LNG, were considered but were not covered within the initial scope of the CBAM. Negotiators have agreed the European Commission will report on the effectiveness of the CBAM before the end of 2027, allowing for possible further sectoral scope expansion in the future.

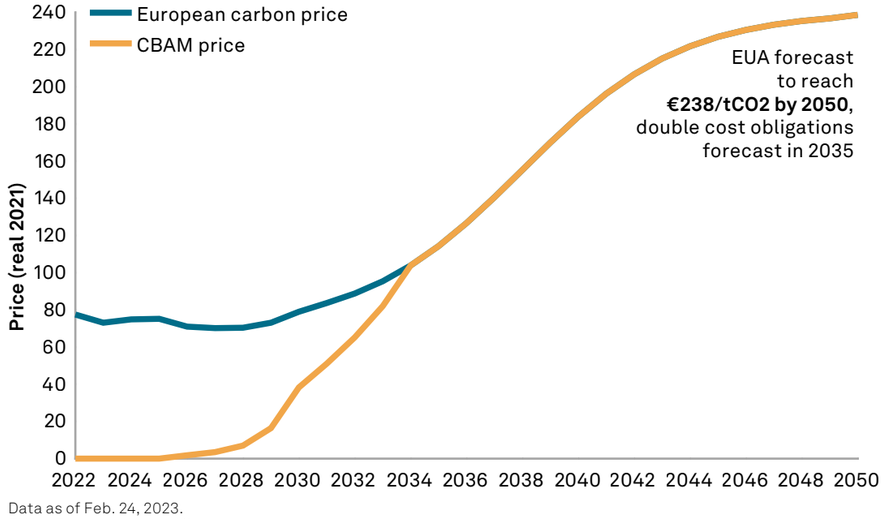
The methodology of the EU CBAM will categorize products into "simple goods," meaning goods produced by materials and fuels that have zero embedded emissions, and "complex goods," meaning goods other than simple goods, where embedded emissions in materials and fuels used in production will also be covered by the CBAM. To calculate embedded emissions (within selected goods), the EU describes a specific embedded emissions methodology in the legislation, with the final details expected to be released following approval of the measure by the European Council and European Parliament in the coming months. To determine CO_2 emissions from electricity, a CO_2 emissions factor will be determined using CO_2 emissions data from the electricity sector, divided by the gross electricity generation based on fossil fuels in the relevant geographic area. Where actual emissions cannot be adequately determined by the authorized CBAM declarant, default values shall be used, set at the average emission intensity of the exporting country increased by a "proportionately designed mark up." Should reliable data not be available for a specific geography, average emission intensities of the worst performing EU ETS installations for that type of good shall be used instead; previous expectations of this were around 10%, but the final value will be subject to future implementing acts. These details set the basis for our initial cut of analysis — where we have applied global average carbon intensity benchmarks to goods to determine emissions volumes covered by the EU CBAM. Refinements of our calculations will follow with additional detail on regional emissions intensities in due course.

Negotiators have agreed the European Commission will report on the effectiveness of the CBAM before the end of 2027.

Reporting obligations for the CBAM will commence from Oct.1, 2023, with the introduction of obligations for importers to purchase CBAM certificates commencing from 2026, increasing to 100% of emissions by 2034. Equivalent EU ETS free allocations issued to the CBAM-covered sectors in the EU market will be phased out over the same period.

CBAM allowance price meets EUA trajectory by 2034

CBAM price outlook (S&P Global Commodity Insights EUA forecast)



Data as of Feb. 24, 2023.
EUA = European Union Allowance.
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CBAM obligation phase in timeline

Year	2026	2027	2028	2029	2030	2031	2032	2033	2034
CBAM obligation (% of reported emissions)	2.5%	5%	10%	22.5%	48.5%	61%	73.5%	86%	100%
Equivalent EU ETS free allocation (for sectors participating under the CBAM)	97.5%	95%	90%	77.5%	51.5%	39%	26.5%	14%	0%

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Impacts of EU CBAM to differ by country, based on carbon price levels and CO_2 intensity of production

Canada, South Africa, Brazil and Turkey lead CBAM-covered EU trade, forecast at more than 40% of total exports to the EU between 2026–2040

The EU CBAM will have a global impact, with the EU accounting for around 16% of total global imports in 2021 (all products)[1]. The US, Russia, the UK and Turkey emerged as key countries that collectively accounted for nearly 30% of value of EU imports in 2021. Levels of exported goods from Russia have since declined significantly following the Russian invasion of Ukraine and therefore fall out of the most affected countries, on a volume of CBAM-covered goods and volume of CBAM-covered emissions between 2026–2040 from our modeling.

