

FIRST-QUARTER 2023 EDITION



S&P Global Sustainability Quarterly

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The Road to
Climate Resilience

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S&P Global Sustainable1

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S&P Global Ratings

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Digital Leads

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S&P Global

Kyle May,
S&P Global

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S&P Global Sustainable1

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S&P Global Sustainable1

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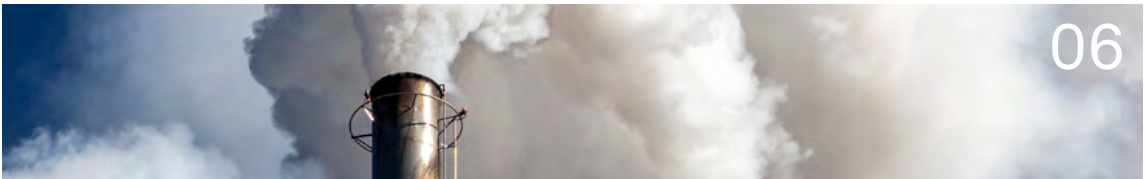
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Introduction

Welcome to the latest edition of the S&P Global Sustainability Quarterly, where we bring together research to help you understand the latest trends and measure progress toward a low-carbon, sustainable future.



Most financial institutions don’t set financed emission targets, putting net-zero goals at risk

Less than a quarter of financial institutions are aiming to reduce emissions across their whole value chain, including across lending or investment portfolios.



Is climate change another obstacle to economic development?

Over the next decades, we think rising temperatures will be a bigger hurdle for emerging markets and developing economies than for advanced economies.



Adaptation planning is the next step for companies to prepare for climate risk

Many companies are moving slowly to adapt their businesses to physical climate risks — even in sectors where many companies consider climate strategy a top material issue.



Crunch Time: Can adaptation finance protect against the worst impacts from physical climate risks?

Investments in climate risk adaptation must close the gap with mitigation financing to avoid the worst outcomes.



Sustainable bond issuance will return to growth in 2023

Green, social, sustainability and sustainability-linked issuance is expected to return to growth in 2023, potentially reaching \$1 trillion in total.

Introduction

Welcome to the latest edition of the S&P Global Sustainability Quarterly, our first of 2023. The physical hazards of climate change are rising in severity and frequency, and countries and companies around the globe are setting net-zero targets in a bid to meet the goals of the Paris Agreement and limit the damage from climate change. But some impact will be unavoidable, and it will not be evenly distributed. An S&P Global Ratings analysis of data from 190 countries shows that a one-time, 1-degree C annual average temperature increase is more damaging for emerging markets and developing economies than for advanced economies.

Mitigation is only one piece of the solution to the climate change puzzle. The World Economic Forum’s [Global Risks Report for 2023](#) lists failure to mitigate and failure to adapt to climate change as the top two risks over the next decade. But research from S&P Global Sustainable1 shows that many large companies are not engaging in climate adaptation efforts.

Adaptation financing also remains a challenge, lagging far behind money going toward mitigation. Issuance of green, social, sustainability and sustainability-linked bonds could contribute to addressing that gap. As analysts from S&P

Global Ratings write in our annual sustainable bond outlook, the focus on adaptation and resilience is likely to increase. This demand could be a source of growth for the sustainable bond asset class in 2023 and beyond.

The urgency is clear. The physical impacts from climate change are increasing, and the window of opportunity for building resilience and adapting at lower costs is rapidly closing. The physical risks caused by climate change are driving calls for faster preparation and for adaptation finance to be mobilized to pay for it. ■



Richard Mattison
President, S&P Global Sustainable1



Most financial institutions don't set financed emission targets, putting net-zero goals at risk

While many banks and other financial institutions have pledged to hit net-zero emissions, the reality is more complicated. Data collected in the 2022 S&P Global Corporate Sustainability Assessment indicates that less than a quarter of financial institutions are aiming to reduce emissions across their whole value chain, including across lending or investment portfolios, which represent the vast majority of companies' emissions.

Published on January 20, 2023 by S&P Global Sustainable1.

Key takeaways

- Less than a quarter of financial institutions have pledged to reduce their financed emissions, according to the latest data from the S&P Global Corporate Sustainability Assessment.
- A majority of financial institutions do not perform scenario analysis on their climate-related risks, despite the growing recognition that climate change is creating economic risk.
- Financial institutions are coming under more pressure to measure and disclose financed emissions as regulators assess climate risks.

► In the past few years, hundreds of financial institutions have made big announcements about becoming net-zero or carbon neutral by 2050. They’ve been setting targets to cut their greenhouse gas emissions as close to zero as possible and offset the remainder, usually by mid-century.

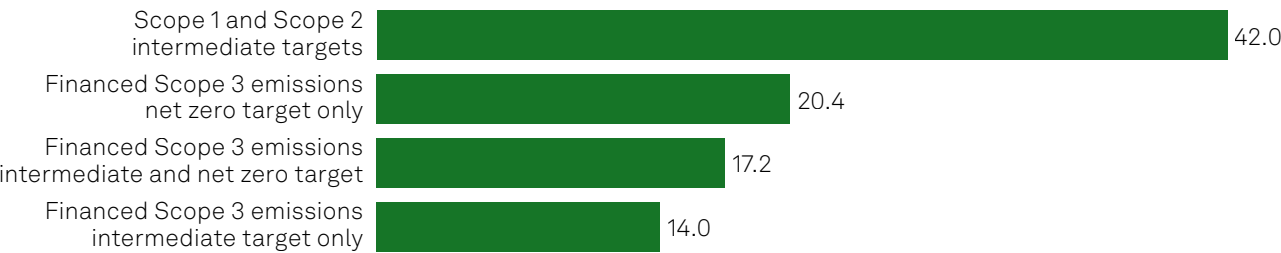
It’s an important step, because financial institutions’ exposure to the wider economy through lending, investing or underwriting across industries means that they could be more exposed to the economic impacts of climate change. Financial institutions also can play a key role in financing the

transition and facilitating the flow of trillions of dollars in capital needed to mitigate and adapt to climate change.

The creation of organizations such as the Glasgow Financial Alliance for Net Zero (GFANZ) — a global coalition of more than 550 financial institutions with more than \$150 trillion in managed or owned assets committed to net-zero by 2050 — has put the financial sector’s progress in achieving net-zero goals under the spotlight. In addition, regulators are increasingly looking under the hood at financial institutions to assess their preparedness for climate-related risks.

Few financial institutions extend emission reduction or net zero targets to their financed Scope 3 emissions

Percentage of financial companies with intermediate emission reduction or net zero targets



Data as of Dec. 2, 2022.
PCAF = Partnership for Carbon Accounting Financials.
A climate target is defined as a future reduction in actual emissions, or in emissions that have been normalized to a business metric, when compared to a base year.
The S&P Global Corporate Sustainability Assessment defines financed Scope 3 emissions as those associated with the reporting company’s investments in the reporting year, or with the provision of capital or financing provided by the reporting company, also known as Scope 3 Category 15. For this question, we consider emissions from loans and investments for which financial institutions do not have operational or financial control in line with the PCAF standard. Results based on responses from 785 companies in the Banks, Diversified Financials & Capital Markets and Insurance industries assessed in the 2022 S&P Global Corporate Sustainability Assessment.
Source: S&P Global Sustainable1.
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While announcements on net-zero targets have grabbed headlines, the reality is more complicated. Data collected in the 2022 S&P Global Corporate Sustainability Assessment (CSA) indicates that while financial institutions are committing to net-zero or to reducing emissions, less than a quarter of them are currently aiming to reduce emissions across their whole value chain.

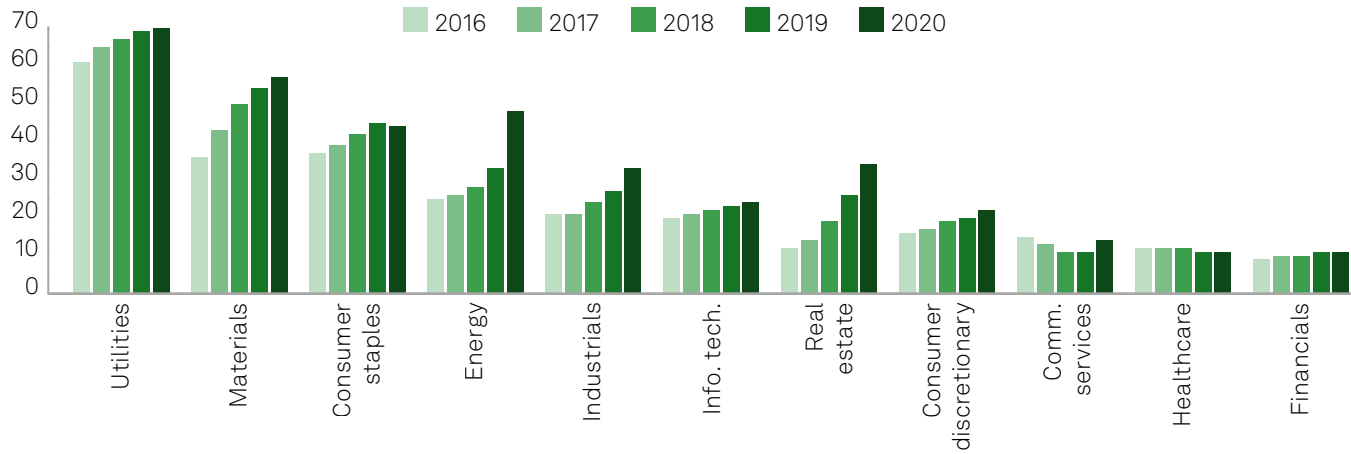
The data shows that 42% of banks, financial services companies and insurers have publicly committed to reduce emissions or achieve net-zero associated with Scope 1 emissions and Scope 2 emissions, out of the 785 financial institutions assessed in the CSA. Scope 1 emissions are emissions from direct operations, while Scope 2 emissions are indirect emissions primarily derived from purchased energy. However, just over 20% have pledged intermediate emission reductions or net-zero targets related to their Scope 3 financed emissions, which come from the investments they make or the loans they finance.

Financial institutions have relatively low Scope 1 and Scope 2 emissions. In general they have much higher Scope 3 indirect emissions, which include the greenhouse gases emitted by businesses or projects they finance, invest in or underwrite — representing their most significant climate impact. The environmental disclosure nonprofit CDP has estimated that financial institutions’ Scope 3 emissions are 700 times greater than their direct emissions.

Addressing Scope 3 is challenging for financial institutions because the clients they lend to or the companies they invest in would need to measure their emissions and implement their own transition plans. And that Scope 3 calculation for financial companies’ clients is difficult to calculate, partly because it depends on accurate emissions information from suppliers.

Greenhouse gas disclosure has been increasing in most sectors

Percentage of US companies disclosing Scope 1 and/or Scope 2 emissions by sector



Data compiled Jan. 10, 2023. Latest available full-year data is for 2020.
Based on 17,497 companies organized by Global Industry Classification Standard sectors.
“Greenhouse gas disclosure” means a company disclosed Scope 1 and/or Scope 2 emissions in tonnes of carbon dioxide equivalent (tCO2e) in a range of sources, including regulatory filings.
Source: S&P Global Sustainable1.
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Some of those suppliers operate in countries without disclosure requirements. The lack of transparency and accountability for emissions created in corporate supply chains is a significant concern when assessing the achievability of net-zero commitments and completeness of reporting against these targets. Disclosure rates for many industries are quite low, which could help explain why a small number of financial institutions are measuring Scope 3 emissions.

Why short-term targets are important

Taking on the task of measuring Scope 3 financed emissions and setting intermediate goals are fundamental steps for financial institutions to assess climate-related risks across their portfolios. Short-term targets can provide a roadmap to net-zero and allow financial institutions to benchmark themselves along the way, especially if they are exposed to the most carbon-intensive sectors such as power generation, steel or aviation and transport. However, the CSA data shows that they are far from doing that. While about 20% of financial companies have set net-zero targets, only 17% have set intermediate targets to help them achieve their long-term targets for financed emissions.

The urgency of reducing emissions is clear, especially in hard-to-abate sectors. Scientists say the world needs to achieve net-zero emissions by 2050 to limit global warming to 1.5 degrees C, relative to pre-industrial levels. But immediate progress is also needed: Scientists have projected that the path to net-zero requires cutting global emissions by about 45% by the end of this decade, which means companies across all sectors need to make measurable progress on curbing emissions within the next few years.

To play a key role in reducing emissions, financial institutions need to work with their clients by identifying where the climate risks

are and gathering related data. According to the European Central Bank, banks' financed emissions often come from a small number of large counterparties, increasing their exposure to climate-related risks. Banks often use proxies to estimate exposure to carbon-heavy industries, it said. While that may help close data gaps, banks need to work more closely with clients to obtain more accurate data and information about their clients' transition plans to measure their climate risk exposure going forward, the ECB said.

However, the CSA data shows that financial institutions are not yet drilling down into their balance sheets and locating the potential risks from their clients. Of the companies that report on Scope 3 financed emissions, about half are able to provide a breakdown of the data by asset class, country or sector. Most of these companies are analyzing emissions in their loan books or portfolios on a sector or industry basis. Often, financial institutions are reporting on sectors according to guidelines established by sector-specific alliances or frameworks, such as the U.N.-backed Principles for Responsible Banking. The U.N. Financial Programme Finance Initiative's guidelines encourage banks to eventually set sector-level targets for carbon-intensive sectors.

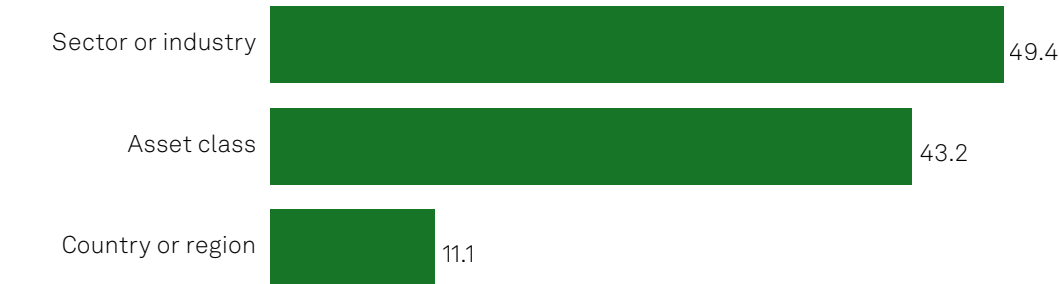
Of the companies able to report on their Scope 3 emissions, only half of financial institutions analyze these emissions by sector or industry, while just over 40% break them down by asset class. Just over 10% do it by geography, despite the fact that doing so can guide them in determining how to reduce their Scope 3 emissions, manage climate-related transition risks and develop climate-friendly financial products.

A changing regulatory landscape

Financial institutions are set to come under increasing pressure to assess and measure their Scope 3 financed emissions. The EU is rolling out several sustainability disclosure

About half of financial institutions reporting financed Scope 3 emissions can analyze them by sector or industry

Percentage of financial institutions with financed Scope 3 emissions able to break down emissions by the following categories



Data as of Dec. 2, 2022. Results based on responses from 785 companies in the Banks, Diversified Financials & Capital Markets and Insurance industries assessed in the 2022 S&P Global Corporate Sustainability Assessment. Source: S&P Global Sustainable1. © 2023 S&P Global.

rules including the Sustainable Finance Disclosure Regulation, which will require investment funds to measure companies' Scope 3 emissions, as of Jan. 1. The U.S. Securities and Exchange Commission's proposed climate disclosure standards would require companies to report Scope 3 emissions up and down their value chains if they deem Scope 3 to be material.

