CHAPTER

3

Environmental Factors

LEARNING OUTCOMES

Mastery	*The candidate should be able to:*	
☐	**3.1.1**	explain key concepts relating to climate change, including climate change mitigation, climate change adaptation, and resilience measures
☐	**3.1.2**	explain key concepts related to other environmental issues, including pressures on natural resources, including depletion of natural resources; water; biodiversity loss; land use and marine resources; pollution; waste; and a circular economy
☐	**3.1.3**	explain the systemic relationships between business activities and environmental issues, including systemic impact of climate risks on the financial system; climate-related physical and transition risks; the relationship between natural resources and business; supply, operational, and resource management issues; and supply chain transparency and traceability
☐	**3.1.4**	assess how megatrends influence environmental factors; environmental and climate policies; international climate and environmental agreements and conventions; international, regional, and country-level policy and initiatives; carbon pricing
☐	**3.1.5**	assess material impacts of environmental issues on potential investment opportunities, corporate and project finance, public finance initiatives, and asset management
☐	**3.1.6**	identify approaches to environmental analysis, including company-, project-, sector-, country-, and market-level analysis; environmental risks, including carbon footprinting and other carbon metrics; the natural capital approach; and climate scenario analysis
☐	**3.1.7**	apply material environmental factors to financial modeling, ratio analysis, and risk assessment
☐	**3.1.8**	explain how companies and the investment industry can benefit from opportunities relating to climate change and environmental issues: the circular economy, clean and technological innovation, green and ESG-related products, and the blue economy

1 INTRODUCTION

☐ **3.1.1** explain key concepts relating to climate change, including climate change mitigation, climate change adaptation, and resilience measures

The range of environmental factors that have a material financial impact on investments—the *E* in "ESG"—is broad and far reaching. Environmental risks have continued to gain prominence, generating heightened concern worldwide. The increased understanding of the mechanisms through which human actions impact the planet has led to growing public acceptance of the need to reduce pollution and global emissions of greenhouse gases, to preserve and improve biodiversity, and to use natural resources more efficiently. In addition to measures aimed at the *mitigation* of environmental impact, there is a growing need of *adaptation* to a changing environment, as advances in climate science have also cast light on processes that are already or may soon become irreversible: "The cumulative scientific evidence is unequivocal: Climate change is a threat to human well-being and planetary health. Any further delay in concerted anticipatory global action on adaptation and mitigation will miss a brief and rapidly closing window of opportunity to secure a liveable and sustainable future for all."[1]

Environmental decision making requires navigating both *factual* considerations (about what is likely to happen) and *normative* considerations (about what conditions of the world are desirable or acceptable). For investors, gaining an appreciation of the evolving policies, technologies, and consumer preferences regarding sustainability can support the pursuit of profitable investments and help prevent losses in investment value. Whether it is governments planning industrial policy, regulators deciding emissions accounting rules and securities regulation, executives setting out corporate strategy, or consumers weighing purchase options, we will illustrate in what follows how environmental factors are already affecting a wide and expanding share of behaviors, sectors, and institutions.

Other investors may see the support of projects and activities with a positive environmental impact as a standalone end, regardless of financial impact. More broadly, the nature of investment mandates, time horizons, ultimate beneficiaries, or personal values—all can play a role in defining the preferences of investors in terms of risk, return, and impact. Growing awareness of environmental and climate impacts is reflected in increasing levels and scope of corporate disclosure (e.g., the adoption of the recommendations of the Task Force on Climate-Related Financial Disclosures, or TCFD) and the introduction of policies (e.g., the European Green Deal) to accelerate sustainable finance.

This chapter identifies and describes some of the key environmental factors and major external drivers to help analysts, portfolio managers, and asset owners define investor beliefs and assess material environmental risks and opportunities in their portfolios.

The term *climate change* has come to mean the changes in the earth's systems that determine the climate, including the increase in heat-trapping gases in the atmosphere and the change in the reflectivity of some of the earth's surfaces. Climate change mitigation is the set of actions that reduce the added warming of the earth that is caused by human actions. Climate change adaptation is the set of actions taken to adapt

1 Intergovernmental Panel on Climate Change (IPCC), "Climate Change 2022: Impacts, Adaptation and Vulnerability: Summary for Policymakers" (2022).

human practices to function better in a warming world with rising seas and more frequent and intense droughts, precipitation, and storms. Climate resilience measures are adaptation actions that are able to function even though the climate is changing.

Economic activities from supplying fuels and raw materials to producing food are extractive in nature, usually leaving exploited planetary systems less capable of providing the next round of goods and services to meet society's and individuals' demands. For example, current metal ores often have less than one-tenth the concentration of metals as when these ores were first mined. This means that there is at least 10 times as much tailings, or crushed rock produced, and greater disturbance to the land. This increases the price of the metal being mined and increases pressure to find and exploit new sources. Increasing harvesting of trees for forest products is putting pressure on natural forest resources as harvest cycles are shortened to meet demand. As these resources are depleted, there is always a search for substitutes, but in many cases, as with water, there is no substitute. This is a growing problem, with increased water demand and decreased supply because of climate change–induced drought in the southwest and western parts of the United States, for example. Urban development is decreasing the amount of agricultural and forest land. Moreover, energy projects, including solar and wind farms, are resorting to taking over agricultural land and cutting down forests. This loss of important ecosystems has led to a dramatic decline in the number of species and the extinction of many species. A 2019 IPBES report predicted that 1 million species would go extinct by 2100.[2]

Our current economic system produces large amounts of waste, such as the vast amount of plastic waste that is making its way into oceans. All industrial processes release pollution, meaning unwanted harmful—sometimes toxic—chemicals, heat, or radiation. In the natural world, there is neither waste nor pollution. All materials not used by any organism become either building materials, food, or energy for a different organism. That is the idea behind the circular economy: It is an economy whereby all materials are used and reused multiple times—for example, turning waste paper into other forms of paper or into cellulose building insulation rather than burning it or putting it into a landfill.

KEY ENVIRONMENTAL ISSUES 2

☐ **3.1.2** explain key concepts related to other environmental issues, including pressures on natural resources, including depletion of natural resources; water; biodiversity loss; land use and marine resources; pollution; waste; and a circular economy

Economics and the environment are inextricably linked. Consider the similarities between one widely used definition of economics—the study of "the relationship between ends and scarce means which have alternative uses"[3]—and a widely used definition of environmental sustainability: seeking "to meet the needs and aspirations

2 IPBES, "Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services," edited by E. S. Brondizio, J. Settele, S. Díaz, and H. T. Ngo (2019). https://ipbes.net/global-assessment.

3 L. Robbins, *An Essay on the Nature and Significance of Economic Science* (London: Macmillan, 1932): p. 15.

of the present without compromising the ability to meet those of the future."[4] The use and depletion of natural resources and the trade-offs between present costs and future benefits are topics that have been central to economics since its inception as a discipline.

Less appreciated, historically, has been the dependency of the successful conduct of economic activity on a stable, habitable planetary system. In recent decades, however, the scientific community has issued increasingly stark warnings that the consequences of economic activities—notably the burning of fossil fuels for energy, the conversion and degradation of ecosystems from resource extraction and land development, and other forms of pollution and environmental degradation—are jeopardizing the stability of what for over 10,000 years has been a relatively stable climate system, supportive of human society.[5] This instability could lead to dangerous, potentially catastrophic consequences for all life on earth.

The differing time horizons for the consequences of the range of human actions present a major challenge for policymakers and investors in this area. First, the *impacts* of environmental change unfold over different scales in time and space, from short-term, acute manifestations to longer-term, chronic patterns (e.g., the failure of a farmer's annual crop due to a flash flood compared to long-term reduced food productivity in an entire region due to the cumulative effects of erosion of fertile topsoil, drought, and a changing climate). Second, the *causes* of change also exhibit different dynamics. In some cases, the removal of a stressor removes the associated harm (e.g., if logging stops, a forest will likely regrow), but in other cases, the harm persists (e.g., if a factory stops emitting greenhouse gases, its past emissions continue to warm the atmosphere). Note that regrowing forests is a start, but it's mitigation, not a solution, until there is a forest capable of doing the same as the old growth forest; this can take 5–10 years or more. This is important to note in the context of carbon offsets.

The notion of "planetary boundaries" has been introduced as a way to highlight certain classes of risks and stressors. They describe boundaries to processes (such as global temperature and nitrogen limits, continued protection from damaging ultraviolet radiation provided by the stratospheric ozone layer, and biodiversity loss) that regulate the stability and resilience of the earth operating system, with concerns raised that certain economic activities are on track to breach the boundary or may have already done so. For example, it is estimated that human activities "now convert more atmospheric nitrogen into reactive forms than all of the earth's terrestrial processes combined." [6]

Beyond these boundaries lie domains of increased risk or uncertainty—including, at the extreme, planetary configurations never seen before in the history of our species. Yet, despite the growing sophistication and power of climate modeling, an element of irreducible uncertainty remains, stemming from the undetermined consequences of actions and policy measures not yet taken. One the one hand, investment techniques and practices developed to help investors navigate uncertainty (such as the assignment of probability to the costs and benefits of future scenarios, appropriately discounted) can be extended to certain areas of environmental decision making. On the other hand, the possibility of systematic, undiversifiable, and potentially catastrophic risks (as in some of the worst-case climate scenarios) highlights the importance of precautionary judgments that must be made in the absence of full evidence and perfect information.

4 United Nations, "Report of the World Commission on Environment and Development: Our Common Future" (1987). https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf.

5 Most notably, the reports from the IPCC, an intergovernmental body of the United Nations.

6 Stockholm Resilience Centre, "Planetary Boundaries" (2017). www.stockholmresilience.org/research/planetary-boundaries.html.

"Better safe than sorry" and "no such thing as a free lunch" have both been used to illustrate aspects of rational decision making; the tension between the absolute and relative approaches to risk taking that they describe is also present for environmentally aware investing. What measures are worth enacting and financing (and at what cost), and what outcomes are worth avoiding (whatever the cost)? Such questions form the conceptual backdrop to much of this chapter.

Conversely, it has been suggested that bringing investment and economic activities back in line with planetary boundaries can not only help to address environmental risks but—through a more judicious and equitable use of natural resources—also protect and enhance important socioeconomic factors, such as employment and access to health.[7] Reconciling traditional notions of financial value with a more nuanced understanding of broader positive and negative impacts ("externalities") that are not easily quantifiable in monetary terms represents an area of ongoing innovation—not just in finance but also in policy and law. To choose a few examples that will be discussed in this chapter, the trade in such securities as carbon allowances uses market mechanisms as an incentive for companies to reduce their *future* pollution; the development of "natural capital" approaches aims to recognize the *present* value of ecosystems as a guide to policy making; and a growing wave of lawsuits seeks compensation for *past* contributions to environmental damages.

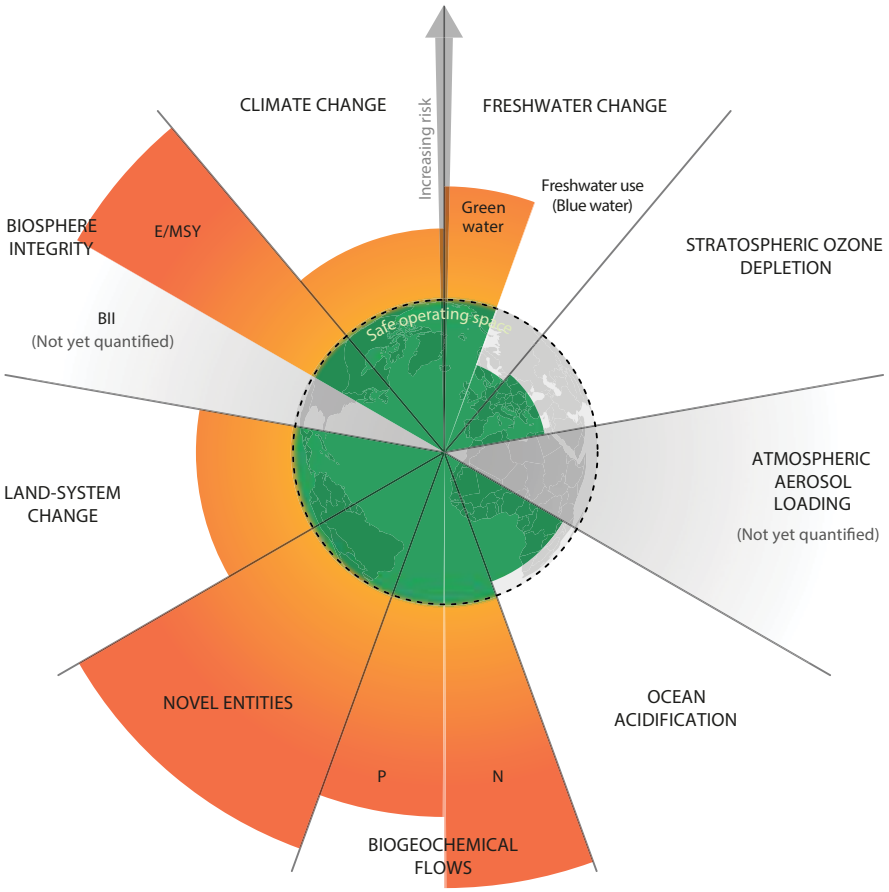
According to an update by the Stockholm Resilience Centre from 2022, six of nine planetary boundaries (see Exhibit 1) have already been crossed as a result of human activity:

- climate change,
- loss of biosphere integrity,
- land-system change,
- freshwater (green water boundary),
- novel entities (including plastic pollution), and
- altered biogeochemical cycles (phosphorus and nitrogen loading).[8]

7 K. Raworth, "Meet the Doughnut: The New Economic Model That Could Help End Inequality," World Economic Forum (28 April 2017). www.weforum.org/agenda/2017/04/the-new-economic-model-that-could-end-inequality-doughnut/.

8 Stockholm Resilience Centre, "Planetary Boundaries."

Exhibit 1: An Illustration of Planetary Boundaries



Source: Stockholm Resilience Centre, "The Planetary Boundaries Framework" (2022). Licensed under CC BY 4.0 Credit: "Azote for Stockholm Resilience Centre, based on analysis in Persson et al 2022 and Steffen et al 2015". https://www.stockholmresilience.org/research/planetary-boundaries.html

While it may be seen as a good in itself, the pursuit of environmental sustainability can also be justified because it benefits financial interests. Conversely, as societal preferences, regulation, and technology change, ongoing investments in environmentally damaging activities may carry unrewarded risks, which can lead to losses in revenues and falling asset values.

There are numerous studies and frameworks that identify a range of environmental factors that are relevant to how investors assess risks and opportunities in their decisions. This field of study is vast and constantly evolving.

In this section, the environmental issues covered will include

A. climate change,

B. pressures on natural resources and systems (including water, biodiversity, land use and forestry, and marine resources), and

C. pollution, waste, and a circular economy.

Although this section will cover each issue separately, it is important to note that these issues are linked and have systemic consequences for business activities and vice versa, as we will further explain.

Climate Change

Climate change is defined as a change of climate, directly or indirectly attributed to human activity, that alters the composition of the global atmosphere and that is, in addition to natural climate variability, observed over comparable time periods.[9] Climate change is one of the most complex issues facing us today and involves many different dimensions, including

- science,
- economics,
- society,
- politics, and
- moral and ethical questions.

It is an issue with local manifestations (e.g., extreme weather events, such as more frequent and/or more intense tropical cyclones) and global impacts (e.g., rising global average temperatures and sea levels), which are estimated to increase in severity over time. Because the planet does not warm uniformly—the Arctic is warming more than three times faster than the global average[10]—atmospheric and ocean circulation patterns are being altered in complex and not fully understood ways.

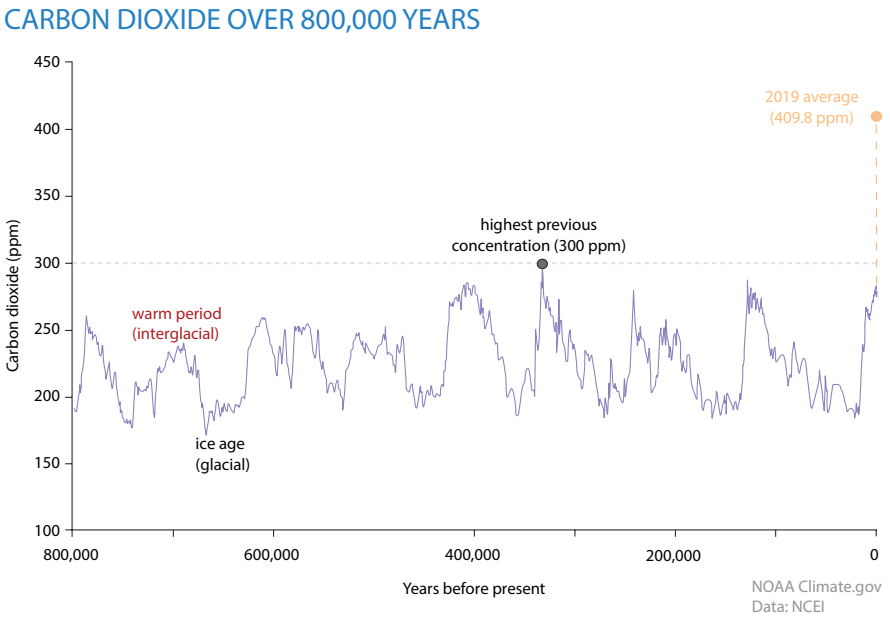
The main man-made driver of the warming of the planet is rising emissions of heat-trapping **greenhouse gases (GHGs)**. These gases are dispersed throughout the atmosphere and allow visible sunlight to reach the earth's surface, where it is absorbed, thereby warming the land, oceans, and atmosphere and evaporating water. And the warm earth radiates heat back toward space, but these gases absorb heat and reradiate some of it back to the earth's surface. The gases act in a similar manner to the glass windows of an automobile that allow visible light energy in but block the radiant heat from leaving. Few people have experienced this effect in a glass "greenhouse," which gives the extra heating its name, and today it is more descriptively referred to as the "hot car effect." Carbon dioxide (CO_2) is the most significant contributor to the warming effect, because of its higher concentration in the atmosphere, which is at levels not seen since long before Homo sapiens first appeared (see Exhibit 2).[11]

9 Definition of climate change by the United Nations Framework Convention on Climate Change (UNFCCC).

10 Arctic Monitoring and Assessment Programme, "Arctic Climate Change Update 2021: Key Trends and Impacts: Summary for Policy-Makers" (2021). www.amap.no/documents/download/6759/inline.

11 NOAA, "Climate Change: Atmospheric Carbon Dioxide" (2020). www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide.

Exhibit 2: CO_2 Levels in the Atmosphere for Past 800,000 Years



Source: NOAA, "Climate Change: Atmospheric Carbon Dioxide" (2020).

Much of this increase has occurred with the accelerated burning of fossil fuels since the industrial revolution, with more than half the CO_2 emissions from the late 17th century onward occurring in the last 30 years.[12]

Other important GHGs include methane, nitrous oxide, and other fluorinated gases. Although the average lifetime in the atmosphere of such gases is shorter than that of carbon dioxide, they have a much higher "global warming potential"—30 times stronger in the case of methane and over 23,000 times stronger for sulphur hexafluoride—that is the same weight of carbon dioxide when compared over a century.[13]

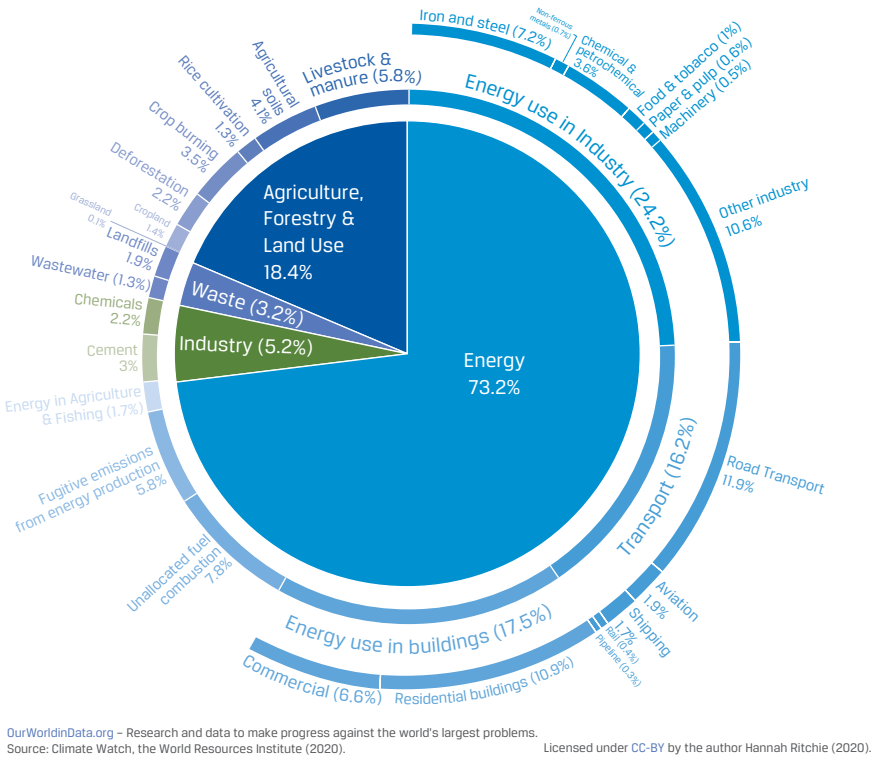
Emissions of GHGs primarily come from energy, industry, transport, agriculture and changes in land use (such as deforestation and the degradation of forests, grasslands, wetlands, and agricultural soils), with CO_2 resulting from the burning of fossil fuels (e.g., in power plants, gas boilers and vehicles) representing the highest share—around two-thirds—of all GHGs (see Exhibit 3).[14]

12 Institute for European Environmental Policy, "More Than Half of All CO_2 Emissions since 1751 Emitted in the Last 30 Years" (29 April 2020). https://ieep.eu/news/more-than-half-of-all-co2-emissions-since-1751-emitted-in-the-last-30-years.

13 United States Environmental Protection Agency, "Climate Change Indicators: Greenhouse Gases" (2021). www.epa.gov/climate-indicators/greenhouse-gases.

14 UN Environment Programme (UNEP), "Cut Global Emissions by 7.6 Percent Every Year for Next Decade to Meet 1.5°C Paris Target—UN Report," press release (26 November 2019). www.unep.org/news-and-stories/press-release/cut-global-emissions-76-percent-every-year-next-decade-meet-15degc.

Exhibit 3: Global GHG Emissions by Economic Sector



Note: This is shown for the year 2016 — global greenhouse gas emissions were 49.4 billion tonnes CO_2eq.

Sources: Data from World Resources Institute; H. Ritchie and M. Roser, "Emissions by Sector" (2020). https://ourworldindata.org/emissions-by-sector#total-greenhouse-gas-emissions-by-sector.

Limiting global warming has been compared with avoiding overfilling a bathtub by simultaneously turning off the faucets and opening the drain—in other words, reducing both the **flow** of new emissions and removing the **stock** of existing GHGs in the atmosphere. When these rates of addition and removal are equal, the level stabilizes. In the case of the atmosphere, our activities are adding carbon dioxide and other GHGs, and it is the natural world that is removing carbon dioxide. However, it is the amount of GHGs remaining in the atmosphere that determines the extent of warming. To achieve the desired global average temperature requires adjusting atmospheric concentrations to specified levels.[15] That point is often overlooked when government and business leaders agree to become "zero net carbon by 2050." Preindustrial levels of atmospheric CO_2 were 278 ppm (parts per million) in the atmosphere, and along with other naturally occurring greenhouse gases, including water vapor and methane, these levels maintained a stable climate conducive to agriculture and the development of urban civilizations as we know them. In 2022, CO_2 levels had climbed to 417 ppm—an increase of 50%![16]

15 UN Framework Convention on Climate Change, "Article 2: Objective" (1992). https://unfccc.int/resource/ccsites/zimbab/conven/text/art02.htm.

16 R. Betts, "Met Office: Atmospheric CO_2 Now Hitting 50% Higher than Pre-Industrial Levels" (16 March 2021). www.carbonbrief.org/met-office-atmospheric-co2-now-hitting-50-higher-than-pre-industrial-levels/.

To achieve any specified temperature rise limitation, there is an additional complication. As the world warms from direct GHG additions, amplifying feedbacks cause additional warming from nature. A warming ocean adds more water vapor, thawing permafrost releases more methane—melting sea ice, ice caps in Greenland and Antarctica, and glaciers everywhere—and less snow cover reduces the amount of sunlight that is reflected back into space. Hence, the warming earth causes natural processes to create additional warming.

One concerning possibility is that these feedbacks might place the world on course to breach certain "tipping points." Like a sand pile toppling when just a few more grains are added, this notion is used to describe abrupt—and potentially irreversible—changes to the earth system in response to a relatively small change in warming.

Such potential tipping points include the following:

- The thawing of the permafrost—frozen ground in the Northern Hemisphere—which allows microbes to decompose previously frozen plant and animal material and release vast amounts of carbon dioxide and methane, thereby further accelerating climate change uncontrollably. This is similar to what happens when electric power is interrupted: Frozen foods thaw and are quickly decomposed by bacteria.
- The disintegration of the West Antarctic ice sheet, which holds enough ice to raise global sea levels by over three meters.
- The "dieback" of the Amazon rainforest—changes in temperature and deforestation that would render the forest unable to sustain itself, making one of the world's largest natural stores of carbon emit more carbon than it absorbs.
- Melting the Greenland ice cap, thereby reducing the salinity and density of North Atlantic waters, which could shut down the system of currents in the Atlantic Ocean that brings warm water and the air over it to Northern Europe. The ironic cooling of this region while the world is warming may lead to "widespread cessation of arable farming" in the United Kingdom and parts of Europe.[17]

Exhibit 4 illustrates some of the socioeconomic impacts resulting from climate change.

17 R. McSweeney, "Explainer: Nine 'Tipping Points' That Could Be Triggered by Climate Change," Carbon Brief (10 February 2020). www.carbonbrief.org/explainer-nine-tipping-points-that-could-be-triggered-by-climate-change.

Exhibit 4: Select Socioeconomic Impacts of Climate Change

Impacted Economic System	Area of Direct Risk	Socioeconomic Impact	How Climate Change Exacerbated Hazard
Liveability and Workability	2003 European heat wave	US$15 billion (£12 bn) in losses	2 × more likely
	2010 Russian heat wave	≈55,000 deaths attributable	3 × more likely
	2013–14 Australian heat wave	≈US$6 bn (£4.8 bn) in productivity loss	Up to 3 × more likely
	2017 East African drought	≈800,000 people displaced in Somalia	2 × more likely
	2019 European heat wave	≈1,500 deaths in France	≈10 × more likely
Food Systems	2015 Southern African drought	Agriculture outputs declined by 15%	3 × more likely
	Ocean warming	Up to 35% decline in North Atlantic fish yields	Ocean surface temperatures have risen by 0.7°C (1.3°F) globally
Physical Assets	2012 Hurricane Sandy	US$62 bn (£49.5 bn) in damage	3 × more likely
	2016 Fort McMurray Fire, Canada	US$10 bn (£8 bn) in damage, 1.5 million acres of forest burned	1.5–6 × more likely
	2017 Hurricane Harvey	US$125 bn (£99.8 bn) in damage	8%–20% more intense
Infrastructure Services	2017 flooding in China	US$3.55 bn (£2.8 bn) of direct economic loss, including severe infrastructure damage	2 × more likely
Natural Capital	30-year record low Arctic sea ice in 2012	Reduced albedo effect, amplifying warming	70%–95% attributable to human-induced climate change
	Decline of Himalayan glaciers	Potential reduction in water supply for more than 240 million people	70% of global glacier mass lost in past 20 years is due to human-induced climate change

Sources: Woods Hole Research Center (now Woodwell Climate Research Center); analysis by Jonathan Woetzel, Dickon Pinner, Hamid Samandari, Hauke Engel, Mekala Krishnan, Brodie Boland, and Carter Powis, "Climate Risk and Response: Physical Hazards and Socioeconomic Impacts," McKinsey Global Institute (16 January 2020). www.mckinsey.com/business-functions/sustainability/our-insights/climate-risk-and-response-physical-hazards-and-socioeconomic-impacts?sid=3046547320.

In 2021, the Intergovernmental Panel on Climate Change (IPCC) estimated that human activities have caused approximately 1.1°C (1.8°F) of global warming above pre-industrial levels, and global warming is likely to reach 1.5°C (2.7°F) by 2040

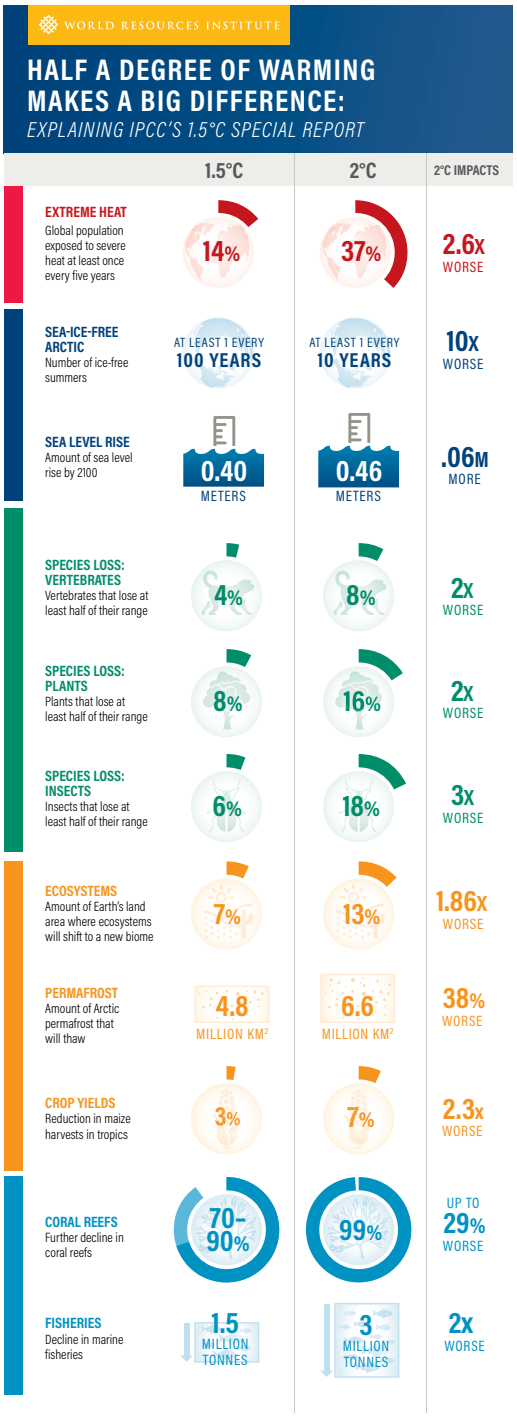
even under the very low emissions scenario.[18] Note that these numbers are global averages, so warming in different regions may be much higher: Warming over land has been twice that observed over oceans, for example.[19] The IPCC is mandated by 196 governments to synthesize climate science and publish reports. A 2018 report determined what needed to be done to meet the somewhat arbitrary goals set in Paris in 2015 and agreed to by all governments of limiting global warming–caused average temperature increases by 2.0°C by 2100 and to make every effort to limit the rise to 1.5°C. The IPCC's Sixth Assessment Report on the physical science of climate change, published in August 2021, was dubbed "code red for humanity" because of the irrevocable evidence that climate change is already having significant impacts and the 1.5°C goal will not be met without immediate and significant action. Specifically, scientists ran multiple scenarios and found that

> *under the five illustrative scenarios, in the near term (2021–2040), the 1.5°C global warming level is very likely to be exceeded under the very high GHG emissions scenario (SSP5-8.5), likely to be exceeded under the intermediate and high GHG emissions scenarios (SSP2-4.5 and SSP3-7.0), more likely than not to be exceeded under the low GHG emissions scenario (SSP1-2.6) and more likely than not to be reached under the very low GHG emissions scenario (SSP1-1.9).*[20]

These differences of a few fractions of a degree may seem small but are highly consequential. The IPCC further estimated that limiting warming to 1.5°C (2.7°F) instead of 2°C (3.6°F) by the end of this century could reduce "climate-related risks to health, livelihoods, food security, water supply, human security and economic growth": around 400 million fewer people frequently exposed to extreme heatwaves and around 10 million fewer people exposed to rising sea levels, in addition to reduced impacts on vulnerable ecosystems, such as the Arctic and warm water coral reefs (which "mostly disappear" at 2°C [3.6°F]).[21] See Exhibit 5 for various potential climate change impacts based on different warming scenarios.

18 IPCC, "Climate Change 2021: The Physical Science Basis: Summary for Policymakers" (2021): p. 15. www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM_final.pdf.
19 M. Byrne, "Guest Post: Why Does Land Warm Up Faster Than the Oceans?" Carbon Brief (1 September 2020). www.carbonbrief.org/guest-post-why-does-land-warm-up-faster-than-the-oceans.
20 IPCC, "Climate Change 2021: The Physical Science Basis" (6 August 2021). www.ipcc.ch/report/sixth-assessment-report-working-group-i/.
21 IPCC, "Special Report: Global Warming of 1.5°C" (2018). www.ipcc.ch/report/sr15.

Exhibit 5: Selected Impacts of Climate Change under Different Warming Scenarios



Source: Kelly Levin, Sophie Boehm, and Rebecca Carter, "6 Big Findings from the IPCC 2022 Report on Climate Impacts, Adaptation and Vulnerability," World Resources Institute (27 February 2022). www.wri.org/insights/ipcc-report-2022-climate-impacts-adaptation-vulnerability.

Estimates of the economic costs of climate change vary but suggest significant potential losses. A 2015 report suggested damages by 2100 equivalent to US$4 trillion (£2.9 trillion) in net present value,[22] and the IPCC has suggested costs of US$54 trillion (£38.8 trillion) and US$69 trillion (£49.6 trillion) for 1.5°C (2.7°F) and 2°C (3.6°F) scenarios, respectively.[23]

There are, however, important caveats when considering such results, which are highly dependent on assumptions and scenarios. First, under the standard economic practice of discounting, cash flows far into the future have very little present value. This perspective, however, may be under-representing the risks of potentially catastrophic outcomes that could severely affect economies and countless human lives. This argument has been put forth by climate economist Martin Weitzman, with his so-called **dismal theorem**, which suggests that standard cost–benefit analysis is inadequate to deal with the potential downside losses from climate change. However small their probability, as long as we cannot completely rule out scenarios of climate-induced civilizational collapse, their expected value must be properly understood as being equivalent to negative infinity, he has argued.[24]

On a different but related note, economist Nicholas Stern has argued that moral considerations warrant the use of a low discount rate when assessing future climate damages, in order to place adequate value on the lives and welfare of future generations.[25] The thrust of Stern's and Weitzman's arguments is that the issue of how much society should invest today in order to safeguard a livable climate in the future requires a different—mathematical and ethical—treatment from standard economic problems, such as, "Would you prefer to receive £10 today or £100 in one year?"

Second, many economic models used to calculate future climate damages usually share the limitation of assuming negative impacts that ramp up only gradually, and usually do not model sharp discontinuities and "tipping points." In other words, they model a society that "keeps warm and carries on," even though some of these scenarios approach the limits of adaptability and habitability.

For example, one widely used model estimates that 6°C (16.2°F) of warming would result in a sacrifice of only about 9% of global income by the end of the century.[26] However, it has been suggested that at global average warming of around 7°C (12.6°F), regions of the world would see persistent combinations of temperature and humidity where the average healthy adult overheats and dies after a few hours (even if they sit in the shade, are resting, and have access to water) because the human body can no longer cool itself through perspiration and breaks down.[27] (This "wet-bulb" temperature threshold has already been momentarily crossed on several occasions in South Asian

22 B. Gardner, "The Cost of Inaction," Economist Intelligence Unit (24 July 2015). https://eiuperspectives.economist.com/sustainability/cost-inaction.

23 IPCC, "Special Report: Global Warming of 1.5°C."

24 M. L. Weitzman, "Fat-Tailed Uncertainty in the Economics of Catastrophic Climate Change" *Review of Environmental Economics and Policy* 5 (Summer 2011): 275–92. https://scholar.harvard.edu/files/weitzman/files/fattaileduncertaintyeconomics.pdf.
For a critical reply, see W. D. Nordhaus, "The Economics of Tail Events with an Application to Climate Change," *Review of Environmental Economics and Policy* 5 (Summer 2011): 240–57. www.journals.uchicago.edu/doi/10.1093/reep/rer004.

25 N. H. Stern, *The Economics of Climate Change: The Stern Review* (Cambridge, UK: Cambridge University Press, 2006).

26 B. Ward, "A Nobel Prize for the Creator of an Economic Model That Underestimates the Risks of Climate Change," Grantham Research Institute (2 January 2019). www.lse.ac.uk/granthaminstitute/news/a-nobel-prize-for-the-creator-of-an-economic-model-that-underestimates-the-risks-of-climate-change/.

27 S. C. Sherwood and M. Huber, "An Adaptability Limit to Climate Change Due to Heat Stress," *Proceedings of the National Academy of Sciences* 107 (3 May 2010). www.pnas.org/content/107/21/9552.

cities.[28]) Almost inevitably, models are calibrated based on past economic outcomes, but this presents a potential tension when dealing with what may be radically different future outcomes.

Responding to climate change is usually presented in terms of two main approaches:

1. reducing and stabilizing the levels of heat-trapping GHGs in the atmosphere (**climate change mitigation**) or
2. adapting to the climate change already taking place (**climate change adaptation**) and increasing climate change resilience.