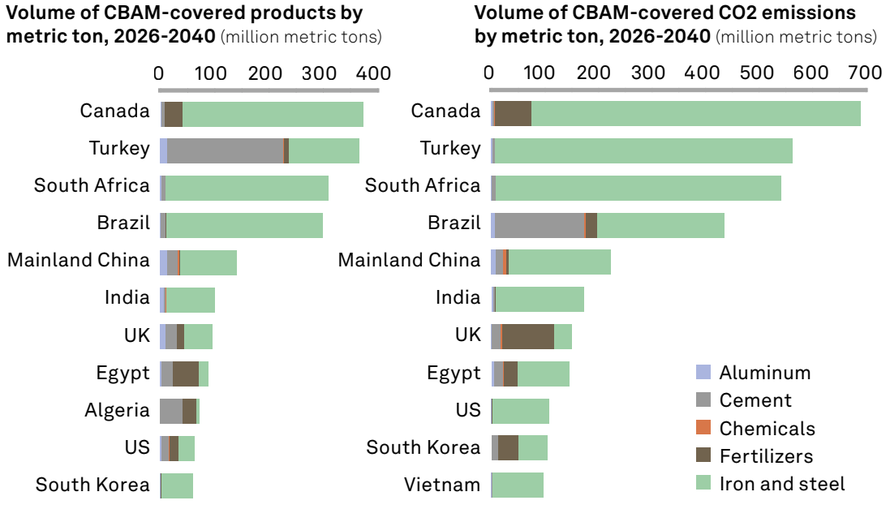
In this analysis, we have calculated using our Global Trade Atlas[2] model forecast CO_2 emissions covered by the EU CBAM between 2026 and 2040. We also determined the CO_2 costs of the EU CBAM between 2026–2040 using draft explicit domestic carbon price forecasts from our Energy and Climate Scenarios service[3]. Our analysis focuses on key CBAM-covered products exported to the EU market, as a proxy for future CBAM obligations[4].

Our country modeling shows Turkey, Brazil, South Africa and Canada are expected to have a higher volume of total CBAM exports between 2026–2040 to the EU market (by metric ton) than the US, mainland China and India. Although Turkey is forecast to export the second-most CBAM-covered products to the EU market (by tonnage) between 2026–2040, these exports comprise a larger share of cement exports, with a lower globally averaged CO_2/metric ton footprint. Consequently, Turkey has a smaller volume of CBAM-covered emissions in our forecasts than Brazil and South Africa.

By sector, our modeling calculates that emissions from iron and steel products could account for more than 75% of CBAM obligations as the sector currently has one of the highest global emission intensities by metric ton of product. There are wide variations in emissions intensity of production of each product; for this analysis we have taken, where appropriate, global average emission intensities to provide a comparable analysis by volume of export to the EU market in order to determine CBAM exposure size. As noted earlier, for CBAM products from geographies where emissions cannot be measured, the EU plans to use a benchmark derived from a certain percentage of the most polluting participants (of that product) in the EU market. This percentage is currently undetermined in the draft regulations published Dec. 14, 2022, but was expected to be around 10% based on previous negotiating positions. It currently remains unclear how this might apply in respect of indirect emissions which will also be in scope for selected products. We have weighted our analysis to consider the average tCO_2e by EU production and associated free allocation benchmarks currently employed under the EU ETS for industrial participants.

Canada, South Africa and Brazil to produce most CBAM emissions

Turkey's CO2 exposure reduced by export of lower carbon intensity goods to EU market