Concerns over the significant risks posed by climate change to financial institutions are also prompting financial regulators and supervisors to conduct climate stress tests on their national financial systems and economies.

Since the 2008 financial crisis, regulators have used stress tests to assess how well banks can withstand hypothetical adverse scenarios, such as a sharp market downturn or an economic shock. Regulators can then better determine whether banks need to shore up capital to weather losses. Regulators are now tailoring these tests to climate change to amass key data on financial institutions' exposure to potentially stranded assets and examine their resilience to climate risk.

What makes them different from existing stress tests is that they force banks and insurers to think beyond their usual three-to-five-year business cycle and look at a 30-year horizon, considering various transition and physical risk scenarios.

Transition risk scenario analysis takes a forward-looking approach to how future policy, regulatory and technological changes as well as legal, market and reputational risks would impact a business. Physical risk scenarios look at the future impact on companies of rising sea levels or an increase in extreme weather events like hurricanes, flooding and wildfires.

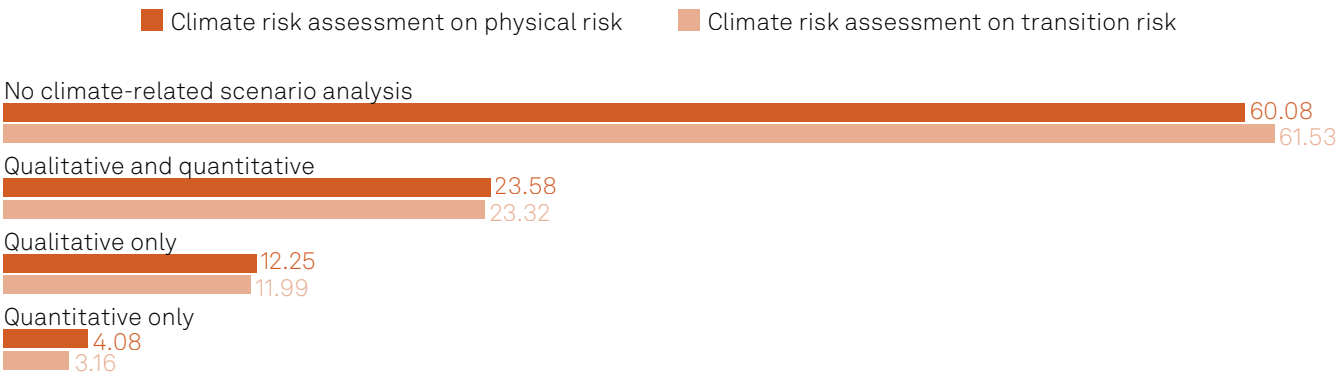
Regulators are largely using scenario analysis created by the Network for Greening the Financial System (NGFS), a group of central banks collaborating on how to tackle climate change, which has asked companies and financial institutions to report on climate risks using the disclosure recommendations of the influential Taskforce on Climate-Related Financial Disclosures. The NGFS framework includes several potential outcomes for financial firms to consider, such as a disorderly scenario in which a



Of the companies able to report on their Scope 3 emissions, only half of financial institutions analyze these emissions by sector or industry.

A majority of financial firms do not conduct climate-related scenario analysis

Percentage of companies conducting scenario analyses on climate-related physical and transition risks



Data as of November 2022.
Results based on responses from 762 companies in the Financials sector assessed in the 2022 S&P Global Corporate Sustainability Assessment.
Source: S&P Global Sustainable1.
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More than half of financial institutions assessed do not conduct any form of scenario analysis on their climate-related physical and transition risks.

delayed or sudden implementation of transition policies creates high costs, and an orderly transition, in which transition policies are enacted quickly around the world with limited costs. The most severe “hot house world” scenario assumes limited action to reduce emissions, leading to significant global warming.

The European Central Bank’s first climate stress test, [published](#) in July 2022, found that about 60% of the 104 lenders that participated in the ECB exercise do not have a climate risk stress-testing framework. Most banks do not include climate risk in their [credit risk models](#), and just 20% consider climate risk in their lending decisions, it said.

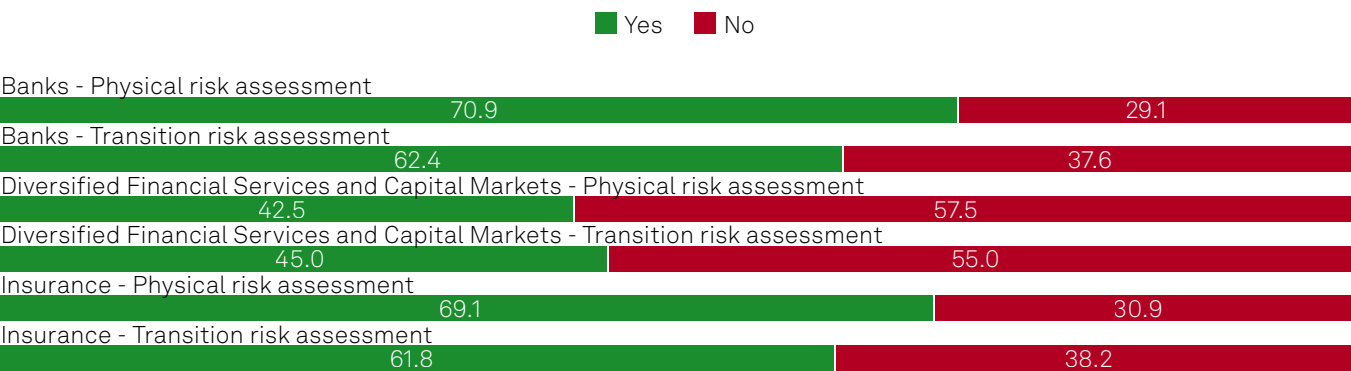
The climate stress test showed that banks suffer lower losses under an orderly transition than in a disorderly scenario. But the ECB noted that banks are not differentiating between the different long-term scenarios because they do not have adequate strategies in place, other than reducing exposure to heavily polluting industries and supporting low-carbon business. As a result, banks need to incorporate climate-related financial risks into their long-term strategies, the central bank said.

The CSA data echoes the finding of the ECB. It demonstrates that more than half of financial institutions assessed do not conduct any form of scenario analysis on their climate-related physical and transition risks. To prepare for long-term targets and incorporate potential climate impacts into long-term planning, financial institutions need to understand the potential effects of climate change on their business, particularly when exposed to carbon-intensive sectors. Climate scenario analysis can demonstrate where risks lie and set out a pathway to manage them. Data from the CSA shows that on average just over a quarter of companies conduct a climate risk assessment on their downstream financing, investing and underwriting activities.

Insurers, which are directly exposed to underwriting the financial cost of physical damage from extreme weather, have the highest rate of downstream assessment. Reinsurer Swiss Re estimated in August 2022 that global insured losses from natural catastrophes in the first half of 2022 stood at \$35 billion, 22% higher than the average of the last 10 years. [In its report](#), it noted

Physical and transition climate risk assessment is more common among banks and insurers

Percentage of companies by industry that conduct climate physical risk or transition risk assessments



Data as of November 2022.
Results based on responses from 762 companies in the Financials sector assessed in the 2022 S&P Global Corporate Sustainability Assessment.
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that climate change was “evident in increasingly extreme weather events” such as floods in Australia and South Africa.

Financial institutions that do not act on climate risks could face supervisory action. The ECB [said](#) in November 2022 that banks were still not taking climate risks sufficiently into account and have until the end of 2024 to meet the central bank’s supervisory expectations on climate and environmental risks. It also said it had imposed “binding qualitative requirements” on more than 30 lenders in its annual supervisory review. A small number of banks have had their capital requirements raised over their inability to manage climate and environmental risks, the ECB said.

Near-term accountability in the face of long-term climate goals

While it is encouraging to see an increasing number of financial institutions committing to net-zero targets, there is more work to be done on setting targets, conducting more portfolio and loan book scenario analysis and measuring their clients’ carbon emissions as a way of reducing their own carbon footprint.

To do this, financial institutions will need to address data gaps and engage with clients on transition plans. That will help them amass key data on climate change risks at counterparties and answer regulators’ questions about their risk assessment strategies. Net-zero goals will remain elusive without interim targets, and banks, insurers and investment firms must demonstrate what steps they are taking to ensure near-term accountability in meeting long-term climate goals. ■

Authors

Jennifer Laidlaw | S&P Global Sustainable1, Thought Leadership Senior Writer
Giulia Hallqvist | S&P Global Sustainable1, ESG Client Engagement Specialist
Francesca Jaworska | S&P Global Sustainable1, ESG Research Specialist
Wera von der Osten | S&P Global Sustainable1, ESG Research Specialist



Is climate change another obstacle to economic development?

A new analysis of data from 190 countries shows that a one-time, 1-degree Celsius annual average temperature increase is more damaging for emerging markets and developing economies than advanced economies. The major economic impacts include permanent income losses arising through lower productivity and investment, with the agricultural sector taking a long-term hit.

Published on January 16, 2023 by S&P Global Ratings.

This report does not constitute a rating action.

Key takeaways

- **Our analysis of data from 190 countries shows that a one-time, 1-degree Celsius annual average temperature increase is more damaging for emerging markets and developing economies (EMDEs) than advanced economies (AEs).** We find that seven years after such a rise, gross domestic product per capita is 0.6-0.7 percentage points lower in countries with current annual temperatures averaging 22 C-24 C (mainly EMDEs) than in those averaging 15 C (AEs) — all other things being equal.
- **Further, we find permanent income losses arising through lower productivity and investment, with the agricultural sector taking a long-term hit.** Where annual temperatures average 24 C, GDP per capita of countries least ready to cope with climate change remains 2 percentage points lower, while countries most ready see no sustained losses, seven years after the 1 C temperature shock.
- **Economies have adapted somewhat to one-off temperature increases over the past decades, with the sensitivity of GDP to temperature shocks decreasing by about 30% over the past 20 years.** Supportive macro policy responses have also helped economies recover from climate-related shocks; restrictive monetary policy seems to amplify the shock, whereas low real interest rates are associated with little scarring.

► **Over the next decades, we think rising** temperatures will be a bigger hurdle for emerging markets and developing economies than for advanced economies. Emerging markets and developing economies (EMDEs) contribute less than 14% of global greenhouse gas emissions but are among the most exposed to and least ready to cope with the effects of climate change. Recent extreme weather events serve as a reminder that climate change is intensifying. In a recent study, S&P Global estimates that, even if all countries meet their current climate policy pledges, low- and middle-income nations could face losses equivalent to 12% of GDP by 2050, compared with 3% for high- and upper-middle income countries (see [“Weather Warning: Assessing Countries’ Vulnerability To Economic Losses From Physical Climate Risks,”](#) published April 27, 2022). That study also suggests as much as 4% of global GDP annually can be at risk from climate change by 2050, absent adaptation measures. By comparison,

during COVID-19 lockdowns in 2020, global GDP dropped 3.3%.

To assess whether the most vulnerable countries can cope with and recover from hotter temperatures, S&P Global Ratings examined the impact of physical risks on economic growth. Using data for 190 countries over roughly six decades (1965-2020), we looked at the relationship between temperature variations and distribution of real GDP per capita.

The results of our analysis show that, after a one-time 1-degree C rise in average annual temperature, GDP per capita tends to recover within two years for EMDEs (mean temperature = 22 C), while there is close to no negative impacts for AEs (mean temperature = 15 C). Moreover, where the regular temperature averages 22 C-24 C, GDP per capita does not return to its previous trend level and continues to lag that of 15 C economies even after seven years.

Since lower middle-income and low-income EMDEs are concentrated in areas with such warmer climates, our results suggest that temperature rise would be another dimension holding back this set of countries to achieve durable growth in the long term — which is a precondition for convergence with high-income economies (as implied by neoclassical growth theory), although causal interpretation is difficult.

Looking under the hood of temperature shocks also highlights that economic development and adaptation — both crucial for resilience to climate change — are two sides of the same coin. More developed economies with a bigger share of services activity in output and more flexible institutional set-ups do better at withstanding temperature increases. At the same time, more granular measures are needed to assess countries’ readiness uncorrelated from economic development.

With the cost of physical climate risks increasing each year, the loss and damage debate also took center stage at the COP27 climate change conference in Egypt in November 2022 (see [“COP27: Top 5 Takeaways That Matter”](#)). Our research highlights that investing in adaptation to climate change could support long-term income prospects for EMDEs. Developing countries are calling on richer nations to help finance loss and damage linked to climate change and making their economies more resilient to cope with acute physical risks, like storms, wildfires and drought.

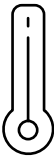
Temperature starting points matter: Closer to 14 C is more optimal

By linking economic output (GDP) to countries’ annual average temperatures, we see that many advanced economies have more favorable temperature starting points when it comes to climate change. Using fixed-effects panel regression models

(less prone to omitted variable bias as they control for unobserved time-invariant group heterogeneity, including, for example, differences in institutions) with data ranging from 1965 to 2020, we find that countries with more temperate climates tend to exhibit higher GDP per capita increases than those with harsher climates (very low or very high temperature averages), with the turning point likely to be around 13 C-15 C (see chart 1). This nonlinear relationship between annual temperature and growth is similar to findings uncovered in external studies (for example, Burke et al. 2015, Kalkuhl and Wenz 2020).

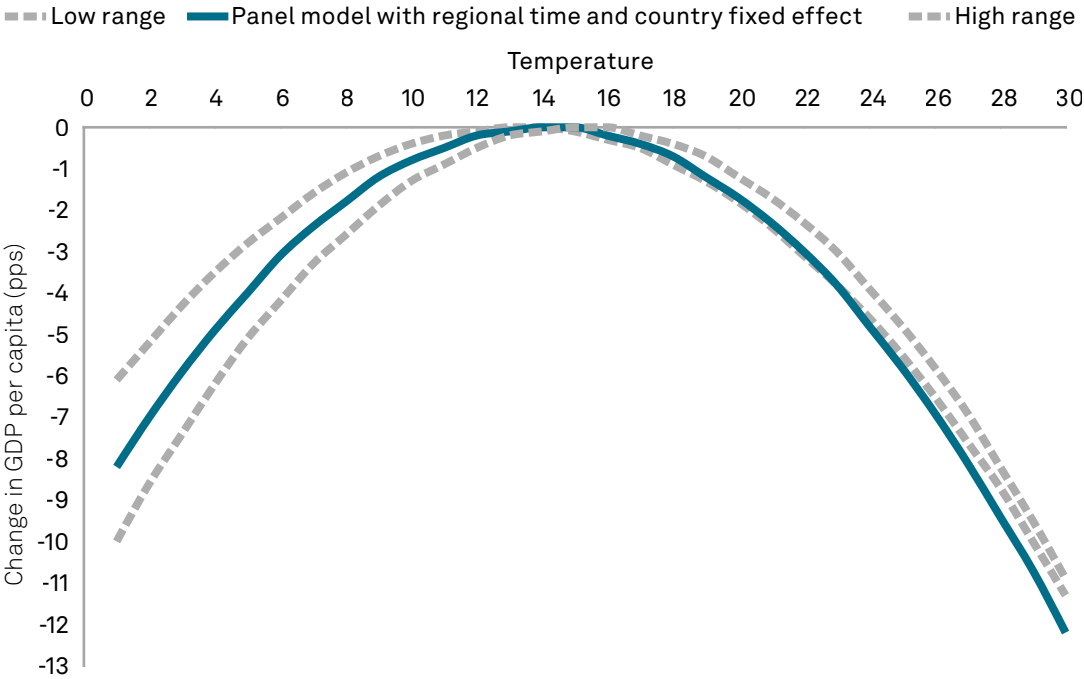
The annual average temperature in advanced economies — such as the EU, U.S., and Japan is close to the optimum, at 15 C, while in EMDEs it is a higher 19 C-24 C, suggesting additional warming is likely to hurt EMDEs more than richer peers. The results of our analysis show that a 1 C temperature increase would be associated with a GDP per capita drop of about 0.9 percentage points for countries where temperatures average 22 C, and 1.2 points where the average is 24 C. By comparison, there is close to no impact for economies where the average temperature is 15 C.