However, this is not a binary option: Climate change adaptation will always be required because we are already experiencing the effects of climate change, and some of the most effective climate policies pursue both objectives simultaneously. We will look at climate change mitigation and adaptation in the following subsections.

Climate Change Mitigation

Climate change mitigation is a human intervention that involves reducing the sources of GHG emissions (for example, the burning of fossil fuels and wood for electricity, heat, or transport) and simultaneously enhancing the sinks that store these gases (such as forests, oceans, and soil) in an attempt to slow down the process of climate change. The goal of mitigation is to

- "avoid dangerous interference with the climate system,"[29]
- stabilize GHG levels in a time frame sufficient to allow ecosystems to adapt naturally to climate change,
- ensure that food production is not threatened, and
- enable economic development to proceed in a sustainable manner.

While discussions of climate change policy usually call for adaptation to the warming that is irreversible, the overarching framing is usually that of mitigation—that is, trying to prevent what is not inevitable. The aim of the international Paris Agreement on climate change, for example, is to hold "the increase in the global average temperature to well below 2°C (3.6°F) above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C (2.7°F) above pre-industrial levels" by the end of the century.[30]

Examples of mitigation strategies include greater adoption and policies to promote sustainability across different areas, such as the following:

- **Energy.** Deploying renewable energy sources (such as wind, solar, geothermal, hydro, and some biofuels that are shown to be low carbon and produced sustainably). Unfortunately, not all biofuels are better than petroleum alternatives when life-cycle emissions, including nitrous oxide from fertilizing crops, and other production emissions are considered.[31] Burning wood

28 "Explained: How Jacobabad in Pakistan crossed a temperature threshold too severe for human tolerance," *Indian Express* (8 July 2021). https://indianexpress.com/article/explained/explained-pakistan-jacobabad-crossed-a-temperature-threshold-too-severe-for-human-tolerance-7383104/.

29 UN Framework Convention on Climate Change, "Article 2: Objective."

30 United Nations, "Paris Agreement" (2015). https://unfccc.int/sites/default/files/english_paris_agreement.pdf.

31 Harish K. Jeswani, Andrew Chilvers, and Adisa Azapagic, "Environmental Sustainability of Biofuels: A Review," *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences* 476 (November 2020). https://doi.org/10.1098/rspa.2020.0351.

to generate electricity or commercial-scale heat releases more CO_2 at the time of combustion and forgoes accumulation of carbon had the trees been allowed to continue growing.[32]

- **Buildings.** Retrofitting buildings to become more energy efficient and using building materials and equipment that reduce buildings' **carbon footprint**.
- **Transport.** Adopting more sustainable, low-carbon transportation and infrastructure (such as electric vehicles, rail and metro, and bus rapid transit), particularly in cities, but also decarbonizing shipping, road, and air transport.
- **Land use and forestry.** Improving forest management, reducing deforestation, and growing more of our existing forests to achieve their potential for biodiversity and carbon accumulation—a management process known as *proforestation*. [33]
- **Agriculture.** Improving crop and grazing land management to increase soil carbon storage.
- **Carbon pricingand other economic measures.** Implementing carbon reduction policies that penalize heavy emitters and promote GHG emission reductions in the form of either a carbon tax or cap-and-trade mechanism and direct payment for carbon accumulation by forests and soils.
- **Industry and manufacturing.** Developing more energy efficient processes and less carbon intensive products; reducing process emissions from cement and steel making and other greenhouse gases, including methane leaks from the fossil fuel industry and agriculture; and developing equipment and processes to facilitate carbon capture, energy storage (e.g., batteries, pump systems), recycling efficiency, and so on.

Industry, materials and manufacturing present particular challenges. Although deindustrialization or a reduction in consumption could, in theory, have mitigation effects (consider the significant drop in GHG emissions and in economic output accompanying the COVID-19 pandemic), due consideration must also be given to the associated negative societal impacts (e.g., recessions and unemployment). Alternatively, achieving green industrialization at scale (including the decommissioning and retrofitting of existing facilities) may, unless addressed through improved resource efficiency and circular design, be a *reforestation material-intensive process*.

The IPCC has noted the relatively uneven state of play with regard to technological innovation in several relevant areas:

For almost all basic materials—primary metals, building materials and chemicals—many low- to zero-GHG intensity production processes are at the pilot to near-commercial and in some cases commercial stage but not yet established industrial practice. Introducing new sustainable basic materials production processes could increase production costs but, given the small fraction of consumer cost based on materials, are expected to translate into minimal cost increases for final consumers. Hydrogen direct reduction for primary steelmaking is near-commercial in some regions. Until new chemistries are mastered, deep reduction of cement process emissions will rely on already commercialised cement material substitution and the

32 John Sterman, William Moomaw, Juliette N. Rooney-Varga, and Lori Siegel, "Does Burning Wood Help or Harm the Climate?" *Bulletin of the Atomic Scientists* (10 May 2022). https://thebulletin.org/premium/2022-05/does-wood-bioenergy-help-or-harm-the-climate/.

33 William R. Moomaw, Susan A. Masino, and Edward K. Faison, "Intact Forests in the United States: Proforestation Mitigates Climate Change and Serves the Greatest Good," *Frontiers in Forests and Global Change* (11 June 2019). www.frontiersin.org/articles/10.3389/ffgc.2019.00027/full.

availability of [carbon capture and storage]. Reducing emissions from the production and use of chemicals would need to rely on a life-cycle approach, including increased plastics recycling, fuel and feedstock switching, and carbon sourced through biogenic sources, and, depending on availability, [carbon capture and utilization], direct air CO_2 capture, as well as [carbon capture and storage]. Light industry, mining and manufacturing have the potential to be decarbonised through available abatement technologies (e.g., material efficiency, circularity), electrification (e.g., electrothermal heating, heat pumps) and low- or zero-GHG emitting fuels (e.g., hydrogen, ammonia, and bio-based & other synthetic fuels).[34]

CASE STUDIES

The Race to Net Zero

Stabilizing global average temperature rise at any level depends on achieving a balance between GHG sources going into and out of the atmosphere—that is, reaching "net-zero" emissions. The earlier this point is reached, the less warming the world is likely to experience. The current "net-zero GHG emissions" strategy endorsed by many governments and CEOs is intended to meet the Paris Agreement goal of keeping temperature from rising by more than 1.5°C.

The world's foremost assembly of climate scientists—the IPCC—found that to have a two in three chance of limiting global average temperature rises to 1.5°C (2.7°F) requires reducing emissions 45% below 2005 levels by 2030, net-zero CO_2 emissions around 2050, and continued net negative emissions until beyond 2100, coupled with deep reductions in emissions of other GHGs, such as methane.[35]

Net-zero targets are increasingly being adopted by governments (e.g., those of the United Kingdom, the EU, China, Japan, Canada, and South Korea), states and territories (e.g., Nevada in the United States and Victoria and Queensland in Australia), and companies (e.g., Amazon, ArcelorMittal, BT Group, BP, Ikea, Qantas, Sony, and Walmart).

As of April 2022, 88% of global emissions of greenhouse gases, 90% of GDP, and 85% of the world's population were in jurisdictions covered by net-zero targets.[36] These 2050 targets have also been adopted by many corporations.

Modeled net-zero pathways can therefore differ significantly in their emissions profile—with the role of interim targets (2025, 2030) and the assumed reliance on carbon capture and/or offsets (e.g., in emissions-intensive companies' net-zero commitments) coming under increased scrutiny. Many offsets simply transfer credit for emission reductions and do not change the amount of CO_2 in the atmosphere.

The higher the ambition of mitigation policies, the higher the required upfront investment. The IPCC has estimated that in the energy sector alone, between US$1 trillion and US$4 trillion (£0.7 trillion to £2.9 trillion) of additional annual investment in energy supply and around US$1 trillion (£0.7 trillion) in energy demand will be

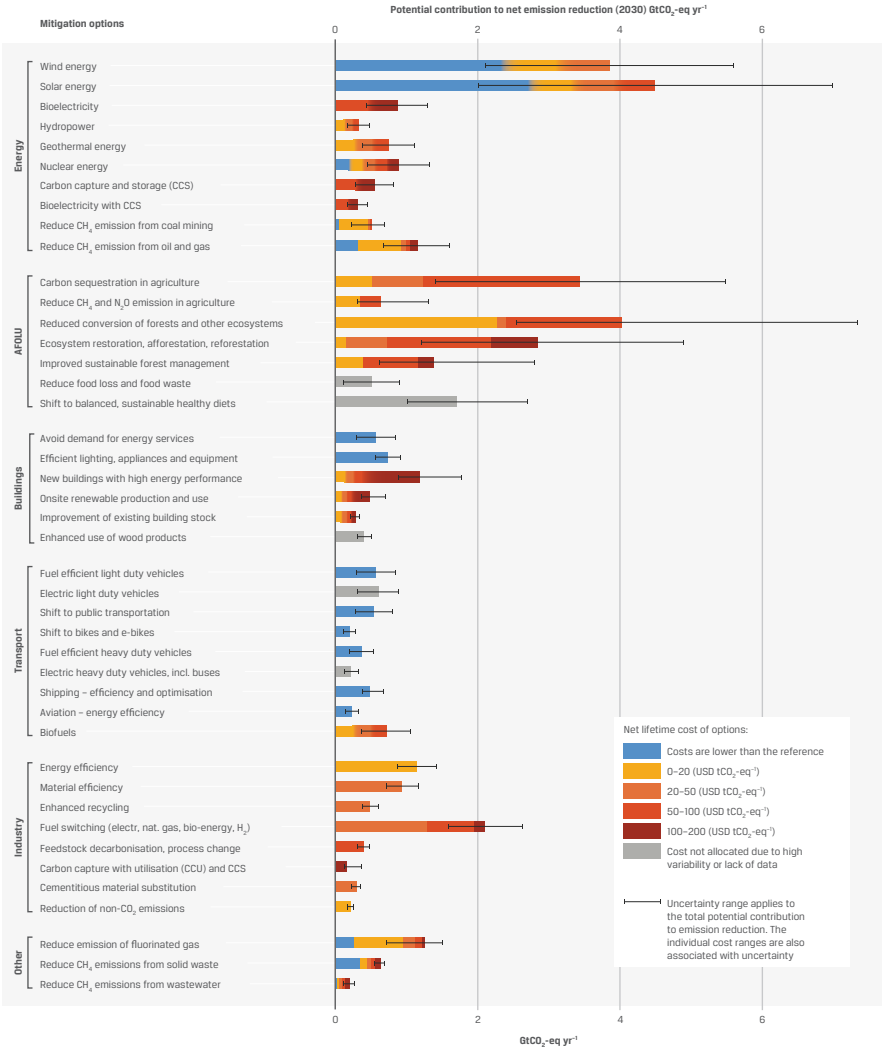
34 IPCC, "Climate Change 2022: Mitigation of Climate Change: Summary for Policymakers" (2022). https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_SummaryForPolicymakers.pdf.
35 Note that this assumes the world will not significantly rely on what are currently speculative, expensive carbon capture technologies. It is technically possible to construct other temperature pathways, depending on modelling assumptions – the scale up of carbon capture, and the potential for reductions in non-CO_2 GHG emissions globally. However, given the risks of "tipping points" discussed in the previous section, caution is needed when considering the extent to which ongoing emissions will be compensated by future technological fixes.
36 Net Zero Tracker (2022). https://zerotracker.net/.

needed up to 2050 to limit warming to 1.5°C (2.7°F).[37] However, the IPCC has further noted that "how these investment needs compare to those in a policy baseline scenario is uncertain."[38] In other words, even scenarios without climate mitigation require investments—for example, in oil and gas extraction and transportation or in coal and gas power plants—and it is unclear how those costs may evolve alongside temperatures. For example, around half of the oil and gas fields in the Russian Arctic are estimated to be in areas where melting permafrost can cause severe damage to infrastructure, such as pipelines and shipping terminals;[39] in mid-2020, such melting under a diesel storage tank caused the largest environmental accident in the Russian Arctic region.[40] Given that the world is already investing approximately US$1 trillion (£0.7 trillion) yearly in the energy sector,[41] the important question is, What kind of energy system is being financed for new and expired capital replacement, and what is the extent to which today's investments risk locking in future emissions?

Looking more broadly across sectors, the IPCC has highlighted that many mitigation options exist today, many of which have lower economic costs compared to alternatives (see Exhibit 6).

37 IPCC, "Special Report: Global Warming of 1.5°C."
38 IPCC, "Special Report: Global Warming of 1.5°C."
39 Jan Hjort, Olli Karjalainen, Juha Aalto, Sebastian Westermann, Vladimir E. Romanovsky, Frederick E. Nelson, Bernd Etzelmüller, and Miska Luoto, "Degrading Permafrost Puts Arctic Infrastructure at Risk by Mid-Century," *Nature Communications* 9 (2018). www.nature.com/articles/s41467-018-07557-4.
40 BBC, "Russian Arctic Oil Spill Pollutes Big Lake Near Norilsk" (9 June 2020). www.bbc.co.uk/news/world-europe-52977740.
41 International Energy Agency, "Investment Estimates for 2020 Continue to Point to a Record Slump in Spending" (23 October 2020). www.iea.org/articles/investment-estimates-for-2020-continue-to-point-to-a-record-slump-in-spending.

Exhibit 6: Overview of Mitigation Options and Their Estimated Range of Costs and Emission Reduction Potentials in 2030



Source: IPCC, "Climate Change 2022: Mitigation of Climate Change: Summary for Policymakers" (2022). https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_SummaryForPolicymakers.pdf .

However, despite the availability of options, the rate of deployment, set against the backdrop of the current rate of emissions and the insufficient strength of the policies so far announced by governments worldwide, may render certain mitigation goals increasingly unachievable. To illustrate the scale of the challenge, in 2020, the COVID-19 pandemic led to the largest recorded drop in yearly CO_2 emissions, approximately 7%. It is estimated that similar reductions would be needed *each year* until 2030 to meet the 1.5°C (2.7°F) goal.[42]

Despite a suite of policies introduced to foster a 'green recovery' after the pandemic (see the following box, "The 'Green Recovery'"), the UN has noted that given the global rebound in emissions, "the opportunity to use pandemic recovery spending to reduce emissions has been largely missed."[43]

42 UNEP, "Emissions Gap Report 2020" (2020). www.unep.org/emissions-gap-report-2020.
43 UNEP, "Emissions Gap Report 2021" (2021). www.unenvironment.org/emissions-gap-report-2021.

THE "GREEN RECOVERY"

The roster of policy measures announced by governments in the aftermath of the COVID-19 pandemic has created an opportunity to promote sustainability objectives, alongside economic development. A survey of economists has highlighted several policy areas perceived to have a high "multiplier" effect on economic activity and high potential to decrease GHG emissions: investments in "clean" physical infrastructure, renovations or retrofits to improve energy efficiency, natural capital investment, clean energy research and development (R&D), and investment in education and training.[44]

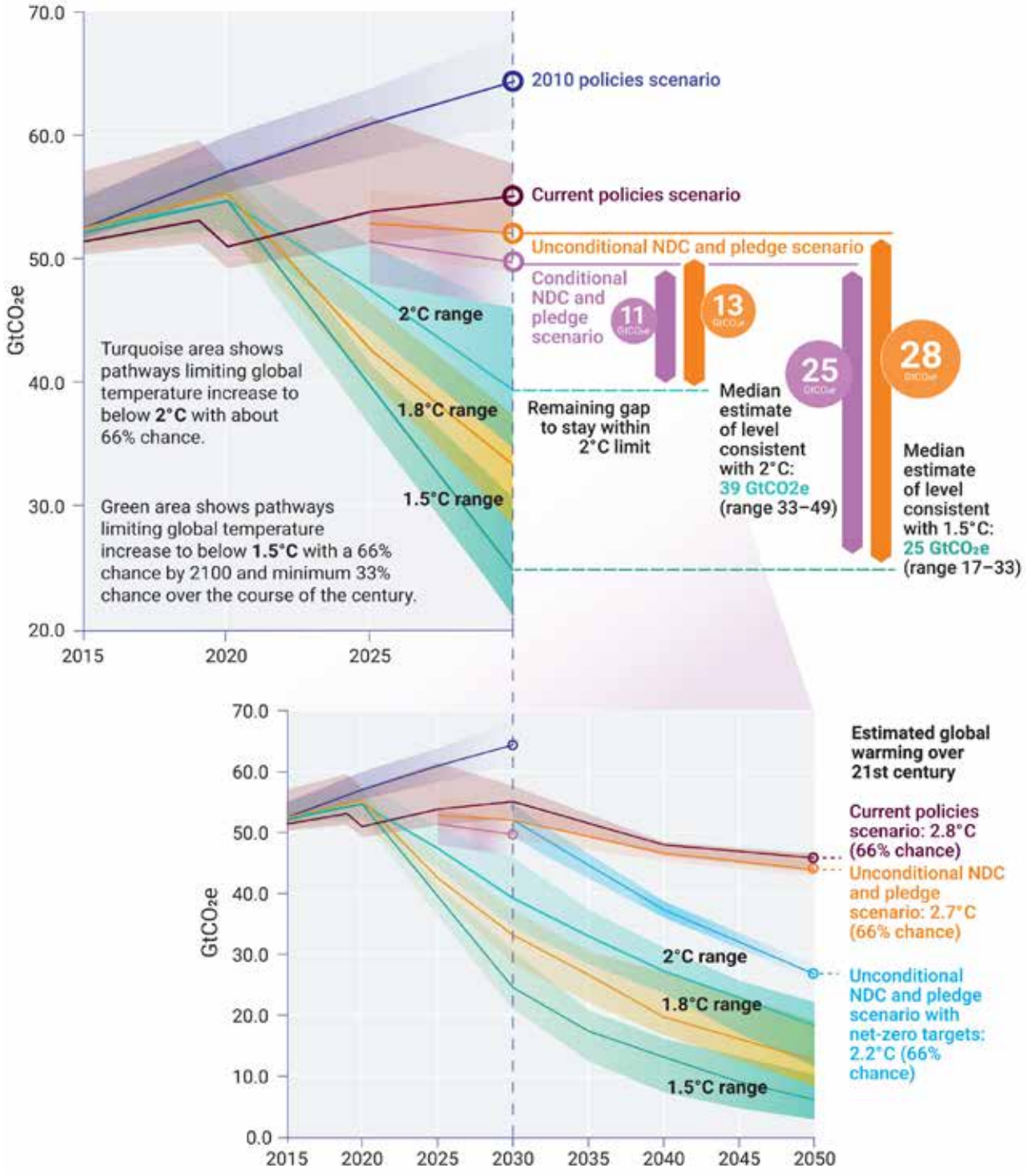
The reality on the ground has been mixed, with capital and policy support continuing to flow to both "green" and "brown" sectors. For example, a review of country-level measures in the EU found that less than a third of the total €700 billion in analyzed recovery plans was assessed as likely to have a positive or very positive climate contribution.[45]

At the global level, the International Energy Agency estimated that at the end of October 2021, US$470 billion have been earmarked by governments to support clean energy.[46]

As illustrated in Exhibit 7, a significant gap still remains between the shorter-term policy commitments of governments (known as nationally determined contributions, or NDCs) and the magnitude of emission cuts needed.

44 C. Hepburn, B. O'Callaghan, N. Stern, J. Stiglitz, and D. Zenghelis, "Will COVID-19 Fiscal Recovery Packages Accelerate or Retard Progress on Climate Change?" Smith School Working Paper 20-02 (2020).
45 Green Recovery Tracker, "Country Reports" (2022). www.greenrecoverytracker.org/country-reports-overview.
46 International Energy Agency, "Sustainable Recovery Tracker" (2021). www.iea.org/reports/sustainable-recovery-tracker.

Exhibit 7: Global GHG emissions under Different Scenarios and the Emission Gap in 2030 (median and 10th and 90th percentile range)



Source: UNEP, "Emissions Gap Report 2021" (2021). www.unenvironment.org/emissions-gap-report-2021.

This brings us to the actions needed in response to warming that cannot be averted—in other words, to climate adaptation.

Climate Change Adaptation

Adapting to a changing climate involves adjusting to actual or expected future climate events, thereby increasing society's resilience to climate change and reducing vulnerabilities to its harmful effects. The faster the climate changes, the more challenging it is to adapt. The World Bank has aptly described adaptation and resilience as "two sides of the same coin."[47]

Most adaptation focuses on anticipating the adverse effects of climate change and taking appropriate action to prevent or minimize the damage they can cause, but there may also be opportunities (such as polar melting opening new maritime trade routes or the growth of viticulture in previously colder areas).

In light of humankind's ability to survive—and even thrive—in hostile climates, it is tempting to assume that adaptation is a less costly option than mitigation, but this is far from certain. Consider one of the most obvious examples of adaptation: air conditioning (AC), the use of which is becoming increasingly common as incomes and populations rise, particularly in the world's warmer regions. AC units are power intensive and use powerful GHGs as refrigerants. By 2050, it is anticipated that air conditioning alone may result in GHG emissions equivalent to that of India, the world's third-largest emitter today, which would create a vicious circle of more global overheating, which requires more AC, and so on.[48]

Alternatively, it is sometimes suggested that because CO_2 is a nutrient for plants, more CO_2 in the atmosphere will ultimately have a positive effect on agriculture around the world. However, other effects of climate change—in particular, increased droughts in some locations and stronger floods in others—are reducing yields and accelerating soil erosion, with the world already losing around 0.5% of its arable land every year.[49] Moreover, rising sea levels already flood some of the world's major rice-producing deltas with salt water. In light of these issues as well as signs of stagnating agricultural productivity, how the world will adapt to the food needs of a fast-rising global population is a crucial open question.

The more climate adaptation strategies are included in the investment plans of the finance sector and the industrial, agricultural, and even defense sector strategies of governments and the urban planning of municipalities, the higher their chances of success.

Examples of adaptation strategies include a variety of development plans on how to deal with

- protecting coastlines and adapting to sea-level rise,
- building flood defenses,
- managing land use and forestry practices,
- planning more efficiently for scarce water resources,
- developing drought-resilient crops,
- protecting energy and public infrastructure, and
- developing clean cooling systems.

47 World Bank, "Action Plan on Climate Change Adaptation and Resilience: Managing Risks for a More Resilient Future" (2019). http://documents1.worldbank.org/curated/en/519821547481031999/The-World-Bank-Groups-Action-Plan-on-Climate-Change-Adaptation-and-Resilience-Managing-Risks-for-a-More-Resilient-Future.pdf.

48 Ankit Kalanki and Sneha Sachar, "Revolutionizing the Air Conditioner Industry to Solve the Cooling Challenge," Rocky Mountain Institute (2018). https://rmi.org/revolutionizing-the-air-conditioner/.

49 See J. Grantham, "The Race of Our Lives Revisited," white paper, GMO (8 August 2018). www.gmo.com/europe/research-library/the-race-of-our-lives-revisited/.

As mentioned earlier, researchers have observed that some of the most effective climate policies (such as the protection of coastal and freshwater wetlands[50] and the promotion of sustainable agroforestry) contribute to both adaptation and mitigation simultaneously.[51]

Not just an issue of government policy, adaptation is also increasingly being factored into corporate business plans. For example, water risks are proving to be an issue of increased importance in the mining sector, which requires sufficient water to convey or help separate the desired ores. It is estimated that up to 50% of global production of copper, gold, iron ore, and zinc—metals with a key contribution to low-carbon energy technologies—is located in areas where water stress is already high.[52]

Too much water can also be a problem, because floods can shut down mines and cause significant local pollution. Close to half of the global production of iron ore and zinc is estimated to be in areas facing high flood risk.[53]

CASE STUDIES

Escondida Copper Mine

Located in one of the most arid places on earth, the Atacama Desert in Chile, Escondida is the world's largest copper mine by production. BHP, the mining company operating it, has been planning a transition away from using fresh groundwater.

In early 2020, BHP announced it was able to operate the mine using only desalinated water from the ocean. BHP already uses more than 50% of the water it needs from the ocean in an effort to reduce pressure on freshwater resources, which are often also used by local communities.[54]

States, provinces,[55] cities, and municipalities[56] are at the frontline of adaptation and resilience due to their high concentration of people, assets, and economic activities. Representing 80% of global gross domestic product (GDP), cities are heavily exposed to climate change risks in the forms of

- sea level rise,
- extreme weather events, such as flooding and drought, and
- increase in the spread of tropical diseases.

50 William R. Moomaw, G. L. Chmura, Gillian T. Davies, C. M. Finlayson, B. A. Middleton, Susan M. Natali, J. E. Perry, N. Roulet, and Ariana E. Sutton-Grier, "Wetlands in a Changing Climte: Science, Policy and Management," *Wetlands* 38 (2018): 183–205. https://link.springer.com/article/10.1007/s13157-018-1023-8.

51 I. Suarez, "5 Strategies that Achieve Climate Mitigation and Adaptation Simultaneously," World Resources Institute (10 February 2020). www.wri.org/blog/2020/02/climate-change-mitigation-adaptation-strategies.

52 Lindsay Delevingne, Will Glazener, Liesbet Grégoir, and Kimberly Henderson, "Climate Risk and Decarbonization: What Every Mining CEO Needs to Know," McKinsey (28 January 2020). www.mckinsey.com/business-functions/sustainability/our-insights/climate-risk-and-decarbonization-what-every-mining-ceo-needs-to-know#.

53 Delevingne, Glazener, Grégoir, and Henderson, "Climate Risk and Decarbonization."

54 C. Jamasmie, "BHP to Supply Water for Escondida Mine from Desalination Plant Only," Mining.com (4 February 2020). www.mining.com/bhp-to-supply-water-for-escondida-mine-from-desalination-plant-only/. See also BHP, "BHP Annual Report 2020" (2020). www.bhp.com/-/media/documents/investors/annual-reports/2020/200915_bhpannualreport2020.pdf.

55 Under2 Coalition: www.theclimategroup.org/under2-coalition.

56 Climate Mayors: https://climatemayors.org/.

All of these will have an economic and social cost to cities' inhabitants, infrastructure, and businesses and the built environment. At the same time, cities are a major contributor of GHG emissions, mainly from transport and buildings. Useful best practices of various cities' climate adaptation strategies include

- incorporating flood risk into building designs (in New York City) and planning for enhanced water absorption rates into city infrastructure ("sponge cities," such as Wuhan, China),[57]
- modeling the impact of natural disasters on energy supply (in Yokohama, Japan), and
- analyzing the resiliency to disruption of food supply systems (in Los Angeles and Paris).[58]

Estimates of the relative costs of adaptation to climate change vary. In the Adaptation Gap Report 2020, the UN Environmental Programme (UNEP) estimated that adaptation costs in developing countries alone were estimated to be in the range of US$70 billion (£50 billion), with the expectation of reaching US$140 billion to US$300 billion (£100 billion to £216 billion) in 2030 and US$280 billion to US$500 billion (£201 billion to £359 billion) in 2050.[59] And as with mitigation, expected costs must be set against the context of potential benefits: The Global Commission on Adaptation in 2019 estimated that approximately US$2 trillion (£1.4 trillion) of investment in adaptation measures would result in an over US$7 trillion (£5 trillion) return in avoided costs and other benefits.[60]

In late 2019, the Climate Bonds Initiative published the first Climate Resilience Principles, which provide a framework for developing location-specific climate resilience measures and financing them in the green bond market.[61] In addition, a group of multilateral development banks have put forward "A Framework and Principles for Climate Resilience Metrics in Financing Operations," which provides guidance on how to create effective climate resilience projects and how to measure direct outcomes and wider system impacts.[62]

It is important to recognize that there can be trade-offs between adaptation/resilience and mitigation. For example, the decision to invest in an a desalination plant that helps prevent a potential water shortage in a crisis may be warranted, despite its high associated emissions. Understanding and assessing such potential conflicts is critical to building resilience with limited impact on mitigation efforts.

57 L. Jing, "Inside China's Leading 'Sponge City': Wuhan's War with Water," *Guardian* (23 January 2019). www.theguardian.com/cities/2019/jan/23/inside-chinas-leading-sponge-city-wuhans-war-with-water.

58 C40 Cities and AXA, "Understanding Infrastructure Interdependencies in Cities" (2019). www.axa.com/en/press/publications/understanding-infrastructure-interdependencies-in-cities.

59 UNEP, "Adaptation Gap Report 2020" (14 January 2021). www.unenvironment.org/resources/adaptation-gap-report-2020.

60 Global Commission on Adaptation, "Adapt Now: A Global Call for Leadership on Climate Resilience" (2019). https://gca.org/wp-content/uploads/2019/09/GlobalCommission_Report_FINAL.pdf.

61 Climate Bonds Initiative, "Climate Resilience Principles" (2019). www.climatebonds.net/climate-resilience-principles.

62 African Development Bank, Asian Development Bank, Asian Infrastructure Investment Bank, European Bank for Reconstruction and Development, European Investment Bank, Inter American Development Bank, International Development Finance Club, and Islamic Development Bank, "A Framework and Principles for Climate Resilience Metrics in Financing Operations" (December 2019). https://publications.iadb.org/en/framework-and-principles-climate-resilience-metrics-financing-operations.

Pressures on Natural Resources

The relationship between businesses and natural resources is becoming increasingly important due to dramatically accelerating biodiversity loss and less secure access to natural resources. For the purposes of this section, natural resources cover

- fresh water,
- biodiversity loss,
- land use, and
- forestry and marine resources.

Natural resources also include non-renewable resources (such as fossil fuels, minerals, and metals), which cannot be replenished quickly enough to keep up with their consumption.

Governments and businesses are having to deal with increased pressure on natural resources, caused by

- population growth,
- health improvements leading to people living longer,
- economic growth, and
- the accompanying increased consumption in developed and emerging economies.

Simultaneously, these drivers are leading to the risk of resource scarcity. These developments are therefore compelling companies to become more efficient in the way that they use natural resources if they are to remain competitive and become more sustainable. This can help drive better financial management of resources but also spur technological innovations that can have a beneficial impact on the bottom line in support of a more sustainable and resilient economy and society.

Depletion of Natural Resources

According to the UN, the current world population of 7.6 billion is expected to reach

- 8.6 billion in 2030,
- 9.8 billion in 2050, and
- 11.2 billion in 2100.

The rising population will put increased strain on the world's natural resources, most notably in terms of access to food. This presents a number of related challenges:

1. "Modern agriculture is dependent on phosphorus derived from phosphate rock, which is a non-renewable resource, and current global reserves may be depleted in 50–100 years. While phosphorus demand is projected to increase, the expected global peak in phosphorus production is predicted to occur around 2030," with the quality of remaining reserves expected to fall while its costs—and the global population—continue to rise.[63]

63 D. Cordell, J.-O. Drangerta, and S. White, "The Story of Phosphorus: Global Food Security and Food for Thought," *Global Environmental Change* 19 (May 2009): 292–305. https://doi.org/10.1016/j.gloenvcha.2008.10.009.

2. The world is already using half its vegetated land for agriculture. Avoiding worsening climate change, which itself would reduce agricultural productivity, requires feeding a rapidly growing population without further deforestation.[64]
3. The issue is compounded by changes in lifestyle: "While population growth was the leading cause of increasing consumption from 1970 to 2000, the emergence of a global affluent middle class has been the stronger driver since the turn of the century."[65] From the rare earths and other metals that go into smartphones and computers to the rising emissions associated with a higher standard of living (for example, bigger homes with higher heating and cooling needs, increased travel, and increased meat and dairy consumption), these dynamics are also set to increase the pressure on natural resources.

To a certain degree, technological innovation and moving from a linear to a circular economy has the potential to reduce the need for virgin resources. The decoupling of economic activities from resource usage has been observed; for example, in the past decade, the United Kingdom's GDP has risen by 18% while its carbon emissions have fallen by about 30%.[66]

However, a literature review of decoupling found a mixed picture: "Relative decoupling is frequent for material use as well as GHG and CO_2 emissions, [but] examples of absolute long-term decoupling are rare."[67]

One reason is that relative improvements in efficiency (using fewer resources per unit of production) may be offset by increased consumption of a given product—an effect known as the **Jevons paradox**.[68]

The issue of resource usage will remain crucial for investors and policymakers, who will have to navigate trade-offs and consider not just use efficiency but also how to facilitate changing the whole model (moving from linear to circular in products, processes, and ultimately, the economy) to reduce the strain on natural resources.

Another idea that is gaining ground is decoupling the definition of development and progress from GDP growth to a measurement of asset wealth and assigning economic value not just to produced capital and human capital but also to natural capital, as proposed in the Dasgupta Review.[69] Historically, growth in produced capital has been at the expense of natural capital, which has been ignored, and at the

64 Janet Ranganathan, Richard Waite, Tim Searchinger, and Craig Hanson, "How to Sustainably Feed 10 Billion People by 2050, in 21 Charts," World Resources Institute (5 December 2018). www.wri.org/blog/2018/12/how-sustainably-feed-10-billion-people-2050-21-charts.

65 B. Oberle, S. Bringezu, S. Hatfield-Dodds, S. Hellweg, "ETH Zurich UN Global Resources Outlook 2019: Natural Resources for the Future We Want" (March 2019). www.researchgate.net/publication/331683904_UN_Global_Resources_Outlook_2019_Natural_Resources_for_the_Future_We_Want. See also T. Wiedmann, M. Lenzen, L. T. Keyßer, and J. K. Steinberger, "Scientists' Warning on Affluence," *Nature Communications* 11 (19 June 2020). www.nature.com/articles/s41467-020-16941-y. As quoted in European Environment Agency, "Growth without Economic Growth" (2021). www.eea.europa.eu/publications/growth-without-economic-growth/growth-without-economic-growth.

66 S. Evans, "Analysis: UK's CO_2 Emissions Have Fallen 29% over the Past Decade," Carbon Brief (2 March 2020). www.carbonbrief.org/analysis-uks-co2-emissions-have-fallen-29-per-cent-over-the-past-decade.

67 H. Haberl, D. Wiedenhofer, D. Virag, G. Kalt, B. Plank, P. Brockway, T. Fishman, D. Hausknost, F. Krausmann, B. Leon-Gruchalski, A. Mayer, M. Pichler, A. Schaffartzik, T. Sousa, J. Streeck, and F. Creutzig, "A Systematic Review of the Evidence on Decoupling of GDP, Resource Use and GHG Emissions, Part II: Synthesizing the Insights," *Environmental Research Letters* 15 (June 2020). www.researchgate.net/publication/340243504_A_systematic_review_of_the_evidence_on_decoupling_of_GDP_resource_use_and_GHG_emissions_part_II_Synthesizing_the_insights.

68 "Jevons Paradox," Wikipedia (2021). https://en.wikipedia.org/wiki/Jevons_paradox.

69 HM Treasury, "Final Report—The Economics of Biodiversity: The Dasgupta Review" (2 February 2021). www.gov.uk/government/publications/final-report-the-economics-of-biodiversity-the-dasgupta-review.

expense of countries rich in natural resources, many of which have been left behind in the distribution of benefits in the form of human capital development and left with the impact of natural capital depletion and increasing social inequities. Valuing "ecosystem services" and their loss as the benefits and costs if they were supplied by the market is another alternative means of including natural inputs in the traditional GDP accounting.[70] There are also examples of individuals and governments paying someone for maintaining a beneficial ecosystem service.[71]

Water

Nearly 70% of the planet is covered by water, but only 2.5% of it is freshwater. Water is a vital natural resource, not only for human consumption but also for a range of agricultural, industrial, and household energy generation, as well as for recreational and environmental activities. It is critical to many industrial processes, including mineral extraction and cooling for industrial plants. Water demand is set to increase in all sectors.[72]

According to the World Economic Forum, water also connects these sectors to a broader economic system that must balance social development and environmental interests. As the world continues to face multiple water challenges, a decision to allocate more water to any one sector implies that less water will be available for other economic uses, for public water supply and other social services, or for environmental protection.[73]

Water scarcity is the lack of freshwater resources to meet water demand. Water scarcity is present on every continent and is one of the largest global risks in terms of potential impact over the next decade. UN-Water has reported that over 2 billion people experience high water stress in different countries, and about 4 billion people experience severe water scarcity at least one month of the year.[74]

The **UN's Sustainable Development Goal (SDG) 6** is the need "to ensure availability and sustainable management of water and sanitation to all" by 2030.[75] Water scarcity—caused either by economic factors, such as lack of investment, or by physical impacts related to climate change—continues to cause major concern, especially among the developing and emerging economies.

Biodiversity Loss

Biodiversity, land use, and associated ecosystems provide a range of invaluable services to society that underpin human health, well-being, and economic growth. Ecosystem services are the benefits that people and businesses derive from ecosystems. Biodiversity, as defined by the Convention on Biological Diversity, means the "variability

70 Robert Costanza, Rudolfde Groot, Paul Sutton, Sandervan der Ploeg, Sharolyn J. Anderson, Ida Kubiszewski, Stephen Farber, R. Kerry Turner, "Changes in the Value of Ecosystem Services," *Global Environmental Change* 26 (May 2014): 152–58. www.sciencedirect.com/science/article/pii/S0959378014000685.

71 B. Kelsey Jack, Carolyn Kousky, and Katharine R. E. Sims, "Designing Payments for Ecosystem Services: Lessons from Previous Experience with Incentive-Based Mechanisms," *Proceedings of the National Academy of Sciences* 105 (15 July 2008): 9465-70. www.pnas.org/doi/10.1073/pnas.0705503104.

72 UNESCO World Water Assessment Programme, "The United Nations World Water Development Report 2018: Nature-Based Solutions for Water" (2018). https://unesdoc.unesco.org/ark:/48223/pf0000261424.

73 World Economic Forum, "Shaping the Future of Global Public Goods" (2019). www.weforum.org/system-initiatives/shaping-the-future-of-environment-and-natural-resource-security.