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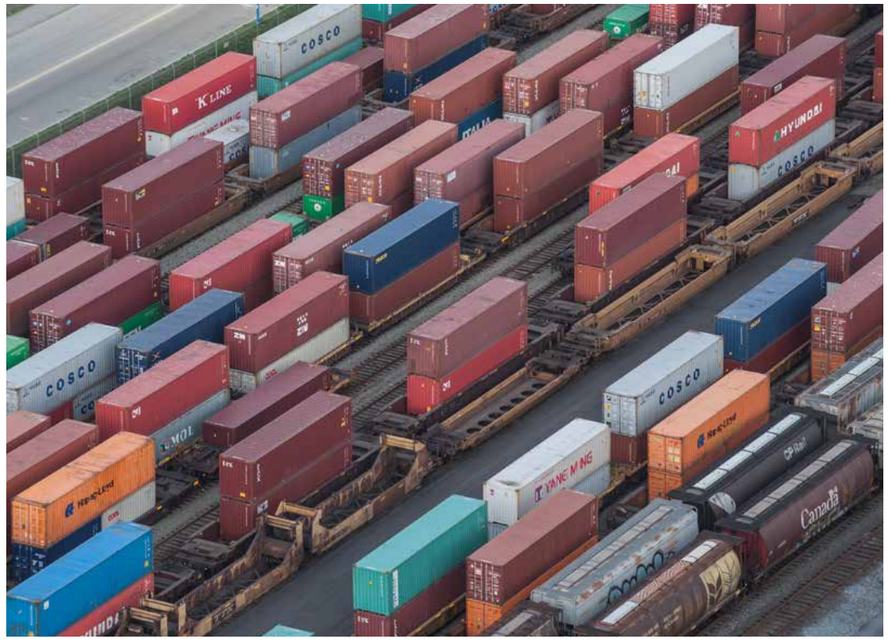


[1] EU position in world trade (europa.eu)

[2] The S&P Global Trade Atlas provides a comprehensive view of global trade data in every commodity at the most detailed level of harmonized system code (HS code). The Global Trade Atlas encompasses dependable monthly bilateral trade data for 113 countries and annual data for close to 200 countries, based on official imports and exports statistics. We have used forecast data from the Global Trade Atlas to model future volumes of EU CBAM-covered products imported into the EU market, as a proxy for determining EU CBAM emissions and cost exposure.

[3] Draft carbon prices in this analysis are valid February 2023. Carbon prices are converted to USD and are taken as prices from our Inflections scenario modeling. All prices used in this analysis assume national level carbon pricing instruments — for jurisdictions that do not apply national level carbon prices (e.g., Japan, US), an average of available carbon prices in the country are used. All carbon prices are subject to further updates. Carbon prices reflect either emission trading systems or carbon taxes.

[4] Note that these calculations assume a global emissions intensity value per sector and are not adjusted or weighted by country. Not all CBAM-covered products are currently covered by our modeling and analysis, but we will update our assumptions as emissions levels captured under the CBAM become clear within the transitional phase between Oct. 1, 2023, and 2026.

DECARBONIZATION

Of all sectors reviewed in this analysis, we identify global carbon intensities of chemical and fertilizer production as sectors with the highest average CO_2/metric ton intensity — with research estimates varying depending on method of ammonia production. Our research identifies a carbon intensity of 2.1tCO_2/ton ammonia produced in the US[5] but more than 3tCO_2/ton from coal gasification production (common in China)[6], with a global value of 2.7tCO_2/ton production reported by the Ammonia Energy Association.[7,8] Depending on the age of the plant, this can increase to around 5tCO_2/ton ammonia, according to S&P Global Commodity Insights research. For our modeling of fertilizer production, which will be included in the CBAM from 2026, we have taken the more conservative average of 2.1tCO_2e as CO_2 emitted will change depending on whether the ammonia is produced using coal, natural gas, naphtha or oil as a feedstock. Given the spread of carbon intensities for ammonia production by country, one of the possible responses to the EU CBAM includes countries opting to reduce the emissions intensity of products, including ammonia, to reduce overall CBAM exposure. We calculate that 100% CBAM certificate costs from 2034 could add around 30% to the dollar-per-metric ton ammonia price in countries that supply the most ammonia to the EU market — Russia, Algeria, and Trinidad and Tobago — meaning such products with the highest carbon intensities currently are most likely to be subjected to higher emission intensity reduction targets in their host countries in the longer term.

Overall, emissions coverage of the EU CBAM certificate price could reach around 2.5% of global emissions from products destined to reach the EU market by 2040. In our view, this demonstrates the potential value of the EU CBAM in driving "global" carbon pricing and incentivizing decarbonization through reducing emission intensity of production of CBAM goods in the highest-polluting economies to reduce the costs paid to the EU Commission to trade these goods into the EU market. However, as explored below, this is not the only response possible to the EU CBAM, and we expect this will depend significantly on geography and CBAM cost exposure.