Although our results may be influenced by structural differences among the economies in our data set and important within-country variations may be hidden, they are similar to the findings of a comparable study utilizing regional and seasonal variations focused on the U.S. Increases in temperature beyond the summer average (that is, unusually warm weather) are associated with lower growth of the gross state product (gross value added during production by labor and capital at the U.S. state level) (Colacito et al. 2018). What’s more, that study found the effect to be most significant in the summer months and for states where average temperatures are higher irrespective of



We find that countries with more temperate climates tend to exhibit higher GDP per capita increases than those with harsher climates.

Chart 1: **GDP responds to temperature shocks in a non-linear way**
Change in GDP per capita associated with a 1 C increase in temperature (first year)



Pps = percentage points.
The results describe the relationship of GDP per capita with temperature using a panel model estimation with country fixed effects and regional time fixed effects; the range refers to results of other modelling specifications.
Sources: Authors' calculations; S&P Global Ratings.
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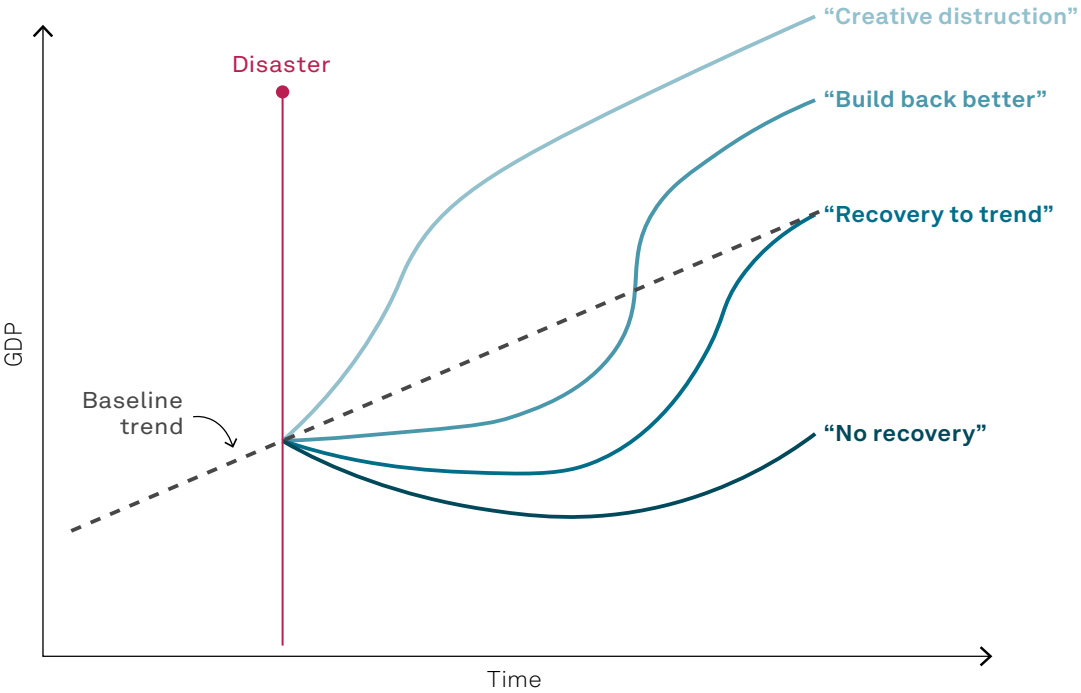
state income level. This further supports our finding that the starting point in temperature matters and that there is a nonlinear relationship between temperature and growth.

Four potential exit paths after a climate shock

One way to look at the macroeconomic ramifications of climate change for vulnerable countries is to consider the impact on growth after temperature fluctuations and weather extremes. We focus on whether temperature increases reduce growth permanently or temporarily. There are four potential hypotheses of generalized economic outcomes in subsequent years, as illustrated by Hsiang and Jina (2014) (see chart 2). The temperature/climate shock triggers:

- A period of accelerated growth (a positive shock) after which growth returns to the baseline rate but at a higher level (creative destruction).
- Slow growth or a contraction, then a quick catchup and eventually convergence to a trajectory that is above the initial baseline growth rate and initial potential GDP level (build back better).
- A downturn, then a return to the previous growth path and potential GDP trajectory (recovery to trend).
- Contraction and slower growth for a finite interval before a resumption of the original growth rate, but without a period of acceleration and no return to the original baseline GDP trend.

Chart 2: **Stylized GDP outcomes: There is more than 1 potential outcome to economic shocks**



Source: Hsiang and Jina (2014).
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Income losses can be permanent even if growth recovers

Our results show that even though a one-time temperature increase has a temporary impact on economic growth, there is a permanent relative loss of GDP in countries with hotter climates than those with lower average temperatures. GDP per capita tends to recover to the previous peak within two years after the shock, at the latest, for countries where the annual average temperature is about 22 C-24 C, namely lower-income countries and emerging markets (see chart 3). However, GDP per capita for such countries does not return to its previous trend or catch up to that of economies with cooler climates (average of 15 C); a GDP per capita gap of 0.6-0.7 points remains seven years after a one-time 1 C temperature increase. This suggests that economies with warmer climates are more likely to follow the “no

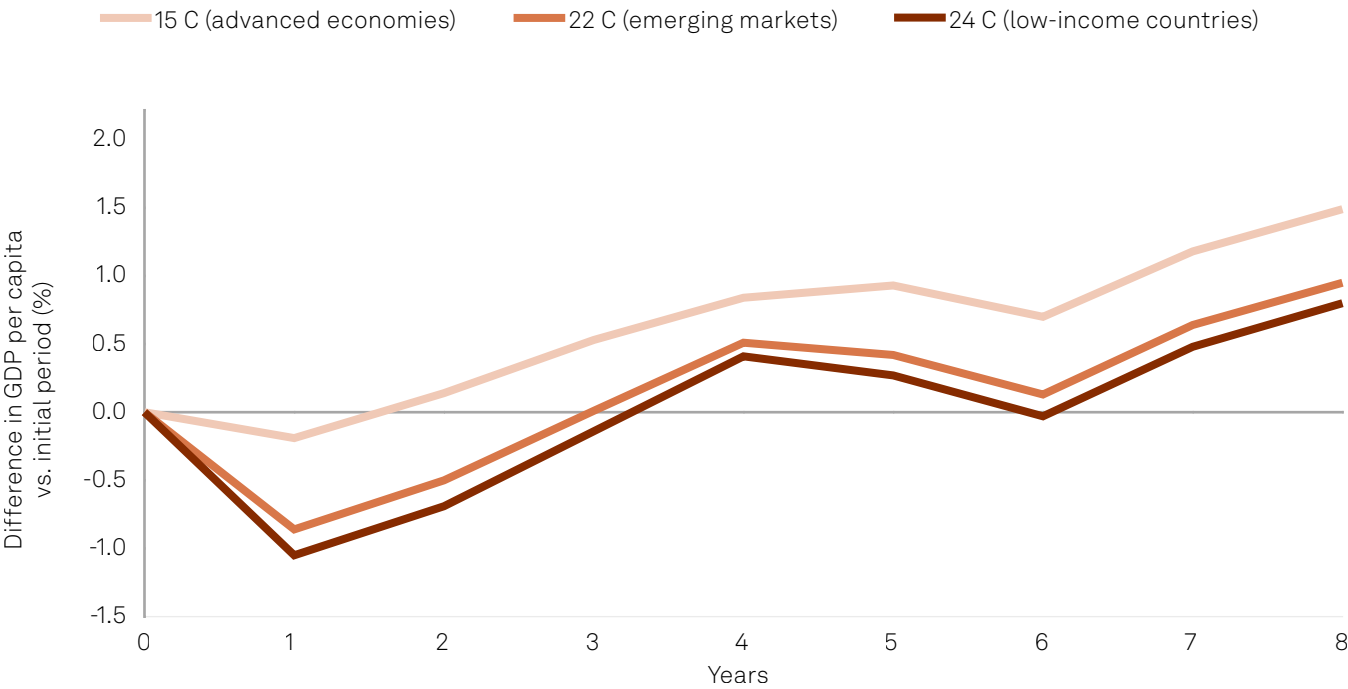
recovery” path, meaning that they may recover to previous growth rates but not to the baseline trend level. There is no catch-up to previous trend path.

Hotter temperatures can make downturns worse

We also examine whether temperature change may make severe GDP contractions more likely conditional on climate. Using quantile regressions linking growth to temperature, we find that downside risks to growth (the lower 10th percentile of GDP growth distribution) are more strongly linked to warmer temperature than the central tendency or upside risks (90th percentile) (see tables in the Appendix and chart 4). This implies that hotter temperatures can make downturns worse, even in economies where the climate is close to what is perceived as the 14 C optimum. As such, the impact of a

Chart 3: **Temperature shocks have a permanent impact on relative global GDP output**

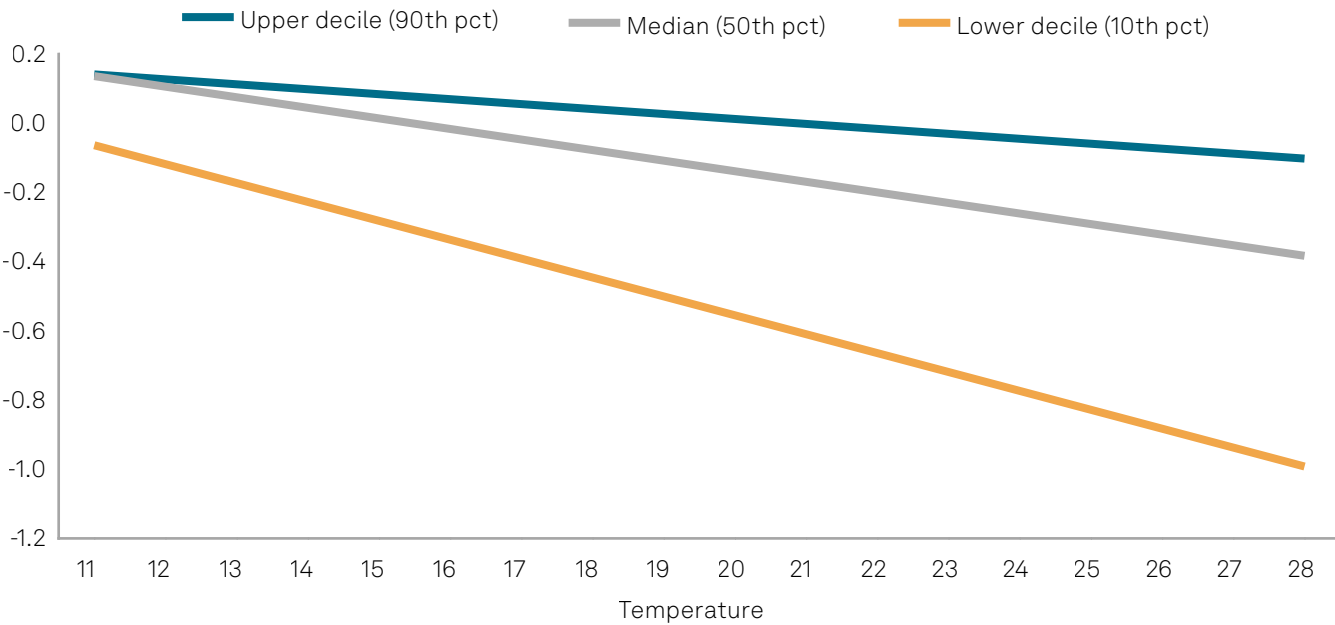
GDP per capita growth response to a 1 C degree annual average temperature rise



The results describe the relationship of the variable shown with average annual temperature using a panel model estimation with country fixed effects and regional time fixed effects. We derive impulse response functions using local projections and controlling for lags and forwards of the temperature. Sources: Authors' calculations; S&P Global Ratings. Copyright © 2023 by Standard & Poor's Financial Services LLC. All rights reserved.

Chart 4: **Output growth-at-risk exercise highlights 1 C increase in temperature is likely to make GDP contractions worse in hotter climates**

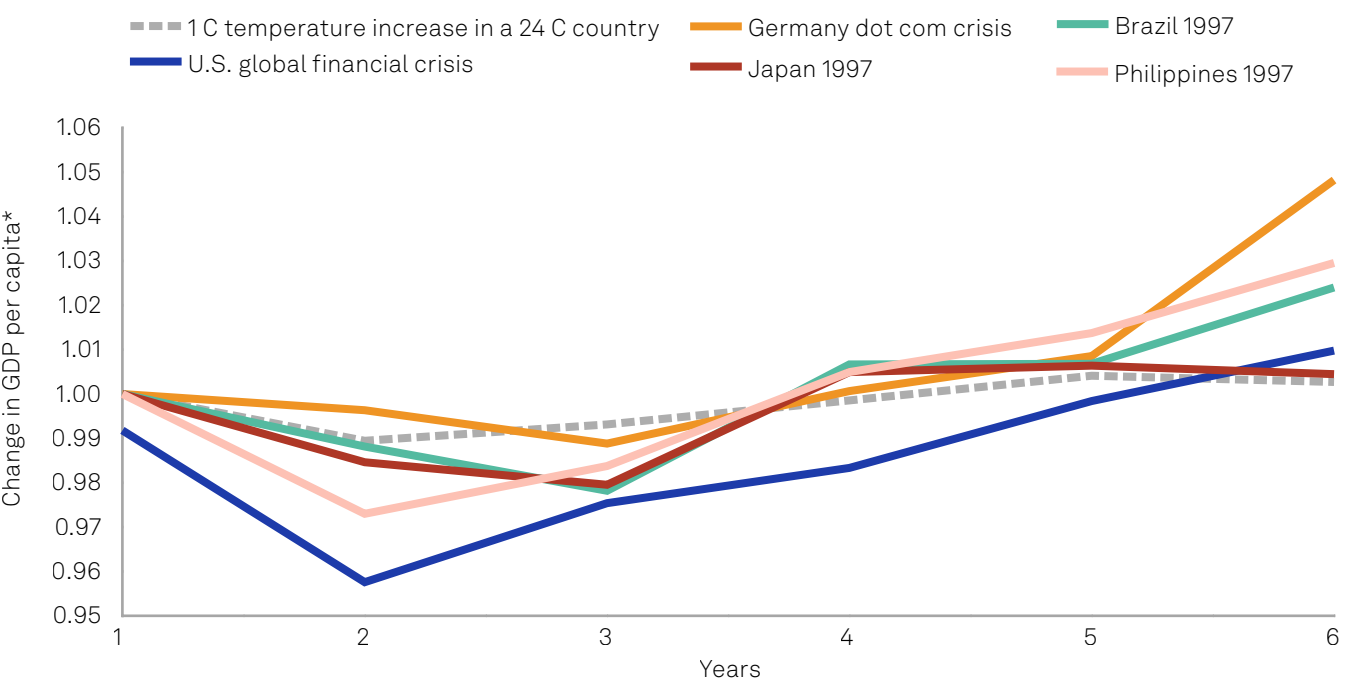
Marginal effect associated with 1 C increase (pps)



Pct = percentile; pps = percentage points. Estimates generated using Stata's Quantile Regression for Panel Data (QRPD), an estimator developed by Powell (2015). Sources: Authors' calculations; S&P Global Ratings. Copyright © 2023 by Standard & Poor's Financial Services LLC. All rights reserved.