74 United Nations, "The United Nations World Water Development Report 2019: Leaving No One Behind," (2019). www.unwater.org/publications/world-water-development-report-2019/.

75 United Nations Department of Economic and Social Affairs, "6: Ensure Availability and Sustainable Management of Water and Sanitation for All" (2021). https://sdgs.un.org/goals/goal6.

among living organisms from all sources including, among other things, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems."[76]

The Summary for Policymakers for the 2022 IPCC report "Impact, Vulnerability and Adaptation," which was approved by all governments, made a strong connection between biodiversity, ecosystems, development, and climate change. The following are examples:

> *Safeguarding biodiversity and ecosystems is fundamental to climate resilient development, in light of the threats climate change poses to them and their roles in adaptation and mitigation (very high confidence). Recent analyses, drawing on a range of lines of evidence, suggest that maintaining the resilience of biodiversity and ecosystem services at a global scale depends on effective and equitable conservation of approximately 30% to 50% of earth's land, freshwater and ocean areas, including currently near-natural ecosystems (high confidence). . . .*
> *Building the resilience of biodiversity and supporting ecosystem integrity can maintain benefits for people, including livelihoods, human health and well-being and the provision of food, fibre and water, as well as contributing to disaster risk reduction and climate change adaptation and mitigation.*[77]

Unfortunately, global biodiversity is facing a dramatic decline. In 2019, the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) published a landmark report that showed that around 1 million animal and plant species are now threatened with extinction, many within decades, more than ever before in human history.[78] The report provides a stark and comprehensive set of scientifically proven findings that highlight the deterioration of biodiversity and its ecosystem functions and services. According to it, humans have impacted over 75% of the earth's land areas and 66% of the oceans. This deterioration is caused by a combined result of land and sea use change, direct exploitation, climate change, and pollution.

The World Wildlife Fund's (WWF's) "Living Planet Report" from 2020 noted that the world's wildlife populations have plummeted by 68% since 1970, with this trajectory likely to be further exacerbated by global warming. A major driver of this decline is loss of habitat linked to overexploitation.[79] In another report, WWF estimated that inaction on biodiversity may result in cumulative costs of approximately US$10 trillion (£7.2 trillion) up to 2050, through changes to crop yields and fish catches, economic damages from flooding and other disasters, and the loss of potential new sources of medicine.[80]

Already, biodiversity loss is presenting challenges to such industries as fishery and agriculture. Around 75% of global food crop types directly rely on animal pollination; given the decline in natural pollinators due to pollution and pesticides, US farmers paid approximately US$300 million (£215.6 million) for artificial (sometimes manual) pollination in 2017. Medicine and health is another area of concern, with an estimated 70% of cancer drugs being organic or derived from organic substances.[81]

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76 United Nations, "Convention on Biological Diversity" (1992). www.cbd.int/doc/legal/cbd-en.pdf.
77 Sections D.4 and D.4.1 of IPCC, "Climate Change 2022: Impacts, Adaptation and Vulnerability: Summary for Policymakers" (2022).
78 IPBES, "The Global Assessment Report on Biodiversity and Ecosystem Services: Summary for Policymakers" (2019). https://ipbes.net/sites/default/files/inline/files/ipbes_global_assessment_report_summary_for_policymakers.pdf.
79 WWF, "The Living Planet Report 2020" (2020). www.wwf.org.uk/living-planet-report.
80 WWF, "Global Futures: Assessing the Global Economic Impacts of Environmental Change to Support Policy-Making" (2020). www.wwf.org.uk/sites/default/files/2020-02/GlobalFutures_SummaryReport.pdf.
81 A. Paun, "Biodiversity in the Balance," HSBC (17 June 2020). www.hsbc.com/insight/topics/biodiversity-in-the-balance.

Biodiversity underpins ecosystem services, provides natural resources and constitutes our "natural capital." Some of these ecosystem services are

- food,
- clean water,
- genetic resources,
- flood protection,
- nutrient cycling, and
- climate regulation.[82]

"The Economics of Biodiversity: The Dasgupta Review" from 2021 argued for assigning economic asset value to biodiversity to reverse its treatment as a free resource and attempt to halt depletion.[83] In the same vein, in 2020, PBL Netherlands Environmental Assessment Agency published an important report titled "Indebted to Nature," exploring the biodiversity risks for the Dutch financial sector, effectively identifying nature and biodiversity as a systemic risk.[84]

NATURAL CAPITAL

Natural capital is defined as:
"the world's stocks of natural assets which include geology, soil, air, water and all living things. It is from this natural capital that humans derive a wide range of services, often called ecosystem services, which make human life possible."[85]

The importance of taking a natural capital approach is explained in more detail in the section titled "Assessment of Materiality of Environmental Issues," which discusses investment opportunities.

It is estimated that the annual monetary value of ecosystem services is around US$125 trillion to US$140 trillion (£90 trillion to £100 trillion), more than 1.5 times the global GDP.[86] Biodiversity also has intrinsic value: The ideas that the beauty of nature is worth preserving and that mankind and other species should strive for a harmonious coexistence have been a mainstay of many cultures, religions, and belief systems.[87]

It is worth emphasising the potentially large *unrecognized value*. There are myriad interactions between different species, playing highly complex roles in cycling nutrients, regulating the numbers of (potentially invasive) plant and animal species, and even altering the formation of landscapes.

The Organisation for Economic Co-Operation and Development (OECD) has noted it is difficult to predict where biodiversity thresholds lie, "when they will be crossed, and what will be the scale of impact. Given this uncertainty and the potential impact of

82 D. Juffe-Bignoli, "Biodiversity for Business: A Guide to Using Knowledge Products Delivered through IUCN" International Union for Conservation of Nature (2014). https://portals.iucn.org/library/node/43361.
83 HM Treasury, "Final Report—The Economics of Biodiversity: The Dasgupta Review."
84 PBL Netherlands Environmental Assessment Agency, "Indebted to Nature. Exploring Biodiversity Risks for the Dutch Financial Sector" (19 June 2020). www.pbl.nl/en/publications/indebted-to-nature.
85 World Forum on Natural Capital, "What Is Natural Capital?" (2021). https://naturalcapitalforum.com/about/.
86 OECD, "Biodiversity: Finance and the Economic and Business Case for Action" (2019). www.oecd.org/environment/resources/biodiversity/G7-report-Biodiversity-Finance-and-the-Economic-and-Business-Case-for-Action.pdf.
87 See, for example, the Convention on Biological Diversity, signed by a majority of governments worldwide.

regime shifts, it is prudent to take a precautionary approach."[88] There is evidence that conservation can be effective: A study from 2009 found that conservation investments over more than a decade reduced extinction risk by almost a third for mammals and birds in 109 countries.[89] Without existing conservation efforts, the extinction risk of mammals, birds, and amphibians would have been at least 20% higher, according to the IPBES.[90] This is not just a conservation issue; the OECD noted the link between safeguarding biodiversity and human health: "Land-use change resulting from agricultural expansion, logging, infrastructure development and other human activities is the most common driver of infectious disease emergence."[91]

In summary, conserving nature and improving the sustainable use of natural resources is possible but can be achieved only through transformative changes across economic, social, political, and technological factors.

Land Use and Forestry

Land use management practices and forestry, also known as agriculture, forestry, and other land use (AFOLU), have a major impact on natural resources, including water, soil, nutrients, plants, and animals.

Covering approximately 30% of the world's land area, or just under 4 billion hectares, forests are a vital part of the carbon cycle.[92] They convert the CO_2 in the air to oxygen, through the process of photosynthesis, and are a natural regulator of CO_2, with the world's tropical forests playing a particularly important role in accumulating and storing carbon. The more mature and old growth trees in our forests, the less atmospheric CO_2 and the more oxygen there is in the atmosphere.[93]

Unfortunately, deforestation is accelerating: From 2001 to 2019, there was a total of 386 million hectares of tree cover loss globally, equivalent to a 9.7% decrease in tree cover since 2000 and 105 gigatonnes of CO_2 emissions, according to Global Forest Watch.[94]

The production of commodities (particularly relating to agriculture) is a key driver of deforestation—responsible for up to two-thirds of deforestation by some estimates.[95] As a result, there is increased investor focus on investee companies' contribution to deforestation. According to the CDP (previously the Carbon Disclosure Project), approximately US$1 trillion (£0.7 trillion) of turnover in publicly listed companies is dependent on commodities linked to deforestation, including soy, palm oil, cattle, and timber. The risks from these soft commodities can be transmitted across supply chains to affect companies' revenues, asset valuation, or costs, which can impact the creditworthiness or market value of the debt or equity of investee companies.[96]

88 OECD, "Biodiversity."
89 A. Waldron, D. C. Miller, D. Redding, A. Mooers, T. S. Kuhn, N. Nibbelink, J. T. Roberts, J. A. Tobias, J. L. Gittleman, "Reductions in Global Biodiversity Loss Predicted from Conservation Spending," *Nature* 551 (25 October 2017): 364–67. www.nature.com/articles/nature24295.
90 IPBES, "The Global Assessment Report on Biodiversity and Ecosystem Services."
91 OECD, "Biodiversity and the Economic Response to COVID-19: Ensuring a Green and Resilient Recovery" (2020). www.oecd.org/coronavirus/policy-responses/biodiversity-and-the-economic-response-to-covid-19-ensuring-a-green-and-resilient-recovery-d98b5a09/.
92 C. Nunez, "Deforestation Explained," National Geographic (2019). www.nationalgeographic.com/environment/global-warming/deforestation/.
93 Beverly E. Law, William R. Moomaw, Tara W. Hudiburg, William H. Schlesinger, John D. Sterman, and George M. Woodwell, "Creating Strategic Reserves to Protect Forest Carbon," *Land* 11 (May 2022). www.mdpi.com/2073-445X/11/5/721.
94 Global Forest Watch, "Global Deforestation Rates and Statistics by Country" (2020). www.globalforestwatch.org/dashboards/global/.
95 Global Canopy, "Time for Change: Delivering Deforestation-Free Supply Chains" (2021). https://forest500.org/publications/time-change-delivering-deforestation-free-supply-chains.
96 CDP and Global Canopy, "Financial Institution Guidance: Soft Commodity Company Strategy" (2017). www.cdp.net/en/reports/downloads/2913.

Companies with exposure to deforestation in their supply chains may face material financial risks, such as

- supply disruption,
- cost volatility, and
- reputational damage.

By contrast, shifting business practices to adopt more sustainable land management approaches contributes to

- agricultural and economic development, both locally and globally,
- the health and stability of forests and ecosystems and the continued provision of ecosystem services at an increasing scale, and
- the reduction of GHG emissions from deforestation and degradation.

Sustainable agriculture will remain an issue of growing focus for policymakers and companies. In 2019, the IPCC published its "Special Report on Climate Change and Land," which warned that the stability of the global food supply is projected to decrease as the magnitude and frequency of extreme weather events that disrupt food chains increases.[97]

In summary, the protection and management of land resources play a vital role in ensuring the balance of nature and the health of the ecosystem. Unsustainable management will negatively affect biodiversity, ecosystems, and all the natural resources that underpin economic growth and human flourishing.

Marine Resources

Storing 43 times more CO_2 than the atmosphere, the ocean is the planet's largest carbon reservoir. It is also the second largest sink in terms of removing CO_2 from the atmosphere.[98] Photosynthetic microorganisms on its surface layer also produce over half of the world's oxygen.[99] It is one of the earth's most valuable natural resources.

The OECD has estimated that ocean-based industries contribute roughly €1.3 trillion (£1.1 trillion) to global gross value added. Oceans provide seafood and are widely used for transportation (shipping). They are also mined for minerals (salt, sand, and gravel, as well as some manganese, copper, nickel, iron, and cobalt, which can be found in the deep sea) and drilled for crude oil. The oceans' resources are a source of economic growth and are also known as the **blue economy**. According to the World Bank, the blue economy is the "sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystem".[100] The blue economy as an investment opportunity is discussed in the section titled, "Applying Material Environmental Factors to Financial Modeling, Ratio Analysis, and Risk Assessment" of this chapter.

97 IPCC, "Climate Change and Land: Summary for Policymakers" (2019). www.ipcc.ch/srccl/chapter/summary-for-policymakers.
98 Global Carbon Project, "Global Carbon Budget 2021" (2022). www.globalcarbonproject.org/carbonbudget/21/publications.htm.
99 National Oceanic Service, "How Much Oxygen Comes from the Ocean?" (2021). https://oceanservice.noaa.gov/facts/ocean-oxygen.html.
100 World Bank, "What Is the Blue Economy?" (2017). www.worldbank.org/en/news/infographic/2017/06/06/blue-economy.

Communities in close connection with coastal environments, small islands (including Small Island Developing States), polar areas, and high mountains are particularly exposed to ocean change, such as sea level rise. Low-lying coastal zones are currently home to around 680 million people (nearly 10% of the 2010 global population), projected to reach more than 1 billion by 2050.[101]

Due to the increase in the human population, the oceans have been overfished, with a resulting decline of fish critical to the economy. In 2015,

- 33% of marine fish stocks were being harvested at unsustainable levels,
- 60% were fished to maximum capacity, and
- only 7% were harvested at levels lower than what can be sustainably fished.[102]

Although there are 66 international agreements governing regional fisheries management organizations, just 7 of them have a secretariat, a scientific body, and enforcement powers. In most cases, fishing quotas are politically agreed to and overrule the recommendation for maximum sustained yield recommended by the scientific body. This "legal overfishing" is in addition to the illegal, unreported, and unregulated catch. In addition, almost all fishing nations subsidize fishing fleets to be much larger than the fishery can sustain.[103] The control of the world's fisheries is a controversial subject, because production is unable to satisfy the demand, especially when there are not enough fish left to breed in healthy ecosystems. Environmental finance think-tank Planet Tracker estimated in 2020 that "if historic trends continue and coastal ecological health continues declining, total production forecasts for coastal farmed Atlantic salmon to 2025 may be 6% to 8% lower than predicted, equivalent to US$4.1 billion" (£3 billion). However, there are options to address this problem: By improvements in traceability and sustainability certifications, which have lower impacts on biodiversity, Planet Tracker estimated that "the typical seafood processor can double its EBIT [earnings before interest and tax] margin, which is currently at a low 3%, mainly due to lower recall, product waste and legal costs."[104]

Pollution, Waste, and a Circular economy

Air Pollution

Clean air is essential to health, the environment, and economic prosperity.

Increased air pollution

- adversely affects the environment,
- has a negative impact on human health,
- destroys ecosystems,
- impoverishes biodiversity, and
- reduces crop harvests as a result of soil acidification.

101 IPCC, "Special Report on the Ocean and Cryosphere in a Changing Climate" (2019). www.ipcc.ch/srocc/.

102 IPBES, "The Global Assessment Report on Biodiversity and Ecosystem Services."

103 William Moomaw and Sara Blankenship, "Charting a New Course for the Oceans" (April 2014). https://sites.tufts.edu/gdae/files/2019/10/MoomawFisheries_2014.pdf.

104 Planet Tracker, "Investors Face Financial Risk as Salmon Industry Approaches Ecological Brink, Says Planet Tracker" (27 May 2020). https://planet-tracker.org/investors-face-financial-risk-as-salmon-industry-approaches-ecological-brink-says-planet-tracker/.

See also Planet Tracker, "Traceability Could Double the EBIT Margin of Seafood Processors While Reducing Investor Risk, Says Planet Tracker" (13 October 2020). https://planet-tracker.org/traceability-could-double-the-ebit-margin-of-seafood-processors-while-reducing-investor-risk-says-planet-tracker/.

Indoor and outdoor air pollution are together responsible for over 7 million deaths globally each year, according to the World Health Organization (WHO). Research by the WHO further shows that in 2019, 99% of the world's population was living in places where the WHO air quality guideline levels were not met.[105] Urban air pollution is predicted to worsen, as migration and demographic trends drive the creation of more megacities.

Pollution is the largest environmental cause of disease and premature death in the world today. According to findings published in October 2017 by the Lancet Commission on Pollution and Health, diseases caused by pollution were responsible for an estimated 9 million premature deaths in 2015—16% of all deaths worldwide—which is three times more deaths than from AIDS, tuberculosis, and malaria combined and 15 times more than from all wars and other forms of violence.[106]

Research published in February 2021 in the journal *Environmental Research* focused on isolating the impact of fossil fuel combustion and concluded that "the burning of fossil fuels—especially coal, petrol, and diesel—is a major source of airborne fine particulate matter ($PM_{2.5}$), and a key contributor to the global burden of mortality and disease. . . . The greatest mortality impact is estimated over regions with substantial fossil fuel related $PM_{2.5}$."[107]

Using new modeling, the scientists estimated that parts of China, India, Europe, and the northeastern United States are among the hardest-hit areas, suffering a disproportionately high share of 8.7 million annual deaths attributed to fossil fuels, compared to a 2017 study, which had put the annual number of deaths from all outdoor airborne particulate matter—including dust and smoke from agricultural burns and wildfires—at 4.2 million.[108] These findings lend further support to the focus on reducing fossil fuel emissions.

Water Pollution

Water is essential to all living organisms. Yet water pollution is one of the most serious environmental threats faced. Water pollution occurs when contaminants (such as harmful chemicals or microorganisms) are introduced into the natural environment through the ocean, rivers, streams, lakes, or groundwater. Water pollution can be caused by spills and leaks from untreated sewage or sanitation systems and industrial waste discharge. Plastic waste also appears in waterways.

CASE STUDIES

Water-Related Fines

Partially due to increased public interest litigation, fines for water pollution are increasing around the world. In 2014, Chinese media reported what was at the time the largest ever fine levied in the country—whereby six companies were fined a total of 160 million yuan (£18.1 million) for chemical discharges into rivers.[109]

105 "Air Pollution." World Health Organization. *World Health Organization* (2020). https://www.who.int/health-topics/air-pollution.

106 P. J. Landrigan et al., "The Lancet Commission on Pollution and Health," *Lancet Commissions* 391 (3 February 2018): 462–512. https://doi.org/10.1016/S0140-6736(17)32345-0.

107 Karn Vohra, Alina Vodonos, Joel Schwartz, Eloise A. Marais, Melissa P. Sulprizio, and Loretta J. Mickley, "Global Mortality from Outdoor Fine Particle Pollution Generated by Fossil Fuel Combustion: Results from GEOS-Chem," *Environmental Research* 195 (April 2021). www.sciencedirect.com/science/article/abs/pii/S0013935121000487.

108 M. Green, "Fossil Fuel Pollution Causes One in Five Premature Deaths Globally: Study," *Reuters* (9 February 2021). www.reuters.com/article/us-health-pollution-fossil/fossil-fuel-pollution-causes-one-in-five-premature-deaths-globally-study-idUSKBN2A90UB.

109 BBC, "Court in China Issues Record Pollution Fine" (31 December 2014). www.bbc.co.uk/news/world-asia-china-30640385.

In 2020, the US Environmental Protection Agency announced its largest ever fine relating to the Clean Water Act. Almost US$3 million (£2.2 million) was charged to a horseracing facility for repeated discharge of animal waste into New Orleans waterways.[110]

Waste and Waste Management

In view of the concerns about growing pressures on natural resources—combined with opposition to all types of pollution—waste and waste management has, in recent decades, become a bigger priority for policymakers, businesses, and citizens. Increasing consumption and waste levels are putting more pressure on space for landfill waste, which, in turn, is causing landfill taxes to rise. Alongside tougher regulation on how waste is handled and managed, businesses are becoming increasingly incentivized to help economies, notably through recycling and by adopting a circular economy business model.

A recent striking example of the public's concern over excessive waste is the campaign against plastics, especially in relation to the serious damage that they are doing to the oceans. This has led to actions by national and local authorities on waste management and greater responsibility conferred on businesses to manage their waste responsibly.

In most developed countries, domestic waste disposal is funded from national or local taxes, which may be related to income or property values. Commercial and industrial waste disposal is typically charged for as a commercial service, often as an integrated charge that includes disposal costs. This practice may encourage disposal contractors to opt for the cheapest disposal option, such as using landfills or incineration—which generate GHG emissions and contribute to local pollution—rather than opting for such solutions as reuse and recycling.

Although many consumer products (such as metal cans and glass bottles) are recyclable, recycling practices are very uneven across (and sometimes even within) countries. However, there has been growing public concern with excessive waste, particularly for single-use plastics and the serious damage that they are doing to the oceans and marine wildlife. This has led to actions by national and local authorities on waste management and greater responsibility conferred on businesses to manage their waste responsibly. Coupled with a slowdown in the ability to export hazardous waste, including plastics, to a rising number of Asian countries (most notably China), this puts further pressure on those in Australia, Europe, and North America, in particular, to develop their own recycling and waste management solutions onshore.

In 2022 at the UN Environment Assembly, heads of state and government representatives from around the world committed to develop by 2024 an international legally binding agreement to end plastic pollution.[111]

A financial mechanism that is growing in popularity in the consumer space is the use of fees and taxes, including a charge on plastic bags, designed to discourage waste and promote recycled usage. The European Strategy for Plastics in a Circular Economy, agreed in January 2018, requires that all plastic packaging must be reusable or recyclable by 2030. This trend has material implications for investors. As the use of oil for transportation declines amid a shift to electric vehicles, numerous companies in the oil industry are looking toward petrochemicals—and plastics in particular—as an alternative source of growth. Yet, think-tank Carbon Tracker has estimated that

110 US Attorney's Office Eastern District of Louisiana, "United States Reaches Agreement to Protect New Orleans Waterways and Lake Pontchartrain" (29 September 2020). www.justice.gov/usao-edla/pr/united-states-reaches-agreement-protect-new-orleans-waterways-and-lake-pontchartrain.

111 UNEP, "Historic Day in the Campaign to Beat Plastic Pollution: Nations Commit to Develop a Legally Binding Agreement" (2 March 2022). www.unep.org/news-and-stories/press-release/historic-day-campaign-beat-plastic-pollution-nations-commit-develop.

if policymakers implement stricter recycling measures in response to ongoing public pressure, up to US$400 billion (£288 billion) of investments in new petrochemical facilities might become "stranded," unprofitable assets.[112]

Conversely, there are opportunities in better waste management, from the reuse or transformation of recovered waste (for example, using old tires to create road surfacing and expanded recycling programs under the TerraCycle initiative)[113] to finding new ways to break down waste into less harmful or useful materials (such as graphene).[114]

A global commitment by companies led by the Ellen MacArthur Foundation and UNEP has set a benchmark for "best practices" to address the plastic waste and pollution system.[115] In a sign of the times, the International Criminal Police Organization (INTERPOL) has also started tracking criminal trends in the global plastic waste market.[116]

Circular Economy

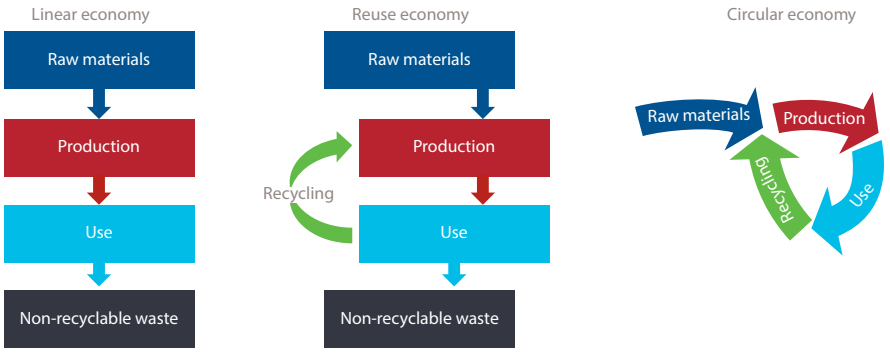
The **circular economy** is an economic model that aims to avoid waste and to preserve the value of resources (raw materials, energy, and water) for as long as possible. It is an effective model for companies to assess and manage their operations and resource management (see Exhibit 8); it is an alternative approach to the use-make-dispose economy. The circular economy is based on three principles:

1. design out waste and pollution,
2. keep products and materials in use, and
3. regenerate natural systems.[117]

The government of the Netherlands has developed a program for a circular economy, aimed at "preventing waste by making products and materials more efficiently and reusing them. If new raw materials are needed, they must be obtained sustainably so that the natural and human environment is not damaged."[118]

112 Carbon Tracker, "The Future's Not in Plastics: Why Plastics Demand Won't Rescue the Oil Sector" (4 September 2020). https://carbontracker.org/reports/the-futures-not-in-plastics/.
113 TerraCycle, "Recycle Everything with TerraCycle" (2021). www.terracycle.com
114 S. Snowden, "Ground-Breaking Method to Make Graphene from Garbage Is Modern-Day Alchemy," *Forbes* (24 July 2020). www.forbes.com/sites/scottsnowden/2020/07/24/ground-breaking-method-to-make-graphene-from-garbage-is-modern-day-alchemy/?sh=364742ed50d7#1d7e.
115 New Plastics Economy, "A Vision of a Circular Economy for Plastic" (2017). https://oceanfdn.org/wp-content/uploads/2010/08/npec-vision-of-a-circular-economy-for-plastic.pdf.
116 INTERPOL, "Emerging Criminal Trends in the Global Plastic Waste Market since January 2018" (2020). www.interpol.int/en/News-and-Events/News/2020/INTERPOL-report-alerts-to-sharp-rise-in-plastic-waste-crime.
117 Ellen MacArthur Foundation, "What Is a Circular Economy?" (2019). www.ellenmacarthurfoundation.org/circular-economy/concept.
118 Government of the Netherlands, "From a Linear to a Circular Economy" (2017). www.government.nl/topics/circular-economy/from-a-linear-to-a-circular-economy.

Exhibit 8: From a Linear to a Circular Economy



Source: Government of the Netherlands, "From a Linear to a Circular Economy" (2017). www.government.nl/topics/circular-economy/from-a-linear-to-a-circular-economy.

A report from the Ellen MacArthur Foundation stresses the importance of a circular economy as a fundamental step toward achieving climate targets.[119] To illustrate this potential, the paper argues that changes in the sources and use of energy could help halve the emissions associated with the production of goods; however, the other half of emissions comes from the use of materials, not energy. Applying circular economy strategies in just five key areas (cement, aluminium, steel, plastics, and food) can eliminate almost half of these remaining emissions. By 2050, the cumulative impact of these strategies would be equivalent to eliminating all current emissions from transport.[120]

The circular economy will also be covered in the section titled "Applying Material Environmental Factors to Financial Modeling, Ratio Analysis, and Risk Assessment."

3 SYSTEMIC RELATIONSHIPS BETWEEN BUSINESS ACTIVITIES AND ENVIRONMENTAL ISSUES

☐ **3.1.3** explain the systemic relationships between business activities and environmental issues, including systemic impact of climate risks on the financial system; climate-related physical and transition risks; the relationship between natural resources and business; supply, operational, and resource management issues; and supply chain transparency and traceability

Much of the understanding of key environmental factors with respect to business and investment centers on specific issues, such as climate change and unsustainable natural resource consumption and production, and on the negative impacts that businesses, consumption habits, and investment demand are having on the health of natural capital stocks. There is, however, less of an understanding of how businesses and financial activities depend on natural resources and properly functioning ecosystem services.

119 Ellen MacArthur Foundation, "Completing the Picture: How the Circular Economy Tackles Climate Change" (2019). www.ellenmacarthurfoundation.org/assets/downloads/Completing_The_Picture_How_The_Circular_Economy-_Tackles_Climate_Change_V3_26_September.pdf.
120 Ellen MacArthur Foundation, "Completing the Picture."

Due to the difficulty in valuing and measuring natural resources, these detrimental impacts have not been fully priced into the costs of doing business (also known as pricing "negative externalities"). If such costs were to be fully internalized by businesses or their investors, there could be significant market disruptions.

Systemic Risks to the Financial System: Physical and Transitional Risks

Over the last 20 years, environmental themes have become an increasingly important consideration of the business agenda. Of note is the growing appreciation of the **physical risks** of climate change, stemming from more frequent or severe weather events, such as flooding, droughts, and storms. The associated costs are rising: Inflation-adjusted losses from extreme weather events have increased fivefold in recent decades.[121] In 2020, Munich RE estimated such losses to be over US$200 billion (£143.8 billion), with both overall losses and insured losses significantly higher than in previous years. Losses from the historic wildfires in the western United States alone were estimated to be around US$16 billion (£11.5 billion), with a similar loss figure due to floods in China.[122]

In 2022, a report by Swiss Re estimated that flood losses represented a third of the estimated US$270 billion global economic damages from natural catastrophes (see Exhibit 9), with 75% of flood risks remaining uninsured.[123]

Exhibit 9: Total Economic and Insured Losses from Natural Catastrophes (US$ billion, 2021 prices)

	2021	2020	Annual change
Total losses	270	217	33%
Insured losses	111	90	23%

Source: Lucia Bevere, "Natural Catastrophes in 2021: The Flood Gates Are Open," Swiss Re Institute (30 March 2022). www.swissre.com/institute/research/sigma-research/sigma-2022-01.html.

Insurers and reinsurers are particularly exposed to these effects, across both sides of their balance sheet. Their investment assets can be impacted if, for example, storms and floods affect real estate in their portfolio. Their liabilities can be affected if extreme weather leads to increases in property insurance claims or extreme-weather-induced diseases and mortality lead to increases in life insurance claims.

As the Bank of England has noted, physical risks can have significant macroeconomic effects: "For instance, if weather-related damage leads to a fall in house prices (and so reduces the wealth of homeowners) then there could be a knock-on effect on overall spending in the economy."[124]

There are also company- and sector-level implications, given the supply chains of a globalized economy.

121 S. Breeden, "Avoiding the Storm: Climate Change and the Financial System," speech, Bank of England (15 April 2019). www.bankofengland.co.uk/-/media/boe/files/speech/2019/avoiding-the-storm-climate-change-and-the-financial-system-speech-by-sarah-breeden.pdf.
122 Munich RE, "Record Hurricane Season and Major Wildfires—The Natural Disaster Figures for 2020" (2020). www.munichre.com/en/company/media-relations/media-information-and-corporate-news/media-information/2021/2020-natural-disasters-balance.html.
123 Lucia Bevere, "Natural Catastrophes in 2021: The Flood Gates Are Open," Swiss Re Institute (30 March 2022). www.swissre.com/institute/research/sigma-research/sigma-2022-01.html.
124 Bank of England, "Climate Change: What Are the Risks to Financial Stability?" (2021). www.bankofengland.co.uk/knowledgebank/climate-change-what-are-the-risks-to-financial-stability.

CASE STUDIES

Thai Floods

In 2011, Thailand experienced its worst flooding in five decades, with US$45 billion (£32.4 billion) of economic damages, resulting in US$12 billion (£8.6 billion) in insurance claims. Although flooding is not uncommon in the region, the effects of the floods were felt across the globe: Over 10,000 factories of consumer goods, textiles, and automotive products had to close, disrupting the supply chain for such businesses as Sony, Nikon, and Honda, resulting in either reduced or delayed production. Many of these international businesses lodged contingent business interruption claims with their insurers and reinsurers, which cost Lloyd's of London US$2.2 billion (£1.6 billion).[125]

Occasionally, extreme weather events may lead not just to a hit to a company's finances but to full-scale bankruptcy.

CASE STUDIES

PG&E

In what has been described as "the first climate-change bankruptcy, probably not the last,"[126] in January 2019, the US power supplier PG&E filed for voluntary Chapter 11 bankruptcy protection, as a result of liabilities stemming from wildfires in northern California in 2017 and 2018. It claimed that it faced an estimated US$30 billion (£21.6 billion) liability for damages from wildfires during those two years, a sum that would exceed its insurance and assets.

Whereas physical risks stem primarily from inaction on climate change, there are also climate risks and trade-offs associated with action—the so-called **transitional risks**—as the world shifts toward a low-carbon economy. As the Bank of England has explained:

- *such transitions could mean that some sectors of the economy face big shifts in asset values or higher costs of doing business. It's not that policies stemming from deals like the Paris Climate Agreement are bad for our economy—in fact, the risk of delaying action altogether would be far worse. Rather, it's about the speed of transition to a greener economy—and how this affects certain sectors and financial stability.*
- *One example is energy companies. If government policies were to change in line with the Paris Agreement, then two thirds of the world's known fossil fuel reserves could not be burned. This could lead to changes in the value of investments held by banks and insurance companies in sectors like coal, oil and gas. The move towards a greener economy could also impact companies that produce cars, ships and planes, or use a lot of energy to make raw materials like steel and cement."*[127]

125 Prudential Regulation Authority, "The Impact of Climate Change on the UK Insurance Sector" (September 2015). www.bankofengland.co.uk/-/media/boe/files/prudential-regulation/publication/impact-of-climate-change-on-the-uk-insurance-sector.pdf.
126 R. Gold, "PG&E: The First Climate-Change Bankruptcy, Probably Not the Last," *Wall Street Journal* (18 January 2019). www.wsj.com/articles/pg-e-wildfires-and-the-first-climate-change-bankruptcy-11547820006.
127 Bank of England, "Climate Change."

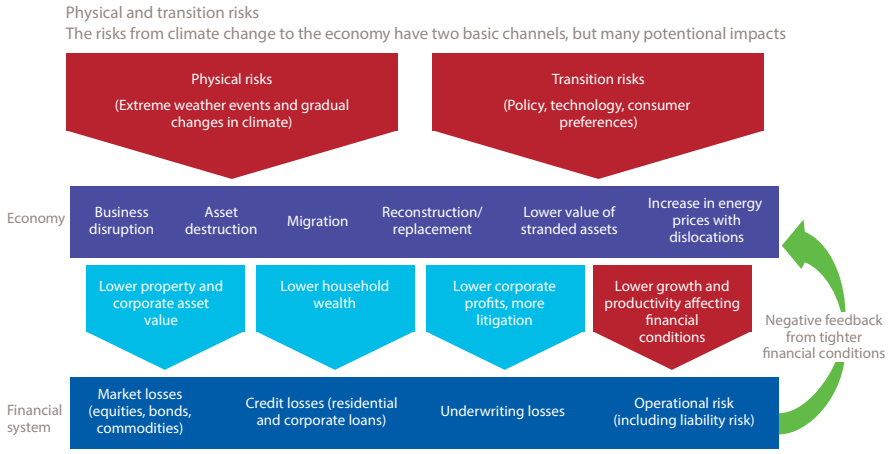
Transition risks are multiple in nature and include the following:

- policy risks, such as increased emission regulation and environmental standards,
- legal risks, such as lawsuits claiming damages from entities (corporations or sovereign states) believed to be liable for their contribution to climate change, and
- technology risks, such as low-carbon innovations disrupting established industries.

These risks are interlocking in nature and potentially have far-reaching impacts, which underscore their systemic relationship to business and financial activities. For example, a 2017 study from the Grantham Research Institute found that more than half of corporate bond purchases by the Bank of England and the European Central Bank (ECB) went to carbon-intensive sectors.[128] Such dependencies are increasingly being scrutinized by regulators, with the Bank for International Settlements—the "bank for central banks"—warning that climate change could "be the cause of the next systemic financial crisis."[129]

Exhibit 10 summarizes the main physical and transitional risks.

Exhibit 10: Risks to Financial Stability Due to Climate-Related Physical and Transition Risks



Source: International Monetary Fund, "Global Financial Stability Report: Lower for Longer," chapter 6 (October 2019). www.imf.org/en/Publications/GFSR/Issues/2019/10/01/global-financial-stability-report-october-2019.

The Relationship between Natural Resources and Business

In general, businesses and investment activities impact and depend on natural resources and ecosystem services in both direct and indirect ways.

128 S. Matikainen, E. Campiglio, and D. Zenghelis, "The Climate Impact of Quantitative Easing," Grantham Research Institute (30 May 2017). www.lse.ac.uk/granthaminstitute/publication/the-climate-impact-of-quantitative-easing/.

129 P. Bolton, M. Despres, L. A. Pereira Da Silva, F. Samama, and R. Svartzman, "The Green Swan: Central Banking and Financial Stability in the Age of Climate Change," Bank for International Settlements (January 2020). www.bis.org/publ/othp31.pdf.

The Global Reporting Initiative (GRI), which is a global sustainability reporting framework, explains the causes of direct and indirect impacts and dependencies of businesses on biodiversity resources.[130]

- A direct impact: An organization's activities directly affecting biodiversity—for example, when
  - degraded land is converted for the benefit of production activities,
  - surface water is used for irrigation purposes,
  - toxic materials are released, or
  - local species are disturbed through the noise and light produced at a processing site.
- An indirect impact: The impact is caused by parties in an organization's supply chain(s)—for example, when an organization imports fruits and vegetables, produces cotton shirts, sells construction materials, or publishes books, the production of the inputs for these goods will have indirect impacts on biodiversity.
- Indirect impacts can also include those from activities that have been triggered by the operations of the organization. For example, a road constructed to transport products from a forestry operation can have the indirect effect of stimulating the migration of workers to an unsettled region and encouraging new commercial development along the road.
- Indirect impacts may be relatively difficult to predict and manage, but they can be as significant as direct impacts and can easily affect an organization. Impacts on biodiversity can be either
  - negative (degrading the quality or quantity of biodiversity) or
  - positive (creating a net contribution to the quality or quantity of biodiversity).

Examples of sectors that rely significantly on natural resources and ecosystem services, with the potential to negatively affect biodiversity, include

- agriculture, aquaculture, fisheries, and food production,
- extractives, infrastructure, and activities or projects involving large-scale construction work,
- fast-moving consumer goods (FMCG) companies, primarily through the sourcing of raw materials in products,
- forestry (wood products, paper, fiber, and energy),
- pharmaceutical (in some cases),
- tourism and hospitality (in some cases), and
- utilities, including those involved in hydropower or open-cycle power plants generating significant thermal discharges.