EU CBAM carbon cost can be mitigated by carbon price in host country; UK forecast as only country to avoid CBAM charge

The EU CBAM has been designed with the potential to accept explicit carbon costs paid in the host territory as a "contributing cost" toward CBAM certificate obligations, essentially requiring importers to demonstrate carbon prices already paid for production of goods and settling the difference to the costs paid by EU industry under the EU ETS.

For most countries, the phase-in of CBAM obligations — along with expectations of domestic carbon prices as a percentage of the EU ETS market price — will delay significant cost implications for importers to the EU until 2029 as annual CBAM charge obligations increase. Exceptions include Canada, where we forecast a stronger price signal that could delay EU CBAM impacts until 2032–2033. Canada currently implements a backstop federal-level carbon tax and is expected to see the strongest carbon price growth in the near term (C$15/year to 2030), rising more quickly than expectations for the European Union Allowance (EUA) price between 2021–2030. By 2034 however, we forecast stronger demand for EUAs from industrial and transport (aviation and maritime) sectors, which will significantly increase EUA carbon prices by 2040.

The UK is the only country expected to have a long-term carbon price — under the UK Emissions Trading System + Carbon Price Support, which applies to electricity generation — that remains at levels above the EU ETS price. We continue to expect strong price parity between these markets in the long term owing to the geographic proximity of the two carbon markets and hedging observed across these markets by participants in the oil and gas and aviation transport sectors, which manage obligations covered by both jurisdictions. The UK maintained a 15% premium to EUAs in 2022, but we forecast this premium is likely to narrow as liquidity in the UK market develops.

Further clarity is expected from the EU over which existing carbon pricing mechanisms will be accepted toward CBAM obligations. This is likely to be disclosed in final publication of the regulations later this year following approval by the European Council and European Parliament. Our expectation is that ETSs will generally be accepted, such as the UK ETS, alongside selected carbon taxes that apply an explicit carbon price to the production of CBAM-covered goods. However, whether the EU will recognize regional carbon pricing schemes, as well as national schemes, remains unclear. We consider that it is possible that such schemes are recognized, subject to proof that the carbon cost has been paid against the production of the good in the jurisdiction where the carbon price applies. Where free allocations or tax exemptions are issued to participants under current carbon pricing initiatives, it is unclear how the EU CBAM charge will be adjusted to reflect the "true" cost of carbon paid toward the production of a particular good.[9] Implicit carbon pricing (as part of fuel duty taxation) is unlikely to be accepted toward reducing EU CBAM obligations, along with voluntary carbon market initiatives (pairing the production with the purchase of carbon credits), where there remain ongoing concerns over the integrity of the emission reductions achieved under select project/credit types.

Overall, our modeling of future EUA carbon prices and exposed CBAM sectors covered in this analysis calculate that the EU CBAM could raise more than US$80 billion per annum to the EU Commission from 2039, accounting for existing carbon pricing mechanisms in force in key jurisdictions. The top 10 countries by volume of CBAM goods to the EU market between 2026–2040 — Canada, Brazil, South Africa, Turkey, mainland China, the US, the UK, India, South Korea and Egypt — represent more than 68% of total export volume by tonnage of product and more than 70% of total CO_2 emissions covered by CBAM obligations during this period. As a result, this group of countries will be liable for nearly 70% of total CBAM costs, despite existing carbon prices already operating in six of the 10 countries under known or implemented mechanisms recorded at of the end of 2022.

Individually, we assess Turkey and Brazil to be among the countries exposed to the highest total CBAM costs between 2026–2040, as countries currently without a carbon pricing mechanism in force, and with a high percentage of iron and steel exports to the EU market. However, South Africa, despite operating a carbon tax since 2019, is forecast to face the highest percentage of CBAM cost obligations by 2040 as the current carbon tax design in the country features a high level of tax exemptions issued to participants, and export volumes of CBAM products to the EU are forecast under our Global Trade Atlas to increase by 40% between 2026–2040. Accounting for differences in the carbon intensity of CBAM products globally, China has the potential to see its CBAM exposure rise from our assessment in this analysis, given a higher carbon intensity production of ammonia and iron and steel products compared to the global average owing to China's dependency on coal power generation, which from our Global Integrated Energy Model forecasts more than 70% of total emissions from coal between 2026–2040.