Chart 5: **External temperature shocks are slightly milder than shocks related to structural issues**

Temperature shock compared to other crisis episodes



* Constant local currency (period 1 = 1). Sources: S&P Global Climate Economics; National Statistical Institutes; S&P Global Ratings. Copyright © 2023 by Standard & Poor's Financial Services LLC. All rights reserved.

temperature shock for the 10th growth percentile is more than 3 times larger than the relationship in the central tendency (the 50th percentile) for 22 C and 24 C economies; the impact on the 90th percentile (that is, when the economy is doing very well in relative terms) appears even slightly positive for temperate climates in comparison and slightly negative as the temperature gets warmer, highlighting a sharp increase in downside risk associated with the overall downward shift in the growth distribution associated with hotter temperatures across countries.

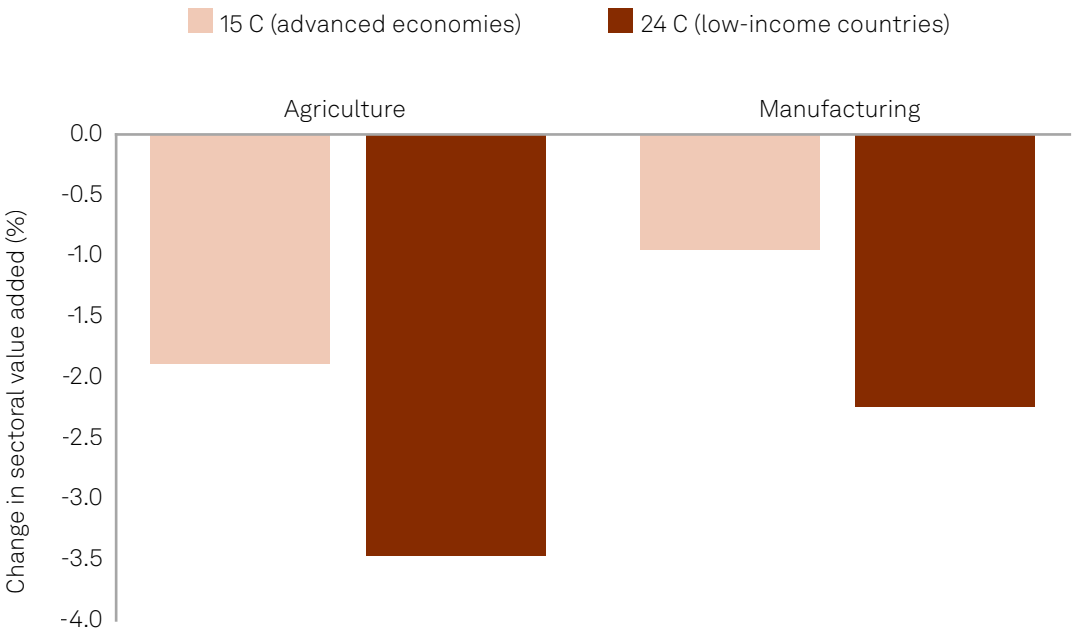
Yet historical data suggests temperature-driven shocks are relatively milder than other economic shocks

Taken together, the findings in previous sections suggest climate change will make economic convergence more difficult for

EMDEs, most of which are located in hotter climates. They also highlight the absence of additional catch-up momentum following a temperature shock. Still, compared with other downturns, such as the global financial crisis, the Asian crisis, or the aftermath of Germany's reunification, our results show that a 1 C increase in temperature for economies averaging 24 C leads to relatively smaller losses (see chart 5). This may result from the external and exogenous nature of extreme weather events, in contrast to the causes of other downturns, which included structural inefficiencies and economic or financial imbalances such as risk buildup or inefficient allocation of resources. That said, the recovery paths are not entirely comparable, since our estimates isolate the effect of a one-time increase in temperature from other drivers of growth, that is if all other factors remain unchanged. Overall, this suggests the

Chart 6: **Agriculture is the sector most affected when temperatures rise**

Impact of 1C annual average temperature rise on sectoral value added in the first year



The results describe the relationship of sectoral value added for a 1C increase in annual average temperature using a panel model estimation with country fixed effects and regional time fixed effects. Sources: Authors' calculations; S&P Global Ratings. Copyright © 2023 by Standard & Poor's Financial Services LLC. All rights reserved.

impact of temperature increases alone, while having a significant impact on economic activity, especially in hotter economies, may not always be visible in aggregate indicators, especially when other trends come into play.

Agriculture, productivity and investments experience permanent losses

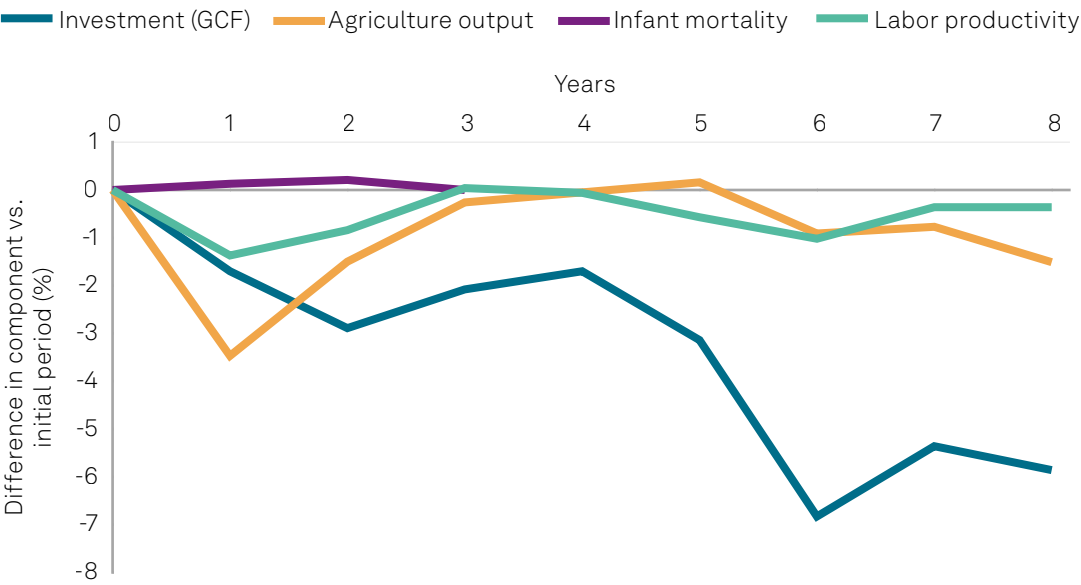
Looking beyond aggregate growth dynamics to individual sectors sheds light on why the most vulnerable economies (with temperatures averaging 22 C-24 C) could struggle to get closer to richer peers after a temperature shock. Even if there is no permanent loss of growth prospects, the structure of the economy changes if there is a reallocation of resources in response to climate change. Using the same modeling framework (see Appendix), we replaced GDP per capita with other dependent variables

(such as value added by sector and GDP components). The results show that, after a rise in temperature, the relative share of agriculture in total output decreases. This seems to come about through lower investment and productivity gains. Mortality also rises, potentially weighing on the long-term labor supply.

On a sectoral basis, agriculture is hardest hit by an increase in temperature, exhibiting a 3.5 percentage point initial loss of output, with output remaining around 1 point lower seven years later in economies where the temperature averages 24 C. This may be because the crop mix is likely to have benefited less from hotter temperatures, and hotter temperatures depress workers' productivity. Manufacturing output also shrinks, but the impact does not go beyond the year of the shock, while services activity doesn't appear to be significantly affected (see chart 6). Our results highlight

Chart 7: **Investment, productivity and agriculture don't recover fully from a temperature shock**

Response over time of selected variables to a 1C annual average temperature rise from 24 C



GCF = Green Climate Fund. The results describe the relationship of the variable shown with average annual temperature using a panel model estimation with country fixed effects and regional time fixed effects. We derive impulse response functions using local projections and controlling for lags and forwards of the temperature. Sources: Authors' calculations; S&P Global Ratings. Copyright © 2023 by Standard & Poor's Financial Services LLC. All rights reserved.

agricultural and manufacturing output is depressed in temperate climates (about 14 C) too, suggesting that those economies also have some way to go to prepare for the threat of climate change.

From a structural growth perspective, we find most of the impact on hotter climate economies (annual temperature averaging 24 C or higher) comes from lower investment, productivity losses and increased mortality. While infant mortality recovers two years after the temperature shock, investment and productivity are still lower eight years later (see chart 7). By contrast, other components of growth such as average hours worked, capital accumulation, or the rate of depreciation of capital don't seem to be affected. However, since some of those variables are unobservable (for example, the capital depreciation rate), it's unclear whether the data can adequately capture a temperature

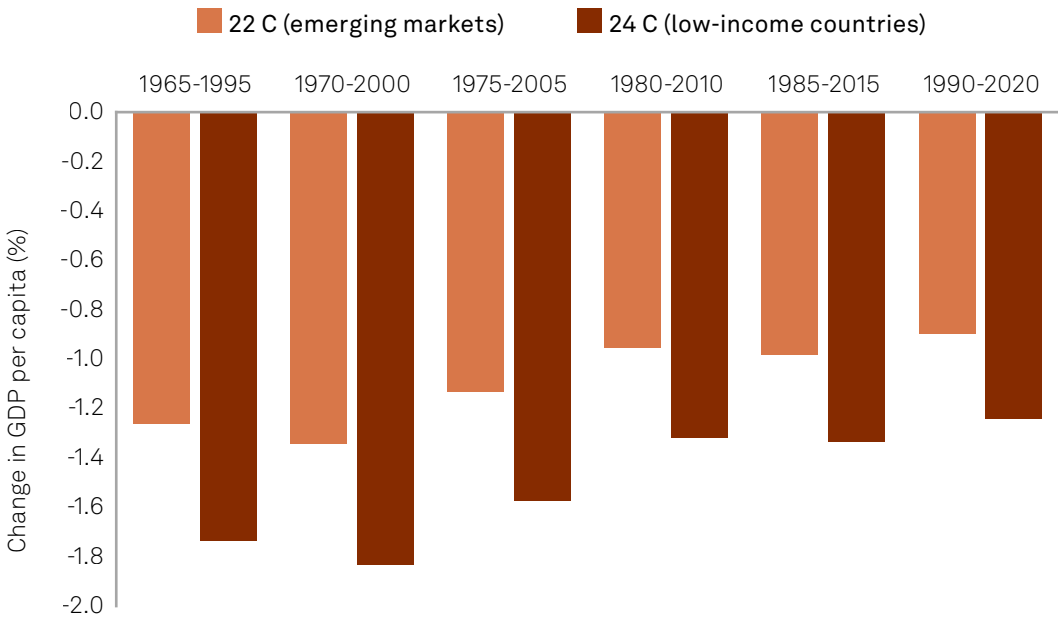
shock impact or whether that is all captured by the productivity variable.

Improving readiness, demand management and adaptation are critical

The results of our analysis provide insight into the economic dynamics at play when a temperature shock occurs. Yet they do not take differences in how countries prepare and respond to climate change into account. In this respect, we find that some adaptation has occurred over the years, with the sensitivity of GDP to a one-off increase in annual average temperature about 30% lower in the late 1990s compared with 1965-1995 (see chart 8). This compares with a 258% increase in labor productivity in low- and middle-income countries (based on GDP per capita) between 1991 and 2021. Economies with better readiness to cope with climate

Chart 8: **Adaptation likely explains economies' decreasing sensitivity to temperature shocks**

The effect of a 1C annual average temperature rise on real GDP per capita growth has declined over time



The results describe the relationship of GDP per capita with temperature using a panel model estimation with country fixed effects and regional time fixed effects.
Source: Authors' calculations; S&P Global Ratings.
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change (as defined by the University of Notre Dame's ND-GAIN index) have been able to avoid most of the negative impact related to higher temperatures, while macroeconomic tools, such as lower interest rates, also helped cushion the impact on growth.

Increased readiness seems to be key to avoiding the negative impact on growth

Countries with the highest readiness (as defined by ND-GAIN indicators those displaying highly flexible product and labor markets, elaborate social safety nets and stable institutional setups), do not experience a drop in income when temperature rises (see chart 9). Such economies may even experience an initial boost, perhaps due to some adaptation investment in response to the shock. By contrast, countries least ready to cope experience more permanent losses, with

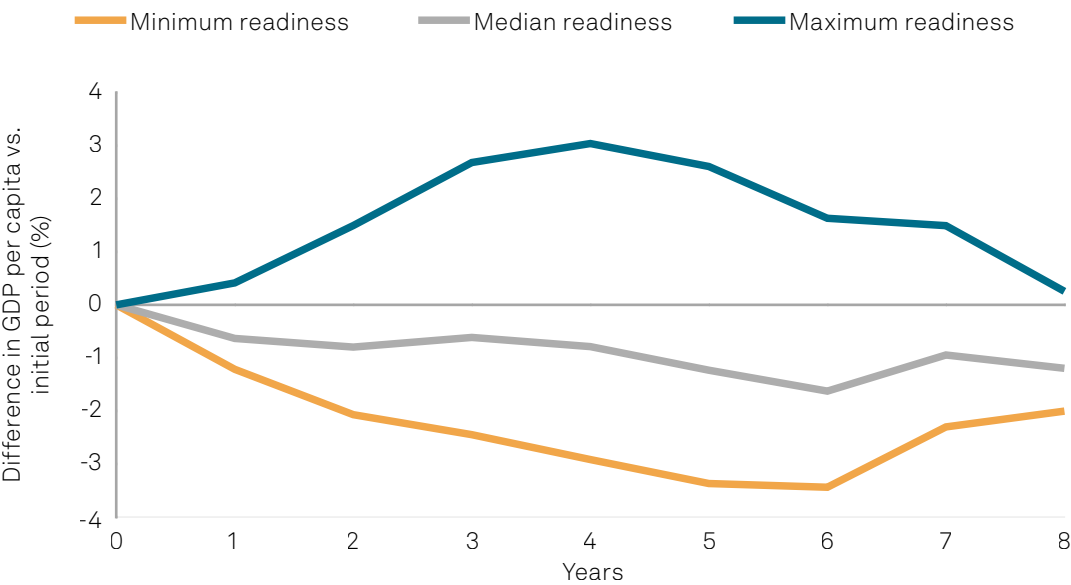
GDP per capita still declining up to six years after the temperature shock. Some of the variation in impact is likely linked to the composition of economies, where countries more ready to cope tend to be less dependent on agriculture and more service-oriented economies, like Singapore. However, it also highlights that geography alone is not the main determinant of economic outcome in the face of climate change.