Supply, Operational, and Resource Management Issues

Companies need to measure, manage, and disclose the environmental impact (both positive and negative) from their direct operations. Investors need to assess the extent to which companies understand the impact of their operations and manage resources that are material to their business.

130 Global Reporting Initiative, "Biodiversity: A GRI Reporting Resource" (2007).

Environmental impacts from direct operations can include

- toxic waste,
- water pollution,
- loss of biodiversity,
- deforestation,
- long-term damage to ecosystems,
- water scarcity,
- hazardous air emissions and high GHG emissions, and
- energy use.

Failure to address these challenges will expose businesses to additional risks, whereas working on solutions presents a business opportunity to develop climate-resilient business strategies. The previously described circular economy is a useful model for companies to assess and manage their operations and resource management.

The UK Government updated its Environmental Reporting Guidelines in March 2019, providing guidelines for businesses to measure and report their environmental impacts, including GHG emissions.[131] The guidelines emphasize the use of environmental key performance indicators (KPIs) to capture the link between environmental and financial performance.

In March 2019, the European Commission adopted the ambitious Circular Economy Action Plan to address the challenges of climate change and pressures on natural resources and ecosystems.[132] This was followed by European Commission guidelines under the Non-Financial Reporting Directive that introduced the concept of "double materiality"—in other words, asking companies to report both the impact of climate change on their activities and, conversely, the impact of a company's activities on climate change and the environment, stipulating that "companies should consider their whole value chain, both upstream in the supply chain and downstream."[133]

CASE STUDIES

Global Mining and Metals Sector

The global mining and metals sector has a considerable impact on the environment and the community in which it operates. In January 2019, Brazil's iron ore producer, Vale, experienced a deadly dam disaster, which resulted in the deaths of more than 250 people. The share price fell, wiping out BRL71.34 billion (£12.7 billion) in market value.[134]

131 Department for Environment, Food & Rural Affairs and Department for Business, Energy & Industrial Strategy, "Environmental Reporting Guidelines: Including Streamlined Energy and Carbon Reporting Requirements" (29 March 2019). www.gov.uk/government/publications/environmental-reporting-guidelines-including-mandatory-greenhouse-gas-emissions-reporting-guidance.

132 European Commission, "Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the Implementation of the Circular Economy Action Plan" (2019). https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52019DC0190&from=EN.

133 European Commission, "Guidelines on Reporting Climate-Related Information" (2019). https://ec.europa.eu/finance/docs/policy/190618-climate-related-information-reporting-guidelines_en.pdf.

134 P. Laier, "Vale Stock Plunges after Brazil Disaster; $19 Billion in Market Value Lost," Reuters (28 January 2019). www.reuters.com/article/us-vale-sa-disaster-stocks/vale-stock-plunges-after-brazil-disaster-19-billion-in-market-value-lost-idUSKCN1PM1JP.

The disaster followed a similar incident in 2015, with the industry's use of a particular structure for the storage of waste—tailings dams—being thrown into the spotlight. Credit (and ESG) rating agencies downgraded Vale, with a number of funds selling out of the company, including from the world's largest sovereign wealth fund.[135]

Recognizing the lack of transparency over the location and safety of such dams, a coalition of investors now representing over US$13 trillion (£9.3 trillion) in assets has written to over 700 extractive companies to call for investigations and reporting into this issue, with a view to the development of a global safety standard.

Environmental (and social) scrutiny of the mining and metals sector has been increasing; many of the world's largest mining companies "have some of the worst scores on sustainability ratings compiled by fund managers . . . as well as external consultants."[136] This reinforces the role of adequate management of supply chain and operational impact.

Supply Chain Transparency and Traceability

Supply chain sustainability is the management of ESG impacts and practices beyond the factory gates, looking at the broader life cycle of goods and services, particularly with regard to the sourcing of raw materials and components.[137] Supply chains are complex to understand due to the fact that they are heavily interdependent. As such, the relationships between products and services and environmental risk factors are intertwined across sectors and throughout every level of the supply chain. Companies are increasingly expected to understand, manage, and disclose their exposure to supply chain ESG risks or be left exposed to reputational, operational, and financial risks. As such, it is becoming increasingly important for investors to factor into their due diligence and active stewardship a stronger understanding of the supply chain management of their portfolio companies.

Addressing emissions in industry and the food system presents a particularly complex challenge. In industry, a growing demand for materials, coupled with a slow adoption rate of renewable electricity and incremental process improvements, makes it especially difficult to bring emissions down to net zero by 2050. In the food system, significantly reducing emissions will also be challenging and will require changing the consumption habits of billions of people, changing the production habits of hundreds of millions of producers, and decarbonizing long and complex food supply chains.

Traceability is a useful practice to identify and trace the history, distribution, location and application of products, parts, and materials. This ensures the reliability of sustainability claims in the areas of human rights, labor (including health and safety), the environment, and anti-corruption.[138]

135 G. Freitas and V. Andrade, "Brazil Ore, Power Giants Excluded from Norway's Wealth Fund," Bloomberg (13 May 2020). www.bloomberg.com/news/articles/2020-05-13/brazil-iron-ore-power-giants-excluded-from-norway-s-wealth-fund.

136 N. Hume and H. Sanderson, "Global Miners Count the Cost of Their Failings," *Financial Times* (15 February 2019). www.ft.com/content/66965d68-2bc2-11e9-88a4-c32129756dd8.

137 UN Global Compact, "Supply Chain Sustainability: A Practical Guide for Continuous Improvement: Second Edition" (2015). www.unglobalcompact.org/docs/issues_doc/supply_chain/SupplyChainRep_spread.pdf.

138 UN Global Compact and BSR, "A Guide to Traceability: A Practical Approach to Advance Sustainability in the Global Supply Chains" (2014). www.unglobalcompact.org/library/791.

In the context of environmental factors, GHG emissions in supply chains are estimated to be, on average, over five times as high as those from direct operations.[139]

Examples of sectors with particularly complex or high-risk supply chains include

- oil and gas,
- mining,
- beef,
- cocoa,
- cotton,
- fisheries,
- leather,
- palm oil,
- agriculture, and
- forestry.

It is therefore important for investors to understand key areas of environmental risks as a result of supply chain factors. Some of the main environmental risks in the supply chain are

- material toxicity and chemicals,
- raw material use,
- recyclability and end-of-life products,
- GHG emissions,
- energy use,
- water use and wastewater treatment,
- air pollution,
- biodiversity, and
- deforestation.

CASE STUDIES

Forest-Risk Commodities

Forests annually remove nearly one-third of emitted carbon dioxide[140] and are essential for meeting net-zero goals. Commodity production—mostly that of beef, palm oil, soy, and timber or pulp—is the leading cause of deforestation around the world, with significant amounts of financing devoted to these "forest-risk commodities." Trase Finance estimated that approximately US$1 trillion (£0.7 trillion) of investments are linked to deforestation, which are facing increased scrutiny from governments and civil society, bolstered by new data and tools (such as satellite monitoring). In 2020, the UK government announced that companies may face fines if they cannot demonstrate that their supply chains are free from illegal deforestation.

Investors have increased their engagement with relevant actors and begun to take action to address these risks. The Norwegian sovereign wealth fund has divested from over 30 palm oil companies, and a coalition of over 30 investors

139 CDP, "Global Supply Chain Report 2019" (2020). www.cdp.net/en/research/global-reports/global-supply-chain-report-2019.

140 Pierre Friedlingstein et al., "Global Carbon Budget 2021," *Earth System Science Data* 14 (26 April 2022): 1917–2005. https://essd.copernicus.org/articles/14/1917/2022/.

with over US$4 trillion (£2.9 trillion) in assets under management has threatened divestment from commodity producers—and even government bonds—due to their impact in accelerating deforestation in the Amazon.[141]

Yet, much remains to be done. The results from Global Canopy's latest annual survey of the 500 most influential companies and financial institutions in forest supply chains shows that 43% do not have deforestation commitments for any of the forest-risk commodities they are exposed to (63% among financial institutions), and US$2.7 trillion (£1.9 trillion) of financing in the most influential high-risk companies comes from Forest 500 financial institutions with no deforestation policy.[142] The think-tank Planet Tracker has estimated that deforestation risks are rising in exchange-traded funds (ETFs), according to its 2020 report "Exchange Traded Deforestation."[143]

Measurement, frameworks, and investor expectations around supply chains keep evolving. For example, in terms of GHG emissions, the initial focus has been on direct emissions from core operations (Scope 1 emissions) and purchased energy (Scope 2 emissions). However, there is increasing focus on how to measure and incorporate indirect emissions from the whole value chain, including those produced by suppliers and customers (Scope 3 emissions).

CASE STUDIES

Scope 3 in the Spotlight

For companies in certain industries, the greatest contribution to their overall carbon footprint comes from outside "the factory gates." In the case of the fossil fuel industry, for example, most emissions come not from the extraction and processing of coal, oil, and gas but from the use of such products by consumers in vehicles, power plants, and steel mills around the world. Although to some degree, the emissions associated with suppliers or consumers (Scope 3) are not under a company's complete control, they nonetheless represent a source of potential business risk: A low-cost oil producer that captured all the emissions from its operations may nevertheless find the market for its main product shrinking or even vanishing as consumers shift to electric vehicles, for example. To address this issue, there has been growing investor pressure for companies to tackle emissions along the value chain that may lie outside "the factory gates."

A growing number of companies are now setting targets to also reduce Scope 3 emissions—associated with the burning of fossil fuels by customers (for miners, such as BHP, Glencore, and Vale), with the production of parts and raw materials by suppliers (in the case of Volkswagen), or with indirect emissions associated with food production, including land-use changes (in the case of Danone).

141 Multiple sources:
Fitch Ratings, "Financial Sector Confronts Deforestation as a Key ESG Risk" (2020). www.fitchratings.com/site/re/10134822.
Trase Finance, "Trase Finance Brings Transparency to More than $1 Trillion in Deforestation Financing" (7 October 2020). https://medium.com/trase/trase-finance-brings-transparency-to-more-than-1-trillion-in-deforestation-financing-a7123a5157e8.
M. McGrath, "Climate Change: New UK Law to Curb Deforestation in Supply Chains," BBC News (25 August 2020). www.bbc.com/news/science-environment-53891421.
Margaryta Kirakosian, "$4.6tn Investor Group Meets Brazilian Congress on Deforestation Concerns," CityWire Selector (2020). https://citywireselector.com/news/4-6tn-investor-group-meets-brazilian-congress-on-deforestation-concerns/a1380621.
142 Forest 500, "Time for Change: Delivering Deforestation-Free Supply Chains" (2021). https://forest500.org/publications/time-change-delivering-deforestation-free-supply-chains.
143 Planet Tracker, "Exchange Traded Deforestation" (2020).

For more information on classification of corporate emissions, see the section titled "Assessment of Materiality of Environmental Issues" on carbon footprinting.

Investors should assess whether a company in their portfolio has policies and systems in place that

1. clearly explain the environmental (and social) requirements that suppliers are expected to meet via a procurement policy (such as a supplier code of conduct) and
2. enable it to assess environmental (and social) risks throughout its supply chain and discuss whether it has a mechanism in place to improve poor practices.

Achieving full transparency and traceability across all stages in a supply chain in order to undertake a complete assessment of a company's environmental risks is often complex. This is a result of multiple actors involved with different systems and requirements in a supply chain that are required to produce an end product, often across international borders.

Despite these challenges, attempting to conduct this full value chain analysis is important for investors to obtain an accurate picture of investee companies and for companies to ensure that their own policies are not undermined by actions taken elsewhere in their supply chain. For example, CDP estimates that while 71% of its partner companies have zero deforestation targets, only 27% of their suppliers had policies to match this ambition. Conversely, corporate buyers polled by CDP stated that suppliers showing environmental leadership were more competitive over the long term.[144] As such, investors should continue to collaborate with and demand greater transparency from both companies and governments.

144 CDP, "Changing the Chain: Global Supply Chain Report 2019/20" (2020). www.cdp.net/en/research/global-reports/changing-the-chain.

CASE STUDIES

Measurement Frameworks and Tools

Not-for-profit organizations offer measurement frameworks and tools that can help trace critical sustainability issues in company supply chains. These include the following:

- The Sustainability Consortium (TSC), which has built a set of performance indicators and a reporting system that highlights sustainability hotspots for more than 110 consumer product categories, covering 80%–90% of the impact of consumer products.
- The WWF offers more than 50 performance indicators for measuring the supply chain risks associated with the production of a range of commodities, as well as the probability and severity of those risks.
- CDP and the GRI have created standards and metrics for comparing different types of sustainability impact.
- The Sustainability Accounting Standards Board (SASB) has developed standards that help public companies in 11 sectors, including consumer goods, to give investors material information about corporate sustainability performance along the value chain.
- The EU Taxonomy and the Climate Bonds Sector Criteria provide sector-specific metrics and indicators to assess whether assets, projects, and activities in energy, transport, buildings, industry, agriculture and forestry, water and waste management, and so on, are compliant with the goals of the Paris Agreement.
- Transparency for Sustainable Economies (Trase), a partnership between the Stockholm Environment Institute and Global Canopy
- The Exploring Natural Capital Opportunities, Risks and Exposure (ENCORE) tool, an initiative of the UN Environment Programme World Conservation Monitoring Centre (WCMC), UN Environment Programme Finance Initiative, and Global Canopy
- The Terra Carta (Earth Charter), an initiative under the patronage of the Prince of Wales, providing a roadmap for business action on climate change and biodiversity

Companies and stakeholders in industries with complex supply chains, such as the agricultural and retail industries, have joined forces to build global multi-stakeholder initiatives in order to trace commodities collaboratively. Examples of global traceability schemes include the following:

- the **Forest Stewardship Council (FSC)**,
- the Marine Stewardship Council (MSC),
- **Roundtable on Sustainable Palm Oil (RSPO)**, and
- the Fairtrade Labelling Organizations International (FLO).

KEY "MEGATRENDS" AND DRIVERS INFLUENCING ENVIRONMENTAL CHANGE IN TERMS OF POTENTIAL IMPACT ON COMPANIES AND THEIR ENVIRONMENTAL PRACTICES

4

☐ **3.1.4** assess how megatrends influence environmental factors; environmental and climate policies; international climate and environmental agreements and conventions; international, regional, and country-level policy and initiatives; carbon pricing

Growth of Environmental and Climate Policies

There has been a considerable number of environmental and climate policies adopted in the last decade, with the majority coming from Europe. The Grantham Research Institute at the London School of Economics (LSE) undertook a global review and found that in 2017 there were approximately 1,400 climate change–relevant laws globally, a 20-fold increase over 20 years.[145] Since then, their number has only continued to increase: In January 2021, the Grantham Research Institute database counted a total of 2,092 climate laws and policies in countries across the globe.[146]

International Climate and Environmental Agreements and Conventions

International climate and environmental policy is particularly important in times of increasing globalization because many environmental problems, particularly climate change and loss of biodiversity, extend beyond national borders and can be solved only through international cooperation.

UN Framework Convention on Climate Change (1992)

The UN Framework Convention on Climate Change (UNFCCC) is the overarching international treaty relating to climate change. It set a general goal "to avoid dangerous anthropogenic interference with the climate system" and established the principle of "common but differentiated responsibilities" that distinguished responsibilities and obligations of developed and developing countries. All agreements including the legally binding Kyoto Protocol are protocols to this treaty. The UNFCCC secretariat is responsible for the annual Conference of the Parties established by the UNFCCC that are held each year so that national governments can evaluate progress and establish new goals, including the non-binding temperature limits established in 2015 in Paris at COP21.

145 M. Nachmany, S. Fankhauser, J. Setzer, and A. Averchenkova, "Global Trends in Climate Change Legislation and Litigation: 2017 Update," Grantham Research Institute (2017). http://eprints.lse.ac.uk/80447/.

146 Grantham Research Institute, "Climate Change Laws of the World" (2021). https://climate-laws.org/.

Kyoto Protocol (2005)

The Kyoto Protocol was adopted in 1997 and became effective in 2005 without US participation. It was the first international convention to set targets for emissions of the main GHGs:

1. CO_2,
2. methane (CH_4),
3. nitrous oxide (N_2O),
4. hydrofluorocarbons (HFCs),
5. perfluorocarbons (PFCs),
6. sulphur hexafluoride (SF_6), and
7. nitrogen trifluoride (NF_3).[147]

It established top-down, binding targets, but only for developed nations, recognizing the historical links between industrialization, economic development, and GHG emissions. The protocol's first commitment period began in 2008 and ended in 2012 but was subsequently extended to 2020. Negotiations on the measures to be taken after the second commitment period ends in 2020 resulted in the adoption of the Paris Agreement.

Paris Agreement (2015)

At the 21st Conference of the Parties to the UNFCCC in Paris in 2015 (COP21), a landmark agreement was reached to mobilize a global response to the threat of climate change in the form of the **Paris Agreement**.

The agreement's long-term goal is to keep the increase in global average temperature to well below 2°C (3.6°F) above pre-industrial levels and to limit the increase to 1.5°C (2.7°F), since this would substantially reduce the risks and effects of climate change.[148]

Although the Paris Agreement does not set any legally binding targets under international law, it serves as a significant landmark in tackling climate change on a global scale.

Nationally determined contributions (NDCs) are at the heart of the agreement.[149] Instead of top-down imposed contributions, they capture voluntary efforts by each country to reduce national emissions and adapt to the impacts of climate change, and they require every signatory (both developed and developing nations) to determine, plan, and report on its NDCs, with updates to commitments every five years. While commitments vary, they tend to fall in the 25%–30% range of GHG emissions (relative to 2005) by 2030. Unfortunately, many countries are not on track to achieving their targets, with existing NDCs estimated to be aligned with a dangerous trajectory of around 3°C (5.4°F) as of 2021.[150]

The deal has been formally endorsed by 191 nations, with only six parties to the UNFCCC that were not signatories to the agreement by February 2021.[151] However, the implementation of certain elements of the agreement—such as the development

147 United Nations Climate Change, "What Is the Kyoto Protocol?" (2021). https://unfccc.int/kyoto_protocol.
148 United Nations, "Paris Agreement."
149 United Nations Climate Change, "Nationally Determined Contributions (NDCs)" (2021). https://unfccc.int/process-and-meetings/the-paris-agreement/nationally-determined-contributions-ndcs/nationally-determined-contributions-ndcs.
150 Climate Action Tracker (2021). https://climateactiontracker.org/.
151 S. Apparicio and N. Sauer, "Which Countries Have Not Ratified the Paris Climate Agreement?" Climate Home News (13 August 2020). www.climatechangenews.com/2020/08/13/countries-yet-ratify-paris-agreement/.

of global carbon markets and the delivery of a proposed yearly US$100 billion (£71.9 billion) in climate finance—remains the subject of further negotiations under the UNFCCC.

Glasgow Climate Pact (2021)

The Glasgow Climate Pact[152] captures key outcomes of COP26 in Glasgow in 2021, marking the first time governments around the world were expected to announce their updated climate policies since the Paris Agreement.

As a diplomatic document, the Pact is notable for a commitment to phase down the use of unabated coal power and for the recognition of shorter-term emissions pathways (50% reduction in CO_2 emissions by 2030, net zero around mid-century) needed to reach the goal of limiting global warming to 1.5°C. The Glasgow Climate Pact has also seen progress made around carbon markets and other forms of international climate cooperation, including more stringent use around carbon offsetting and strengthened pledges from developed countries to increase the financing available for climate adaptation in emerging markets and to reduce the use of non-CO_2 GHGs—notably, methane.

In terms of aggregate impact, it is difficult to assess the outcomes of the Glasgow Climate Pact, because they involve a combination of individual NDCs submitted by countries via the formal UN process (pledges that only cover 5- or 10-year time frames, some of which are also conditional on access to development finance), as well as a swathe of longer-term unilateral and multilateral commitments (such as India's pledge to reach net zero by 2070 and the Global Methane Pledge made by over 100 countries).[153]

Analysis suggests that median projected levels of warming by 2100 would fall to around 2.4°C if all Glasgow NDCs were met, with the potential to reach 1.8°C if all other longer-term pledges were implemented on time.[154] Although compared to the policy trajectories before 2015, the Glasgow Climate Pact has potentially brought the Paris "well below 2°C" temperature goals within closer reach, the significant gaps and uncertainties surrounding the implementation and financing of policies still create the risk of missing the goals, potentially by a wide mark.

The following are other international agreements and frameworks that have impacted companies' environmental practices:

> The UN **Sustainable Development Goals (SDGs)** are a set of 17 global goals set in 2015 by the UN General Assembly seeking to address key global challenges, such as poverty, inequality, and climate change. Although primarily intended as a framework for government action, the SDGs are now regularly cited by corporate and investment actors as material to their business planning and operations. SDGs 7 (affordable and clean energy), 11 (sustainable cities and communities), 12 (responsible consumption and production), 13 (climate action), 14 (life below water), and 15 (life on land) are some of the most directly relevant to the environmental debate.

152 UNFCCC, "Glasgow Climate Pact" (2021). https://unfccc.int/documents/310475.

153 P. Forster, C. Smith, and J. Rogelj, "Guest Post: The Global Methane Pledge Needs to Go Further to Help Limit Warming to 1.5C," Carbon Brief (2 November 2021). www.carbonbrief.org/guest-post-the-global-methane-pledge-needs-to-go-further-to-help-limit-warming-to-1-5c.

154 Z. Hausfather and P. Forster, "Analysis: Do COP26 Promises Keep Global Warming below 2C?" Carbon Brief (10 November 2021). www.carbonbrief.org/analysis-do-cop26-promises-keep-global-warming-below-2c.

The **Kigali Amendment to the Montreal Protocol of 2016** is a global agreement to phase out the manufacture of hydrofluorocarbons. These gases were used in an attempt to replace ozone-depleting chemicals but have the downside of causing a potent warming effect on the planet.[155]

The **International Maritime Organization (IMO) 2020 Regulation** caps the maximum sulphur content in the fuel oil used by ships. Limiting sulphur oxide emissions, which contribute to air pollution and acid rain, is estimated to have a very positive impact on human health and the environment.[156]

CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation) is a UN mechanism designed by the UN International Civil Aviation Organization (ICAO) to help the aviation industry reach its aspirational goal to make all growth in international flights after 2020 carbon neutral, with airlines required to offset their emissions. The scheme is important because domestic aviation emissions are covered by the Paris Agreement, but international flights—which are responsible for around two-thirds of the CO_2 emissions from aviation—are under the remit of ICAO.[157]

International, Regional, and Country-Level Climate Policy and Initiatives

Over the last five years, there has been an acceleration in environmental and climate initiatives targeting the financial and business sector. The 2015 Paris Agreement has no doubt been the most instrumental driver in terms of bringing together all nations for a common cause to undertake ambitious efforts to combat climate change and adapt to its effects. It has also helped regulators and policymakers at national levels to take action.

Sustainable Finance in the EU

In December 2019, the European Union (EU) announced the **European Green Deal**, a plan to make the EU economy climate neutral by 2050 by boosting the efficient use of resources, restoring biodiversity, and cutting pollution. As part of this program, the EU has renewed its strategy focused on sustainable finance, whose main ambitions are as follows:

- **To reorient capital flows** by
  - establishing the following:
    - a classification system (taxonomy) for sustainable activities and
    - standards and labels for green bonds, benchmarks, and other financial products
  - increasing EU funding for sustainable projects
- **To mainstream sustainability into risk management** by efforts to incorporate sustainability into financial advice, credit ratings, and market research, as well as more technical proposals on the treatment of "green" assets in the capital requirements of banks and insurers (the so-called green supporting factor)

155 UNEP, "The Kigali Amendment to the Montreal Protocol: Another Global Commitment to Stop Climate Change" (8 December 2016). www.unenvironment.org/news-and-stories/news/kigali-amendment-montreal-protocol-another-global-commitment-stop-climate.

156 IMO, "IMO 2020—Cutting Sulphur Oxide Emissions" (2020). www.imo.org/en/MediaCentre/HotTopics/Pages/Sulphur-2020.aspx.

157 Note that, due to the impact of the pandemic, the emissions baseline was adjusted to 2019, not 2020. J. Timperley, "Corsia: The UN's Plan to 'Offset' Growth in Aviation Emissions," Carbon Brief (4 February 2019). www.carbonbrief.org/corsia-un-plan-to-offset-growth-in-aviation-emissions-after-2020.

- **To foster transparency and long-term thinking** by strengthening the disclosure requirements relating to sustainability (on both the financial industry and companies more broadly)[158]

These developments are intended to embed sustainability across the entire investment chain—from the owners of capital (such as pension funds and insurance companies) to the beneficiaries of capital (such as investee companies), as well as key intermediaries (banks, asset managers, financial advisers, consultants, and credit rating agencies).

EU Taxonomy

One of the most heavily debated topics in the investment community has been the EU taxonomy for sustainable activities. Approved by the EU Parliament in June 2020, the Taxonomy Regulation aims to significantly reduce the risk of green-washing financial products by providing a classification system to determine whether an economic activity is environmentally sustainable.[159] The taxonomy requires that economic activities make a substantial contribution to environmental objectives, do no significant harm to any other environmental objective, and comply with minimum social safeguards and the technical screening criteria (discussed below).

At a high level, inclusion in the taxonomy is restricted to activities that contribute to at least one of the six environmental objectives:

1. climate change mitigation,
2. climate change adaptation,
3. sustainable use of and protection of water and marine resources,
4. transition to a circular economy, waste prevention, and recycling;
5. pollution prevention and control, and
6. protection of healthy ecosystems.

Further delegated acts in 2021 and 2022 have provided further clarifications, including screening criteria around each of the objectives—for example, the levels of GHG emissions associated with the manufacture of certain technologies and energy usage requirements for the construction of new buildings.[160] The inclusion of specific nuclear and gas energy activities, approved in principle by the EU Commission in February 2022, has been the subject of ongoing controversy among EU member states, industry groups, and civil society.[161]

Under the taxonomy regulation, institutional investors and asset managers offering investment products labeled as environmentally sustainable would need to explain whether and how they have used the taxonomy criteria. This forms a part of the growing disclosure requirements for investors relating to sustainability.

Sustainability Disclosures

Two further significant EU developments include the **Sustainable Finance Disclosure Regulation (SFDR)** and the **Corporate Sustainability Reporting Directive (CSRD)**.

158 European Commission, "Renewed Sustainable Finance Strategy and Implementation of the Action Plan on Financing Sustainable Growth" (2020). https://ec.europa.eu/info/publications/sustainable-finance-renewed-strategy_en.

159 European Commission, "Sustainable Finance Taxonomy—Regulation (EU) 2020/852." https://ec.europa.eu/info/law/sustainable-finance-taxonomy-regulation-eu-2020-852_en.

160 European Commission, "EU Taxonomy for Sustainable Activities" (2022). https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en. See also European Commission, "Commission Delegated Regulation (EU) 2021/2139" (4 June 2021). https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32021R2139&from=EN.

161 BBC, "Climate Change: EU Moves to Label Nuclear and Gas as Sustainable Despite Internal Row" (2 February 2022). www.bbc.co.uk/news/world-europe-60229199.

Under SFDR, investors are required to provide more transparency around

- how the impacts of sustainability risks on their financial products are being systematically assessed (e.g., integrated into due diligence and research processes),
- how asset managers consider—and seek to address—the potentially negative implications of investment activities on sustainability factors, and
- products labeled with an explicit ESG focus.[162]

The SFDR introduces a categorization of the depth of ESG integration between so-called

- Article 6 products (which are not promoted as incorporating any ESG factors or objectives),
- Article 8 products (products claimed to promote environmental and social characteristics), and
- Article 9 products (products that have sustainable investment as an objective).

In October 2021, the final draft rules harmonizing disclosure requirements for financial products under SFDR and the Taxonomy Regulation were published by the European Supervisory Authorities, covering both pre-contractual and periodic disclosures.[163]

One challenge common to investors in meeting their obligations is the requirement for Article 8 and 9 funds, as of January 2022, to report the proportion of investments contributing to the first two objectives of the EU taxonomy. However, the companies (that in many cases represent a majority of the underlying holdings of these funds) are not required to report the alignment of their activities to the taxonomy until the following year.

The proposed Corporate Sustainability Reporting Directive (CSRD) would replace and strengthen the existing EU requirements around non-financial reporting, covering all large companies and all listed companies on EU-regulated markets (except for "micro-enterprises"). The companies in scope would have to report in line with upcoming EU sustainability reporting standards and have the resulting information audited and made available in a digital format to be incorporable into a "European Single Access Point" that aims to serve as a "one-stop-shop" for sustainability-related information regarding EU companies and investment products.[164]

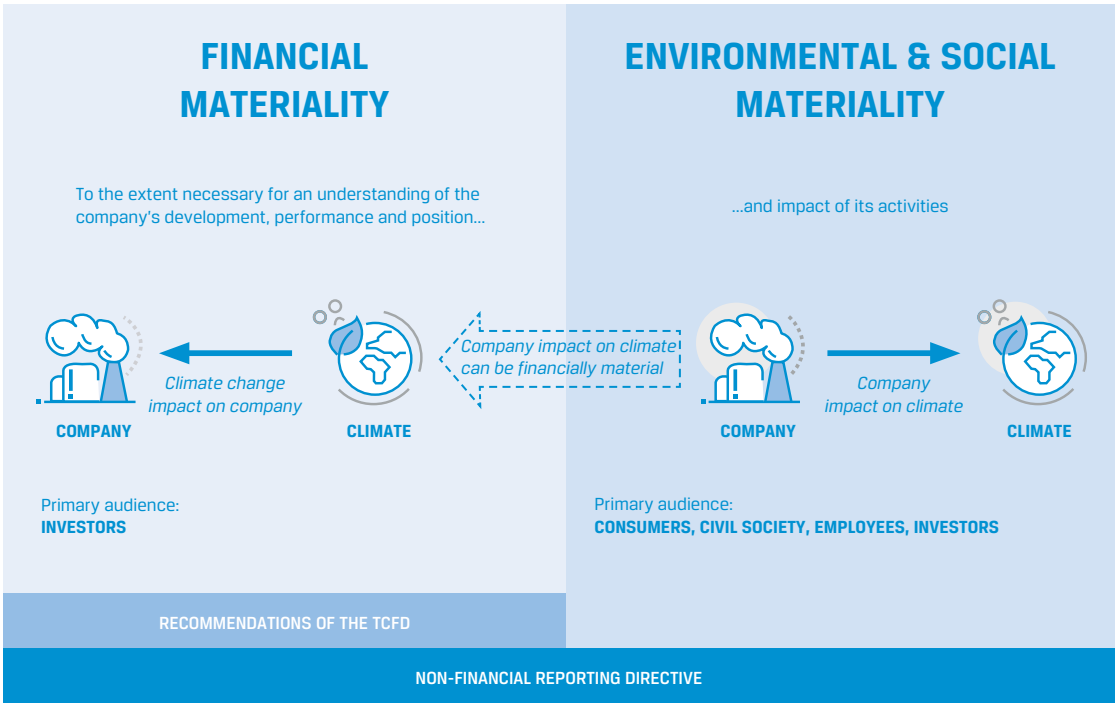
One notable concept gaining prominence in EU non-financial reporting rules is that of "double materiality,"—that is, the two-way impacts between companies and climate change, the environment, and society (see Exhibit 11). This extends the historical focus on the micro, company level (for example, understanding a company's energy usage as a proxy for future production costs) to a broader discussion of a company's role in the macroeconomic environment. At the same time, it renders more explicit the challenge of navigating multiple dimensions of sustainability (e.g., selecting among energy producers for lower-cost sources of energy may inadvertently favor companies in countries with a problematic record on human rights).

162 European Commission, "Regulation (EU) 2019/2088 of the European Parliament and of the Council of 27 November 2019 on Sustainability-Related Disclosures in the Financial Services Sector" (2019). http://data.europa.eu/eli/reg/2019/2088/oj.

163 Joint Committee of the European Supervisory Authorities, "Final Report on Draft Regulatory Technical Standards with Regard to the Content and Presentation of Disclosures Pursuant to Article 8(4), 9(6) and 11(5) of Regulation (EU) 2019/2088" (2021).

164 European Commission, "Questions and Answers: Corporate Sustainability Reporting Directive Proposal" (2021). https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_1806.

Exhibit 11: The Double Materiality Perspective in the Context of Reporting Climate-Related Information



* *Financial materiality is used here in the broad sense of affecting the value of the company, not just in the sense of affecting financial measures recognised in the financial statements.*

Note: TCFD recommendations are explained in the following section.

Source: European Commission.[165]

Climate Benchmarks

Another area of EU activity is the creation of **climate benchmarks**. Benchmarks play an important role in investments, serving—as their name suggests—as a comparator to measure the performance of investments (in the case of actively managed funds) or as a target for the construction of investment solutions, which aim to replicate (or "track") the composition of certain widely used benchmarks (e.g., stock market indexes, such as the FTSE 100 Index and S&P 500 Index, in the case of so-called passive, tracker, or index funds).

However, the most widely used benchmarks are primarily based on company size (at least for equities) and thus do not directly reflect low-carbon considerations in their methodologies. This raises the possibility that a significant and, given the rising share of assets managed under index strategies, growing portion of the investment universe might be pursuing environmentally unsustainable investment strategies. In fact, research suggests that "current benchmarks are likely to be more aligned with a 'business-as-usual' scenario, where temperature rises range from 4°C to 6°C (7.2°F to 10.8°F), leading to catastrophic damage to the earth."[166]

165 European Commission, "Guidelines on Reporting Climate-Related Information" (2019). https://ec.europa.eu/finance/docs/policy/190618-climate-related-information-reporting-guidelines_en.pdf.
166 EU Technical Expert Group on Sustainable Finance, "TEG Interim Report on Climate Benchmarks and Benchmarks' ESG Disclosures" (June 2019). https://ec.europa.eu/info/sites/info/files/business_economy_euro/banking_and_finance/documents/190618-sustainable-finance-teg-report-climate-benchmarks-and-disclosures_en.pdf.

Therefore, the EU has developed two types of climate benchmarks for equities and corporate bonds that aim to start with lower associated carbon emission intensity relative to their investable universe and then continually cut emission thresholds each year by at least 7%, in line with IPCC estimates for annual reductions necessary for a 1.5°C (2.7°F) temperature scenario.

The following are the two main categories of benchmarks:

1. **EU Paris-Aligned Benchmarks (EU PABs)**, which must
   - reduce carbon emission intensity by at least 50% in their starting year,
   - have a four-to-one ratio of "green" to "brown" investments relative to the investable universe, and
   - not invest in fossil fuels
2. **EU Climate Transition Benchmarks (EU CTBs)**, which require a 30% intensity reduction in the starting year and at least an equal green-to-brown ratio but permit fossil fuel investments as part of a transition process[167]

One of the main innovations in the EU climate benchmarks is the attempt to compare company performance relative to the absolute emission pathways necessary for the global economy to reach climate targets, rather than the more relative approaches that exist in the market (whereby, for example, a company may receive a positive score as long as its emission performance was better than its sector average). However, concerns have also been raised as to whether the proposed approach sufficiently encourages the decarbonization of the *real economy*, across sectors, as opposed to the reduction of *portfolio-level emissions* by overly focusing on the exclusion of high-carbon sectors and stocks.[168]

Further progress on developments from the European Commission's Sustainable Action Plan will continue to play a pivotal role in the development of EU and global markets toward greater harmonization through the International Platform on Sustainable Finance (IPSF), thereby influencing policy.[169]

Country-Level Policy and Prudential Actions

Some countries and regions are leading the way in influencing the regulatory framework to promote the economic and financial mainstreaming of climate change and environmental factors.

France

France's Energy Transition for Green Growth Law took effect in January 2016. It requires mandatory disclosures from major institutional investors around their exposure to climate risks and efforts to mitigate climate change.[170] Because the law explicitly targets institutional investors but not banks, it provided a control group for

167 EU Technical Expert Group on Sustainable Finance, "TEG Final Report on Climate Benchmarks and Benchmarks' ESG Disclosures" (September 2019). https://ec.europa.eu/info/sites/default/files/business_economy_euro/banking_and_finance/documents/190930-sustainable-finance-teg-final-report-climate-benchmarks-and-disclosures_en.pdf.

168 N. Amenc, F. Goltz, and V. Liu, "Doing Good or Feeling Good? Detecting Greenwashing in Climate Investing," EDHEC Business School (August 2021). www.edhec.edu/sites/www.edhec-portail.pprod.net/files/210921-1_doing_good_or_feeling_good.pdf.

See also I. Daramus and R. Ram, "The Tracking Error Error: Why Climate Alignment Calls for Bolder Steps" (2022). www.fulcrumasset.com/inst/uk/en/white-papers/the-tracking-error-error-why-climate-alignment-calls-for-bolder-steps./.

169 European Commission, "International Platform on Sustainable Finance" (2021). https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/international-platform-sustainable-finance_en.

170 Gouvernement.fr, "Energy Transition" (2015).

a kind of natural experiment; a 2021 report by the Banque de France found "evidence of a sharp relative decrease in holdings of fossil energy securities in the portfolios" of the investors affected by the law.[171]

The United Kingdom

In 2020, the UK government announced a 10-point plan for a green industrial revolution that aims to

- scale up low-carbon technologies and infrastructure,
- increase protections for biodiversity, and
- further the green finance agenda.[172]

An important element of the plan is a roadmap toward mandatory climate-related disclosures for UK companies, starting with large financial institutions and premium listed companies and then gradually widening the scope to other UK-registered companies and financial actors.[173]

This plan follows a growing focus on sustainability from the main financial supervisors in the United Kingdom. Note that the United Kingdom is the first to introduce mandatory climate disclosures based on TCFD.