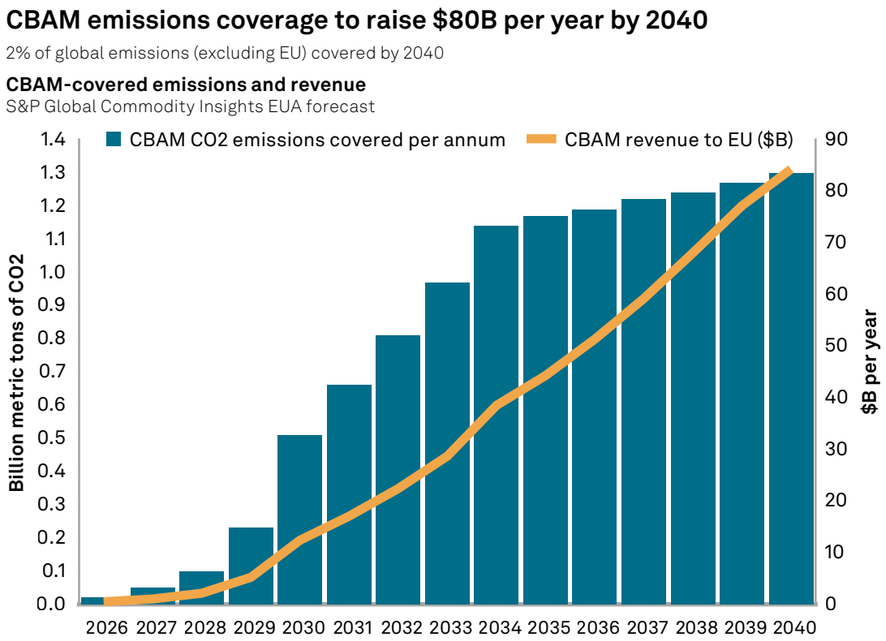
[5] US Natural Gas Weekly Update (eia.gov)

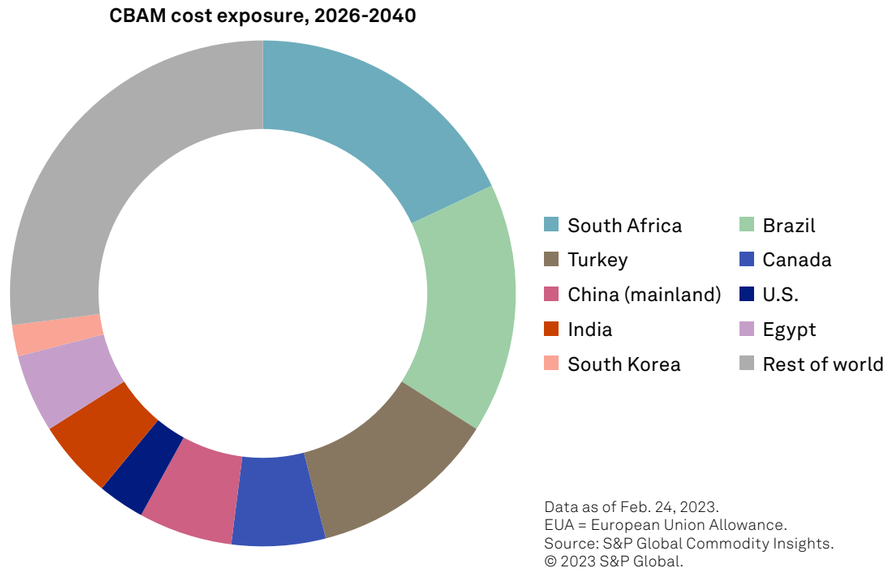
[6] Measuring and Reporting Fertilizer Emissions: https://www.fertilizer.org/images/Library_Downloads/2018_IFA_Measuring_and_Reporting_Fertilizer_Emissions.pdf

[7] Life-cycle analysis of green ammonia and its application as fertilizer building block – Ammonia Energy Association

[8] Broader chemical sector inclusion in the CBAM is currently limited as MRV methodologies for organic chemicals is technically challenging and therefore requires more time to determine an accurate emission intensity per ton. The EU Commission will review the CBAM before 2026, when a decision on whether chemical production will be covered by CBAM obligations will be made. If expanded to more chemical products, we expect the sector to account for around a quarter of CBAM obligations between 2026–2040, while fertilizers make up 9% over the same period.