Tools to manage demand also influence the direct impact of weather shocks

For example, we identify that when temperature shocks occur during a period of low interest rates, that environment can be of significant help to cushion a one-time climate shock. Economies with the highest real interest rates (of about 1.1% in our sample) don't show signs of recovery, even after eight years, in contrast to those with

Chart 9: **Countries with low readiness display a long-lasting impact on growth**

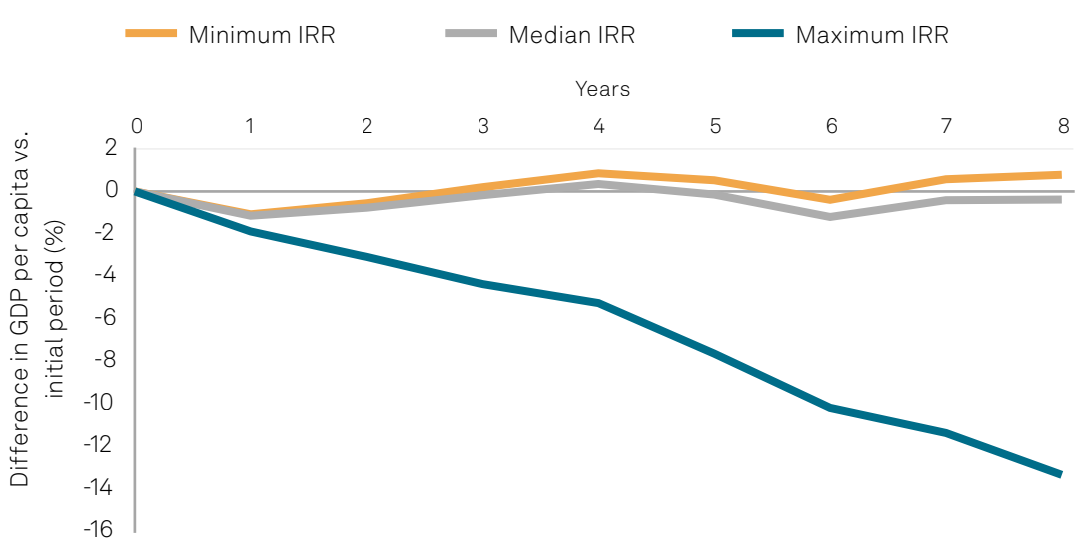
Response over time to a 1C annual average temperature rise from 24 C



The results describe the relationship of the variable shown with average annual temperature using a panel model estimation with country fixed effects and regional time fixed effects. We derive impulse response functions using local projections and controlling for lags and forwards of the temperature.
Sources: Authors' calculations; S&P Global Ratings.
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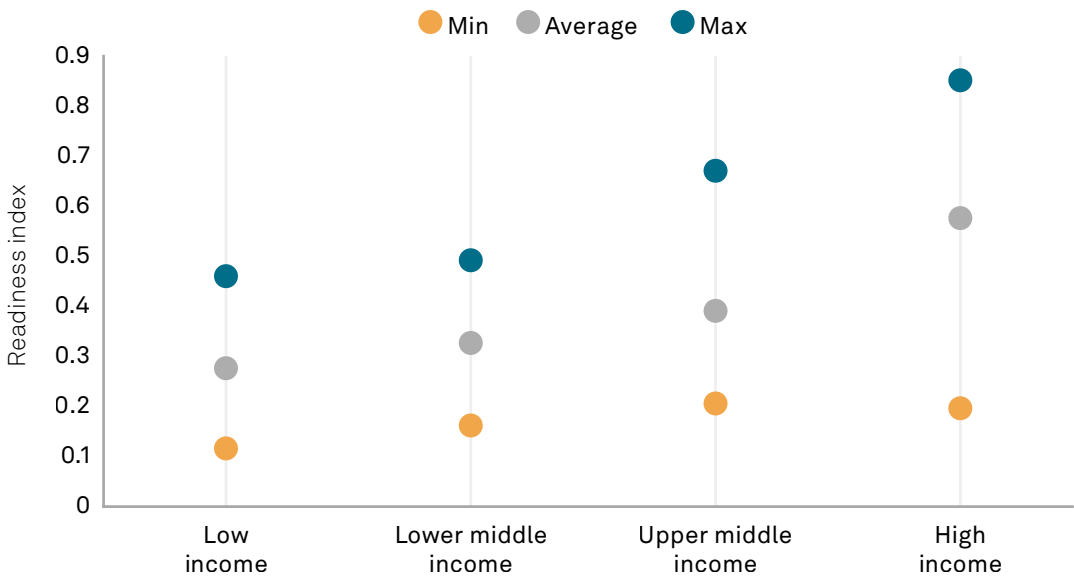
Chart 10: **Countries with higher real interest rates display long-lasting effects on growth**

Response over time to a 1C degree annual average temperature rise from 24°C by real interest rate level (IRR)



IRR = internal rate of return.
The results describe the relationship of the variable shown with average annual temperature using a panel model estimation with country fixed effects and regional time fixed effects. We derive impulse response functions using local projections and controlling for lags and forwards of the temperature.
Sources: Authors' calculations; S&P Global Ratings.
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Chart 11: **Readiness to cope with climate change correlates with higher economic development**



A higher score indicates a greater readiness.
Sources: Notre Dame Global Adaptation Initiative; authors' calculations; S&P Global Ratings.
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low or the median interest rate (0.01% and 0.1% respectively; see chart 10). This implies lower interest rates help economies recover, for example, by providing incentives for investment and lowering the cost of financing for the whole economy. In a broader context, this would suggest that one way less vulnerable countries can help more vulnerable economies cope with climate shocks is by providing concessional finance (see “COP27: Top 5 Takeaways That Matter”).

Adaptation and resilience foster economic development, and vice versa

While we find that high readiness helps countries mitigate the impact of climate shocks, we note that indicators of readiness themselves correlate with economic development given their focus on economic, institutional and social factors (see chart 11). At the same time, our analysis highlights that climate change is already making it harder for lower-income countries to catch up to more

developed nations. This circularity seems to indicate that changes in climate are another barrier to development for EMDEs.

It also implies that economic development and resilience to climate change feed off each other. Viewing adaptation to climate change in this context could thus also support long-term growth prospects for EMDEs. As such, institutional measures to promote adaptation, such as improving education, social-safety nets, and product and labor market flexibility, are likely to overlap with economic development goals. Countries may find a third way to escape what seems to be a climate change-economic growth doom loop. Those would likely stem from more granular, readiness measures that work specifically for certain EMDEs, absent strong economic development (for which data is scarce); whereas our cross-country comparison of readiness to cope with climate change focuses on high-level institutional, economic and social differences. ■

What adaptation looks like in practice

Adaptation to climate change can be evident even when readiness is relatively low. Measures of countries' readiness mostly typically reflect high-level drivers, proxies of adaptation (that is, the changes required to withstand the impacts from climate change) and resilience (that is, our ability to withstand the impacts from physical climate risks, while incurring minimal damage to society, the economy, and environment), as well as whether a country has the necessary finances and provides an adequate business and institutional environment to make effective use of investments in adaptation.

While our findings suggest that financial capacity and institutional set-ups play an important role in cushioning economies from losses linked to climate change, they don't tell us much about what countries, companies and communities have already done to face and manage climate-related risks. Adaptation can also occur where readiness is relatively low, although this often happens with international support for financing and designing technical tools.

In practice, adaptation measures are multifaceted, reflecting the location- and context-specific nature of vulnerability. However, it's possible to distill adaptation measures into different types, for example:

- **Structural or physical options:** Including engineered options such as a sea wall, technology (like an early warning system) or ecosystem-based adaptation, such as the restoration or creation of habitats (like mangroves that can help to reduce the impacts of cyclones, flooding and coastal erosion).
- **Social:** Including improvements to education, information awareness or behavioral change.
- **Institutional:** Including economic incentives, laws or regulations, policies or programs.

It's also worth noting the significant overlap between adaptation measures and disaster risk reduction (DRR), or disaster risk management (DRM), measures and frameworks — for example, the Sendai Framework for Disaster Risk Reduction (SFDRR) (supported by the European Commission) and the EU Strategy on Adaptation to Climate Change, both of which serve to leverage synergies between DRR and climate change adaptation.

Appendix: Methodology and data

Our model focuses on the short- to medium-term dynamics stemming from a one-time annual temperature shock, rather than the very long-term impact of a chronic increase in temperature. We look at the relationship between temperature and real GDP per capita using a sample of 190 countries. The data underlying this analysis is taken from several sources:

- Climate variables from the Centre for Environmental Data Analysis.
- Readiness measures provided by the ND-GAIN database
- Macroeconomic variables from the World Bank’s database (GDP per capita, gross capital formation and infant mortality) and Penn World Tables (sectoral value added, capital, depreciation of capital, productivity, real rates of return and human capital).

- Data sample from 1965 to 2020; the availability of historical data varies by country.

For our main model, we use a panel regression where GDP per capita growth is a function of:

$$\begin{aligned} \text{dlog(GDP per capita)}_{i,t} = & \beta_1 \text{ xWeather}_{i,t} + \beta_2 \text{ xWeather}_{i,t}^2 \\ & + \gamma_1 \text{ xWeather}_{i,t-1} + \gamma_2 \text{ xWeather}_{i,t-1}^2 \\ & + \text{dlog(GDP per capita)}_{i,t-1} + \varepsilon_{i,t} \end{aligned}$$

Weather variables include average annual temperature (T) and average annual precipitation (P). We also use country (i) and regional year (t) fixed effects to control for country differences (like macroeconomic conditions, latitude and economic structure) and regional shocks time specific. Standard errors are clustered at the country level. Note that we replace GDP per capita with other

dependent variables, when we investigate the channels of the shock (like sectoral value added and growth components).

For impulse response functions to model the impact over time, we use the Jorda (2005) local projection method. The dependent variable becomes the cumulative growth rate of GDP (or the other dependent variable mentioned) between horizons t-1 and t+h. In the local projection regression, we also add controls for forwards of the weather variables (i.e. temperature and precipitation values in time t to t+h), to ensure we isolate the effect of the weather shock occurring in

time (t). In other words, the model only looks at the short to medium-term effects of temperature increases on GDP.

For the growth at-risk exercise, we employ quantile regression for panel data on the same specification as above. The following tables show the results for the 10th, 50th and 90th growth deciles, that is, we create subsamples of the data according to where they sit in the GDP per capita growth distribution (for example, the lowest growth rates would be found in the lowest 10th decile).

Table 1: Basic summary statistics by income*

	Number of observations	Mean	Standard deviation	Minimum	Maximum
Advanced economies					
High income					
GDP per capita growth	2,931	2.1	4.9	-79.1	56.9
Temperature	4,026	15.0	9.5	-17.2	29.5
Emerging markets and developing economies					
Upper middle income					
GDP per capita growth	2,402	2.1	7.6	-105.0	87.7
Temperature	3,233	19.2	7.8	-6.7	28.7
Lower middle income					
GDP per capita growth	2,521	1.5	5.2	-46.2	35.9
Temperature	3,111	21.8	7.2	-2.0	29.3
Low income					
GDP per capita growth	1,199	0.4	6.7	-64.6	31.9
Temperature	1,586	24.3	4.6	4.6	29.4

* Data observations for 196 countries in annual average terms from 1960 to 2020.
Source: S&P Global Ratings.
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Table 2: Basic summary statistics by region

	Number of observations	Mean	Standard deviation	Minimum	Maximum
East Asia & Pacific					
GDP per capita growth	1,411	2.5	5.8	-79.1	35.9
Temperature	1,952	22.3	7.3	-2.0	28.9
Europe & Central Asia					
GDP per capita growth	2,067	2.2	5.4	-60.4	65.3
Temperature	3,233	8.4	5.5	-17.2	20.6
Latin America & the Caribbean					
GDP per capita growth	1,952	1.5	4.8	-33.8	35.6
Temperature	2,196	24.0	3.7	7.9	29.5
Middle East & North Africa					
GDP per capita growth	742	1.3	9.6	-105.0	61.9
Temperature	1,098	22.3	3.9	15.4	29.3
North America					
GDP per capita growth	152	1.8	3.0	-7.1	11.6
Temperature	183	8.5	10.8	-7.3	22.6
South Asia					
GDP per capita growth	364	2.6	4.4	-42.6	22.3
Temperature	427	20.1	8.0	6.7	28.6
Sub-Saharan Africa					
GDP per capita growth	2,365	1.0	6.4	-64.6	87.7
Temperature	2,867	24.6	3.3	11.3	29.4

Source: S&P Global Ratings.
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Table 3: Results for quantile regression for panel data (QRPD)

Number of obs:	8,856
Number of groups:	193
Min obs per group:	6
Max obs per group:	59

For 90th percentile						
gdppc_growth	Coefficient	Std. err.	z	--95% confidence interval--		
				P>z		
temp	(0.07)	0.01	(5.10)	0.00	(0.09)	(0.04)
temp_sq	(0.01)	0.00	(22.12)	0.00	(0.01)	(0.01)
lag_temp	(0.23)	0.01	(18.55)	0.00	(0.26)	(0.21)
lag_temp_sq	0.01	0.00	36.09	0.00	0.01	0.01
lag_gdppc_growth	0.20	0.00	493.09	0.00	0.20	0.20
For 50th percentile						
temp	0.69	0.01	63.95	0.00	0.67	0.71
temp_sq	(0.02)	0.00	(54.39)	0.00	(0.02)	(0.02)
lag_temp	(0.66)	0.01	(57.66)	0.00	(0.68)	(0.63)
lag_temp_sq	0.02	0.00	45.04	0.00	0.02	0.02
lag_gdppc_growth	0.33	0.00	184.02	0.00	0.33	0.34
For 10th percentile						
temp	0.78	0.04	17.66	0.00	0.69	0.86
temp_sq	(0.04)	0.00	(25.06)	0.00	(0.04)	(0.04)
lag_temp	(0.73)	0.04	(16.32)	0.00	(0.82)	(0.64)
lag_temp_sq	0.03	0.00	20.24	0.00	0.03	0.04
lag_gdppc_growth	0.32	0.01	50.86	0.00	0.31	0.34

Estimates generated using Stata's QRPD, an estimator developed by Powell (2015). Powell, David. 2015. Quantile Regression with Nonadditive Fixed Effects, RAND Labor and Population Working Paper.
Source: S&P Global Ratings.
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Related Research

S&P Global research

- [COP27: Top 5 Takeaways That Matter](#), Nov. 23, 2022
- [Weather Warning: Assessing Countries' Vulnerability To Economic Losses From Physical Climate Risks](#), April 27, 202

External research

- Burke, Hsiang, and Miguel (2015), “Global Non-Linear Effect of Temperature on Economic Production,” Nature 527: 235–39Kalkuhl and Wenz (2020) “The impact of climate conditions on economic production. Evidence from a global panel of regions,” Journal of Environmental Economics and Management, 2020, vol. 103, issue C
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- Colacito, Hoffmann, and Phan (2018) “Temperature and Growth: A Panel Analysis of the United States,” Federal Reserve Bank of Richmond Working Paper No. 18-09, March
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Authors

Marion Amiot | S&P Global Ratings, Head of Climate Economics
Satyam Panday | S&P Global Ratings, Chief Emerging Market Economist



Adaptation planning is the next step for companies to prepare for climate risk

While the sense of urgency around climate change adaptation is growing, many companies are moving slowly to adapt their businesses to physical climate risks — even in sectors where many companies consider climate strategy a top material issue. Data collected in the 2022 S&P Global Corporate Sustainability Assessment shows that just one in five companies across sectors has a plan to adapt to the physical impacts of climate change.