The Prudential Regulation Authority (PRA) and the Financial Conduct Authority published separate consultations on climate change in 2018, which resulted in increased requirements for UK banks and insurers—notably, the introduction of a climate change **stress test** for their liabilities and investments to investigate the resilience of the financial system by testing the implications of high-impact climate change scenarios.[174]

This has elements of a precautionary approach, which focuses not on forecasts of plausibility but on avoidance of worst-case outcomes.

CASE STUDIES

The Precautionary Principle

The precautionary principle states that "if an action or policy has a suspected risk of causing severe harm to the public domain (affecting general health or the environment globally), the action should not be taken in the absence of scientific near-certainty about its safety." It is intended to provide a safeguard "in cases where the absence of evidence and the incompleteness of scientific knowledge carry profound implications and in the presence of risks of 'black swans,' unforeseen and unforeseeable events of extreme consequence."[175]

171 J.-S. Méssonier and B. Nguyen, "Showing Off Cleaner Hands: Mandatory Climate-Related Disclosure by Financial Institutions and the Financing of Fossil Energy" (2021). www.banque-france.fr/sites/default/files/medias/documents/wp800.pdf.

172 HM Government, "Policy Paper: The Ten Point Plan for a Green Industrial Revolution" (2020). www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution.

173 HM Treasury, "A Roadmap towards Mandatory Climate-Related Disclosures" (2020). https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/933783/FINAL_TCFD_ROADMAP.pdf.

174 Financial Conduct Authority, "FS19/6: Climate Change and Green Finance" (2018). www.fca.org.uk/publications/discussion-papers/dp18-8-climate-change-and-green-finance.
See also PRA, "Enhancing Banks' and Insurers' Approaches to Managing the Financial Risks from Climate Change" (2019). www.bankofengland.co.uk/prudential-regulation/publication/2018/enhancing-banks-and-insurers-approaches-to-managing-the-financial-risks-from-climate-change.

175 Nassim Nicholas Taleb, Rupert Read, Raphael Douady, Joseph Norman, and Yaneer Bar-Yam, "The Precautionary Principle (with Application to the Genetic Modification of Organisms)" (2014). https://arxiv.org/abs/1410.5787.
See also Joseph Norman, Rupert Read, Yaneer Bar-Yam, and Nassim Nicholas Taleb, "Climate Models and Precautionary Measures" (2015). https://fooledbyrandomness.com/climateletter.pdf.

It is impossible to predict with full certainty the future evolution of the global climate system. But this does not mean it is impossible to state whether certain interventions are likely to increase, rather than decrease, climate risks. Moreover, by the time climate damages are confirmed, it may be too late—hence the importance of precaution.

Environmental standards in certain jurisdictions, such as the EU, already embody elements of the precautionary principle. However, some have argued that financial authorities also "need to move towards precautionary approaches to maintaining the safety and soundness of the financial system. Precautionary policy prioritises preventative action and a qualitative approach to managing risk above quantitative measurement and information disclosure. It aims to steer away from tipping points and build system resilience as a superior means of managing radical uncertainty."[176]

One notable area where precaution is a legal requirement concerns the duties of pension fund trustees.[177] Bound to act in the best interest of their beneficiaries, trustees in a number of jurisdictions are expected to act "as a prudent person acting in a like capacity would . . . in the conduct of an enterprise of like character and aims."[178] The implications of these duties with regard to, for example, the fossil fuel investments of pension funds have been the subject of significant debate in recent years.

Regulation is also increasing for pension funds, with successive clarifications from the United Kingdom's policymakers that ESG and climate considerations can have material financial impacts and therefore are not "to do with personal ethics, or optional extras,"[179] but fall within the remit of the risks that must be monitored and addressed by pension trustees as part of their investment duties.

The Pensions Regulator (TPR) in the United Kingdom has issued guidance to pension funds relating to ESG issues and climate change along similar lines. Since 1 October 2020, trustees of defined contribution (DC) pension schemes will be required to produce an implementation report setting out how they acted on the principles set out in the statement of investment principles. In February 2021, amendments to the **Pensions Schemes Act** required UK pension schemes, among increased climate requirements, to consider "the steps that might be taken for the purpose of achieving the Paris Agreement goal."[180]

In 2021, the UK government unveiled "Greening Finance: A Roadmap to Sustainable Investment,"[181] which detailed several policy areas, including the following:

- New disclosure requirements for corporates, asset managers, asset owners, and investment products, aligned with the recommendations of the TCFD and ISSB (discussed in the next section)
- The establishment of a "UK Green Taxonomy" of sustainable activities

176 K. Kedward, J. Ryan-Collins, and H. Chenet, "Managing Nature-Related Financial Risks: A Precautionary Policy Approach for Central Banks and Financial Supervisors," UCL Institute for Innovation and Public Purpose (18 August 2020). www.ucl.ac.uk/bartlett/public-purpose/wp2020-09.
177 I. S. Daramus, "Liability and Precaution," *Environment: Science and Policy for Sustainable Development* 59 (18 August 2017): 48–56. https://doi.org/10.1080/00139157.2017.1350012.
178 R. Galer, "'Prudent Person Rule' Standard for the Investment of Pension Fund Assets" (2021). www.oecd.org/finance/private-pensions/2763540.pdf.
179 Department of Work and Pension, "Consultation Outcome: Pension Trustees: Clarifying and Strengthening Investment Duties" (2018). www.gov.uk/government/consultations/pension-trustees-clarifying-and-strengthening-investment-duties.
180 UK Government, "Pension Schemes Act 2021" (2021). www.legislation.gov.uk/ukpga/2021/1/section/124/enacted.
181 HM Government, "Greening Finance: A Roadmap to Sustainable Investment" (2021). www.gov.uk/government/publications/greening-finance-a-roadmap-to-sustainable-investing.

The United States

The United States has historically had a more conservative stance on this issue compared to the United Kingdom and the EU. Notably, there has been ongoing debate (and successive policy shifts) as to whether trustees may, may not, or should consider ESG and climate factors in the management of their investments. Under the different administrations since 2015, the US Department of Labor's (DOL's) guidance on the issue has varied, and it is currently once more subject to review. Much of the discussion focuses on the extent to which the incorporation of ESG issues can be interpreted as prioritizing non-financial objectives (such as the pursuit of social and policy goals) over the long-term financial security of retirees. Recognizing the evolution of ESG investing, feedback from market participants in response to a DOL consultation in 2019 overwhelmingly stressed the financial materiality of ESG factors.[182]

In 2021, the Federal Reserve launched a Financial Stability Climate Committee and a Supervision Climate Committee to investigate the micro- and macro-prudential implications of climate change, respectively,[183] including the possibility of "climate stress testing" (see also the subsequent section on NGFS).

In 2022, the Securities and Exchange Commission (SEC) unveiled proposals[184] to require companies to report on

- the governance and impacts of climate-related risks,
- GHG emissions (Scope 1, Scope 2, and, where material, Scope 3 emissions) and other climate-related financial statement metrics, some of which would need to be subject to audit/assurance, and
- climate-related targets and goals and transition plans, if any.

China

Reckoning with the climate costs associated with decades of explosive economic growth, China's policymakers have begun combining its global leadership position on renewable energy with a greater desire for its financial system to address environmental issues. China is the world's largest manufacturer of solar cells, lithium-ion batteries, and electric vehicles, and these are areas of clear policy priority.[185] In 2020 alone, China doubled its construction of new wind and solar power plants compared to the previous year.[186] It remains the country with the highest levels of investment in the low-carbon energy transition and the highest absolute GHG emissions (see Exhibit 12).

182 T. Quinson, "Biden Administration Considers Reversing Trump's ESG Rule Change," Bloomberg (20 January 2021). www.bloomberg.com/news/articles/2021-01-20/biden-administration-considers-reversing-trump-s-esg-rule-change.

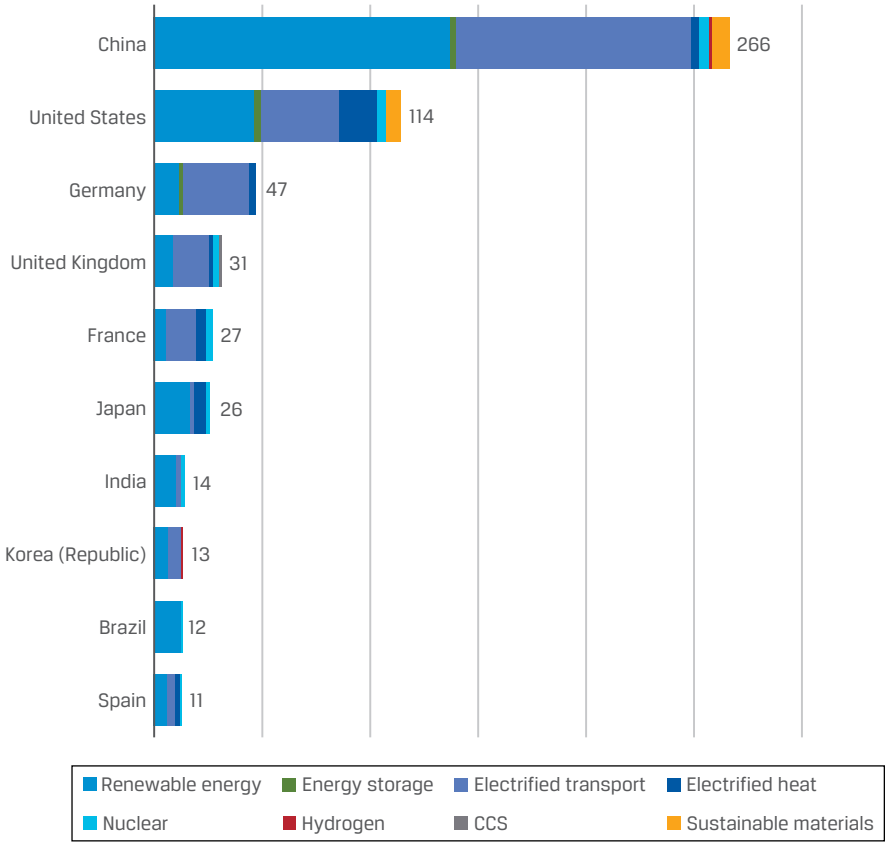
183 L. Brainard, "Financial Stability Implications of Climate Change" (2021). www.federalreserve.gov/newsevents/speech/brainard20210323a.htm.

184 Securities and Exchange Commission, "SEC Proposes Rules to Enhance and Standardize Climate-Related Disclosures for Investors" (2022). www.sec.gov/news/press-release/2022-46.

185 BloombergNEF, "China's Accelerated Decarbonization: Economic Benefits" (2020). https://assets.bbhub.io/professional/sites/24/BNEF-Chinas-Accelerated-Decarbonization-Pathways_12012020_FINAL.pdf.

186 J. Murtaugh, "China Blows Past Clean Energy Record with Wind Capacity Jump," Bloomberg (20 January 2021). www.bloomberg.com/news/articles/2021-01-20/china-blows-past-clean-energy-record-with-extra-wind-capacity.

Exhibit 12: Global Investment in Energy Transition by Country (2021, $ billions)



Source: BloombergNEF, "Energy Transition Investment Trends 2022" (2022). https://assets.bbhub.io/professional/sites/24/Energy-Transition-Investment-Trends-Exec-Summary-2022.pdf.

At the UN General Assembly in 2020, China's policymakers committed to have the country's CO_2 emissions peak before the year 2030, and in 2021 China published its roadmap to net-zero carbon by 2060. This was followed by an action plan for peak emissions, released a year later by the State Council.[187] More efforts to further embed environmental considerations into the economy are underway, with the rollout of a national carbon market and China's seven ministerial agencies, including the central bank, having previously indicated their support for institutional investors to perform environmental stress tests and for mandatory environmental disclosures for issuers of public debt and equity.[188]

The country's policymakers are increasingly engaging with international counterparts on issues pertaining to green finance and the green taxonomy. The country's green bond market is now the world's largest, but it has faced barriers regarding investor access and lack of international harmonization. Regulators announced they will exclude fossil fuel projects from their green bonds taxonomy, bringing the country closer to international practice.[189]

187 State Council of the People's Republic of China, "Full Text: Action Plan for Carbon Dioxide Peaking Before 2030" (2021). english.www.gov.cn/policies/latestreleases/202110/27/content_WS6178a47ec6d0df57f98e3dfb.html.

188 J. Ma, "Ma Jun on the Importance of Environmental Risk Analysis to Financial Institutions" (2017). www.climatebonds.net/files/files/Ma_Jun_Speech_17_07_17.pdf.

189 L. Fatin, "China's Top Regulators Announce They Will Exclude Fossil Fuels from Their Green Bonds Taxonomy. It's a Major Development!" Climate Bonds Initiative (10 June 2020). www.climatebonds.net/2020/06/chinas-top-regulators-announce-they-will-exclude-fossil-fuels-their-green-bonds-taxonomy-it.

India

The growing focus of financial regulators on environmental risks is reverberating in other Asian countries, too. In 2021, the Securities and Exchange Board of India strengthened and extended disclosure requirements, now covering the 1,000 largest listed companies, which are to report on certain social and sustainability aspects of their businesses.[190] India's central bank also published a study in 2020 arguing that climate change can exacerbate food price inflation, and the country also is host to one of the largest green bond markets among emerging markets.[191]

Japan

Japan has now committed to net-zero GHG emissions by 2050,[192] with multiple policy workstreams, including a new clean energy strategy expected in 2022, the development of a "Sustainability Standards Board of Japan" to systematize corporate disclosure in this area,[193] and the introduction of climate "stress testing" in the banking sector.[194]

Australia

The Australian Securities and Investments Commission is consulting on proposals to develop mandatory climate reporting rules and will investigate potential "greenwashing" with regard to ESG- or green-labeled financial products.[195]

As the science on climate change and its impact on the environment continues to improve and become more sophisticated, it would be reasonable to expect these issues to expand the agenda of financial regulators and policymakers. These are likely to have important implications for economic, financial, and business policies.

Task Force on Climate-Related Financial Disclosures

The most influential international framework for disclosure of climate change risks and opportunities affecting companies and financial institutions is the framework from the **Task Force on Climate-Related Financial Disclosures (TCFD)**.[196]

The TCFD was launched in 2015 following a request from the G20 countries' finance ministers and central bank governors for the Financial Stability Board—the organization that coordinates the work of national financial supervisors and international standard-setting bodies—to investigate the risks of climate change for the stability of the financial system and the appropriate response.

The TCFD set out to provide a set of recommendations and a framework for companies and financial institutions to provide better information to support investors, lenders, insurers, and other financial stakeholders to identify, build, and quantify climate-related risks and opportunities in their decisions. The TCFD also took the view that better information will help investors engage with companies on the resilience

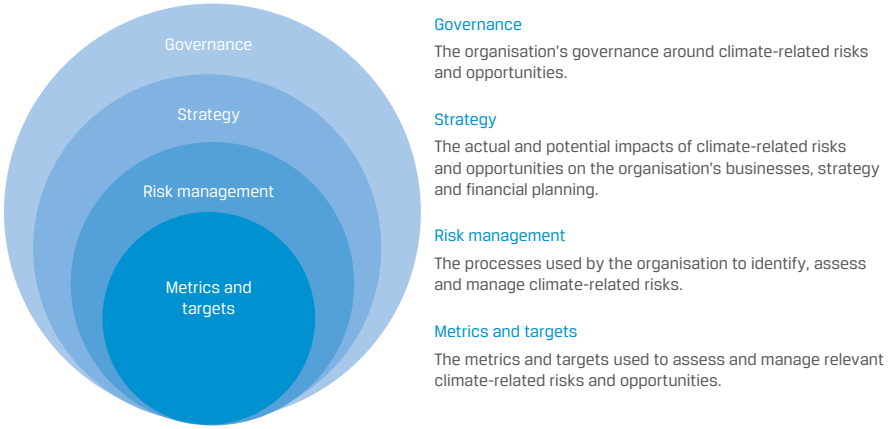
190 Securities and Exchange Board of India, "SEBI Issues Circular on 'Business Responsibility and Sustainability Reporting by Listed Entities" (2021). www.sebi.gov.in/media/press-releases/may-2021/sebi-issues-circular-on-business-responsibility-and-sustainability-reporting-by-listed-entities-_50097.html.
191 S. Tandon, "What Next for Sustainable Finance in India?" Grantham Research Institute (2020). www.lse.ac.uk/granthaminstitute/news/what-next-for-sustainable-finance-in-india/.
192 E. Lies, "Japan Aims for Zero Emissions, Carbon Neutral Society by 2050—PM," Reuters (26 October2020). www.reuters.com/article/uk-japan-politics-suga/japan-aims-for-zero-emissions-carbon-neutral-society-by-2050-pm-idUKKBN27B0C7?edition-redirect=ca.
193 Financial Accounting Standards Foundation, "Establishment of the Sustainability Standards Board of Japan (SSBJ) and Formation of the SSBJ Preparation Committee" (2021).
194 E. Milburn, "Japanese Regulator Gears Up for Climate Scenario Analysis Pilot for Banks," Responsible Investor (3 September 2020). www.responsible-investor.com/articles/japanese-regulator-gears-up-for-climate-scenario-analysis-pilot-for-banks.
195 Australian Securities and Investments Commission, "ASIC's Corporate Governance Priorities and the Year Ahead" (2022). https://asic.gov.au/about-asic/news-centre/speeches/asic-s-corporate-governance-priorities-and-the-year-ahead/.
196 TCFD, "Task Force on Climate-Related Financial Disclosures" (2020). www.fsb-tcfd.org.

of their strategies and capital spending, including more efficient allocation of capital, which should help promote a smooth transition to a more sustainable, low-carbon economy.

In July 2017, the TCFD published its final recommendations for how companies should report, structured around four thematic areas (see Exhibit 13):

1. governance,
2. strategy,
3. risk management, and
4. metrics and targets.

Exhibit 13: TCFD Core Elements of Climate-Related Financial Disclosures



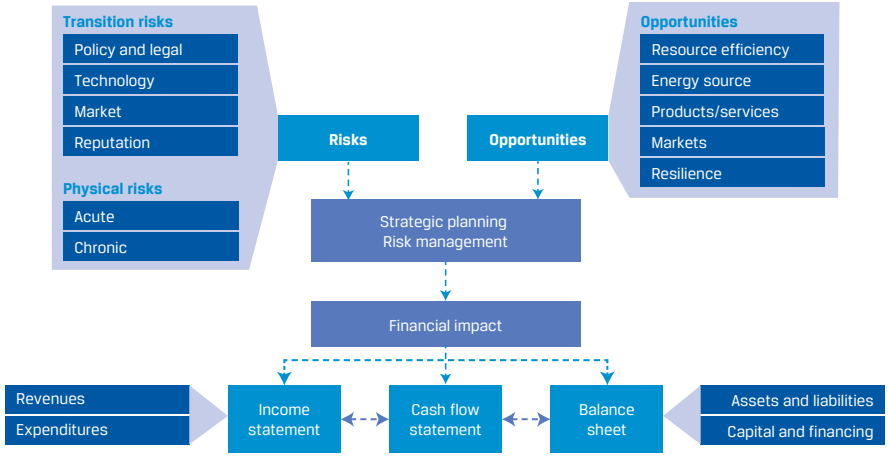
Source: TCFD, "Final Report: Recommendations of the Task Force on Climate-Related Financial Disclosures" (2017). https://assets.bbhub.io/company/sites/60/2020/10/FINAL-2017-TCFD-Report-11052018.pdf.

The work of the TCFD introduced the influential classification of climate-related risks into physical and transition risks, recommending that companies report on both of these dimensions. One notable recommendation was the use of climate scenario analysis (which will be considered in more detail in the section titled "Assessment of Materiality of Environmental Issues."

A growing number of public and private sector organizations are showing their support for the TCFD recommendations, including over 1,300 companies with a total market capitalization of US$12.6 trillion (£9.1 trillion) and financial institutions responsible for assets of US$150 trillion (£107.8 trillion). Although initially intended as guidelines for voluntary reporting, some jurisdictions, including the United Kingdom, the EU, and New Zealand, have announced policies requiring TCFD-aligned disclosures.[197] Exhibit 14 illustrates climate-related risks, opportunities, and financial impact.

197 TCFD, "2020 Status Report" (2020). www.fsb.org/wp-content/uploads/P291020-1.pdf.

Exhibit 14: Climate-Related Risks, Opportunities, and Financial Impact According to TCFD



Source: TCFD, "Final Report: Recommendations of the Task Force on Climate-Related Financial Disclosures."

Network for Greening the Financial System

A notable related initiative is the **Network for Greening the Financial System (NGFS)**, comprising over 70 central banks and financial supervisors. It was set up to strengthen the global response required to meet the goals of the Paris Agreement and to enhance the role of the financial system to manage risks and to mobilize capital for green and low-carbon investments in the broader context of environmentally sustainable development. The NGFS has developed technical guidance—including publishing a set of climate scenarios—for the regulatory supervision of climate risks.[198] Elements of NGFS guidance for supervisors are increasingly being transposed into national or supranational regulation—most notably, the introduction of "climate stress tests" for banks and other financial institutions by the likes of the European Central Bank (ECB),[199] the Hong Kong Monetary Authority (HKMA), the Brazilian central bank, and other regulators.[200]

Carbon Pricing

There is a growing consensus among governments, the financial community, and businesses on the fundamental role of carbon pricing in the transition to a decarbonized economy. Putting a price on carbon emissions is viewed as one of the most effective methods of tackling climate change; it is often called the **polluter pays principle**.

There are many types of carbon pricing; the most common are the **emission trading system (ETS)** and **carbon taxes**, roughly corresponding to quotas and tariffs in international trade.

198 Network for Greening the Financial System, "NGFS Climate Scenarios for Central Banks and Supervisors" (2020). www.ngfs.net/sites/default/files/medias/documents/820184_ngfs_scenarios_final_version_v6.pdf.
199 European Central Bank, "ECB Economy-Wide Climate Stress Test: Methodology and Results" (2022). www.ecb.europa.eu/pub/pdf/scpops/ecb.op281~05a7735b1c.en.pdf.
200 NGFS, "Progress Report on the Guide for Supervisors" (2022). www.ngfs.net/sites/default/files/progress_report_on_the_guide_for_supervisors_0.pdf.

Emission Trading System

An ETS is a system based on the exchange of permits for emission units, where actors that exceed their emission limits are required to buy permits from those that have emitted less. The overall quantity of emissions is fixed, and market mechanisms are used to set their price.

In theory, this system creates an economic incentive for emission reductions to occur at the point of least cost; rather than mandating similar levels of reductions for all actors, price discovery helps reward those that can afford to reduce more.

The effectiveness in practice, however, depends crucially on the design of the ETS. If the scheme is too restrictive, it may encourage the offshoring of industries to jurisdictions with fewer constraints (a phenomenon known as "carbon leakage") and thus fail to reduce emissions. As a result, free allocation of allowances (to give industry an initial "buffer") has been a widely used feature of ETSs,[201] although in some cases, overallocation resulted in the price of an emission unit being too low to properly incentivize decarbonization.

Carbon Taxation

Carbon taxation takes a different approach by directly setting an explicit price for GHG emissions (e.g., per tonne of CO_2). This has the advantage of predictability, although the carbon tax rate, alongside the elasticity of demand for different products and the extent to which companies can pass on the carbon costs to their end consumers, will be key a determinant of effectiveness. It has been estimated that an explicit global carbon price of US$40 to US$80 (£29 to £58) per tCO_2 in the 2020s, more than doubling to US$50 to US$100 (£36 to £72) per tCO_2 by 2030, is required to meet the goals of the Paris Agreement.[202] This price is substantially higher than the current global average price, which the International Monetary Fund has estimated is US$2 (£1.4) per tCO_2.[203]

Carbon pricing and the trading of emission trading certificates began trial use in the United Kingdom in the early 2000s, a process that contributed substantially to the swift displacement of coal in the United Kingdom's electricity mix (which provided less than 1% of electricity in 2020,[204] compared to 40% as recently as 2012).[205] The EU subsequently adopted emission trading as one of its flagship climate policies with the establishment of the EU ETS in 2005. It covers the main energy and carbon-intensive industries, regulating about half the European economy with a carbon price. The EU carbon price has been rising in recent years, reaching an average of €53 (and a high of €89) per tCO_2 in 2021.[206] The EU ETS is undergoing significant developments—including plans to establish a "carbon border adjustment mechanism" that will seek to level the playing field with imported goods that do not face similar carbon costs in the country of origin.[207]

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201 International Energy Agency, "Implementing Effective Emissions Trading Systems" (2020). www.iea.org/reports/implementing-effective-emissions-trading-systems.

202 Carbon Pricing Leadership Coalition, "Report of the High-Level Commission on Carbon Prices: Executive Summary" (2017). https://static1.squarespace.com/static/54ff9c5ce4b0a53decccfb4c/t/59b7f26b3c91f1bb0de2e41a/1505227373770/CarbonPricing_EnglishSummary.pdf.

203 World Bank, "State and Trends of Carbon Pricing 2021" (2021). https://openknowledge.worldbank.org/handle/10986/35620.

204 Department for Business, Energy & Industrial Strategy, "Energy Trends: December 2020" (2020). www.gov.uk/government/statistics/energy-trends-december-2020.

205 S. Evans, "Countdown to 2025: Tracking the UK Coal Phase Out," Carbon Brief (10 February 2016). www.carbonbrief.org/countdown-to-2025-tracking-the-uk-coal-phase-out.

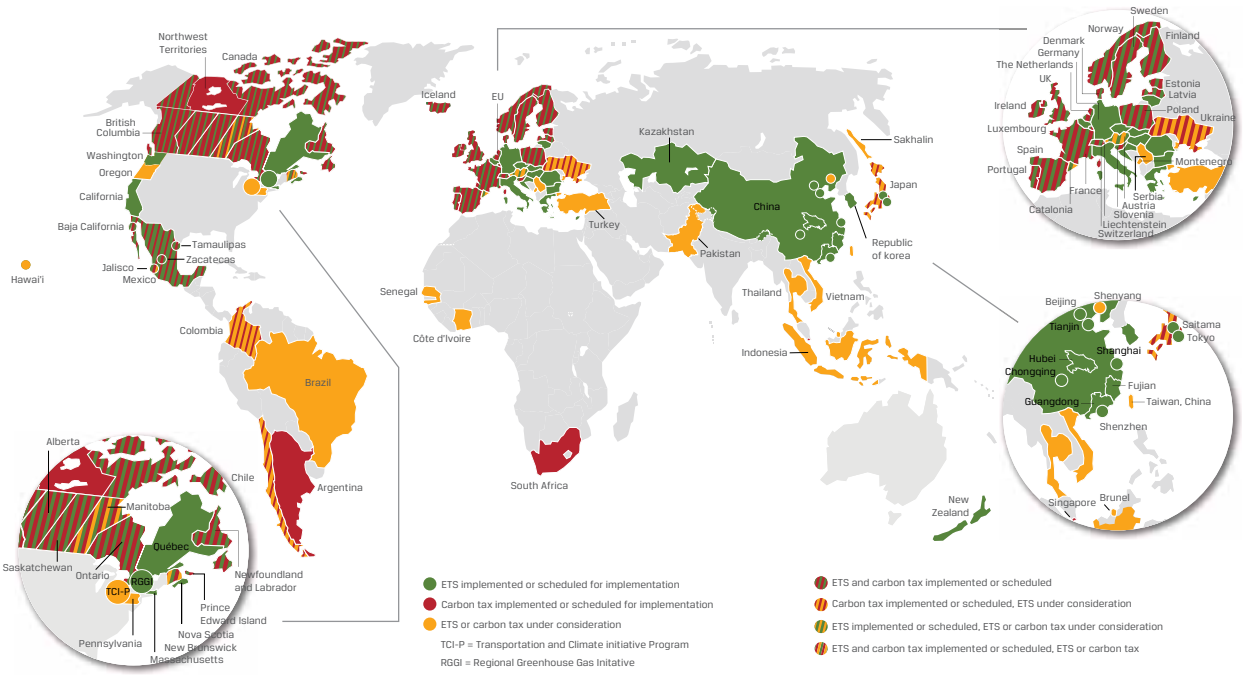
206 Ember, "EU Carbon Price Tracker" (2022). https://ember-climate.org/data/carbon-price-viewer/.

207 European Council, "Council Agrees on the Carbon Border Adjustment Mechanism (CBAM)" (2022). www.consilium.europa.eu/en/press/press-releases/2022/03/15/carbon-border-adjustment-mechanism-cbam-council-agrees-its-negotiating-mandate/.

The growth of national and international carbon markets since then has been steady but sporadic, with growth in such regions as the East Coast and West Coast of the United States, New Zealand, South Korea, and some Canadian provinces. In early 2021, China launched its national ETS, becoming the world's largest carbon market, superseding the EU ETS.

Overall, as of 2021, there were 65 carbon pricing initiatives implemented or scheduled—split roughly equally between carbon taxation (35) and ETS mechanisms (30). They cover approximately 22% of global GHG emissions and are responsible for raising US$53 billion (£40 billion) in revenues.[208]Exhibit 15 provides an overview of carbon markets around the world.

Exhibit 15: Carbon Markets around the World



Source: World Bank, "State and Trends of Carbon Pricing 2021."

Over the last 10 years, many companies—especially in energy-intensive sectors—have used the practice of shadow carbon pricing to guide their decision-making process. An internal or shadow price on carbon creates a theoretical or assumed cost per ton of carbon emissions. For example, the large oil company BP uses a price assumption of a US$100/te$CO_2$ by 2030[209] to better understand the potential impact of future climate regulation on the profitability of a project, a new business model, or an investment. Its use reveals hidden risks and enables businesses to build this factor into future valuations and estimates of capital expenditure. In addition, when emissions bear a cost in profit-and-loss statements, it helps uncover inefficiencies and incentivize low-carbon innovation within departments, cutting a company's energy use and carbon pollution.

208 World Bank, "State and Trends of Carbon Pricing 2021."

209 BP, "Progressing Strategy Development, BP Revises Long-Term Price Assumptions, Reviews Intangible Assets and, as a Result, Expects Non-Cash Impairments and Write-Offs," press release (15 June 2020). www.bp.com/en/global/corporate/news-and-insights/press-releases/bp-revises-long-term-price-assumptions.html.

Some governments are using internal carbon pricing as a tool in their procurement process, policy design, and project assessments in relation to climate change impacts. More recently, financial institutions have also begun using internal carbon pricing to assess their project portfolio. In 2019, approximately 1,600 companies—including more than 100 Fortune Global 500 companies, with a total annual revenue of about US$7 trillion (£5 trillion)—reported that they are currently using an internal price on carbon or plan to do so in the next two years.[210]

Carbon Offsetting

A concept that runs through different aspects of carbon markets is that of offsetting—the extent to which an activity providing an emission reduction in one part of the economy may be seen as compensating for the emission of greenhouse gases elsewhere.

The need for offsetting can be justified by the fact that, in a majority of scenarios compliant with the goals of the Paris Agreement, the world does not reach zero *absolute* GHG emissions in the next few decades—with some residual emissions being balanced out by natural or artificial "carbon sinks" (e.g., tree planting).[211] As such, companies or countries that are unable to reduce their emissions organically may require some accounting mechanism through which they can compensate those actors that are contributing *negative* emissions, in order for the global system to reach *net* zero.

However, there are substantial challenges around offsetting, because this market comprises both voluntary and regulated aspects, with uneven levels of transparency and scientific rigor. Part of the challenge stems from the *counterfactual* nature of offsetting and the risk of claiming credits for emission reductions that would have happened anyway, even if a given offset was not purchased (e.g., compensating a farmer to maintain a forest when the farmer had no intention of cutting it down in the first place), or that have not happened yet (e.g., netting present emissions against the *future* carbon sequestered by a newly planted tree over its lifetime). Additional complexities stem from how to account for carbon credits across jurisdictions and over time (i.e., should overachievement *in the past* allow actors to reduce their emission targets in the future?).

One of the positive outcomes of COP26 has been progress around carbon markets and international cooperation (Article 6 of the Paris Agreement), by introducing more stringent rules around the use of past credits, adjustments to avoid double counting of reductions, and restrictions around what projects are eligible to count as a genuine offset.[212]

5 ASSESSMENT OF MATERIALITY OF ENVIRONMENTAL ISSUES

☐ **3.1.5** assess material impacts of environmental issues on potential investment opportunities, corporate and project finance, public finance initiatives, and asset management

210 World Bank, "State and Trends of Carbon Pricing 2021."

211 Projected median GHG emissions across 1.5°C scenarios, both with and without "overshoot," range between 9 and 14 in scenarios from p. 63 of IPCC, "Climate Change 2022: Mitigation of Climate Change: Summary for Policymakers."

212 Simon Evans, Josh Gabbatiss, Robert McSweeney, Aruna Chandrasekhar, Ayesha Tandon, Giuliana Viglione, Zeke Hausfather, Xiaoying You, Joe Goodman, and Sylvia Hayes, "COP26: Key Outcomes Agreed at the UN Climate Talks in Glasgow," Carbon Brief (15 November 2021). www.carbonbrief.org/cop26-key-outcomes-agreed-at-the-un-climate-talks-in-glasgow.

Material environmental issues are factors that could have a significant impact—both positive and negative—on a company's business model and value drivers, such as operating and capital expenditure, revenue growth, margins, and risk. Materiality is not static, and it evolves in line with changes in the market, policies, and consumer attitudes. For example, the surge in public concern over plastic pollution seen in recent years—and the subsequent regulatory clampdowns on single-use plastics—has been quoted by the oil company BP as having the potential to have a "material impact" on the future oil demand.[213]

As such, efforts by investors to assess the material financial impacts caused by environmental risks have begun to increase in terms of their analytical scope and sophistication. This includes, for example, considering a wider range of environmental factors, such as those from policy and technology responses (transition risks), as well as the impacts of environmental events and physical risks.

Investors need to undertake relevant research and materiality analysis to determine the environmental impact—both positive and negative. The type of analysis and approach will mostly depend on the type of assets being assessed—company, sector, and geographic location and on a portfolio level. Based on both quantitative and qualitative data, environmental analysis will potentially determine adjustments to forecasted financials and ratios, valuation model variables, valuation multiples, credit assessments, and portfolio allocation weightings.

Without sufficient consideration of materiality, investors may be exposed to changes in policy, technology, and consumer sentiment or forgo investment opportunities. However, the challenge is that environmental issues unfold in complex ways over time and across regions and sectors, and there is significant variation in the definitions, classifications, and measurement of these risks and opportunities.

Corporate and Project Finance

At a company or project level, investors looking to identify and measure a company's environmental impact or materiality would need to analyze both quantitative and qualitative environmental factors in order to make an informed evaluation of the environmental risks embedded within. A judgment is then made on how material the risks are and whether those risks are priced in or not. A scoring system is also typically used to benchmark the company against its peers. Materiality is also highly influenced by the industry or sector of the company, as well as its country and jurisdictions where projects are located. This is also particularly relevant in the financing and investments of infrastructure projects.

A useful starting point is analyzing how a company or project uses energy, water, and waste:

- **Energy consumption** can be measured by the level of absolute emissions of GHGs from fossil fuel combustion and industrial processes and is measured by the amount of CO_2e. This could also include savings in energy and performance relative to a benchmark year and can be provided on an annualized or lifetime basis, based on estimates (particularly relevant for projects) or actual measurement (relevant to operational assets).
- **Water utilization** can be calculated as the costs generated by water usage efficiency in operations taken directly from the ground, taken from surface water, or purchased. Water and wastewater treatment can be assessed against indicators tracking reductions in pollutants and harmful substances in supply areas, as well as incident reports and sanctions.

213 E. Gosden, "Plastic May Do Less Harm Than Alternatives, Says BP," *The Times* (7 February 2019). www.thetimes.co.uk/article/plastic-may-do-less-harm-than-alternatives-says-bp-n7p0tt7w7.

- **Waste utilization** is measured as the costs generated from the disposal of waste in operations, such as through landfills, incinerated waste, or recycled or hazardous waste. Aspects that may need to be factored into the analysis include carbon capture and storage (e.g., for closed landfill and industrial operations), pollution control (soil, air, water), waste-to-energy facilities, and waste-to-biofuel facilities.

At a project finance level, when assessing project infrastructure initiatives, the International Finance Corporation's (IFC's) Equator Principles, which are based on IFC's Performance Standards, have become a globally recognized risk management framework and are adopted by financial institutions for determining, assessing, and managing environmental and social risk in project finance. They set out performance standards that address environmental factors (such as resource efficiency, biodiversity, and land resettlement), as well as other social-oriented standards. Examples of potential risks to be considered are presented in Exhibit 16.

Exhibit 16: Identification of Environmental Risks and Impacts at the Company or Project Level

Risks		Potential Impacts
Release of air pollutants (air emissions)	→	Pollution of air, land, and surface water
Release of liquid effluents or contaminated wastewater into local water bodies or improper wastewater treatment	→	Surface water pollution
Generation of large amounts of solid waste and improper waste management	→	Pollution of land and groundwater and surface water
Improper management of hazardous substances	→	Contamination of adjacent land and water
Excessive energy use	→	Depletion of local energy sources and release of combustion residuals leading to air pollution
Excessive water use	→	Depletion of water resources
High or excessive noise levels	→	Negative effects on human health and disruption of local wildlife
Improper or excessive land use	→	Soil degradation and biodiversity loss

Source: IFC, "Environmental and Social Management System Implementation Handbook" (2015). www.ifc.org/wps/wcm/connect/4c41260d-1ba8-4d10-a77d-f762d60a1380/ESMS+Handbook+General+v2.1.pdf?MOD=AJPERES&CVID=lllFYII.

While considering the potential negative impacts of investments can illuminate important sources of material risk, considering potential positive impacts (for example, whether a given investment contributes to nature conservation or emission reductions) can highlight opportunities.