[9] Draft carbon prices used in this report (under our Energy and Climate Scenarios service) include assumptions regarding free allocations and tax exemptions issued to participants. However, the EU methodology for capturing these allocations to determine EU CBAM cost obligations currently remains unclear. Therefore, we do not make any specific determinations of this in this analysis, and EU CBAM cost values used in this report are subject to change.





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Although the China national ETS only applies to power generation at present, we expect this scheme will expand ahead of CBAM obligations to include heavy industry and financial participants, which are expected to increase the carbon price signal in the country and keep China's total CBAM cost exposure below levels forecast in Brazil, South Africa and Turkey.

Next steps: EU to provide clarification over methodology (recognition of existing CO_2 costs, measurement, reporting and verification for indirect emissions) following approvals in European Parliament and Council; other governments to consider response

To implement the CBAM, the final agreed-upon text is subject to approval by the European Parliament and European Council. The European Parliament gave its approval to the file in February 2022, and European Council approval is expected before the end of the first quarter of 2023. This is expected to be a routine procedure, and we do not anticipate any delays, with reporting obligations due to commence from Oct. 1, 2023.

For importers subject to future CBAM obligations, preparations will begin for the measurement, reporting and verification (MRV) data collection period that is expected to run between Oct. 1, 2023, and Dec. 31, 2025. The EU CBAM is designed to apply to direct emissions of greenhouse gases emitted during the production process of the imported products but also to indirect emissions from selected goods where the methodology for determining these emissions remains unclear. Participants therefore await final publication of the methodology for calculating emission rates, which will be set out in the annex to the regulation; a draft copy of the regulation was released Dec, 14, 2022, following the negotiations and is available here. Clarity on how emissions values will be determined for EU "default values" will be significant in determining final exposure of charges to importers under the mechanism. The EU proposed that these values (for use on CBAM-covered products other than electricity) will be determined using the average emission intensity of each exporting country and increased "proportionately." Default values for electricity will be set at the CO_2 emission factors in the third country based on best data available to the European Commission.

Importers and governments will also be keeping a close observation on how the EU plans to recognize any existing carbon prices paid toward the production of CBAM-covered goods; this will also be set out in the final CBAM regulations. Our current expectation is that compliance carbon markets and carbon taxation policies may be recognized while markets that have been developed from the global voluntary carbon market — such as credit exchanges emerging in Southeast Asia and plans for a carbon market in India based on existing Perform Achieve and Trade credits and renewable energy credits — are less likely to be considered acceptable as contributing carbon costs.

Overall, we expect that less-developed countries will pursue exemptions to the CBAM or even dispute the measure.

We expect government responses to the CBAM will differ by geography and by cost exposure to the mechanism. Overall, we expect that less-developed countries will pursue exemptions to the CBAM or even dispute the measure at the World Trade Organization level. While legislation of the EU CBAM has made clear plans to use collected revenue toward the decarbonization of manufacturing industries in less-developed countries, some countries have already vocalized concern over how they will be impacted from the EU CBAM and the signal it sends for the potential of future "carbon clubs,"

where jurisdictions provide favorable trading opportunities based on the harmonization of climate action and, in some cases, carbon market prices. The UK, US and Canada are all separately considering similar carbon leakage mechanisms, with many either in public consultation or due to be, such as the UK's consultation expected in 2023, or under political discussion, such as the Clean Competition Act in the US. Maintaining key political relationships will be of importance to EU policymakers; the US and EU have already held dialogue over the potential for exemptions based on shared climate objectives; we expect pressure for this to increase as CBAM compliance obligations become better understood following the reporting phase.

Lastly, EU industry is not immune to the impacts of the shift to the CBAM, and preparations by EU businesses are expected in the coming years to prepare for future EU ETS carbon price exposure. Free allocations to sectors covered by the CBAM regulation will be phased out in line with the phase-in of CBAM obligations importers. We reflect the rollout of CBAM obligations in our EU ETS market balances by reducing EU ETS free allocations to CBAM-participating sectors from 2026–2034. In our current modeling, we do not make any adjustments in our balances for downstream products, hydrogen, polymers and indirect emissions, pending further details of how the CBAM MRV methodology will apply in respect of these products.