Published on February 21, 2023 by S&P Global Sustainable¹.

Key takeaways

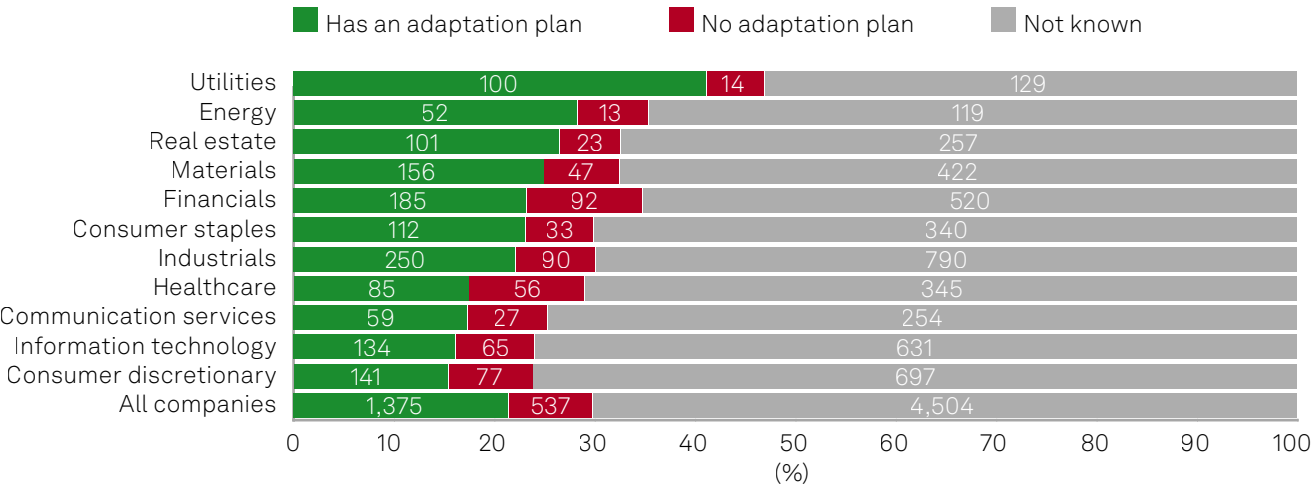
- Only one in five companies has a plan in place to adapt to the physical risks of climate change, according to the latest data from the S&P Global Corporate Sustainability Assessment.
- The utilities and energy sectors are more advanced in adapting their business to extreme weather events and other climate-related hazards.
- Even among some of the sectors that consider climate change a top material issue, there are gaps in physical risk adaptation planning.

► **The physical hazards of climate change,** from destructive weather events to longer droughts or heat waves, are becoming more severe and more frequent. Yet many large companies around the world are not engaging in climate adaptation efforts to build resilience to these hazards, new research from S&P Global Sustainable1 shows. This gap is emerging as one of the crucial risks facing the global economy. According to the World Economic Forum’s [Global Risks Report for 2023](#), the failure of climate change adaptation ranks as the second-greatest risk for companies over the next 10 years.

Investments in adaptation will need to increase to cope with the rising costs from physical climate risks such as wildfires, flooding and hurricanes. According to the World Meteorological Organization, climate-related disasters are now nearly five times as frequent. If the current trend continues, the number of disasters could rise to 560 per year by 2030, up 40% from 2015. Up to \$340 billion per year of adaptation finance is needed by 2030 to pay for investments in technology and in transforming agriculture and water systems.

Only 1 in 5 companies has a physical risk adaptation plan

Number of companies by sector that have climate physical risk adaptation plans



Data as of Jan. 25, 2023.
"Not known" includes companies that responded "not known" in the assessment; companies that did not answer the physical risk adaptation plan question or left the question blank; and companies whose adaptation plans could not be verified using publicly available sources.
"No adaptation plan" includes companies that responded "no" or "not applicable" in the assessment and companies for which publicly available sources indicated there is no adaptation plan.
Results based on responses from 6,416 companies assessed in the 2022 S&P Global Corporate Sustainability Assessment.
Source: S&P Global Sustainable1.
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More stakeholders across the public and private sectors are recognizing adaptation as a key part of solving the climate crisis. It was a major focus at COP27, the U.N. Climate Change Conference in Sharm el-Sheikh, Egypt, where companies and governments announced several initiatives to boost capital flows toward adaptation and raise billions of dollars in investment to protect vulnerable communities from the effects of climate change.

But while the sense of urgency around climate change adaptation is growing, many companies are moving slowly to adapt their businesses to the physical risks of climate change. Data collected in the 2022 S&P Global Corporate Sustainability Assessment (CSA) shows that just one in five companies across sectors has a plan to adapt to the physical impacts of climate change. The CSA defines an adaptation plan as a plan to adapt to any climate risks across a company’s value chain that the company has identified through a climate risk assessment. The plans can be specific

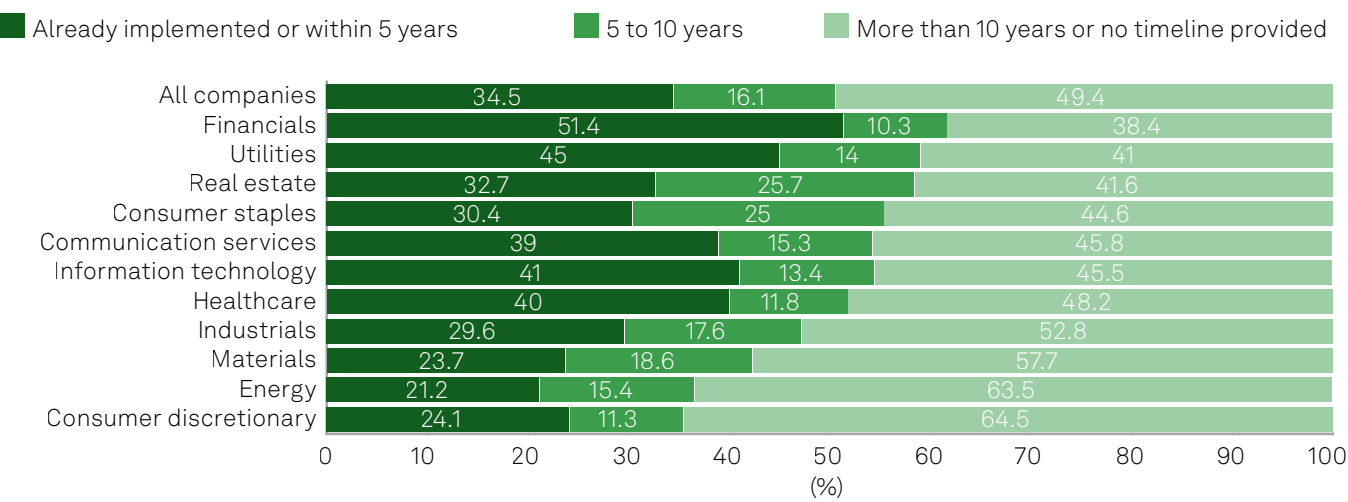
climate-related mitigation plans included in wider risk assessments, or separate climate-specific reports.

The sectors with the highest rates of physical risk adaptation planning are utilities, at just over 40%, and energy, at almost 30%, based on assessments of 6,416 companies in the 2022 CSA. Both industries are heavily reliant on physical infrastructure, which will be increasingly at risk of damage and disruption from storms, flooding and other climate hazards.

In the financial sector, less than a quarter of companies report having an adaptation plan. Banks, insurers, asset managers and asset owners are exposed to the wider economy through lending, investing or underwriting across industries, which can make them more exposed to the economic impacts of climate change — including its physical impacts. Financial institutions also play a key role in financing the transition and facilitating the flow of the trillions of dollars in capital that

Roughly half of companies with adaptation plans are implementing them within 10 years

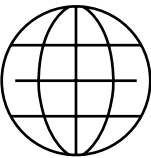
Percentage of companies with adaptation plans by implementation timeline



Data as of Jan. 25, 2023.
Results based on responses from 1,375 companies with adaptation plans assessed in the 2022 S&P Global Corporate Sustainability Assessment.
Source: S&P Global Sustainable1.

economists have said is needed to mitigate and adapt to climate change.

Four sectors have slower progress on adaptation planning than the cross-sector average: healthcare, communication services, information technology and consumer discretionary. Some of these sectors are traditionally seen as less directly exposed to physical climate-related risks yet will face significant physical risks to their assets over the coming decades, absent adaptation. Hospitals in major coastal cities may need to adapt to rising sea levels and more severe storms. Internet and cloud computing firms that rely on infrastructure such as server facilities will contend with heat waves that can interrupt operations.



About 23% of companies assessed in the 2022 CSA selected climate strategy as one of their three main material topics in their assessments, and that percentage varied widely across sectors.

S&P Global data shows that about half of the 1,375 assessed companies with adaptation plans have an implementation timeline of 10 years or sooner. About one-third of companies have already implemented at least one of their adaptation plan measures or aim to put their plan in action within five years. The other half of companies with plans, however, are not acting with urgency to prepare for physical risks. In four sectors — industrials, materials, energy and consumer discretionary — a majority of companies with plans indicated they will not take action for at least a decade or have no timeline for action.

Preparing for climate impacts, and securing the funding to pay for adaptation, is a challenge for municipalities and countries as well as the private sector. Adaptation financing lags far behind money going toward mitigation, which includes actions taken to lower emissions and limit global warming. Less than 8% of global [climate finance](#) goes toward projects aimed at building climate resilience. The impacts from climate change will not be [evenly distributed](#), with lower- and lower-middle income countries more at risk and less

ready to cope than higher-income nations. An agreement reached at COP27 for a “loss and damage” fund will seek to address adaptation and resilience challenges of developing countries. Companies can play a role in facilitating private funding.

According to the World Economic Forum, only 3% of adaptation funding comes from private sources, but climate risks could equal annual revenues of 10% for some companies. Investments in adaptation can help firms manage those risks and provide growth opportunities, WEF wrote in a [white paper](#).

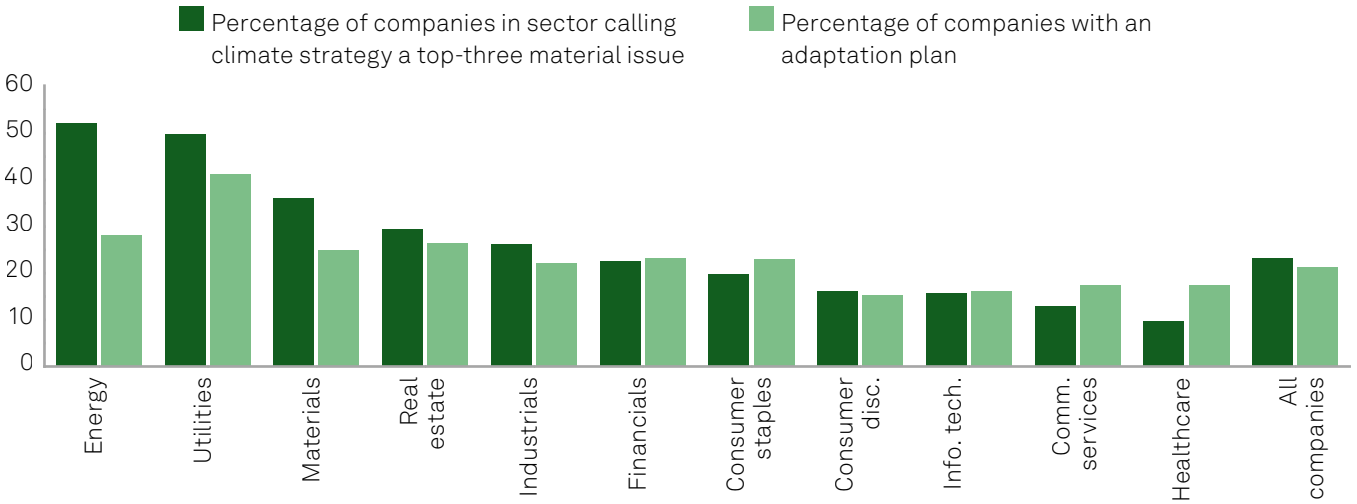
Some sectors do not see climate as a top material issue

One clue to why adaptation plans are scarce is that many companies in every sector do not consider climate strategy to be a top material issue. About 23% of companies assessed in the 2022 CSA selected climate strategy as one of their three main material topics in their assessments, and that percentage varied widely across sectors. Roughly half of energy and utilities companies see climate as a top material issue, while less than 10% of assessed healthcare companies do.

Yet even some of the sectors that consider climate strategy to be a primary material issue have a gap in adaptation planning. Less than one-third of energy companies have an adaptation plan despite about half of assessed companies putting climate strategy in their top three material topics. The gap is smaller for utilities, but the sector still shows a discrepancy between how companies view climate and what action they are taking to address climate risks. Nearly 50% of utilities regard climate strategy as material, but just 41% have an adaptation plan. One in three materials sector firms believe climate strategy is material, but only one in three have a plan to adapt to the physical risks.

Some sectors that consider climate strategy a top material issue have a gap in adaptation planning

Percentage of companies by sector that chose climate strategy as a top-three material issue and that have a climate adaptation plan



Data as of Jan. 25, 2023. Results based on responses from 6,416 companies assessed in the 2022 S&P Global Corporate Sustainability Assessment. Source: S&P Global Sustainable1.

Conversely, some sectors are taking action to develop adaptation plans despite not viewing climate strategy as a material issue. More than 17% of healthcare companies have an adaptation plan, but only 9.7% regard climate strategy as material. In communication services, 17.4% of companies have an adaptation plan, but only 12.9% consider climate to be material.

Climate assessments and scenario analysis

CSA data also shows that climate risk assessments and scenario analysis, which usually form the basis for adaptation plans, are uncommon in some sectors.

A climate risk assessment can show how consideration of climate-related risks — both transition and physical risks — are embedded throughout an organization, and how vulnerable an organization might be. Scenario analysis can help companies understand how climate change will impact their business and financial performance under different potential future scenarios. Companies can test for physical risks, such

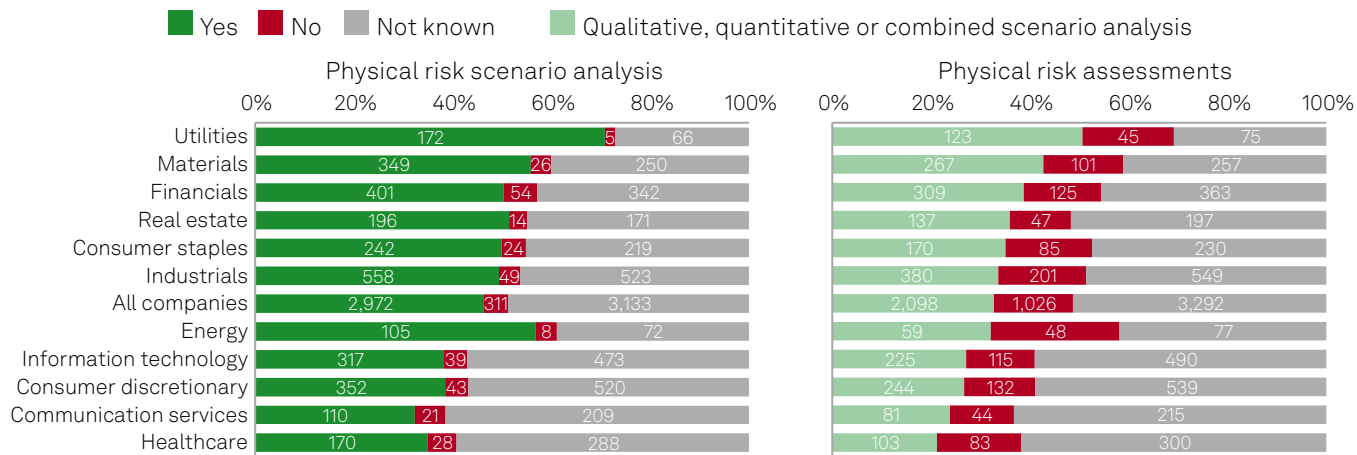
as rising sea levels or an increase in extreme weather events like hurricanes, flooding and wildfires. Transition risk scenario analysis takes a forward-looking approach to how future policy, regulatory and technological changes as well as legal, market and reputational risks would impact a business.