Public Finance Initiatives

As governments continue to raise their climate targets in line with the Paris Agreement, resources are being allocated and investments from the public sector are being mobilized to implement these plans—including in partnership with private investors. For example, the **Helsinki Principles**, signed by a number of finance ministers around the

world, encourage signatories to "take climate change into account in macroeconomic policy, fiscal planning, budgeting, public investment management, and procurement practices."[214]

Public finance is a key policy instrument to both incentivize and enable the transition to green growth. Domestically, governments are a significant economic actor—commissioning new buildings, roads, and other forms of infrastructure, for example—highlighting the importance of aligning public procurement and sustainability. Governments also contribute to international development, with public sector financing often blended with funding from multilateral development finance institutions in developing countries and disbursed through investment vehicles, such as

- green infrastructure funds (e.g., the Association of Southeast Asian Nations [ASEAN] Catalytic Green Finance Facility under the ASEAN Infrastructure Fund),
- specialized banks (e.g., Asian Infrastructure Investment Bank), and
- funding platforms (e.g., the Tropical Landscapes Finance Facility).[215]

A variety of financing initiatives leveraging public sector and development finance for sustainable agriculture, biodiversity conservation, and the blue economy are also emerging, particularly targeting more vulnerable and developing economies.[216]

The Climate Policy Initiative reported that the average annual public climate finance was around US$321 billion in 2019–2020,[217] out of a total of US$632 billion of climate finance, with the highest proportion dedicated to energy systems. Other areas of spending include adaptation and resilience, low-carbon transport, land use, and infrastructure projects with cross-sectoral impacts.[218] Direct finance flows (domestic and international) from governments accounting for 12% of public flows (US$38 billion) were driven by low-carbon transport and delivered primarily through grants.

214 J. Rydge, "Aligning Finance with the Paris Agreement: An Overview of Concepts, Approaches, Progress and Necessary Action" Grantham Research Institute (2020). www.lse.ac.uk/granthaminstitute/wp-content/uploads/2020/12/Aligning-finance-with-the-Paris-Agreement-3.pdf.

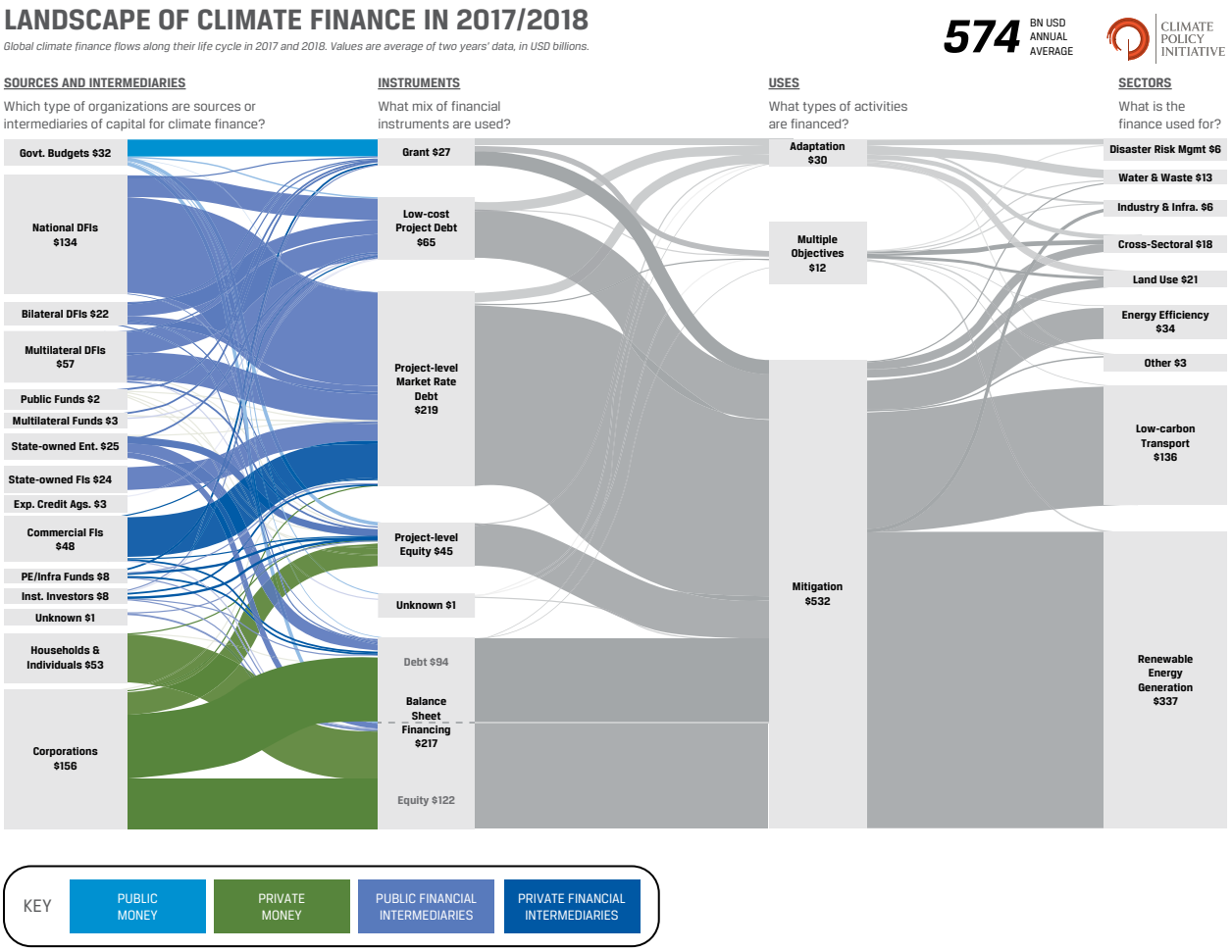
215 Climate Bonds Initiative, "ASEAN Green Financial Instruments Guide" (2019). www.climatebonds.net/resources/reports/asean-green-financial-instruments-guide.

216 Climate Bonds Initiative, "Latin America & Caribbean: Green Finance State of the Market 2019" (2019). www.climatebonds.net/resources/reports/latin-america-caribbean-green-finance-state-market-2019.

217 Barbara Buchner, Baysa Naran, Pedro de Aragão Fernandes, Rajashree Padmanabhi, Paul Rosane, Matthew Solomon, Sean Stout, Githungo Wakaba, Yaxin Zhu, Chavi Meattle, Sandra Guzmán, and Costanza Strinati, "Global Landscape of Climate Finance 2021," Climate Policy Initiative (14 December 2021). www.climatepolicyinitiative.org/publication/global-landscape-of-climate-finance-2021/.

218 Climate Policy Initiative, "Updated View on the Global Landscape of Climate Finance 2019" (2020). www.climatepolicyinitiative.org/wp-content/uploads/2020/12/Updated-View-on-the-2019-Global-Landscape-of-Climate-Finance-1.pdf.

Exhibit 17: The Landscape of Climate Finance, 2017–2018



Source: Climate Policy Initiative, "Updated View on the Global Landscape of Climate Finance 2019" (2020). www.climatepolicyinitiative.org/wp-content/uploads/2020/12/Updated-View-on-the-2019-Global-Landscape-of-Climate-Finance-1.pdf.

Examples of the types of **public finance** include

- export credit,
- development banks,
- concessionary lending to small and medium-sized enterprises (SMEs),
- guarantees,
- research and development (R&D), and
- investment in infrastructure.

Initiatives that typically require **public (and private) sector funding** with high environmental impacts are

- energy,
- water and waste,
- transport, and
- flood defenses.

Asset Management

As stewards of capital, asset managers play a key role in helping steer capital toward sustainability. Whether directly (e.g., by deciding to fund a particular green infrastructure project or to buy the debt of a high-carbon company) or indirectly (e.g., by using investor rights to appoint and reward company directors and through the related engagement with investee companies), the decisions made by asset managers can make positive or negative contributions to ESG factors, such as the global emission trajectory.

The environmental profiles of asset managers' portfolios have come under increased scrutiny from the media and civil society in recent years, often relating to campaigns for fossil fuel divestment. However, client mandates from asset owners may impose constraints on the options available to asset managers (particularly in the case of index-tracking funds). Exclusions are only one of a range of potential strategies that asset managers can deploy to manage environmental risks, alongside positive screening or impact investing funds.

Historically, however, the majority of the world's assets under management do not fall under either of these two categories but are invested in a variety of assets classes and strategies, which may not explicitly incorporate climate change or environmental objectives. This is changing, because both asset owners and asset managers are increasing their sustainability efforts. In December 2020, over 30 asset managers managing over US$9 trillion (£6.5 trillion) in assets joined the Net Zero Asset Managers initiative, pledging to support investing aligned with net-zero emissions by 2050 or sooner.[219] As of December 2021, 220 signatories representing US$57 trillion in AUM have joined the initiative over five waves of public announcements.[220] This initiative mirrors the growing number of asset owners who are setting net-zero emissions targets for their portfolios (e.g., the UN-convened Net-Zero Asset Owner Alliance, which gathers institutional investors with over US$5 trillion (£3.6 trillion) in assets).[221]

As a result of growing investor interest, asset managers are increasingly focused on the development of standardized frameworks and data points to be able to assess climate and environmental risks across multiple sectors, down to the level of individual companies or their securities. This recognizes that

1. companies in the same sector may face different levels of risk and
2. these risks are likely to be complex and interlocking and affect all sectors, not just those with high carbon emissions.

Such a framework, used by companies for reporting and disclosure and by investors in assessing the environmental, social, and governance risks of companies, comes from SASB, which was established in 2011 to develop and disseminate sustainability accounting standards. The standards identify financially material issues that are reasonably likely to impact the financial condition or operating performance of a company and therefore are most important to investors. SASB provides an interactive proprietary tool that identifies and compares disclosure topics across different industries and sectors, described as a "materiality map."[222] Environmental factors cover

- GHG emissions,

219 Net Zero Asset Managers Initiative, "The Net Zero Asset Managers Initiative" (2020). www.netzeroassetmanagers.org/.

220 Net Zero Asset Managers Initiative, "Net Zero Asset Managers initiative: Progress Report" (2021). www.netzeroassetmanagers.org/media/2021/12/NZAM-Progress-Report.pdf.

221 UNEP, "Institutional Investors Transitioning Their Portfolios to Net Zero GHG Emissions by 2050" (2020). www.unepfi.org/net-zero-alliance/.

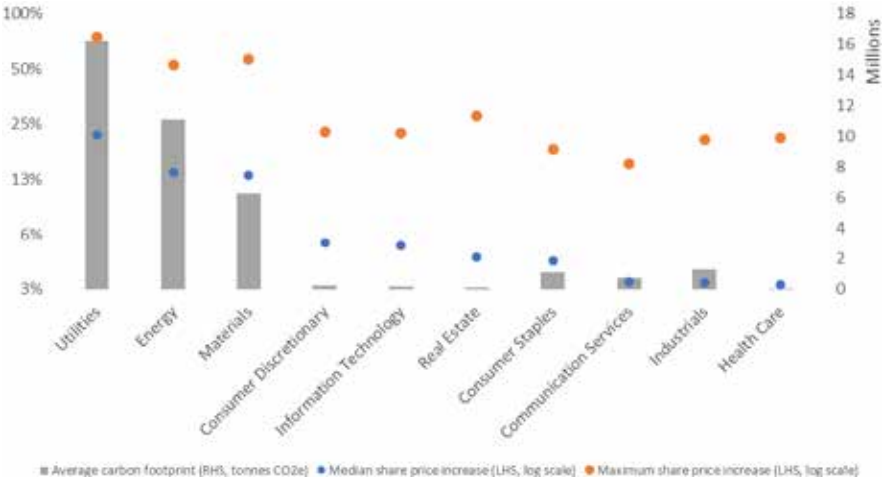
222 Sustainability Accounting Standards Board, "SASB Materiality Map" (2018). https://materiality.sasb.org.

- air quality,
- energy management,
- water and wastewater management,
- waste and hazardous materials management, and
- ecological impacts.

SASB's analysis reflects the varied nature of different sectors. GHG emissions are assessed to be material for more than 50% of industries in such sectors as extractives and minerals processing and transportation but for less than 50% of industries in such sectors as health care and technology and communications—where the management of energy, waste, and hazardous materials features more prominently.

One initiative aims to identify "ESG upside" for large, listed companies if they were to bring ESG performance in line with that of top-rated peers. Controlling for industry, size, and sector, improving performance on carbon emissions is found to be the most material variable for over 2,000 large, listed companies. On average, companies could unlock up to a 3% share price increase across all sectors, with potential for double-digit increases in high-emitting sectors, such as energy (see Exhibit 18).[223]

Exhibit 18: Potential Share Price Increase from Improving Emissions in Various Sectors



Source: ESG for Investors, "Counting Down Carbon: Higher Share Prices through Lower Emissions" (24 January 2022). https://esgforinvestors.com/articles/detail/22/.

However, there are different definitions of materiality and related reporting metrics under the multiple standards and frameworks used for sustainability reporting, including the GRI, the Climate Disclosure Standards Board (CDSB), Integrated Reporting, and CDP. In 2021, the IFRS Foundation, which works on the development of accounting standards, announced the consolidation of CDSB, SASB, and Integrated Reporting into a single organization, the International Sustainability Standards Board (ISSB), which aims to develop a "comprehensive global baseline of high-quality sustainability disclosure standards to meet investors' information needs."[224]

223 ESG for Investors, "Counting Down Carbon: Higher Share Prices through Lower Emissions" (24 January 2022). https://esgforinvestors.com/articles/detail/22/.

224 IFRS Foundation, "IFRS Foundation Announces International Sustainability Standards Board, Consolidation with CDSB and VRF, and Publication of Prototype Disclosure Requirements" (2021). www.ifrs.org/news-and-events/news/2021/11/ifrs-foundation-announces-issb-consolidation-with-cdsb

At the same time, many investors are incorporating this increasingly available climate and environmental data into their own proprietary investment frameworks, which reflect their house views on the climate and energy transition.

While some environmental risks can be addressed quantitatively, others require a more qualitative approach—for example, through engagement with companies to align management incentives with sustainability goals. Asset managers have stepped up individual engagement efforts but are also collaborating to achieve this.

CASE STUDIES

Investor Collaboration on Climate

Launched in 2017, Climate Action 100+ is an investor network with over 500 investors engaging the world's largest corporate emitters of GHGs.[225] Its members conduct joint company engagements and collaborate on shareholder proposals, and the initiative has been developing tools and benchmarks to be able to track company progress toward net-zero emissions.

APPROACHES TO ACCOUNT FOR MATERIAL ENVIRONMENTAL ANALYSIS AND RISK MANAGEMENT STRATEGIES

6

☐ **3.1.6** identify approaches to environmental analysis, including company-, project-, sector-, country-, and market-level analysis; environmental risks, including carbon footprinting and other carbon metrics; the natural capital approach; and climate scenario analysis

Environmental risks can be effectively integrated into company analysis and investment decision-making processes using various financial tools and models. According to a G20 green finance study, financial institutions need to combine two types of approaches to assess environmental risks:

1. understanding environmental factors that may pose risks to financial assets and liabilities (for example, the wrong pricing of a pollution liability or natural disaster insurance policy could be a risk to liability if the event probability is underestimated) and how such risks may evolve over time and
2. translating environmental risk factors into quantitative measures of financial risk that can, in turn, inform firms' risk management and investment decisions.[226]

The types of risk analysis tools and associated metrics primarily depend on the asset classes and risk types financial institutions are exposed to (for instance, a fixed-income analyst may be most interested in credit risk). Similarly, the choice of approach depends on the type of direct or indirect exposure to an environmental risk factor. For example, the probability of physical risks from flooding will have to

-vrf-publication-of-prototypes/.

225 Climate Action 100+, "About Climate Action 100+" (2021). www.climateaction100.org/about/.

226 UNEP, "Enhancing Environmental Risk Assessment in Financial Decision Making" (2017).

be incorporated differently than transition risks stemming from the transition to a low-carbon economy due to policy change. Depending on the investment strategy and objectives, different levels of analysis will likely be performed: at the individual asset level, portfolio level, and macroeconomic or systemic level.

It is important to analyze the extent to which environmental and climate-related impacts could affect a company's value chain—supply chain, operation and assets, logistics, and market—which would have an impact on financial performance.

Levels of Environmental Analysis

It is important to note that environmental risk assessments are conducted along with social and governance assessments at the

A. company or project level,

B. sector level,

C. country level, or

D. market level.

We will look at each of these in the following subsections.

Company or Project Level

At a company or project level, an assessment of material environmental risk factors will inform key financial metrics as monitored and disclosed in financial statements (such as profit and loss and balance sheet). For example, companies operating in water-scarce areas are exposed to higher risk than are those operating in areas where water availability is high. Therefore, it is important to undertake an analysis of how well the company is managing these risks (e.g., improvement in water efficiency over time).

Often, analysts and portfolio managers will have their own internal environmental (social and governance) scoring system that uses a combination of external third-party data providers and internal analysis. Qualitative and quantitative assessments are then made to determine the materiality of environmental risks for a particular company and how they will affect key efficiency or profitability ratios that might be used to value and compare across different companies. This could include a decision being made to adjust the target price-to-earnings ratio (P/E), which reflects a company's competitiveness in comparison to its peers with higher or lower environmental standards. Cost assumptions can also be adjusted according to future capital expenditure in environmental (mitigation or adaptation) spending.

THE "CARBON RISK PREMIUM"

A "carbon risk premium" is said to exist when investors require a higher compensation for the perceived risk from investing in high-carbon companies. Several studies have argued that companies with higher (absolute levels of or relative increases in) CO_2 emissions are associated with higher returns. However, studies have also found evidence for the converse—a positive link between reductions in carbon footprint and improvements returns.[227]

227 Multiple sources: P. Bolton and M. Kakperczyk, "Do Investors Care about Carbon Risk?" *Journal of Financial Economics* 142 (November 2021): 517–49. www.sciencedirect.com/science/article/abs/pii/S0304405X21001902?via%3Dihub.
Maximilian Görgen, Andrea Jacob, Martin Nerlinger, Ryan Riordan, Martin Rohleder, and Marco Wilkens, "Carbon Risk" (2020). https://ssrn.com/abstract=2930897.
Mats Andersson, Patrick Bolton, and Frédéric Samama, "Hedging Climate Risk," *Financial Analysts Journal* 72 (May/June 2016): 13–32. www.tandfonline.com/doi/abs/10.2469/faj.v72.n3.4.

These results illustrate the importance of defining investment beliefs, given that risk and return can be seen as two sides of the same coin. For some, remaining invested in sectors or stocks that may be shunned by a growing proportion of "climate-conscious" investors can create an opportunity for excess returns; others may see companies lagging on environmental metrics as being at risk of having permanently depressed future cash flows from changes in consumer preferences, technology, and regulation.

Given the complex nature of the technologies, sectors, and commodities involved; the liquidity of underlying markets; and the availability of alternatives, conclusions around the existence of a carbon risk premium in one sector or industry may not be readily applicable in other sectors.

For example, a study from the University of Oxford found an increase of 54% in loan spreads for coal mining (a perceived measure of the risk of corporate debt relative to government bonds) between 2017 and 2020 compared to the previous decade but that loan spreads for oil and gas had remained relatively stable, reflecting a more "ambivalent" attitude from lenders.[228]

Sector Level

Environmental and climate-related factors have varying degrees of impact on different sectors. Some sectors—whether through their higher carbon intensity or location of their assets—have higher exposure to

- environmental risks, such as
  - chemicals,
  - energy,
  - steel and cement,
  - extractives,
  - food or beverages, and
  - transportation, or
- physical risk from natural disasters—for example, to
  - buildings,
  - production facilities,
  - agricultural land, or
  - urban infrastructure.

Companies in these sectors tend to be influenced by an environmental risk premium, which may affect the discount rate used. Hence, alongside the previous company-level analysis, these sector-wide considerations need to be considered, and they should be overlaid on the company analysis. Adjustments are made to remove any regional or sector biases that align with the manager's investment strategy and process.

Gerald T. Garvey, Mohanaraman Iyer, and Joanna Nash, "Carbon Footprint and Productivity: Does the 'E' in ESG Capture Efficiency as Well as Environment?" *Journal of Investment Management* 16 (2018): 59–69. https://joim.com/downloads/carbon-footprint-and-productivity-does-the-e-in-esg-capture-efficiency-as-well-as-environment/.

228 X. Zhou, C. Wilson, and B. Caldecott, "The Energy Transition and Changing Financing Costs" (2021). www.smithschool.ox.ac.uk/research/sustainable-finance/publications/The-energy-transition-and-changing-financing-costs.pdf.

Country Level

A country's environmental regulations, emission targets, and enforcement may vary in emphasis across different jurisdictions. Often, investments may be multi-jurisdictional, and hence, several country-specific considerations and regulations will need to be factored into the valuation of a company based on the country in which it is located or where its operations lie. Disclosure and transparency of environmental data will also vary by region; for example, companies in emerging markets tend to have fewer comprehensive disclosures.

Country analysis is relevant not just to corporate securities but also to government bonds. Climate change, air quality, water stress, vulnerability to natural hazards, and food security can have an immediate and direct impact on a sovereign's ability or willingness to pay (credit risk) or its ESG profile. For example, the consistent deterioration in a country's rating scores on food security and high vulnerability to climate change could lead an asset manager to reduce its position despite the bond's scarcity and attractive relative value, but—conversely—it can also hold an overweight position based on a view that starting with a relatively low environmental score is acceptable when reforms and a green economy push from the government are expected to lead to ESG score improvements.[229]

Market Level

Recognizing the cross-cutting impacts of environmental risks, central banks and the Bank for International Settlements have warned of the potential systemic effects of both physical and transitional risks: "In the worst case scenario, central banks may have to confront a situation where they are called upon by their local constituencies to intervene as climate rescuers of last resort."[230]

Consideration of such market-wide impacts can influence investors' strategic asset allocation and long-term investment strategy, although research has sounded a note of caution with regard to the limits of some traditional risk mitigation strategies, such as diversification and hedging. In a report titled "Unhedgeable Risk," the Cambridge Institute for Sustainability Leadership warned that in a scenario where investor sentiment changes away from high-carbon sectors, there may not be sufficient available assets—including low-carbon assets—for investors to successfully reallocate capital. It found that around half of the potential decline in the modeled equity and fixed-income portfolios is "unhedgeable," meaning investors and asset owners would be exposed unless some system-wide action is taken to address the risks.[231]

This finding reaffirms the need for predictable policy measures, which prioritize real-world emission reductions and an orderly transition to the low-carbon economy. A growing number of investors (such as those under the Climate Action 100+ initiative) are advocating for this.

Analyzing Environmental Risks

It is not possible to outline all the available approaches for investors to assess environmental risks, because there is no one common standard. However, based on a combination of independent third-party research and data along with useful frameworks,

229 R. Agha and S. Singla, "ESG in LGIM's Active EMD Investment Process" (2020). www.lgim.com/uk/en/insights/our-thinking/esg-and-long-term-themes/esg-in-lgims-active-emd-investment-process.
230 P. Bolton, M. Despres, L. A. Pereira Da Silva, F. Samama, and R. Svartzman, "The Green Swan: Central Banking and Financial Stability in the Age of Climate Change," Bank for International Settlements (January 2020). www.bis.org/publ/othp31.pdf.
231 Cambridge Institute for Sustainability Leadership, "Unhedgeable Risk: How Climate Change Sentiment Impacts Investment" (2015). www.cisl.cam.ac.uk/resources/sustainable-finance-publications/unhedgeable-risk.

practitioners are able to map out and analyze the environmental risks and costs for different types of asset classes by company and sector in order to make their own quantitative and qualitative risk assessments. The following outlines some of the approaches that are used by investors to assess material environmental risks (and opportunities):

A. carbon footprinting and other carbon metrics,

B. natural capital approach, and

C. climate scenario analysis.

We will look at each of these approaches in further detail in the following subsections.

Carbon Footprinting and Other Carbon Metrics

Carbon footprinting is one of the most common approaches used by companies and investors. A portfolio carbon footprint effectively measures carbon emissions and intensity associated with operations of the companies in a portfolio. Measuring the carbon footprint of a portfolio means that an investor can

- compare it to global benchmarks,
- identify priority areas and actions for reducing emissions, and
- track progress in making those reductions.

The use of carbon footprinting applies the international accounting tool of the GHG Protocol Standards. Scope 1 emissions are direct greenhouse emissions that occur from sources that are controlled or owned by an organization (e.g., emissions associated with fuel combustion in furnaces or company vehicles). Scope 2 emissions are indirect GHG emissions associated with the purchase of electricity, for example. Scope 3 emissions cover all indirect emissions arising from the activities of an organization. These include emissions from both suppliers and consumers, as shown in Exhibit 19.

Exhibit 19: GHG Protocol Standards: Examples of Direct and Indirect Emissions

Scope 1	Scope 2	Score 3
▸ Fuel combustion ▸ Company vehicles ▸ Fugitive emissions	▸ Purchased electricity, heat, and steam	▸ Purchased goods and services ▸ Business travel ▸ Employee commuting ▸ Waste disposal ▸ Use of sold products ▸ Transportation and distribution (upstream and downstream) ▸ Investments ▸ Leased assets and franchises

Source: Greenhouse Gas Protocol, "Standards" (2019). https://ghgprotocol.org/standards.

The benefits of carbon footprinting include the potential to aggregate emissions across industries and value chains (for countries and portfolios, enabling comparisons between companies or portfolios) and across sectors and geographies, as well as to focus the analysis on emission intensity. However, the analysis has its limitations and challenges as a risk measure and is increasingly seen as too backward looking or static.

Some of the main challenges of carbon footprinting are

- the lack of disclosure for unlisted or private assets,
- Scope 3 emissions rarely being included, thus failing to capture companies' full value chain,
- double counting' (e.g., a metallurgical coal miner's Scope 3 emissions can be a steel maker's Scope 1 emissions),
- the use of different estimation methodologies, and
- ignoring potential investment risks related to the physical impacts of climate change.

Depending on objectives, carbon footprinting can be an absolute or relative metric. It can be used to assess, for example, the **total carbon emissions** associated with a given investee company or portfolio. This recognizes that investments that are viewed as having a disproportionately high contribution to global emissions may have a higher exposure to future policy interventions on carbon emissions.

TOTAL CARBON EMISSIONS

$$\text{Total carbon emissions} = \sum_n i \frac{\text{Current value of investment}_i}{\text{Issuer's market capitalization}_i} \times \text{Issuer's Scope 1 and 2 emissions}_i. \quad (1)$$

Source: TCFD, "Implementing the Recommendations of the Task Force on Climate-Related Financial Disclosures" (2017). www.fsb-tcfd.org/wp-content/uploads/2017/06/FINAL-TCFD-Annex-062817.pdf.

Alternatively, investors may wish to track carbon emissions **intensity** (e.g., emissions scaled in relation to a particular metric, such as a company's revenues). The TCFD recommends that asset owners and managers report the weighted average carbon intensity associated with their investments.[232]

WEIGHTED CARBON EMISSIONS

$$\text{Weighted average carbon intensity} = \sum_n i \frac{\text{Current value of investment}_i}{\text{Current portfolio value}} \times \frac{\text{Issuer's Scope 1 and 2 emissions}_i}{\text{Issuer's US\$m of revenue}_i}. \quad (2)$$

Source: TCFD, "Implementing the Recommendations of the Task Force on Climate-Related Financial Disclosures."

This can provide a measure of how carbon efficient companies are, allowing for an element of comparability between companies of different sizes. The question of comparability (both between companies and different portfolios, which potentially harbor multiple asset classes) remains a complex one, and there is currently variation among different voluntary and mandatory frameworks in terms of the choice of denominator. Alternative methods of calculation include scaling emissions by companies' market capitalization or enterprise value (which takes into account companies' issuance of both equity and debt, as well as in some cases, the companies' cash reserves).

232 TCFD, "Implementing the Recommendations of the Task Force on Climate-Related Financial Disclosures" (2017). www.fsb-tcfd.org/wp-content/uploads/2017/06/FINAL-TCFD-Annex-062817.pdf.

More broadly, high levels of carbon emissions are not a perfect proxy for high climate risks. A coal-burning power plant and a coal-burning steel plant may have very similar levels of emissions. But renewable energy can much more easily—and for two-thirds of the world's population, more cheaply[233]—replace the use of coal for generating electricity, whereas cleaner and economic alternatives to coal for steel production are not as widespread. As such, the policy focus and future profitability profile of the two plants may look radically different. A useful starting point is to consider companies' announced emission targets and related environmental ambitions, also in relation to carbon pricing in different climate scenarios.

Net-Zero/Science-Based Targets

As mentioned previously, companies are increasingly adopting **net-zero targets**. However, there is significant variation among these targets, because they can

- be absolute or relative targets,
- cover different scopes of emissions (just operational, or Scope 1 and 2) or include some or all of the value chain (Scope 3) and different types of emissions (just carbon dioxide or all GHGs),
- focus on differing or multiple time frames, or
- rely on offsets.

This can make it difficult for investors to accurately measure and benchmark their carbon emission reduction objectives.

One element of standardization comes from science-based targets (SBT): targets underpinned by the latest climate science and evaluated by the **Science-Based Target initiative (SBTi)**, a partnership between several environmental institutions that provides independent certifications of the strength of companies' targets. It has produced decarbonization guidance in different sectors, including power, apparel and footwear, and information and communication technology, and more recently for the financial sector. Over 1,000 companies have set targets through the SBTi.[234]

Public companies' and their commitments are only one—albeit an important—part of investors' portfolios. Methodologies to assess the environmental profile of private companies, sub- and supra-national debt, or other asset classes are still evolving. The UN Principles for Responsible Investment (PRI), UNEP Finance Initiative, and the Institutional Investor Group on Climate Change are developing frameworks to help benchmark investors' transition to net zero.[235] The Partnership for Carbon Accounting Financials (PCAF) has also developed guidance for financial institutions to assess the GHG emissions of their loans and investments.[236]

Emission Trajectories

Emission trajectories can be used to assess the required reductions to reach a stated goal (for example, net-zero carbon by 2050) and compare the pathways implied by corporate commitments, policies, or individual assets (for example, proposed refurbishments to a building to improve its energy efficiency). For instance, the Transition

233 BloombergNEF, "Scale-Up of Solar and Wind Puts Existing Coal, Gas at Risk" (2020). https://about.bnef.com/blog/scale-up-of-solar-and-wind-puts-existing-coal-gas-at-risk/.
234 SBTi, "Companies Taking Action" (2020). https://sciencebasedtargets.org/companies-taking-action.
235 See, for example, PRI and UNEP Finance Initiative, "Inaugural 2025 Target Setting Protocol" (2021). www.unepfi.org/wordpress/wp-content/uploads/2021/01/Alliance-Target-Setting-Protocol-2021.pdf. See also IIGCC, "Paris Aligned Investment Initiative" (2021). www.iigcc.org/our-work/paris-aligned-investment-initiative/.
236 For more information, go to https://carbonaccountingfinancials.com/.

Pathway Initiative is an asset owner–led collaboration that has developed a publicly available tool that aims to assess companies' preparedness for the low-carbon transition.[237]

Temperature Alignment

Another approach comes from measures of **temperature alignment**. It seeks to compare the climate profiles of companies, sectors, or portfolios against a benchmark of global temperature. Because global "carbon budgets" impose constraints on the amount of emissions that are compatible with maintaining a reasonable chance of global temperatures not exceeding certain levels, this allows a degree of quantification of the implied future temperature levels associated with a company or portfolio. For example, Japan's Government Pension Investment Fund (GPIF), the world's largest pension fund, estimates its portfolio of equities and bonds are aligned with a warming trajectory of around 3°C (5.4°F).[238]

As an illustration, Legal & General Investment Management analyzed the emission intensity trajectory of approximately 2,000 companies against various climate change scenarios and found that the majority were not aligned with the goals of the Paris Agreement. This raised "concerns that some institutional portfolios may be aligned with temperature outcomes of greater than three degrees (3°C)," leaving them exposed to tightening climate policies.[239]

While it is intuitively easy to understand the aim of these measures and seemingly easy to compare temperatures, there is significant variation in the market around such metrics. They

- include implied temperature rise, global warming potential, and temperature alignment,
- use different inputs for climate performance, including carbon footprint, share of investments in "green" technologies, and proportion of investee companies with (science-based) emissions targets, and
- result in a different quantification of output—a binary statement (aligned or not), a score, a percentage of misalignment, or a temperature number.

Lastly but importantly, different methodologies can offer significantly different alignment results.[240]

TEMPERATURE ALIGNMENT TOOLS

There are several analytical products, both commercial and freely available. In line with changes in investor demand, the major providers of environmental data (which had historically been backward looking) have expanded their toolkit to develop more forward-looking approaches, with temperature ratings emerging as a major area of focus.

Free-to-use tools include the following:

- The CDP temperature rating methodology [241]

237 TPI, "The TPI Tool" (2021). www.transitionpathwayinitiative.org.
238 GPIF, "Analysis of Climate Change-Related Risks and Opportunities in the GPIF Portfolio" (2020). www.gpif.go.jp/en/investment/GPIF_CLIMATE_REPORT_FY2019_2.pdf.
239 Legal & General, "LGIM Announces Climate Solutions Capability Powered by Risk and Alignment Framework Co-Developed with Baringa Partners" (2020). https://group.legalandgeneral.com/en/newsroom/press-releases/lgim-announces-climate-solutions-capability-powered-by-risk-and-alignment-framework-co-developed-with-baringa-partners.
240 Institut Louis Bachelier, "The Alignment Cookbook: A Technical Review of Methodologies Assessing a Portfolio's Alignment with Low Carbon Trajectories or Temperature Goal" (2020). www.louisbachelier.org/wp-content/uploads/2020/10/cookbook.pdf.
241 CDP, "CDP Temperature Ratings" (2020). www.cdp.net/en/investor/temperature-ratings.

- The Paris Agreement Capital Transition Assessment (PACTA), developed by the 2° Investing Initiative with backing from the UN PRI, which provides tools to model publicly listed securities (equity and fixed income) and an open-source data and modeling suite for private portfolios (such as bank loan books) [242]
- The climate portfolio optimizer from ESG for Investors, which models temperature as part of a "3D" framework, covering risk, return, and climate impact [243]

There is also a wide range of analytical products.

Green Capital Expenditures, Revenues, and Research and Development

A different approach looks in more detail at companies' level of **green capital expenditures**, **revenue streams**, and **R&D** to gauge the direction of travel for their business models.

For the oil and gas sector, the Carbon Tracker Initiative has created a framework to assess companies' potential **capital expenditures** on new oil and gas projects, compared against their cost of production, associated emissions, and demand levels in different climate scenarios.[244]

An alternative is to consider **existing revenues**. Data providers including FTSE Russell and HSBC have compiled proprietary databases to assess the sales companies generate from over 100 low-carbon products and services.[245]

Several data providers have constructed methodologies to analyze the **patents** for low-carbon technologies filed by companies. R&D is a potentially useful indicator; however, the mere accumulation of patents need not imply strategic commitment. For example, Kodak engineers invented and patented the digital camera that would eventually render its company's main business obsolete.[246]

Natural Capital Approach

A term often used to describe the relationship between nature and measuring and valuing nature's role in decision making is natural capital. **Natural capital** helps businesses identify, measure, value, and prioritize their impacts and dependencies on biodiversity and the ecosystem, which ultimately give businesses new insight into their risks and opportunities (see Exhibit 20).[247] Understanding the value of both natural capital impacts and dependencies helps business and financial decision makers assess the significance of these issues for their institution and therefore make more informed decisions.

242 2° Investing Initiative, "PACTA/Climate Scenario Analysis Program" (2020). https://2degrees-investing.org/resource/pacta/.

243 ESG for Investors, "3D Climate Optimiser" (2022). https://esgforinvestors.com/climate_optimiser/.

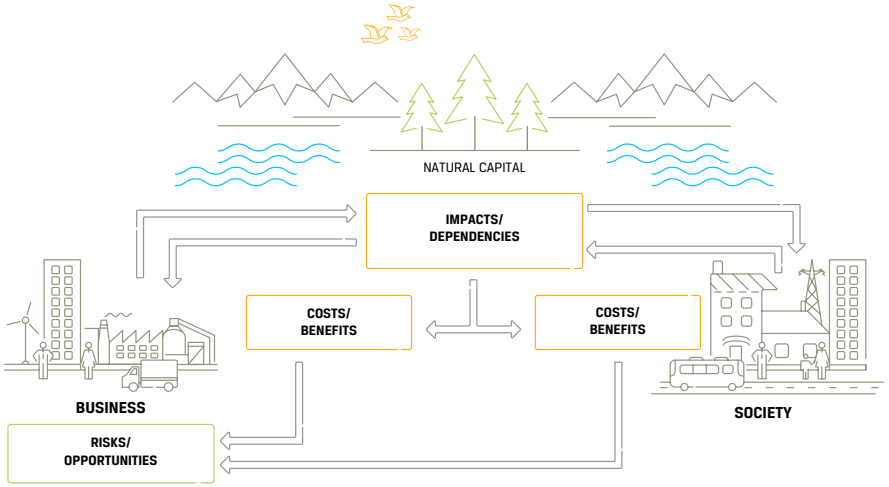
244 Carbon Tracker Initiative, "Breaking the Habit: Methodology" (2020). https://carbontransfer.wpengine.com/wp-content/uploads/2019/09/Breaking-the-Habit-Methodology-Final-1.pdf.

245 FTSE Russell, "Green Revenues 2.0 Data Model" (2020). www.ftserussell.com/data/sustainability-and-esg-data/green-revenues-data-model.
See also HSBC, "HSBC Climate Solutions Database" (2020). www.research.hsbc.com/C/1/1/315/KrqWFj9.