Based on our calculations of reduced free allocations to these sectors (that we calculate account for more than 75% of total free allocations issued under the EU ETS in 2022), total EU ETS free allocations will be reduced more than 73% by 2030 and by 660 million metric tons of CO_2 between 2022–2030. This we expect will add bullish pressure on EUA prices toward 2030 as EU ETS free allocations are nearly halved to participating sectors, with the trajectory of free allocation phase-out increasing between 2028–2030 while the EU ETS cap declines by 17% over the same period and more than 40% between 2021–2030. Despite potential pressure arising from some EU industries, particularly regarding the role of an export rebate for EU businesses to claim when exporting products to territories operating without a carbon price, we continue to assume that a CBAM will become operational in line with the agreed legislative text in Fit for 55 negotiations in December 2022. ■

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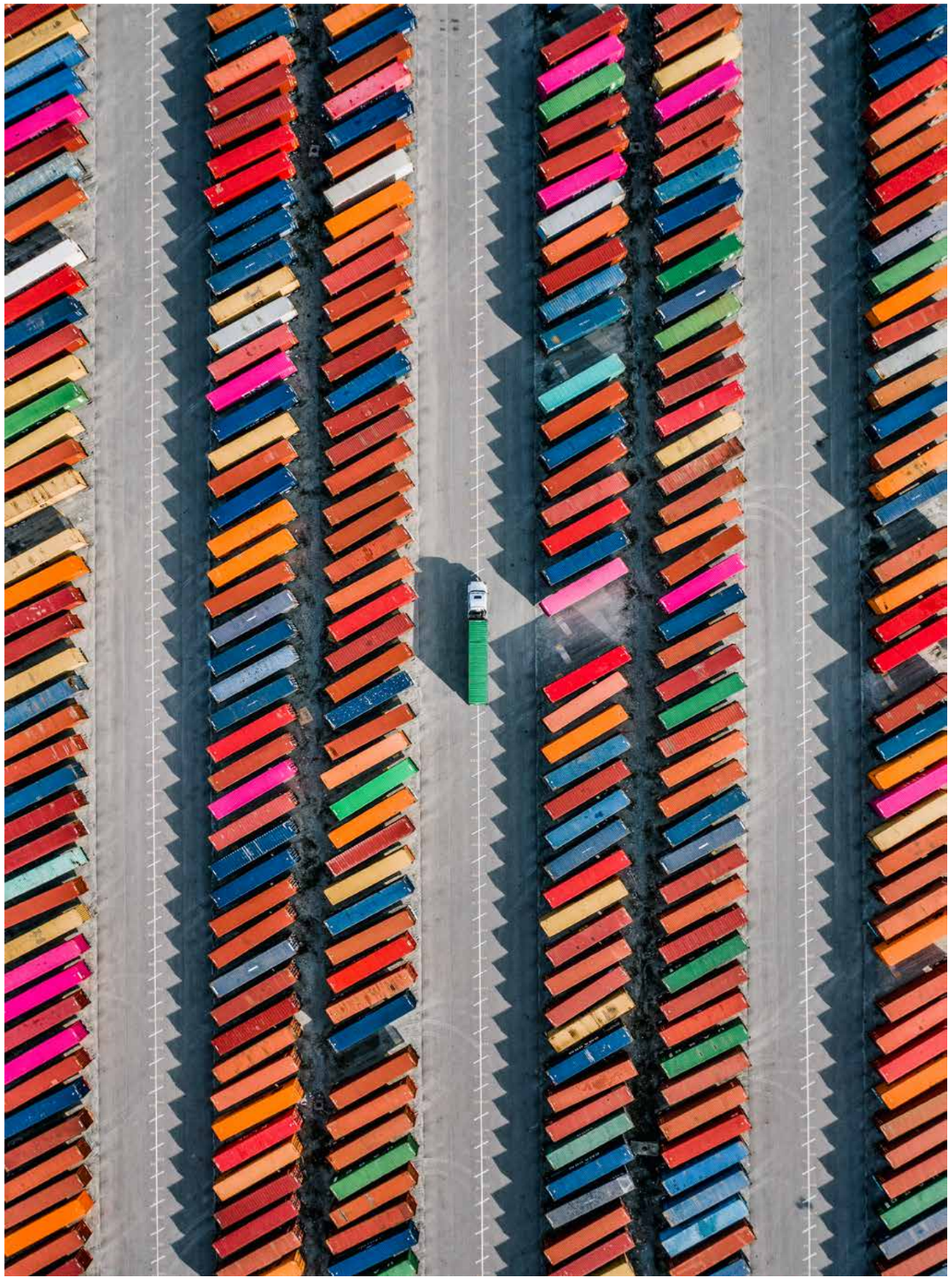

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