Just over 46% of assessed companies globally conduct physical risk assessments, according to CSA data. Sectors where physical risk adaptation plans are common are also those where the rate of physical risk assessment is high, reflecting the importance of understanding a company’s exposure to climate change before implementing a strategy on how to deal with climate risks. For example, nearly 71% of [utilities](#) conduct physical risk assessments, as do nearly 56% of materials firms and 50.3% of financial companies. Healthcare and communications services companies rank the lowest, with only about a third conducting physical risk assessments.

However, fewer companies are performing scenario analysis. Only about half of utilities undertake either quantitative or qualitative

Physical risk assessments are more common than scenario analysis

Number of companies by sector conducting climate physical risk scenario analysis or physical risk assessments



Data as of Jan. 25, 2023.
Results based on responses from 6,416 companies assessed in the 2022 S&P Global Corporate Sustainability Assessment.
"Not known" includes companies that responded "not known" in the assessment; companies that did not answer the risk assessment or scenario analysis question or left the question blank; and companies for which publicly available sources could not confirm whether risk assessment or scenario analysis was conducted.
"No" includes companies that responded "no" or "not applicable" in the assessment and companies for which publicly available sources confirmed there is no risk assessment or scenario analysis conducted.
Source: S&P Global Sustainable1.

scenario analysis, or a mixture of both. Quantitative scenario analysis uses analytical models to determine a wide range of climate-risk outcomes, while qualitative scenario analysis uses descriptive narratives and is often the first step for organizations to explore potential future climate outcomes.

TCFD uptake has far to go

CSA data shows that high-emissions sectors have a higher percentage of companies integrating the recommendations of the Task Force on Climate-related Financial Disclosures, or (TCFD) which uses standardized guidelines to steer companies in disclosing material climate risks and conducting scenario analysis. Those are also the sectors that are more likely to have an adaptation plan in place.

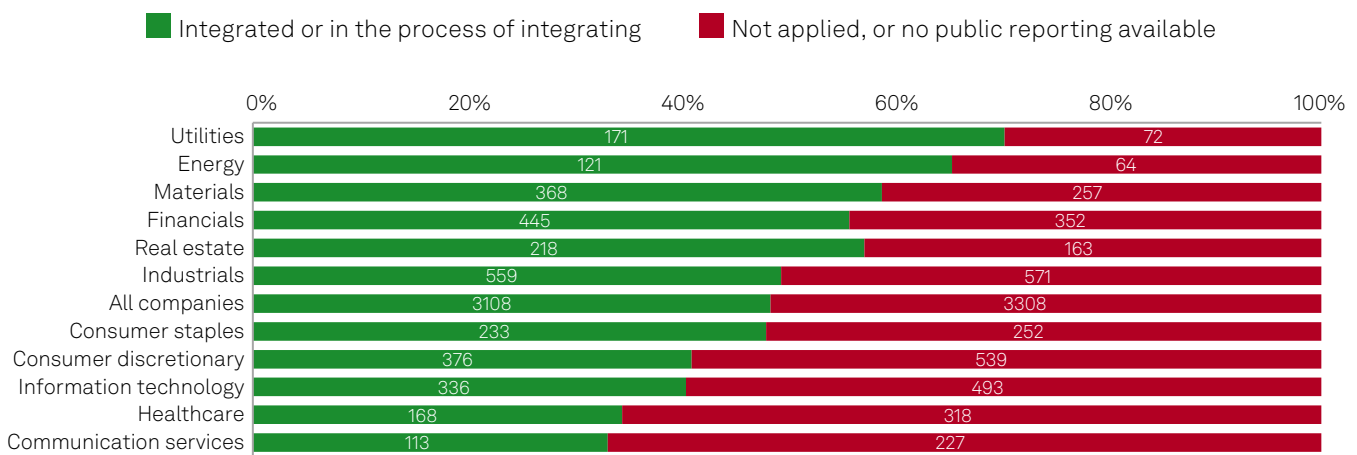
For example, more than 70% of utility companies are fully or partially reporting in line with the TCFD’s 11 disclosure

recommendations. These [recommendations](#) include detailing management’s role in calculating and overseeing climate-related risks, as well as conducting scenario analysis to test a company’s resilience to different climate-related scenarios, including one in which the world limits global warming to 2 degrees Celsius or lower. The goal of the 2015 Paris Agreement is to limit global warming to “well below” 2 C and “preferably” to 1.5 C compared to preindustrial temperatures. About 65% of energy firms assessed integrate TCFD, compared to 59% of materials and 56% of financials.

The sectors that have a low percentage of adaptation planning, as well as climate risk assessment and scenario analysis, are also unlikely to integrate TCFD recommendations. Only one-third of communication services firms integrate the framework. Healthcare has a similar rate, while about 40% of information technology companies are disclosing in line with the framework.

TCFD uptake varies widely by sector

Number of companies by sector that integrate or are in the process of integrating the Task Force on Climate-Related Financial Disclosures' recommendations



Data as of Jan. 25, 2023.
Results based on responses from 6,416 companies assessed in the 2022 S&P Global Corporate Sustainability Assessment.
Source: S&P Global Sustainable1.

Growing regulatory pressure

Companies, particularly those based in Europe, are facing regulatory changes that will force them to take action on adaptation. The EU’s green taxonomy — a dictionary of sustainable activities designed to steer companies as they adapt their business strategies to climate change — requires companies to disclose on climate adaptation. The 11,700 firms currently subject to the EU’s Non-Financial Reporting Directive have to disclosure their [taxonomy alignment](#), including on climate adaptation, as of Jan. 1, 2023. The number of companies having to report will expand from the year 2026 under a reformed version of the directive, the [Corporate Sustainability](#)

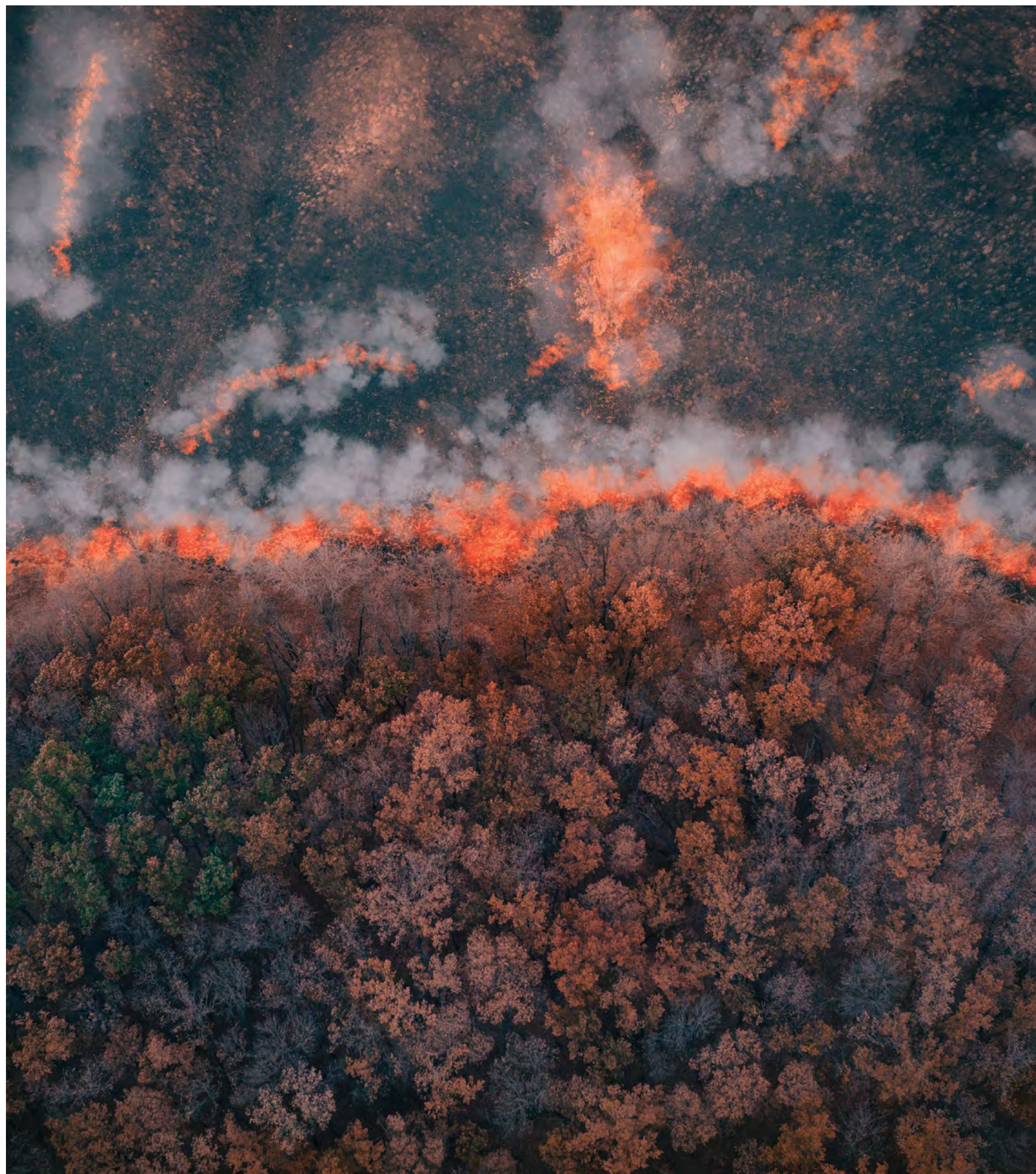
[Reporting Directive](#). Nearly 50,000 companies will be subject to the new rules.

The financial sector will also come under pressure as banking regulators step up climate stress tests, typically using [scenario analysis](#) created by the Network for Greening the Financial System, a group of central banks collaborating on how to tackle climate change.

Adaptation is becoming as [important as climate transition](#) in terms of protecting lives, assets and the productive capacity of the economy over time. Climate risk assessments and scenario analysis can give companies the foundation to implement physical risk adaptation plans that prepare them for the effects of extreme weather events on their business and the broader economy. ■

Authors

Jennifer Laidlaw | S&P Global Sustainable1, Thought Leadership Senior Writer
Stuart Bowles | S&P Global Sustainable1, ESG Analyst
Hana Beckwith | S&P Global Sustainable1, ESG Specialist



Crunch Time:

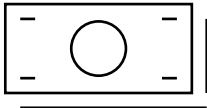
Can adaptation finance protect against the worst impacts from physical climate risks?

Adaptation to climate change will become as important as climate mitigation in terms of protecting wealth and lives over the next few decades. Accelerated investments in adaptation finance will be needed to avoid the most severe impacts, and there are signs those investments may be at a turning point. But the physical impacts from climate change are increasing, and the window of opportunity for building resilience and adapting at lower costs is closing rapidly.

Published on January 13, 2023.

Key takeaways

- Adaptation to climate change will become as important as climate mitigation in terms of protecting wealth and lives over the next few decades. Accelerated investments in adaptation finance will be needed to avoid the most severe impacts, and there are signs those investments may be at a turning point.
- The physical impacts from climate change are increasing, and the window of opportunity for building resilience and adapting at lower costs is closing rapidly.
- Agreements reached at COP27, including the go-ahead for a “loss and damage” fund for developing countries and the Sharm el-Sheikh Adaptation Agenda, which describes 30 actions needed by 2030, will build on other initiatives and serve as catalysts through which investments in adaptation and resilience projects can gain significant traction.
- The pace of change over the coming years will likely accelerate, driven by the realization and inevitability of climate impacts as well as the market-based incentives starting to emerge.



About 4% of global gross domestic product could be lost annually by 2050, according to S&P Global Ratings research, surpassing the 3.3% contraction caused by COVID-19 in 2020.

► **Countries, companies and communities are** going to have to face the impacts of acute physical risks related to climate change as global emissions and temperatures rise. Still, these effects will not be evenly distributed. Lower- and lower-middle-income countries are more at risk than wealthier peers, even though they have contributed less to climate change and are less ready to cope. Lagging investment in the technologies and interventions needed for adaptation is also widening the gap. With this in mind, adaptation will become as important as climate transition financing in terms of protecting wealth and lives over the next few decades. Accelerated investments in adaptation finance will be needed to avoid the most severe impacts, and there are signs the quality and amount of funding being deployed, including from the private sector, is nearing a turning point.