246 D. Gann, "Kodak Invented the Digital Camera—Then Killed It. Why Innovation Often Fails," World Economic Forum (23 June 2016). www.weforum.org/agenda/2016/06/leading-innovation-through-the-chicanes/.

247 Capitals Coalition, "Natural Capital Protocol" (2016). https://capitalscoalition.org/capitals-approach/natural-capital-protocol.

Exhibit 20: The Natural Capital Approach Explains the Complex Ways in Which Natural, Social, and Economic Systems Interact, Affect, and Depend on One Another



Source: Capitals Coalition, "Natural Capital Protocol" (2016). https://capitalscoalition.org/capitals-approach/natural-capital-protocol.

Assessing environmental factors using the Natural Capital Protocol (NCP), a decision-making framework, enables organizations to identify, measure, and value the direct and indirect impacts and dependencies of companies on natural capital. It currently provides guidance for the apparel sector, food and beverage sector, and forest products sector.

The protocol aims to allow companies to measure, value, and integrate natural capital impacts and dependencies into existing business processes, such as risk mitigation, sourcing, supply chain management, and product design.[248]

Recognizing the need for increased consideration of natural capital issues by financial decision makers, an initiative to establish the **Task Force on Nature-Related Financial Disclosures (TNFD)** was announced in mid-2020. It is a collaboration between Global Canopy and WWF, supported by financial institutions and governments.[249] In 2022, the TNFD released its first version of its nature-related risk management framework for market consultation.[250]

NATURAL RESOURCE RISK ASSESSMENT TOOLS FOR INVESTORS AND POLICYMAKERS

The Integrated Biodiversity Assessment Tool (IBAT), developed by the International Union for Conservation of Nature, is a central global biodiversity database that includes key biodiversity areas and legally protected areas. Through an interactive mapping tool, decision makers can easily access and use this up-to-date information to identify biodiversity risks and opportunities within a project boundary.[251]

248 Capitals Coalition, "Natural Capital Protocol."
249 TNFD, "Who We Are" (2020). https://tnfd.global/about/#who.
250 TNFD, "TNFD Releases First Beta Version of Nature-Related Risk Management Framework for Market Consultation" (2022). https://tnfd.global/news/tnfd-releases-first-beta-framework/.
251 IBAT, "Integrated Biodiversity Assessment Tool" (2022). www.ibat-alliance.org/.

Enabling a Natural Capital Approach (ENCA) is a policy tool and guidance developed by the UK Department for Environment, Food & Rural Affairs.[252]

CERES and WWF have developed water risk assessment tools, targeted at investors, lenders, and policymakers:

- The CERES Aqua Gauge, developed by CERES and CDP[253]
- The WWF Water Risk Filter[254]
- The World Resources Institute water tool, Aqueduct[255]

Climate Scenario Analysis

Scenario analysis is an approach for the forward-looking assessment of risks and opportunities. Scenario analysis is a process of evaluating how an organization, sector, country, or portfolio might perform in various future states, in order to understand its key drivers and possible outcomes.

Climate-related risk has been identified as one of the most complex macro-existential risks; it is not well understood and hard to quantify. The TCFD recommends that companies and financial institutions "describe the resilience of the organisation's strategy, taking into consideration different climate-related scenarios, including a 2°C (3.6°F) or lower scenario and, where relevant to the organisation, scenarios consistent with increased physical climate-related risks."[256]

In the current landscape, there is no common set of scenario analysis methodology used by investors. Instead, the types of approaches and models will depend largely on the objectives and scope of the work.

The **Institutional Investors Group on Climate Change (IIGCC)** published a practical investor guide, which provides a useful framework with which to approach climate-related scenario analysis.[257] The guide sets out two objectives of undertaking scenario analysis:

1. Financial impact: The use of scenario analysis enables the assessment and pricing of climate-related risks and opportunities.
2. Alignment: Aligning the portfolio(s) with a 2°C (3.6°F) or lower future, which is typically driven by a set of investment beliefs

At the overarching level, however, there is no one-size-fits-all methodology that investors can use to determine materiality, and they consequently use financial modeling and concepts, such as financial ratio analysis. The EU's Non-Financial Reporting Directive, which helps analysts and investors to evaluate the non-financial performance of large companies, sums up the most effective and recommended approach. It involves

- taking a set of transparent and credible data sources and assumptions, which can be quantitative or qualitative,

252 Department for Environment, Food & Rural Affairs, "Enabling a Natural Capital Approach (ENCA)" (2020). www.gov.uk/guidance/enabling-a-natural-capital-approach-enca.
253 Ceres, "Ceres Aqua Gauge: A Comprehensive Assessment Tool for Evaluating Corporate Management of Water Risk" (2021). www.ceres.org/resources/tools/ceres-aqua-gauge-comprehensive-assessment-tool-evaluating-corporate-management.
254 WWF, "WWF Water Risk Filter 6.0" (2022). https://waterriskfilter.org/.
255 World Resources Institute, "Aqueduct: Using Cutting-Edge Data to Identify and Evaluate Water Risks around the World" (2022). www.wri.org/aqueduct.
256 TCFD, "2019 Status Report: Task Force on Climate-Related Financial Disclosures: Status Report" (2019). www.fsb-tcfd.org/wp-content/uploads/2019/06/2019-TCFD-Status-Report-FINAL-053119.pdf.
257 IIGCC, "Navigating Climate Scenario Analysis—A Guide for Institutional Investors" (2019). www.iigcc.org/resource/navigating-climate-scenario-analysis-a-guide-for-institutional-investors/.

- applying recognizable, accepted methodologies, which will probably have the backing of an industry body, government department, or multilateral institution,
- focusing on materiality (looking in particular at business models, operations, and financial performance), and
- generating a set of outputs that can be measured in terms of key performance indicators.[258]

In order for the financial system to achieve a better appreciation of climate change risks (and opportunities), there is a need for more data, greater disclosure, better analytical toolkits, advanced scenario analysis, and new risk management techniques.[259]

7 APPLYING MATERIAL ENVIRONMENTAL FACTORS TO FINANCIAL MODELING, RATIO ANALYSIS, AND RISK ASSESSMENT

☐ **3.1.7** apply material environmental factors to financial modeling, ratio analysis, and risk assessment

The following case study is based on a 2018 WWF and Cadmus survey[260] of more than 20 infrastructure investors and related stakeholders and looks at how investors evaluate the sustainability of infrastructure assets. It can, however, be adapted for evaluating individual companies.

It demonstrates how and where to integrate the results of a comprehensive ESG assessment as input into the key financial ratios and variables of a financial model, such as the forecasting of revenues, operating costs, and capital expenditures, which form the basis of discounted cash flow (DCF) analysis.

Note that this example focuses only on the environmental impacts. In reality, the social and governance factors need to be considered in parallel for a full ESG materiality assessment.

CASE STUDIES

ESG Review—Environmental Factors and Materiality

Over the lifetime of an infrastructure project—from development to construction, to operation, and all the way through to the decommissioning phase—infrastructure assets face all kinds of ESG issues. These vary depending on asset type, sector, size, geographic location, and stage in the life cycle.

Some of the environmental issues may originate outside the asset but could impact its technical ability to operate or impact its profitability (for instance, temperature rise and increased water scarcity). Other issues may be caused by the asset itself and impact its surrounding environment and communities

258 European Commission, "Directive 2014/95/EU" (2014). https://ec.europa.eu/info/business-economy-euro/company-reporting-and-auditing/company-reporting/non-financial-reporting_en.
259 S. Breeden, "Avoiding the Storm."
260 WWF/Cadmus, "Valuing Sustainability in Infrastructure Investments: Market Status, Barriers and Opportunities — A Landscape Analysis," (2019). https://www.wwf.ch/de/unsere-ziele/sustainable-finance-nachhaltige-finanzfluesse-foerdern.

(such as water effluence and the quality of life of the communities around it). In this latter case, these are called externalities, which can (and will) increasingly impact the asset's financial performance via various feedback loops (including protests of the surrounding community). It is thus important to realize that both directions of potential environmental impact (impact *on* the asset and impact *from* the asset) may have financial consequences for the investors.

For the purpose of arriving at a shortlist of environmental factors for which the potential impact of environmental risk on infrastructure financials can be demonstrated, a two-step process was followed:

1. A longlist of widely recognized environmental factors was derived. The longlist was reduced to a shortlist of environmental factors that are typically among those considered key to an environmental assessment in the context of infrastructure.
2. Whether and the extent to which any of the selected environmental factors have a material impact on the infrastructure asset will be revealed by the asset-specific ESG due diligence process.

Environmental Factors Material to Infrastructure Projects:

Typical Environmental Factors		Material Environment Factors for Infrastructure
Degradation and pollution ▸ Air (climate)—GHG emissions ▸ Air (health)—other pollution ▸ Water ▸ Ground or contamination ▸ Noise and light ▸ Biodiversity **Resource efficiency—sourcing, use, or treatment:** ▸ (Raw) materials including supply chain ▸ Energy ▸ Water ▸ Waste **Physical risk—impact on asset, such as flooding**	→	**(A) Quantifiable** *Degradation and pollution* 1. Air (health) and water pollution 2. Air (climate)—GHG emissions *Resource efficiency—sourcing, use, or treatment* 3. Energy (E) 4. Water (E) 5. Solid waste (E) 6. (Raw) materials and supply chain (E/S) **(B) Difficult to quantify** 7. Biodiversity and habitat (E) 8. Physical climate change impacts (E)

Approach to Assess the Implications of Environmental Risk on Financial Ratios and Models

The approach used in this caSe study, which uses survey input across a range of infrastructure projects, simplifies the TCFD classification of risks introduced previously, while broadening it to ESG, not just climate, themes.

The following table helps show how the selected environmental factors may impact the financial performance of infrastructure organizations. It elaborates on the potential impact pathways from the selected environmental factors to specific financial ratios or inputs into financial models.

Environmental Factor	Risks Considered	Financial Ratio or Factor Impact	Impact of the Risk
Air pollution or water pollution	Tightening regulations	Asset write-off/capital expenditure (CapEx)	Write-offs, asset impairment, or early retirement of existing assets may result from the tightening of regulation.
		Provisions	Provisions may be needed to cover potential fines in case of non-compliance with new regulations. They may also need to be made for potential lawsuits or other legal proceedings.
	Costs for obtaining relevant permit increase	Operating expenditure (OpEx)	The overall production cost will increase due to an additional discharge cost.
	Imposition of new environmental tax	Tax	Taxes will increase.
	Enhanced disclosure requirements	OpEx	Monitoring, reporting ,and auditing costs will increase.
	Reputational	Provisions	Reputational damage may lead to loss of revenues.
		Financing costs	Additional interest paid due to higher interest rate or lower credit rating.
GHG emissions	Client demand for lower-carbon products and services (e.g., cleaner electricity in the case of a utility company)	Revenues	Decrease in revenues from high-carbon activities.
	Introduction or increase of price for GHG emissions, implementation of a carbon tax, loss of subsidies for high-GHG-intensity energy sources	OpEx/tax/CapEx	Production cost increases (OpEx, tax). Preventive investment (CapEx) in measures of technology to reduce GHG emissions per unit of output or to reduce energy intensity of processes
Greenhouse gas emissions	In a utility example: Clients switch to electricity generated with lower GHG intensity than traditional electricity.	Revenues	Decrease in revenues due to lower demand for conventional fossil fuels
	Introduction or increase of price for greenhouse gas emissions, implementation of a carbon tax, loss of subsidies for high-GHG-intensity energy sources	OpEx/tax/Capex	Production cost increases (OpEx, tax). Preventive investment (CapEx) in measures of technology to reduce GHG emissions per unit of output or to reduce energy intensity of processes
Energy	Physical: rising temperatures	OpEx	Higher temperatures may influence the functioning of equipment and lead to an increase in fuel consumption or lower performance levels (OpEx).

Environmental Factor	Risks Considered	Financial Ratio or Factor Impact	Impact of the Risk
Water	Physical: increased water scarcity	Revenue/OpEx	Insufficient supply for water-reliant assets, such as hydro-power plants or district heating networks, leads to loss of revenues due to loss of energy production (hydro-power plant) or an increase in operating costs because of the rise in water prices.
	Reputational: conflicts with the surrounding community on water withdrawal	Revenues/provisions/ OpEx	Conflicts with community may lead to project delays, which in turn may lead to loss of revenues or fines for late completion. Increase in operating expenses due to additional community engagement and marketing measures
	Regulatory: implementation of more stringent regulation regarding water withdrawal	CapEx/OpEx	Investments in water-saving measures may become necessary but may reduce water usage going forward. Implementation of new production processes, which substitute water with more expensive resources, leads to higher OpEx.
Solid waste	Regulatory: tightened regulation on waste disposal and land restoration	Provisions	Potentially stricter regulation for waste disposal, recycling, or land restoration during the decommissioning phase
(Raw) materials supply chain	Reputational: environmental, social, or governance issues may be found in the supply chain	Provisions	Dealing with reputational issues is time consuming and costly, and provisions may need to be made to cover for such cases.
Biodiversity and habitat	Regulatory/legal: tightening of regulations or other operating requirements regarding the protection of critical species or habitats	Revenues/CapEx/OpEx	Potential operating restrictions on certain days of the year or on certain times of the day leading to a reduction in sales (revenues) Investments into alterations to existing structures, such as implementation of sound curtains for offshore wind turbines, may be necessary. Adherence to stipulations may lead to increased monitoring and reporting cost.
Climate change impacts (E)	Physical: Extreme weather (storms and floods) can lead to disruptions.	Revenues	Periodic loss of energy production (windfarms) due to shutdown

Environmental Factor	Risks Considered	Financial Ratio or Factor Impact	Impact of the Risk
	Physical: Extreme weather may destroy the asset partially or fully.	Asset book value/ revenues/CapEx/OpEx	A write-down or write-off of the assets and a loss of revenues may be the immediate result. Investments will be needed to repair or even rebuild the damaged asset. If the probability of extreme weather increases, the probability of damage or destruction increases; therefore, insurance policies are likely to increase.

Source: Adapted from WWF and B Capital Partners, "Guidance Note: Integrating ESG Factors into Financial Models for Infrastructure Investments" (2019). http://awsassets.panda.org/downloads/wwf_guidance_note_infra_.pdf.

8 OPPORTUNITIES RELATING TO CLIMATE CHANGE AND ENVIRONMENTAL ISSUES

☐ **3.1.8** explain how companies and the investment industry can benefit from opportunities relating to climate change and environmental issues: the circular economy, clean and technological innovation, green and ESG-related products, and the blue economy

Previous sections have covered the risks of neglecting the implications of key environmental factors for companies as a result of direct or indirect business activities. The increased awareness of climate change and environmental impact has resulted in an accelerating search for viable societal and economic solutions to enable a transition to a less carbon-intensive economy. Estimates for this transition reach trillions of dollars, and the magnitude of change required will be pervasive, across all aspects of life as we understand it today.

A 2016 study by the Global Commission on the Economy and Climate found that the world is expected to invest about US$90 trillion (£64.7 trillion) in infrastructure over the next 15 years, requiring an urgent shift to ensure that this capital is spent on low-carbon, energy-efficient projects. The report further described that "transformative change is needed now in how we build our cities, produce and use energy, transport people and goods, and manage our landscapes."[261] It is therefore no surprise that there is an increasing number of investment strategies that focus primarily on the opportunities of the low-carbon transition and green finance. Investing in such sectors as technology and resource efficiency, waste management, circular economy, and sustainable agriculture and forestry are just some of the available investment opportunities relating to climate change and environmental issues.

261 New Climate Economy, "The Sustainable Infrastructure Imperative" (2016). https://newclimateeconomy.report/2016/misc/downloads/.

Already, the investment opportunities are becoming visible. FTSE Russell estimated that the green economy (the total market capitalization of the companies generating revenues from activities providing environmental benefits) in 2020 was "equivalent to 5% of the total listed equity market. It has grown faster than the overall equity market since 2009 and is estimated to have overtaken the size of the oil and gas sector."[262]

This section provides an overview of some of these opportunities as they relate to

A. the circular economy,
B. clean and technological innovation,
C. green and ESG-related products, and
D. the blue economy.

It also highlights how clean technology and innovation will play a critical role and be an investment opportunity in mitigating and adapting to the impacts of climate change and environmental degradation. This section also covers some of the financial products most prevalent in supporting environmental (green) considerations in investments.

Circular Economy

With only a fraction of material inputs being currently recycled (less than 12% in the EU in 2019, for example),[263] there are significant investment opportunities from innovations to encourage a shift toward a **circular economy**. This shift is already underway: In September 2020, assets managed through public equity funds with the circular economy as their sole or partial focus were estimated to have increased six-fold compared to the beginning of that year, from US$0.3 billion to US$2 billion (£0.2 billion to £1.4 billion), with the number of such funds almost doubling.[264]

Companies that factor in circularity in their business model are able to play a major role in safeguarding natural resources and transform the way we currently use natural resources and support a transition to a low-carbon economy.

In a circular economy, products and materials are repaired, reused, and recycled rather than thrown away, ensuring that waste from one industrial process becomes a valued input into another. The circular economy concept is now a core component of both the EU's 2050 Long-Term Strategy to achieve a climate-neutral Europe and China's five-year plans.

Due to the expanding market of investible opportunities, both in the private and public markets, companies are working to bring circularity closer to the heart of their business models.

CASE STUDIES

Jurong Island

Singapore's Jurong Island is one of the world's top 10 chemical parks. The close proximity of industries on the island "provides an ecosystem where one company's product can become the feedstock of another. For example, waste from some companies is burned to generate steam for industrial use. Similarly,

262 FTSE Russell, "Investing in the Green Economy—Sizing the Opportunity" (2020). https://content.ftserussell.com/sites/default/files/investing_in_the_green_economy___sizing_the_opportunity_final.pdf.
263 European Environment Agency, "Growth without Economic Growth" (2021). www.eea.europa.eu/publications/growth-without-economic-growth/growth-without-economic-growth.
264 Ellen MacArthur Foundation, "Financing the Circular Economy: Capturing the Opportunity" (2020). www.ellenmacarthurfoundation.org/assets/downloads/Financing-the-circular-economy.pdf.

wastewater is recovered and recycled for industrial use."[265] Industrial developer JTC Corporation is partnering with local companies and regulators to explore further avenues for circularity, by mapping water, energy, and waste flows.

Heineken

As part of its Zero Waste Programme, 102 of Heineken's 165 production units sent zero waste to landfills in 2018. The waste from these sites was instead recycled into animal feed, material loops, or compost or used for energy recovery.[266]

Schneider Electric

This company specializes in energy management and automation. It uses recycled content and recyclable materials in its products, prolongs product lifespan through leasing and pay-per-use, and has introduced take-back schemes into its supply chain. Circular activities now account for 12% of its revenues and will save 100,000 metric tons of primary resources between 2018 and 2020.[267]

Stora Enso

This company provides renewable solutions in packaging, biomaterials, wooden construction, and paper. Reducing waste operates at the heart of the "bioeconomy and contributes to a circular economy."[268]

In 2019, the European Investment Bank launched an investment fund to support the circular bioeconomy.[269]

Close the Loop

This Australian company works to turn old printer cartridges and soft plastics into roads by mixing them with asphalt and recycled glass, resulting in a road surface that is estimated to be up to 65% more durable than traditional asphalt. For a kilometer of road, the equivalent of 530,000 plastic bags, 168,000 glass bottles, and the waste toner from 12,500 printer cartridges is used.[270]

Clean and Technological Innovation

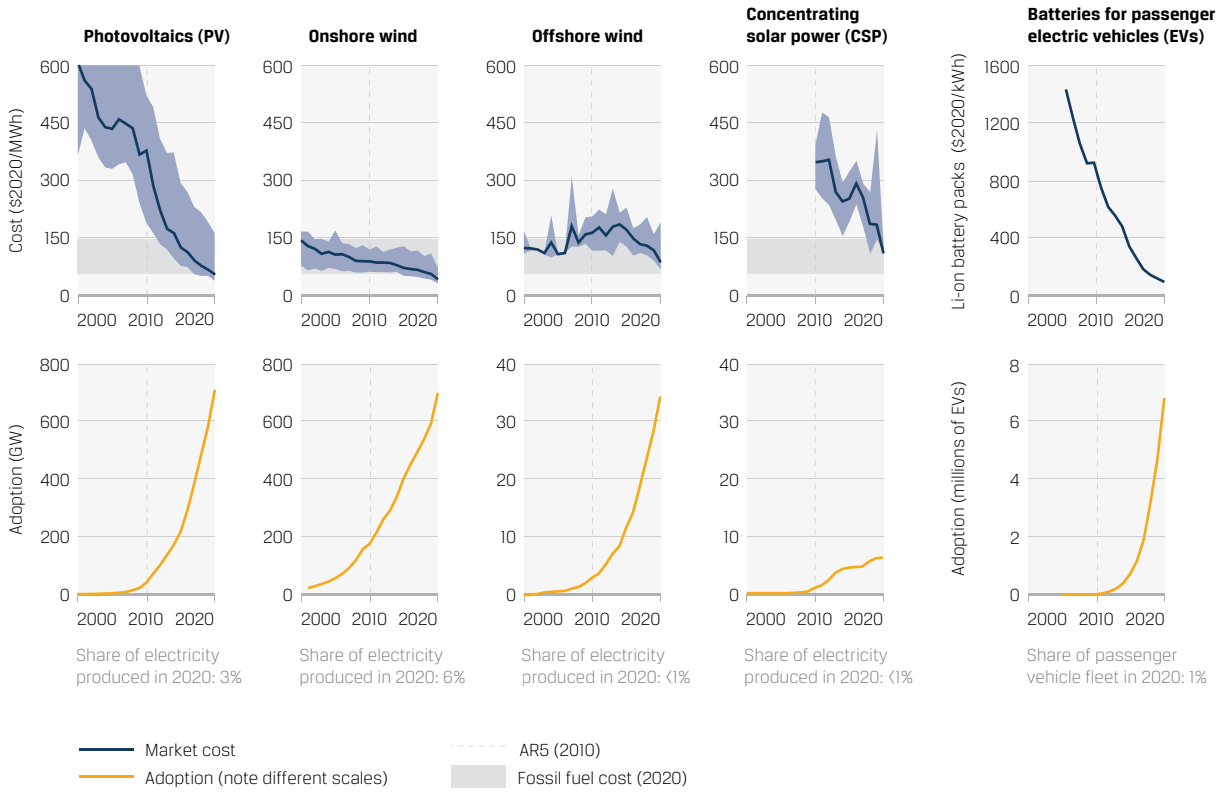
Technological innovation and the development of new business ventures associated with the environment have been around for some time. However, the term cleantech as an umbrella term "encompassing the investment asset class, technology, and business sectors which include clean energy, environmental, and sustainable or green products and services" became increasingly popular approximately 20 years ago.[271]

As with many other technological innovations, such as the internet or GPS, state support and a favorable policy and regulatory environment have been instrumental in driving the early growth of technologies, such as wind and solar energy. However, as the technologies have matured, unsubsidized solar and wind have become the cheapest source of new electricity in most regions around the world. Moreover,

265 Singapore Ministry of the Environment and Water Resources, "Zero Waste Masterplan" (2019). www.towardszerowaste.gov.sg/zero-waste-masterplan/.
266 Heineken, "Drop the C: Reducing Our CO_2 Emissions" (2018). www.theheinekencompany.com/pt-pt/node/607.
267 Schneider Electric, "About Us" (2018). www.se.com/uk/en/about-us/.
268 Stora Enso, "About Stora Enso" (2018). www.storaenso.com/en/about-stora-enso.
269 European Investment Bank, "A European Fund to Support the Circular Bioeconomy" (2019). www.eib.org/en/press/all/2019-328-a-european-fund-to-support-the-circular-bioeconomy.
270 World Economic Forum, "These 11 Companies Are Leading the Way to a Circular Economy" (2019). www.weforum.org/agenda/2019/02/companies-leading-way-to-circular-economy/.
271 ISO, "Energy Management Systems—Requirements with Guidance for Use" (2018). www.iso.org/obp/ui/#iso:std:iso:50001:ed-2:v1:en.

this dynamic is increasingly undercutting *operational* costs of some existing assets; research has shown that in 2020, on a levelized cost basis, it was cheaper to build new wind and solar capacity than to operate 60% of the existing coal power plants in the world.[272] See Exhibit 21 for data on the costs and adoption rates of several clean energy technologies.

Exhibit 21: Falling Costs (US$ 2020/MWh) and Growing Adoption (GW) of Selected Clean Energy Technologies, 2000–2020



Source: IPCC, "Climate Change 2022: Mitigation of Climate Change: Summary for Policymakers" (2022). https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_SummaryForPolicymakers.pdf.

As a result, there is increased interest from private investors in this area. Over the past seven years—a period of intense digitalization and research into automation—it has been estimated that venture capital investment into cleantech grew three times faster than similar investments into artificial intelligence.[273]

Next, we discuss some of the technologies that can play a role in decarbonizing sectors, which contribute substantially to global emissions.

Energy is the "prime mover" of the economy, and reducing the emissions associated with energy production has knock-on effects across all sectors. The production of low-carbon **electricity** has been at the forefront of these developments, from such

272 Lazard, "Levelized Cost of Energy, Levelized Cost of Storage, and Levelized Cost of Hydrogen 2020" (2020). www.lazard.com/perspective/levelized-cost-of-energy-and-levelized-cost-of-storage-2020/. See also Carbon Tracker Initiative, "Coal Developers Risk $600 Billion as Renewables Outcompete Worldwide" (2020). https://carbontracker.org/coal-developers-risk-600-billion-as-renewables-outcompete-worldwide/.

273 PricewaterhouseCoopers, "The State of Climate Tech 2020: The Next Frontier for Venture Capital" (2020). www.pwc.com/gx/en/services/sustainability/publications/state-of-climate-tech-2020.html.

sources as solar photovoltaics, onshore and offshore wind, hydroelectricity, nuclear energy, tidal energy, and geothermal energy. Fuels derived from biomass (e.g., "biofuels," such as bioethanol) may also be considered as a renewable energy source, although this depends on the sustainability of the source, with significant debates around the environmental impacts of large-scale biofuel cultivation.[274]

A full, global accounting of the agricultural sector shows that it produces about 40% of global emissions when heat, electricity, and transportation are included, so biofuels are seldom the low-GHG source that some claim. Harvesting wood and burning it for electricity is slowly renewable but releases more carbon dioxide than burning coal or other fossil fuels and reduces the amount of CO_2 that can be removed by forests.[275] Wood burning also releases large amounts of fine particulates that damage human health, leave sunlight-absorbing black carbon on land, and darken ice and snow, hastening their melting.

Albeit very important, electricity is only one component of energy. The challenge is harder when it comes to decarbonizing **heat and cooling**. For residential and commercial properties, ground and air source heat pumps, combined heat and power, and district heating are some of the potential heating solutions. More difficult is the decarbonization of high-temperature processes. The use of renewable energy to produce hydrogen—which can burn at high temperatures—is increasingly the focus of governments' and investors' strategies, although the deployment of supportive green hydrogen infrastructure is currently lacking. Other speculative technologies include research into nuclear fusion (very long term) and next-generation battery storage.

The electrification of **industrial processes**—from clean sources—is an essential lever for the decarbonization of industry. In steel making, which has a substantial carbon footprint, the use of electric arc furnaces coupled with increased steel recycling and alternative reductants (e.g., hydrogen or gas instead of coal) are important avenues. The process CO_2 released from turning iron ore into iron can be captured and stored. In the chemicals industry, the use of green hydrogen, synthetic fuels, new catalysts, and alternative feedstocks (including the use of biogenic materials), as well as the development of lightweight materials and plastic alternatives, can contribute.

The **built environment** sector contributes up to 40% of total GHGs as a result of the whole life-cycle carbon of the building—the embodied carbon and the carbon associated with construction (building materials) and the operation (energy used to heat, cool, and light). Embodied carbon is associated with the construction materials, major refurbishments, and waste in their production, the building process, and the fixtures and fittings inside, as well as from deconstruction and disposal at the end of a building's lifetime.

In terms of technology drivers in this sector, CO_2 is an inevitable by-product of the chemical reaction used to create the most widely used form of cement. Developing alternatives to "clinkers" (one of cement's major components) will play a key role, as will capture and storage of the process CO_2 that is released. Several large cement producers have already begun to develop breakthrough technologies in producing cement with lower emissions and higher energy efficiency.

In the **transport** industry, many of the world's large automobile makers have begun to shift their business models toward battery electric vehicles (BEVs), with global sales of electric cars more than doubling in 2021 and capturing all the net growth in global

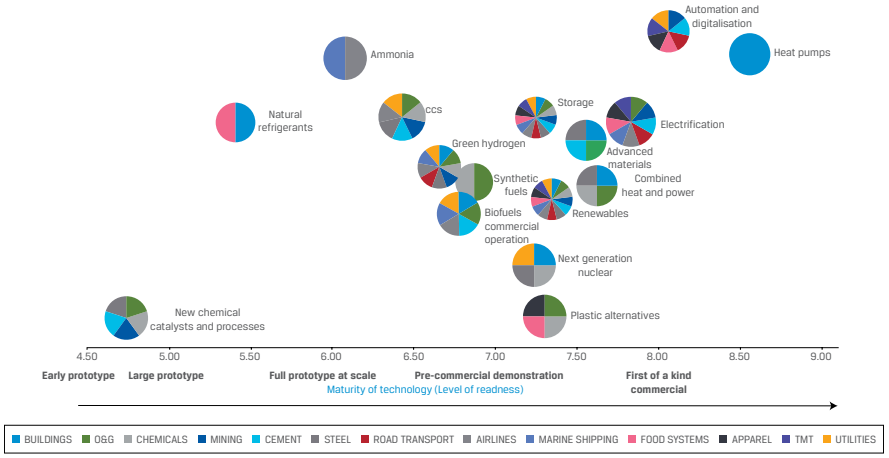
274 S. Evans, "CCC: UK Should 'Move Away' from Large-Scale Biomass Burning," Carbon Brief (15 November 2018). www.carbonbrief.org/ccc-uk-should-move-away-from-large-scale-biomass-burning.
275 John Sterman, William Moomaw, Juliette N. Rooney-Varga, and Lori Siegel, "Does Wood Bioenergy Help or Harm the Environment?" (10 May 2022). https://thebulletin.org/premium/2022-05/does-wood-bioenergy-help-or-harm-the-climate/.

car demand.[276] Nearly half of the 6.5 million BEVs sold worldwide in 2021 were in China, and just 535,000 were sold in the United States.[277] In Norway, 65% of a much smaller but record number of car sales were BEVs; price and other incentives are rapidly transforming the market.[278] The extent to which batteries and electrification will play a substantial role in the decarbonization of heavy-duty transport or whether other fuel sources (such as ammonia, hydrogen fuel cells, or biofuels) may be used to power trucks, planes, and ships remains an open question and subject to intense research and investment.

Given the substantial emissions associated with food production, packaging, and consumption, innovation will be needed in the **food** industry. The development of protein alternatives (whether plant based, including algae,[279] or laboratory-grown meat, for example) is a fast-growing market. Further innovation in agricultural techniques (e.g., around precision and regenerative agriculture or the development of less toxic pest management and low–nitrous oxide emission nitrogen fertilizers) will also be needed.

Finally, in light of the interdependencies in the global economic system, it is often the case, as illustrated in Exhibit 22, that technologies have the potential to be used across multiple sectors.

Exhibit 22: Clean Energy Technologies' Level of Readiness and Applicability in Various Sectors



Note: O&G = oil and gas, CCS = carbon capture and storage, and TMT = technology, media, and telecommunications

Sources: LGIM; IEA, "ETP Clean Energy Technology Guide" (2020). www.iea.org/articles/etp-clean-energy-technology-guide.

276 Leonardo Paoli and Timur Gül, "Electric Cars Fend Off Supply Challenges to More Than Double Global Sales," IEA (2022). www.iea.org/commentaries/electric-cars-fend-off-supply-challenges-to-more-than-double-global-sales.

277 Canalys, "Global Electric Vehicle Sales up 109% in 2021, with Half in Mainland China" (14 February 2022). www.canalys.com/newsroom/global-electric-vehicle-market-2021

278 Victoria Klesty, "Electric Cars Hit 65% of Norway Sales as Tesla Grabs Overall Pole," Reuters (5 January 2022). www.reuters.com/business/autos-transportation/electric-cars-take-two-thirds-norway-car-market-led-by-tesla-2022-01-03/.

279 William Moomaw, Isaac Berzin, and Asaf Tzachor, "Cutting Out the Middle Fish: Marine Microalgae as the Next Sustainable Omega-3 Fatty Acids and Protein Source," *Industrial Biotechnology* 13 (October 2017). www.liebertpub.com/doi/10.1089/ind.2017.29102.wmo.

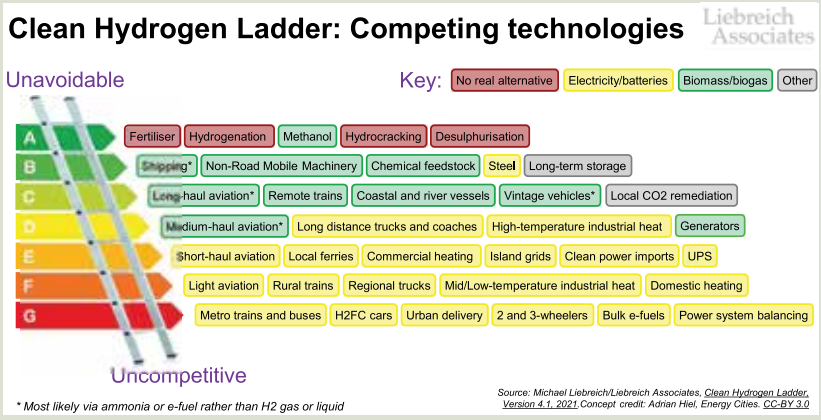
However, it is important to understand that the *technical potential* for a technology to contribute to decarbonization—the list of *possible use cases*—does not guarantee actual deployment, which will also be a function of economics, the availability of alternatives, social preferences, and other factors.

HYDROGEN:HOPE OR HYPE?

The clean-burning qualities of hydrogen, for example, make it a candidate for a variety of applications, including industrial (e.g., in certain high-temperature processes), transport (e.g., long-haul trucking), and domestic (such as replacing gas boilers). As a result, while some governments (notably Japan) have for decades been subsidizing hydrogen research, particularly around fuel cell vehicles, there is renewed policymaker interest in this area, with "hydrogen strategies" and funding commitments announced recently by such governments those in the United Kingdom, the EU, and China.

However, analysts have also highlighted barriers to adoption (e.g., the volumetric density and embrittling effect on steel pipes and the thermodynamic efficiency of transforming electricity into hydrogen and back via a fuel cell). Exhibit 23 shows one energy analyst's ranking of hydrogen use cases in various sectors. Inspired by the energy performance bands now common on electrical appliances, the "hydrogen ladder" aims to situate potential uses cases for clean hydrogen as a function of the availability (or lack thereof) of other, competing cleantech alternatives.

Exhibit 23: The Clean Hydrogen Ladder: An Analyst's Illustration of Clean Hydrogen Use Cases in Relation to Competing Technologies for Decarbonization



Source: Liebreich Associates, "The Clean Hydrogen Ladder" (2021) www.linkedin.com/pulse/clean-hydrogen-ladder-v40-michael-liebreich/.

The choice of technologies and scenario assumptions remains an area of intense debate in both academia and industry, and the technological realities on the ground are fast evolving. For example, according to Bloomberg New Energy Finance, the rise in gas prices in early 2022 has led to the costs of green hydrogen falling below those of "grey" hydrogen (produced from unabated fossil gas) in the Europe, Middle East, and Africa region and China—a point of price parity reached a decade earlier than in some previous estimates.[280]

280 W. Mathis, R. Morison, and V. Dezem, "Russia's War Supercharges Push to Make New Green Fuel," Bloomberg (10 April 2022). www.bloomberg.com/news/articles/2022-04-10/russia-s-invasion-supercharges-push-to-make-a-new-green-fuel.

And as noted earlier, the development of cleantech often works in tandem with standard setting by governments and levels of policy support. One notable example of this is in the case of our built environment.

CASE STUDIES

Environmental Standards in Real Estate

The real estate sector is currently undergoing significant change, with major property developers and managers stepping up their sustainability practices in their role to tackle climate change.

In the United Kingdom, the Better Buildings Partnership (BBP), a coalition of some of the largest commercial property owners, has committed to achieving net-zero carbon by 2050. This is a bold ambition and one that will require significant changes in the current practices throughout the life cycle of a building. The BBP believes that the UK energy efficiency standard and regulations, which are intended to achieve better energy performance, are actually not "fit for purpose" and will certainly not support the BBP's net-zero carbon goal. These standards are focused on design intent rather than on how a building actually performs in use, hence creating a "performance gap."

As such, the BBP has embarked on an initiative called Design for Performance (DfP), which is based on the National Australian Built Environmental Rating System (NABERS), which measures and rates the operational efficiency of commercial offices. NABERS has proven to be very successful as it focuses on target ratings, outcomes, and transparency, and so, it recently published the "NABERS UK Guide to Design for Performance," aimed at the UK market.

In the near future, we can expect to see other governments that have made commitments to achieve carbon neutrality by 2050 start to strengthen their existing energy performance standards and regulations in the real estate sector and adopt best practice approaches such as this one.[281]

According to BloombergNEF, in 2021, total investment in the low-carbon energy transition worldwide was US$755 billion (£575 billion), with China as the largest investor, followed by the United States.[282] The largest area of funding in 2021 was renewable energy, followed by electrified transport and heat.

There has also been increasing activity in corporate venturing and investments by incumbent fossil fuel–based corporations into clean and renewable technologies. These private sector efforts have been complemented by greater supra-national and public sector support—for example, EIT **InnoEnergy**, which was established to invest in and accelerate sustainable energy innovations. Another initiative, still in the concept phase, is the World Economic Forum's **Sustainable Energy Innovation Fund (SEIF)**, which matches up private funding with public investment.

See also quote from BNEF in L. Collins, "Ukraine War | Green Hydrogen 'Now Cheaper than Grey in Europe, Middle East and China': BNEF," Recharge News (7 March 2022). www.rechargenews.com/energy-transition/ukraine-war-green-hydrogen-now-cheaper-than-grey-in-europe-middle-east-and-china-bnef/2-1-1180320.

281 Better Buildings Partnership, "BBP Climate Change Commitment" (2020). www.betterbuildingspartnership.co.uk/node/877.

282 BloombergNEF, "Energy Transition Investment Trends 2022" (2022). https://assets.bbhub.io/professional/sites/24/Energy-Transition-Investment-Trends-Exec-Summary-2022.pdf.

Green and ESG-Related Products

The risks and opportunities associated with environmental sustainability and mitigating climate change necessitate a realignment of financial products and services in order to facilitate the transition to a low-carbon economy. There are three attributes of energy and products: renewability, carbon (or GHG) intensity, and sustainability. For climate, low or zero carbon is the major criterion for determining whether it is "green." Sustainability is a second criterion: Is it "enduring"? Renewability means that the energy or material is replaced in a short time relative to its use. The overall assessment of these three factors determines what is green, but there is no universally agreed-on definition of "green." There have been several developments in this area, along with expectations for rapid expansion of the breadth and depth of these green products and services, over the next few years.

At the Glasgow Climate COP in 2021, the Glasgow Financial Alliance for Net Zero, a group of 450 financial institutions with assets of $130 trillion, announced a goal of net-zero carbon investments by 2050.[283] This goal is at odds with the large investments that have been made in heavy CO_2-releasing industries by many of these institutions.

Some specific financial products that have emerged are

- a range of green, sustainability, and ESG indexes,
- green bonds and loans, sustainability funds, and ETFs,
- retail and institutional deposit and savings products, and
- crowdfunding investments.[284]

Green Bonds, Loans, and Other Labeled ESG-Related Products

The first green bond issuance was announced in 2007 by the European Investment Bank to raise funding for climate-related projects. Green bonds were created to fund projects that have positive environmental or climate benefits. The majority are green "use-of-proceeds" or asset-linked bonds (see Exhibit 24).

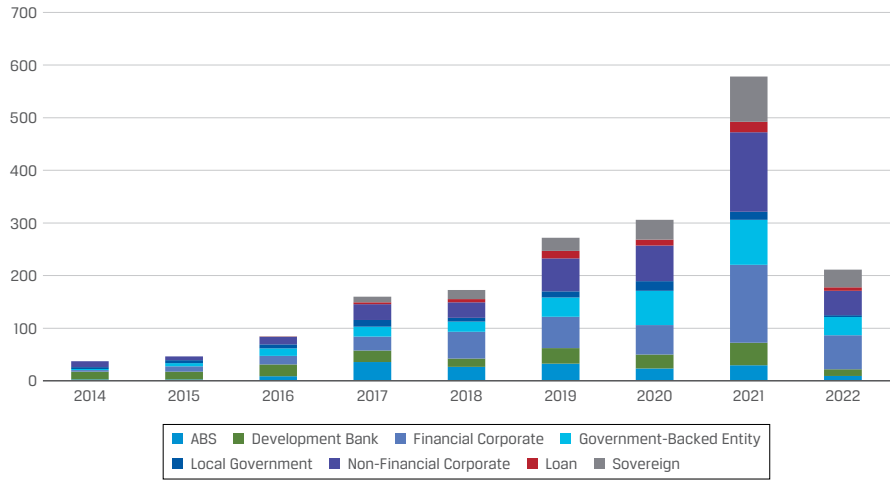
Green bond issuances by banks and corporates have accelerated in recent years, with total cumulative issuance surpassing the US$1 trillion (£0.7 trillion) mark in late 2020, with annual issuance almost doubling in 2021 versus the previous year.[285]

283 J. Baker, "Mark Carney's Ambitious $130 Trillion Glasgow Financial Alliance for Net Zero," Forbes (8 November 2021). www.forbes.com/sites/jillbaker/2021/11/08/mark-carneys-ambitious-130-trillion-glasgow-financial-alliance-for-net-zero/?sh=5b6dd573a312.

284 Climate Bonds Initiative, "Green Bonds: The State of the Market 2018" (2019). www.climatebonds.net/resources/reports/green-bonds-state-market-2018.

285 L. Jones, "$1Trillion Mark Reached in Global Cumulative Green Issuance: Climate Bonds Data Intelligence Reports: Latest Figures," Climate Bonds Initiative (15 December 2020). www.climatebonds.net/2020/12/1trillion-mark-reached-global-cumulative-green-issuance-climate-bonds-data-intelligence. See also www.climatebonds.net/market/data/.

Exhibit 24: Green Bond and Green Loan Issuance Volume, 2015–2020



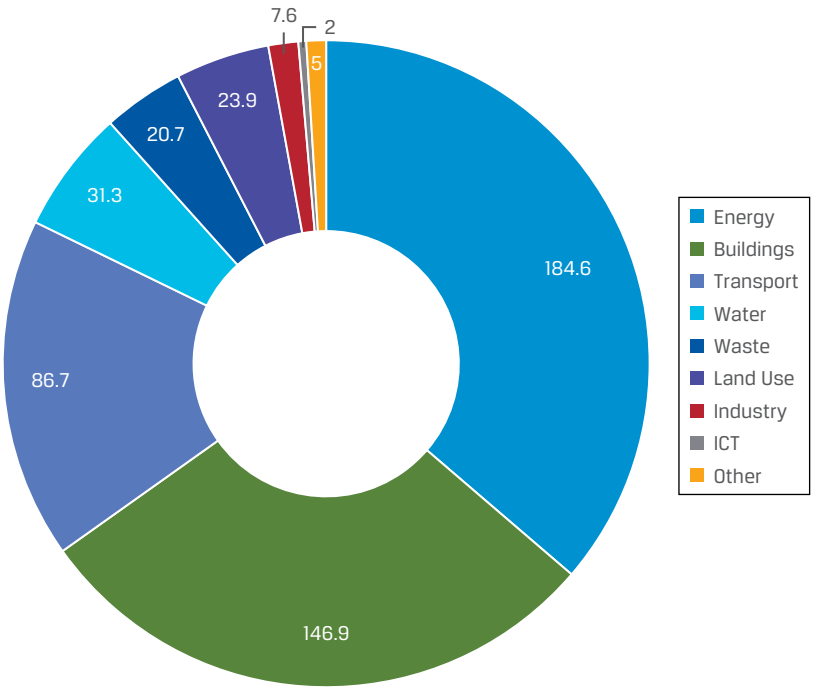
Notes: Data cover up to the end of 2021. All debt instruments have been screened in accordance with the Climate Bonds Initiative Green Bond Database Methodology[286] and Social & Sustainability Bond Database Methodology.[287] Definitions of *green* are derived from the Climate Bonds Taxonomy,[288] and issuer type classification follows Climate Bonds Initiative convention.

Source: Climate Bonds Initiative, "Climate Bonds Interactive Data Platform" (2022). www.climatebonds.net/market/data/.

While clean energy and low-carbon building investment continues to dominate allocations, funding for low-carbon transport has increased dramatically and issuers from the information and communications technology (ICT) and manufacturing sectors have entered the green bond market (see Exhibit 25).

286 Climate Bonds Initiative, "Green Bond Database Methodology" (2021). www.climatebonds.net/market/green-bond-database-methodolgy.
287 Climate Bonds Initiative, "Social & Sustainability Bond Database Methodology" (2021). www.climatebonds.net/market/social-sustainability-bond-database-methodology.
288 Climate Bonds Initiative, "Climate Bonds Taxonomy" (2020). www.climatebonds.net/standard/taxonomy.

Exhibit 25: Use of Green Bond and Loans Proceeds, 2021



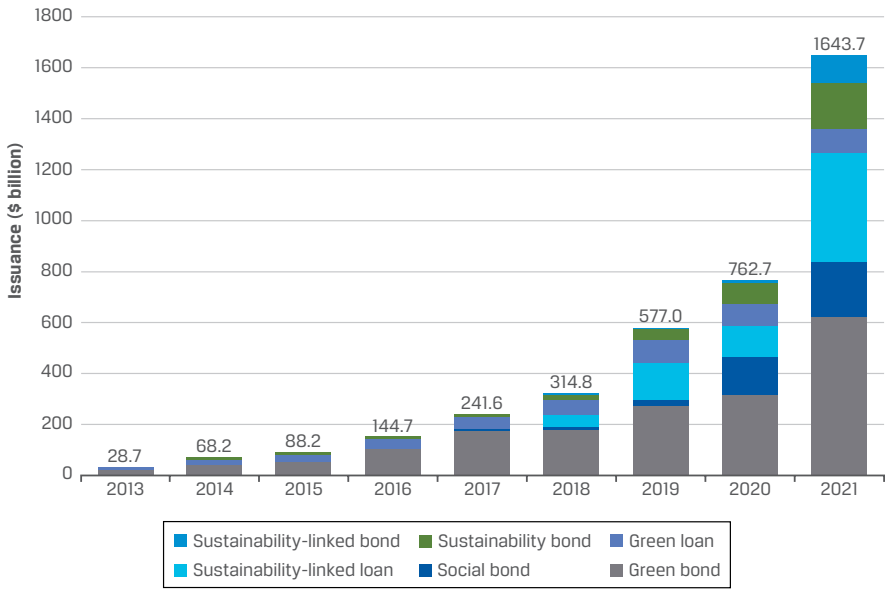
Note: Data cover up to the end of 2021. All debt instruments have been screened in accordance with the Climate Bonds Initiative Green Bond Database Methodology[289] and Social & Sustainability Bond Database Methodology.[290] Definitions of *green* are derived from the Climate Bonds Taxonomy,[291] and issuer type classification follows Climate Bonds Initiative convention.

Source: Climate Bonds Initiative, "Climate Bonds Interactive Data Platform" (2022). www.climatebonds.net/market/data/.

In addition to green bonds, which focus closely on climate change solutions, there has been increased issuance in other labeled debt (see Exhibit 26), primarily green and sustainability loans, where the financing terms are linked to climate or environmental performance indicators (for example, investors may receive an increase in the bond's coupon if the company fails to meet certain targets).

289 Climate Bonds Initiative, "Green Bond Database Methodology."
290 Climate Bonds Initiative, "Social & Sustainability Bond Database Methodology."
291 Climate Bonds Initiative, "Climate Bonds Taxonomy."

Exhibit 26: Global Sustainable Debt Issuance, 2013–2021 (US$ billions)



Source: BloombergNEF, "Sustainable Debt Issuance Breezed Past $1.6 Trillion in 2021" (2022). https://about.bnef.com/blog/sustainable-debt-issuance-breezed-past-1-6-trillion-in-2021/.

Exhibit 27 shows examples of such transactions, ranging from green bonds to sustainability or SDG-linked bonds and loans.

Exhibit 27: Examples of Sustainable Financing Transactions

Issuer and Type	Use of Proceeds
Green bond issued by Louisiana Local Government Environmental Facilities and Community Development Authority (2018)	Coastal flood defenses
Dutch sovereign green bond (2019)	Flood protection under its Delta Programme
First dedicated resilience bond under the Climate Resilience Principles by European Bank for Reconstruction and Development (2019)[292]	Climate-resilient infrastructure in Eastern Europe and North Africa
Chile's sovereign green bond (2019 and 2020)	The first issue in 2019 was focused on financing solar, low-carbon transport, low-carbon building upgrades, and water infrastructure. The 2020 issue was focused primarily on low-carbon transport.

292 V. Bennett, "World's First Dedicated Climate Resilience Bond, for US$ 700m, Is Issued by EBRD," European Bank for Reconstruction and Development (20 September 2019). www.ebrd.com/news/2019/worlds-first-dedicated-climate-resilience-bond-for-us-700m-is-issued-by-ebrd-.html.

Issuer and Type	Use of Proceeds
Rizal Commercial Banking Corporation (RCBC), one of the Philippines' largest banks, issued the first ASEAN sustainability bond (2019)[293]	RCBC applied its Sustainability Finance Framework, which includes seven eligible green categories (energy, buildings, transport, urban and industrial energy efficiency, waste, water, and land use) and five eligible social categories (affordable basic infrastructure, access to essential services, employment generation, affordable housing, and socioeconomic advancement and empowerment).
First SDG-linked bond, launched by the Italian energy producer Enel (2019)	Proceeds were aimed at general corporate purposes. However, the new instrument requires Enel to measure its performance against several environmental and social KPIs, to which the coupon will be dependent.
First SDG-linked sovereign bond, launched by the government of Mexico[294]	Eligible categories need to meet two criteria: • geospatial (prioritizing location of vulnerable populations) and • governance (involvement of a UN organization).
Seychelles launched the world's first sovereign "blue bond"[295]	Proceeds were used to help finance the island's transition to sustainable fisheries and marine protection.
Starbucks issued a sustainability bond (2019), following its previous issues in 2016 and 2017.	Eligible categories fall under socioeconomic advancement and empowerment and access to essential services and under green (green buildings).
Thames Water became the United Kingdom's first corporation to issue a sustainability-linked revolving credit facility (£1.4 billion, 2018)[296]	Interest payments are linked to its Global Real Estate Sustainability Benchmark (GRESB) infrastructure score.
Solvay, a Belgium chemical company, issued a sustainability-linked loan.[297]	Linked to an ambitious GHG reduction target—in this case, 1 million tonnes of CO_2 by 2025
Luxembourg was the first European country to launch its own Sustainability Bond Framework, in line with the European taxonomy for green financing (2020)[298]	Combination of EU green projects and sustainability projects

From an investment perspective, as the supply of green or ESG-related products continues to grow, it is important to note that what may be considered green or sustainable for one investor may not be so for another. Therefore, investors need to have a clear framework by which to assess these assets. The following are some of the considerations:

- the eligibility of assets and criteria to meeting their green, ESG, or SDG-related objectives,
- the use of proceeds effectively allocated to eligible projects,

293 Rizal Commercial Banking Corporation, "RCBC to Issue First ASEAN Sustainability Bond in the Philippines," press release (2019). www.rcbc.com/Content/Web/img/about/pdf/disclosure/RCBC%20to%20issue%20First%20ASEAN%20Sustainability%20Bond%20in%20the%20Philippines.pdf.

294 International Institute for Sustainable Development, "Mexico Issues Sovereign SDG Bond for Most Vulnerable Municipalities" (2020). https://sdg.iisd.org/news/mexico-issues-sovereign-sdg-bond-for-most-vulnerable-municipalities/.

295 World Bank, "Seychelles Launches World's First Sovereign Blue Bond," press release (2018). www.worldbank.org/en/news/press-release/2018/10/29/seychelles-launches-worlds-first-sovereign-blue-bond.

296 Thames Water, "Press Release: Thames Water Ties Interest Rate on New £1.4 Billion Revolving Credit Facility to Sustainability Performance" (2019).

297 Solvay, "Solvay Links the Cost of €2 Bn Revolving Credit Facility to Its Ambitious Greenhouse Gas Reduction Commitments," press release (2019). www.solvay.com/en/press-release/solvay-links-cost-eu2-bn-revolving-credit-facility-its-ambitious-greenhouse-gas.

298 Gouvernement.lu, "Luxembourg—First European Country to Lunch a Sustainability Bond Framework," press release (2020). https://gouvernement.lu/en/actualites/toutes_actualites/communiques/2020/09-septembre/02-cadre-obligations-durables.html.

- the transparency and reporting requirements and key measures of impacts, and
- the issuer or borrower has a clear sustainability and ESG strategy.

Exhibit 28 shows an example of the "shades of green" methodology developed by the Center for International Climate Research (CICERO) to provide second-party opinions that determine how a green or sustainability bond aligns with a low-carbon resilient future.

Exhibit 28: Example of the "Shades of Green"

Dark green	Solutions and projects that currently realize the long-term vision of a climate-resilient and low-carbon future. Typically, this equates to zero-emission solutions and government support that integrates enviornmental effects into all governance structures. Examples include renewable energy projects such as wind or solar.
Medium green	Solutions and projects that are making progress toward the long-term vision but that are not fully realized. Examples include sustainable buildings with good (but not excellent) energy efficiency ratings.
Light green	Solutions and projects that aren't a part of the long-term vision but are still environmentally friendly. Projects should be careful not to lock into fossil fuel systems permanently. Examples include short-term improvements in fossil fuel efficiency that result in reductions of greenhouse gas.
Brown	Solutions and projects that do not enable long-term vision of a climate-resilient and low carbon future. Examples include new infrastructure projects for coal.

Source: CICERO, "CICERO Shades of Green" (2015). https://cicero.green/.

At the intersection of "brown" and "green" in Exhibit 28, the term "transition bonds" has been coined for bonds issued by high-emission companies to finance their reduction in GHG emissions. Some of these products finance measures that may not be considered "green enough" but still aim to address climate change.

There will continue to be a proliferation of green financial products in the marketplace. The important consideration to note is that the quality and transparency of environmental and climate-related data and disclosure will need to improve in order to avoid "greenwashing." Efforts by the EU to harmonize and create a common language will be a significant development for green financial products.

CASE STUDIES

What Is "Green"?

The International Capital Markets Association (ICMA) sets out voluntary guidelines called the Green Bond Principles (GBP), which were established in 2014 by a consortium of investment banks to promote the integrity of the green bond market by recommending transparency, disclosure, and reporting.[299] As part of ensuring the integrity of the use of proceeds, external review is obtained through a second-party opinion provider that will track and report on whether proceeds are used as promised.

299 ICMA, "Green Bond Principles (GBP)" (2018). www.icmagroup.org/green-social-and-sustainability-bonds/green-bond-principles-gbp/.

The Climate Bonds Initiative has regular information about the state of the green bond market. The Climate Bonds Taxonomy and sector-specific criteria have been scientifically developed to meet the object of the Paris Agreement of keeping global warming under 2°C (3.6°F), and the range of sector criteria keeps expanding. The organization has started focusing on transition and published a framework for delineating green and transition finance.[300]

In 2018, the Green Loan Principles (GLP) were established by the Loan Market Association (LMA) and the Asia Pacific Loan Market Association (APLMA). The four pillars of the GLP are as follows:

1. There is clear green use of loan proceeds.
2. The project's sustainability objectives have been clearly evaluated and communicated to lenders.
3. Loan proceeds are strictly managed through project accounts.
4. Detailed and strict reporting is mandated.[301]

Further to the GLP, in 2019, the LMA, the APLMA, and the Loan Syndications and Trading Association launched the Sustainability-Linked Loan Principles.[302]

In addition to labeled debt, green and sustainable finance includes debt from companies that operate in such sectors. The Climate Bonds Initiative provides regular information on the scale of the unlabeled climate bond market relative to the green bond market.[303] Defined as entities that generate 75% or more of their revenues from green business lines, climate-aligned issuers had issued US$913 billion (£656 billion) in outstanding bonds as of 30 September 2020, up from US$811 billion (£583 billion) as of 30 June 2018.[304] LGX, the Luxembourg Green Exchange, launched a climate-aligned issuer segment to complement its existing green bond, sustainability, and social bond segment.[305]

Blue Economy

The World Bank defines blue economy as the "sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystems."[306] All other definitions of the term essentially relate to a broader perspective on sustainable economic and social activity associated with the world's oceans and coastal areas.

Examples of ocean-based industries representing the blue economy are shown in Exhibit 29.

300 Climate Bonds Initiative, "Financing Credible Transitions: How to Ensure the Transition Label Has Impact," white paper (2020). www.climatebonds.net/resources/reports/financing-credible-transitions-white-paper.
301 Loan Market Association, "Green Loan Principles: Supporting Environmentally Sustainable Economic Activity" (2018). www.lma.eu.com/application/files/9115/4452/5458/741_LM_Green_Loan_Principles_Booklet_V8.pdf.
302 Loan Market Association, "Sustainability Linked Loan Principles" (2019). www.icmagroup.org/assets/documents/Regulatory/Green-Bonds/LMASustainabilityLinkedLoanPrinciples-270919.pdf.
303 Climate Bonds Initiative, "Bonds and Climate Change: The State of the Market 2018" (2018). www.climatebonds.net/resources/reports/bonds-and-climate-change-state-market-2018.
304 2020 data provided by Climate Bonds Initiative in response to a data request by CFA UK.
305 Luxembourg Stock Exchange, "LGX Expands to Welcome Climate-Aligned Issuers" (2021). www.bourse.lu/pr-lgx-welcomes-climate-aligned-issuers. The segment is Luxembourg Stock Exchange, "Climate Bonds—LGX Climate-Aligned Issuers" (2021). www.bourse.lu/climate-bonds-lgx-climate-aligned-issuers.
306 World Bank, "The Potential of the Blue Economy: Increasing Long-Term Benefits of the Sustainable Use of Marine Resources for Small Island Developing States and Coastal Least Developed Countries" (2017). https://openknowledge.worldbank.org/bitstream/handle/10986/26843/115545.pdf.

Exhibit 29: Examples of Ocean-Based Industries Representing the Blue Economy

- Aquaculture
- Fisheries
- Fish processing industry
- Ports and warehousing
- Ship building and repair
- Coastal tourism
- Marine extraction
- Maritime transport
- Desalination
- Blue bioeconomy and biotechnology
- Coastal and environmental protection
- Offshore wind energy
- Ocean energy
- Deep water source cooling

The blue economy has more recently begun to gather more attention and has climbed the policy agenda. As covered in the previous section on oceans as a natural resource, it is clear that the ocean is already under stress from over-exploitation, pollution, declining biodiversity, and climate change.

Investors and policymakers are now beginning to recognize

- the growth prospects for the ocean economy,
- its capacity for future employment creation and innovation, and
- its role in addressing global challenges.[307]

There is growing scope for science and technology to manage the economic development of our seas and ocean responsibly. Marine ecosystems lie at the heart of many of the world's global challenges, providing food and medicines, new sources of clean energy and natural cooling systems, climate regulation, job creation, and inclusive growth. But safeguards are required to improve the health of these ecosystems to support an ever-growing use of marine resources. As we have seen in the section on biodiversity, the issue of accounting for natural capital remains a promising but underdeveloped area; this is also true in the case of the blue economy. The World Ocean Initiative has suggested the inclusion of **ocean accounting**—adding ocean-related services and assets—to national balance sheets.[308]

Based on a study by the OECD, three priority areas for action are presented:

1. approaches that produce win–win outcomes for ocean business and the ocean environment across a range of marine and maritime applications,
2. the creation of ocean-economy innovation networks, and
3. initiatives to improve the measurement of the ocean economy via satellite accounts of national accounting systems.

The OECD suggests that many ocean-based industries have the potential to outperform the growth of the global economy as a whole, both in terms of value added and employment. Projections suggest that the ocean economy could more than double its contribution to global value added, to over US$3 trillion (£2.2 trillion), in addition to huge potential in employment growth by 2030.

307 OECD, "The Ocean Economy in 2030" (2016). https://doi.org/10.1787/9789264251724-en.
308 World Ocean Initiative, "The Wealth of Oceans: New Research Shines a Light on Ocean Accounting" (2020). https://ocean.economist.com/blue-finance/articles/the-wealth-of-oceans-new-research-highlights-importance-of-ocean-accounting.

CASE STUDIES

Blue Economy Development Framework

The World Bank and the European Commission have launched the Blue Economy Development Framework (BEDF), which is a new step in the area of international ocean governance.[309] It helps (developing) coastal states transition to diverse and sustainable blue economies while building resilience to climate change.

The BEDF aims to create a roadmap that assists governments in

- preparing policy, fiscal, and administrative reforms,
- identifying value creation opportunities from blue economy sectors, and
- identifying strategic financial investments.

The BEDF intends to help coastal countries and regions develop evidence-based investment and policy reform plans for its coastal and ocean resources.

309 World Bank and European Commission, "World Bank and European Commission Promote Blue Economy through New Tool" (2019). https://oceans-and-fisheries.ec.europa.eu/news/world-bank-and-european-commission-promote-blue-economy-through-new-tool-2019-02-14_en.

KEY FACTS

1. The range of environmental factors that have a material impact on investments are broad and far reaching. They include but are not limited to:
    a. a rapidly changing climate,
    b. natural resources (including water, biodiversity, land use and forestry, and marine resources), and
    c. pollution, waste, and the circular economy.
2. Driven by the emissions of greenhouse gases (GHGs) into the atmosphere, accelerating climate change carries significant risks to human health, economies, and ecosystems. Effective responses will involve a combination of climate mitigation and adaptation measures.
3. The Paris Agreement of 2015 was reached to mobilize a global response to the threat of climate change, amid growing concern reported by scientific experts. The agreement's long-term goal is to keep the increase in global average temperature well below 2°C (3.6°F) above pre-industrial levels and to limit the increase to 1.5°C (2.7°F).
4. Since the Paris Agreement was signed, a global consensus has begun to emerge that reaching net-zero carbon dioxide emissions around 2050 is required to turn its goals into reality. Governments, companies, and investors are increasingly adopting net-zero targets as a result. It is essential to understand that this goal is not an end point but a midpoint in a century-long effort to stabilize atmospheric concentrations in the atmosphere. It should be seen as a floor under aspirations and not a ceiling over accomplishments.
5. Putting a price on carbon emissions is seen by many economists as one of the most effective methods of tackling climate change. Carbon markets have steadily grown around the world, but current levels of carbon pricing remain low.
6. Policymakers and investors must navigate both
    - the physical risks of climate change (associated with climate inaction) and
    - the transition risks of climate change (associated with climate action).

    Rising carbon costs carry financial risks of their own, because they can affect the value of high-carbon assets, with potential knock-on effects across sectors. This reinforces the need for an orderly and just transition to the low-carbon economy.
7. Environmental degradation, the depletion of natural resources, and the associated losses in biodiversity are presenting multiple, interrelated challenges for governments, the public, and businesses. Such issues as water scarcity, deforestation, degradation of land and oceans, unsustainable agricultural practices, waste, and pollution are increasingly impacting business and investment activities. To help alleviate some of these pressures, the model of the circular economy promotes a more efficient use of raw materials, coupled with increased reuse, recycling, and waste management.
8. Material environmental issues are factors that could have a significant impact—both positive and negative—on a company's business model and value drivers, such as operating and capital expenditure, revenue growth, margins, and risk. The material factors differ from one sector to another.

9. Environmental risks can be effectively integrated into company analysis and investment decision-making processes, using various financial tools and models. The types of risk analysis tools and associated metrics primarily depend on the asset classes and risk types financial institutions are exposed to. Similarly, the choice of approach depends on the type of direct and indirect exposure to an environmental risk factor. Investors have developed a combination of metrics, from carbon footprinting to forward-looking climate scenario analysis. Many solutions for reducing risk bring economic benefits; for example, increasing energy and material productivity (efficiency of use) and such renewables as wind and solar reduce production costs and often have a higher rate of economic return than continuing the use of inefficient technologies and fossil fuels.
10. There is an increasing number of policy initiatives at both the country and regional levels to promote the economic and financial mainstreaming of climate change and environmental factors in jurisdictions around the world. Requirements for climate-related disclosures (both mandatory and voluntary) are increasing in different parts of the entire investment chain, from the owners of capital (pension funds and insurance companies) to the beneficiaries (investee companies).
11. Coupled with regulatory tailwinds, technological innovation is giving rise to increasing investment opportunities from the provision of climate and environmental solutions, in areas including clean energy and mobility, sustainable buildings, and advanced materials. For a majority of the world's population, unsubsidized clean energy represents the cheapest source of new electricity.
12. There is a growing number of specialized investment products, including low-carbon (active and index) funds and sustainability-linked debt, that aim to capture this opportunity set.

FURTHER READING

Temperature Alignment Tools

Raynaud, Julie, Stephane Voisin, Peter Tankov, Anuschka Hilke, Alice Pauthie. 2020. "The Alignment Cookbook: A Technical Review of Methodologies Assessing a Portfolio's Alignment with Low-Carbon Trajectories or Temperature Goal." https://gsf.institutlouisbachelier.org/publication/the-alignment-cookbook-a-technical-review-of-methodologies-assessing-a-portfolios-alignment-with-low-carbon-trajectories-or-temperature-goal/.

Climate Scenario Analysis

Zürich, E. T. H. 2020. "Taming the Green Swan: How to Improve Climate-Related Financial Risk Assessments." www.research-collection.ethz.ch/handle/20.500.11850/428321.

Principles for Responsible Investment 2020. "Pathways to Net Zero: Scenario Architecture for Strategic Resilience Testing and Planning." www.unpri.org/climate-change/pathways-to-net-zero-scenario-architecture-for-strategic-resilience-testing-and-planning/6006.article.

Task Force on Climate-Related Financial Disclosures 2020. "Guidance on Scenario Analysis for Non-Financial Companies." www.fsb.org/wp-content/uploads/P291020-3.pdf.

Green and ESG-Related Products

Climate Bonds Initiative 2018. "Bonds and Climate Change: The State of the Market 2018." www.climatebonds.net/resources/reports/bonds-and-climate-change-state-market-2018.

SELF PRACTICE AND SELF ASSESSMENT

1. The Paris Agreement:
   a. is legally binding under the local law of each signatory country.
   b. requires every signatory to provide an annual update on its national emission commitments.
   c. aims to limit the increase in global average temperature to 2°C above pre-industrial levels by the end of the century.
2. The first international convention to set targets for emissions of the main greenhouse gases was the:
   a. Kyoto Protocol.
   b. Paris Agreement.
   c. United Nations Sustainable Development Goals.
3. In relation to the European Green Deal, the "green supporting factor" refers to:
   a. standards and labels for green bonds.
   b. a classification system for sustainable activities.
   c. the treatment of "green" assets in the capital requirements of banks and insurers.
4. Sustainability integration is *most* effective when sustainability is embedded in the practices of:
   a. asset owners and investee companies.
   b. asset owners and financial intermediaries.
   c. asset owners, investee companies, and financial intermediaries.
5. Which of the following countries has the highest level of investments in the low-carbon energy transition?
   a. Japan
   b. China
   c. United States
6. A sustainability bond funding a climate-friendly project that may be exposed to physical and transitional climate risks yet has no strategies in place to mitigate their impact would be graded by CICERO as:
   a. brown.
   b. light green.
   c. medium green.
7. Which of the following initiatives recommends that signatories incorporate climate change effects into macroeconomic policy and fiscal planning?
   a. Helsinki Principles
   b. Equator Principles
   c. Climate Resilience Principles
8. The Network for Greening the Financial System (NGFS) comprises:
   a. multilateral institutions and agencies.
   b. asset managers and investment banks.

c. central banks and financial supervisors.

9. Which of the following carbon pricing methods is used by companies to determine the impact of climate change on the profitability of a new project?

a. Carbon taxation
b. Shadow carbon pricing
c. Emission trading system (ETS)

10. In relation to ESG analysis, investors should make adjustments to the credit assessment of a company based on:

a. solely quantitative environmental factors.
b. the sector and geographic location of the company's assets.
c. all environmental effects on the company, irrespective of their materiality.

The following information relates to questions 11-25

Self Assessment Questions

These questions are provided only to enable you to test your understanding of the chapter content. They are not indicative of the types and standard of questions you may see in the examination. The Self-Assessment questions do not include an explanation of the correct answer.

11. Which of the following would be considered a climate change adaptation strategy?

a. Releasing sunlight-reflecting aerosols into the atmosphere to reduce temperatures
b. Retrofitting buildings to become more energy efficient
c. Developing clean cooling systems
d. Protecting coastlines from erosion

12. What is "natural capital"?

a. Natural resources (such as oil, gas, or timber) that can be sold for a profit in a capitalist economy
b. The stock of natural assets, which include geology, soil, air, water, and all living things
c. An international collaboration to increase the proportion of natural spaces in capital cities
d. The sum total of monetary benefits that are directly dependent on nature

13. Which of the following has the highest potential to contribute to global decarbonization?

a. The electrification of industrial processes, powered by clean energy sources
b. Coal gasification combined with carbon capture and storage
c. A global shift to a flexitarian diet
d. Shifting all passenger cars to hydrogen fuel cells

14. What is the most common method of waste management globally?

a. Recycling
b. Incineration
c. Landfills

d. Treatment

15. Which of the following best describes the principles of a circular economy?

a. Extracting natural resources for products that are then used and eventually discarded

b. Designing out waste and pollution, keeping materials in use, and regenerating natural systems

c. Ensuring that all products are returned to the manufacturers to reuse component parts

d. Producing goods only for consumption by customers in the manufacturer's domestic market

16. For a reasonable chance of limiting the global average temperature rise to 1.5°C (2.7°F), the Intergovernmental Panel on Climate Change (IPCC) recommends that global emissions of CO_2 must reach "net zero" around:

a. 2050.

b. 2030.

c. 2100.

d. 2075.

17. What is the blue economy?

a. Industrial activities that generate pollution of oceans and inland waterways

b. The global network of shipping that transports people and manufactured goods

c. Products and processes used to clean up water-based environmental pollution

d. Sustainable economic and social activity related to oceans and coastal areas

18. Which of the following represents a transition risk?

a. Policy change to encourage low-carbon technologies

b. Occurrence of extreme weather events

c. Breakdowns in business supply chains

d. Long-term rises in global temperatures

19. In relation to shadow carbon pricing, which of the following is incorrect?

a. Shadow carbon pricing is used to understand the potential impact of external prices on the profitability of a project.

b. Shadow carbon pricing is used to reduce a business's carbon footprint.

c. Shadow carbon pricing is used to reveal hidden risks and to factor these into future valuations and estimates of capital expenditure.

d. Shadow carbon pricing is used to create a theoretical cost per tonne of carbon emissions by establishing a business's internal price on carbon.

20. Which of the following is not a Task Force on Climate-Related Financial Disclosures (TCFD) core element of climate-related disclosures?

a. Governance

b. Impact

c. Risk management

d. Strategy

21. Which of the following is not an explicit UN Sustainable Development Goal (SDG)?

- **a.** Ending poverty in all its forms everywhere
- **b.** Access to affordable, clean nuclear energy
- **c.** Ensuring healthy lives and promoting well-being for all ages
- **d.** Taking urgent action to combat climate change and its impacts

22. What is the primary objective of the EU Taxonomy?

- **a.** Clear labeling of the use of proceeds for green bonds
- **b.** An EU-wide classification system of sustainable activities.
- **c.** A classification of what "green" activities states can finance domestically without breaching competition rules
- **d.** A classification system of the Scope 1, 2, and 3 emissions associated with the activities of EU companies

23. Scope 3 of the GHG Protocol Standards covers which of the following emission sources?

- **a.** Company vehicles
- **b.** Company facilities
- **c.** Purchased electricity
- **d.** Purchased goods and services

24. Which of the following is *not* a requirement for a bond or a loan to be considered "green" under such frameworks as the Green Bond Principles (GBP) or Green Loan Principles (GLP)?

- **a.** A description of the environmental benefits associated with the use of proceeds
- **b.** A minimum of 10 tonnes of certified emissions reductions per every US$1 (£0.7) of debt
- **c.** A clear process for the evaluation and selection of eligible projects
- **d.** Detailed and regular reporting

25. The long-term goal of the Paris Agreement, adopted in 2015, is to keep the increase in the global average temperature above pre-industrial levels to well below what level?

- **a.** 1.0°C (1.8°F)
- **b.** 1.5°C (2.7°F)
- **c.** 2.0°C (3.6°F)
- **d.** 2.5°C (4.5°F)

SOLUTIONS

1. C is correct. The aim of the international Paris Agreement on climate change is to pursue efforts to limit the temperature increase to 2°C (3.6°F) above pre-industrial levels by the end of the century. The Paris Agreement does not set any legally binding targets under international law. Signatories to the Paris Agreement are required to determine, plan, and report on its NDCs, with updates to commitments every five years.

2. A is correct. The Kyoto Protocol was adopted in 1997 and became effective in 2005. It was the first international convention to set targets for emissions of the main GHGs.

3. C is correct. The treatment of "green" assets in the capital requirements of banks and insurers is referred to the "green supporting factor."

4. C is correct. Effective ESG integration is intended to embed sustainability across the entire investment chain—from the owners of capital (asset owners) to the beneficiaries of capital (such as investee companies), as well as key intermediaries.

5. B is correct. China remains the country with the highest levels of investment in the low-carbon energy transition.

6. B is correct. In the light green grade, projects may be exposed to physical and transitional climate risks without appropriate strategies in place to protect them.

7. A is correct. Helsinki Principles encourage signatories to "take climate change into account in macroeconomic policy, fiscal planning, budgeting, public investment management, and procurement practices."

8. C is correct. The NGFS comprises over 70 central banks and financial supervisors.

9. B is correct. An internal or shadow price on carbon creates a theoretical or assumed cost per tonne of carbon emissions. This is used to better understand the potential impact of future climate regulation on the profitability of a project, a new business model, or an investment.

10. B is correct. Investors should consider quantitative and qualitative environmental factors, the company, the sector, and the geographic location. Investors should assess the material financial impacts caused by environmental risks.

11. D is correct.

12. B is correct.

13. B is correct.

14. C is correct.

15. B is correct.

16. A is correct.

17. D is correct.

18. A is correct.

19. B is correct.

20. B is correct.

21. B is correct.

22. B is correct.

23. D is correct.

24. B is correct.

25. C is correct.