Physical effects from climate change are occurring, and the impact is rising. In 2022, the U.S. saw at least 15 disasters resulting in \$1 billion or more in damage, extending a growing trend since the 1980s, according to the [National Oceanic and Atmospheric Administration](#). S&P Global Ratings recently estimated that home and office insurance

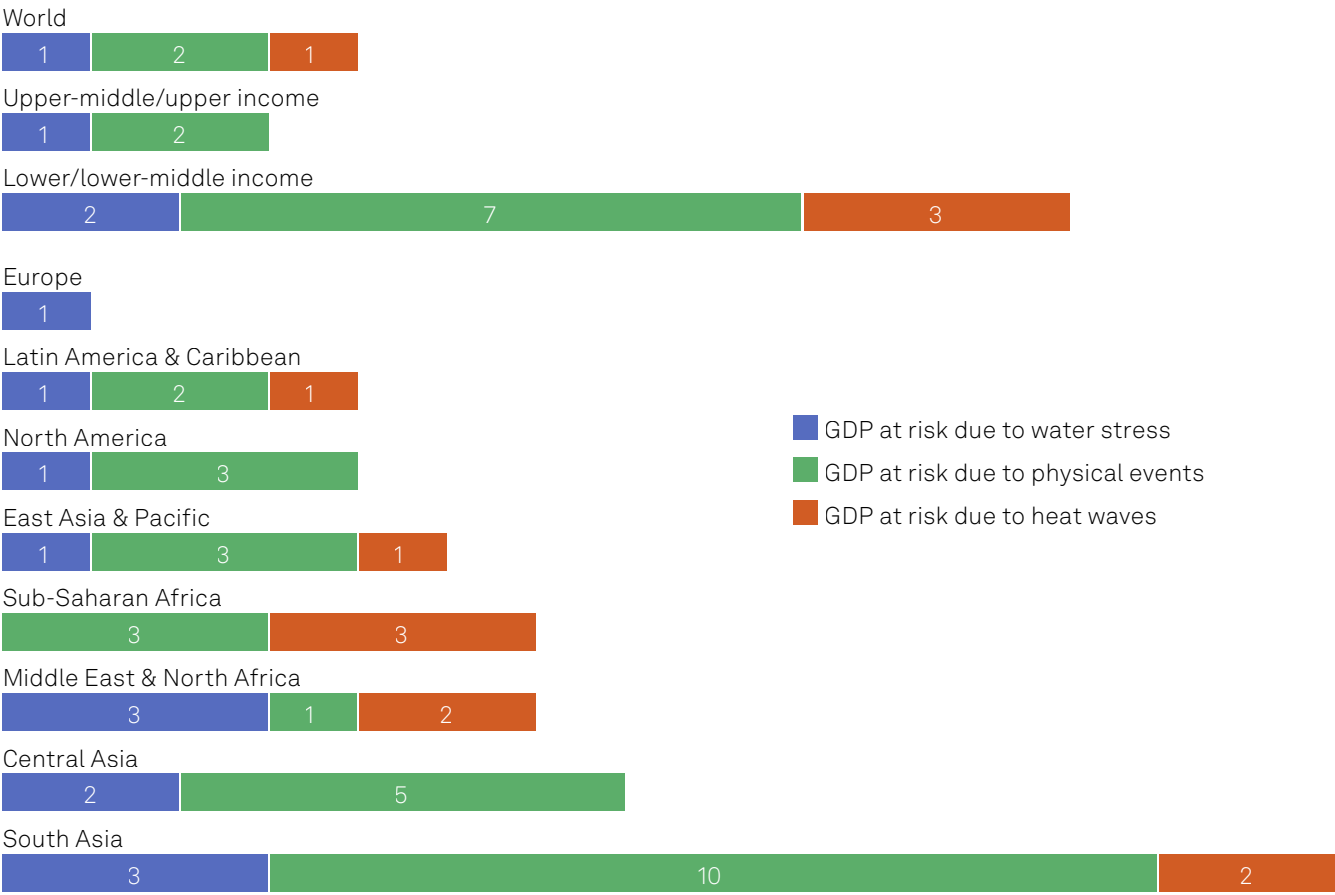
claims in the U.S. rose 5.7% year over year to \$148 billion (as measured in direct premiums written) in 2021. Global average annual insured losses attributed to natural catastrophes (affecting all property-related lines) increased to approximately \$96 billion in 2017-2021 from \$21 billion in the prior five years, according to Munich Re. Rising losses are likely driven by increases in the severity and frequency of extreme weather events as well as a greater number of assets located in vulnerable areas. S&P Global research and other climate studies, including the Intergovernmental Panel on Climate Change’s latest assessment report (AR6), point to worsening economic losses even under low-emission scenarios in the absence of a significant uptick in adaptation investments.

Many countries will be affected and are not ready to cope

About 4% of global gross domestic product could be lost annually by 2050, according to S&P Global Ratings research, surpassing the 3.3% contraction caused by COVID-19 in 2020. The S&P estimate was based on an assessment of 135 countries’ vulnerability to and readiness for climate change over

Chart 1: Physical climate risks are not the same for all regions - South Asia is over 10 times more exposed than Europe

2050 combined GDP at risk under RCP4.5, physical risk contribution (%)



As of Mar. 14, 2022.
RCP = Representative Concentration Pathway.
Countries’ income and regional classification are based on World Bank.
Source: S&P Global Ratings.
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the next 30 years. It used a scenario (RCP4.5) that assumes countries deliver on current emissions reductions commitments as per their nationally determined contributions (see chart 1).

The adaptation challenges facing individual countries — and, by association, companies — differ because of the varying frequency and severity of climate hazards, such as storms and wildfires. The vulnerability of assets also differs by location and asset type. Still, adaption measures can help companies and countries withstand climate risks. Japan, for instance, has avoided large

wealth damage even in the face of high climate risks, including typhoons. Lower- and lower-middle-income countries have less ability to cope with and adjust to damaging events, leading to higher and more persistent economic losses. This highlights the importance of international cooperation to support equitable distribution of adaptation investments, particularly given that those most at risk have contributed comparatively little to climate change. A compounding problem is that the finance available to support countries’ adaptation to physical climate risks is severely lagging what is needed.

Furthermore, even ambitious investments in adaptation will not fully avoid climate-related impacts.

The adaptation finance gap continues to widen and shows little sign of stopping

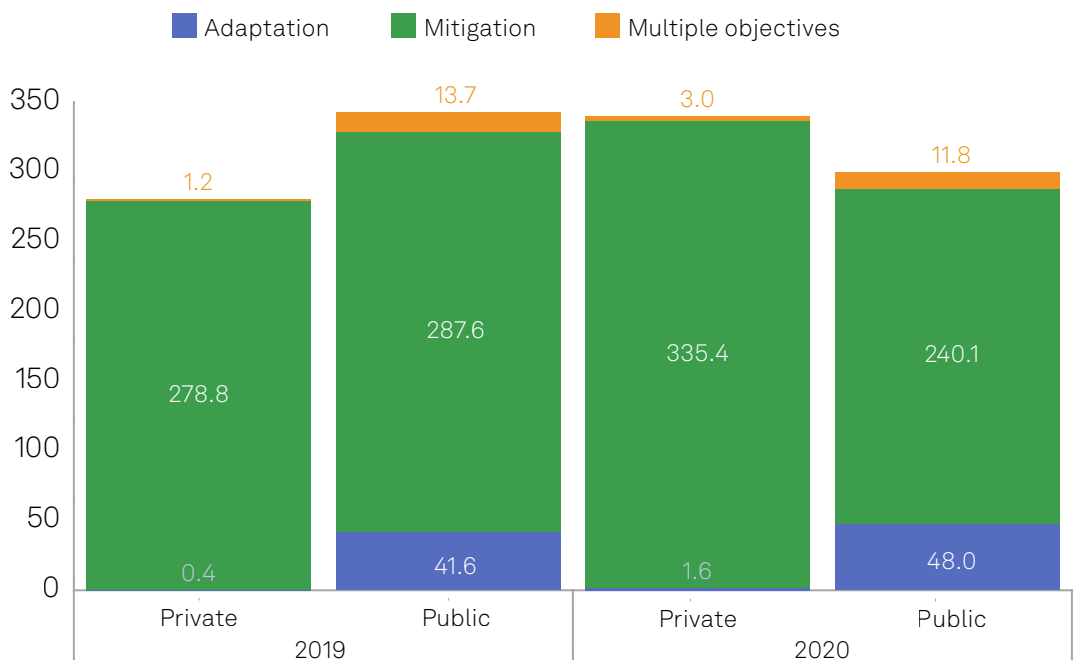
Annual adaptation costs for developing countries, accounting for inflation, will be in the range of \$160 billion to \$340 billion by 2030, and between \$315 billion and \$565 billion by 2050, according to the [United Nations’ Environment Programme \(UNEP\) Adaptation Gap Report 2022](#). In contrast, only about \$83 billion of climate finance, covering both adaptation and mitigation,

was mobilized in 2020, missing the \$100 billion-per-year pledge made by developed countries to developing countries under the Paris Agreement on climate change. The picture is similar when looking at global climate finance flows, where mitigation finance dominates, as reported by the Climate Policy Initiative (see chart 2).

Instruments such as green bonds could partly refocus financial flows toward climate-positive outcomes helped by initiatives such as recent guidance from the Global Center on Adaptation. However, while green bond issuance has increased fourfold since 2018 — surpassing the \$3 trillion total issuance mark earlier this year — most green use of proceeds and sustainability-linked bonds are focused on mitigation, with adaptation and resilience accounting for only 4% of green bond spend last year (see chart 3).

Building resilience to physical climate risks means addressing a full system, not just an individual company’s assets.

Chart 2: Less than 8% of global climate finance goes to adaptation (US\$B)

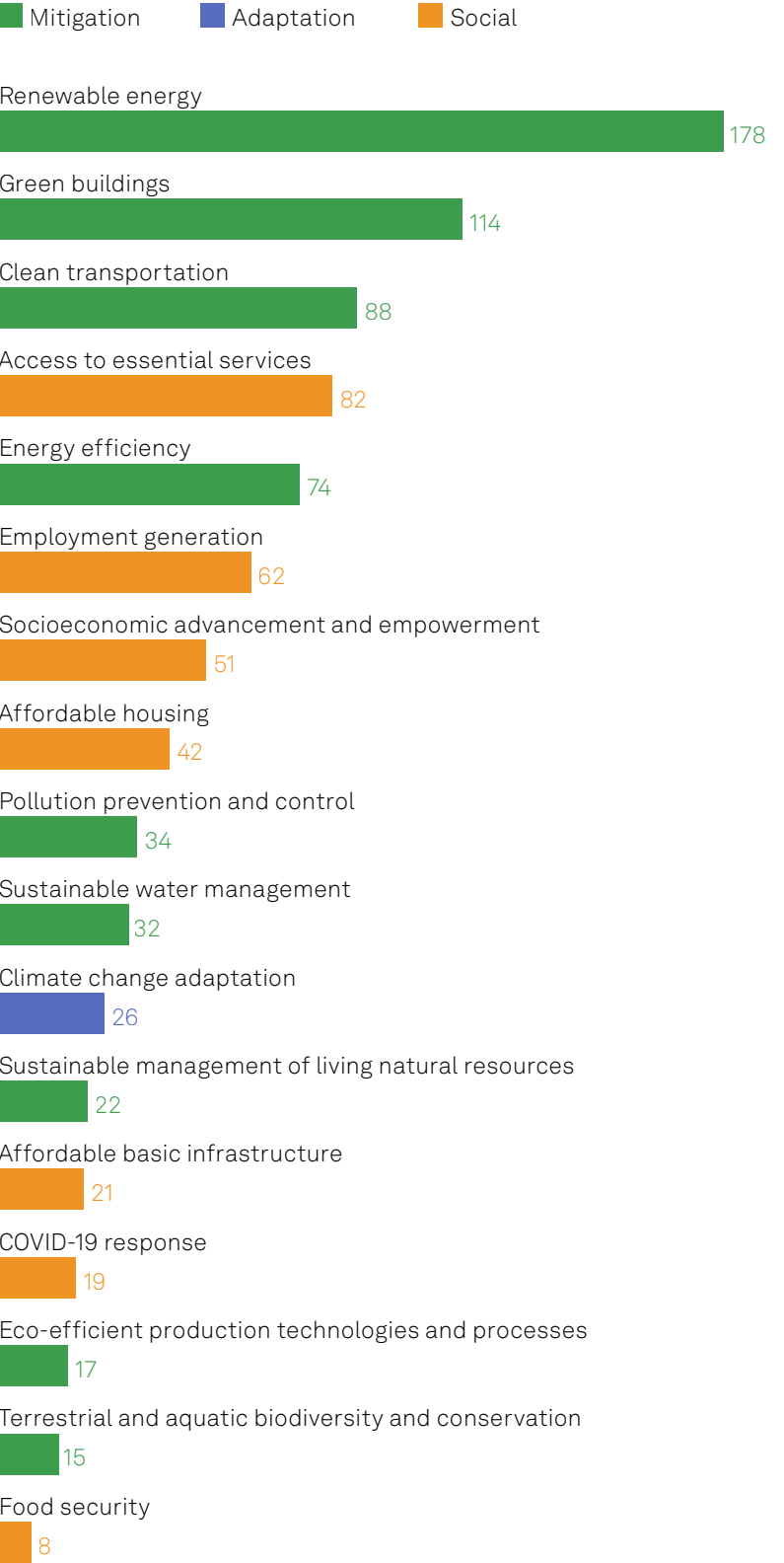


As of Feb. 16, 2022.
Data source: Climate Policy Initiative (2022).
Source: S&P Global Ratings.
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The challenges associated with scaling adaptation and resilience finance to the levels required are clear.

- Adaptation tends to be less attractive than mitigation because results and returns are harder to predict and measure. For example, data that describe differences in revenues between resilient and nonresilient assets are not readily available. In addition, some adaptation and resilience investments — such as public infrastructure with a multidecade operational lifetime — may not generate a return for investors.
- There is uncertainty about impacts and necessary responses. Translating the outputs of climate models into specific predictions is not straightforward, even with advances in climate analytics that have improved transparency regarding particular exposures and financial losses.
- Data and standardization, including around investments that should be considered “resilient,” are lacking.
- Building resilience to physical climate risks means addressing a full system, not just an individual company’s assets. This wider approach can be challenging, as it is difficult to secure critical coordination between various stakeholders. The benefits of these adaptation projects also manifest over time, making governments and policymakers less likely to get credit for adaptation efforts, and therefore less likely to pursue them.
- A lack (or perceived lack) of projects appears to be constraining investment. Creating investor awareness of the pipeline of deals in adaptation and resilience is a challenge. Size is also important: Smaller adaptation projects can find it difficult to get on the radar of institutional investors.

Chart 3: Green finance is dominated by mitigation, with adaptation accounting for only 4% of green bond spend in 2021 (US\$B)



As of Feb. 16, 2022.
Sources: Environmental Finance Bond Database; S&P Global Ratings.
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New financial instruments and recent commitments suggest improvement

Despite these challenges, there appears to be growing interest from market participants in financing adaptation and resilience projects. Financial instruments such as privately issued climate resilience bonds, debt-for-climate swaps, public-private partnerships and infrastructure investment trusts are likely to go some way toward plugging the growing adaptation gap. Large institutional investors including JPMorgan Chase, Nuveen and Wellington already have dedicated adaptation investments in their climate or impact funds (which exceed \$1 billion). In 2022, The Lightsmith Group closed a \$186 million private equity fund dedicated solely to adaptation.

Over 90% of the world’s largest companies have at least one asset highly exposed to a climate hazard by the 2050s.

At the 2022 COP27 conference in Sharm el-Sheikh, Egypt, there were also calls for more investments in adaptation and resilience, at a time when the window of opportunity to stop the worst impacts of climate change is rapidly closing. We believe that agreements reached at COP27 — including the Sharm el-Sheikh Adaptation Agenda, which describes 30 adaptation actions needed by 2030 — and ongoing initiatives like the Global Goal on Adaptation (established under the Paris Agreement) and Race to Resilience (agreed at COP26) will serve as catalysts through which investments in adaptation and resilience projects can gain traction through 2030. This trend will accelerate

amid a growing focus on companies and governments that do not take sufficient action to adapt and build resilience to the physical impacts of climate change. Analysis by S&P Global Sustainable¹ shows that 92% of the world’s largest companies have at least one asset highly exposed to a climate hazard by the 2050s.

In tandem, growing familiarity with, and availability of, climate risk data, improvements in understanding the uncertainties associated with such datasets, efforts to standardize terminologies and the use of specialist labels in the market may partially help to turn the tide against the impacts of the most severe warming scenarios.

The pace of change will be driven by rising losses

The physical impacts of climate change will increase over the coming decades — even if the world makes significant progress in cutting global greenhouse gas emissions — due to the lag in the climate system between emissions reductions and global temperature change. The opportunity to build resilience and adapt to the worst impacts of climate change is also fading as emissions increase each year. Companies and countries are waking up to a future of more frequent and extreme physical climate risks and growing commitments (and costs) associated with mitigating emissions. We believe that this dawning reality will render adaptation finance as important as transition finance in protecting wealth and saving human lives in the coming decades. The pace of change over the years ahead will likely be driven by the realization and inevitability of what is happening as well as market-based incentives that are already emerging. ■

Related Research

- [Storm Clouds Or Clear Skies Ahead: How Rising Insurance Premiums From Environmental Physical Risks Could Affect U.S. RMBS And CMBS](#)
- [Weather Warning: Assessing Countries’ Vulnerability To Economic Losses From Physical Climate Risks](#)
- [Global Reinsurers Grapples With Climate Change Risks](#)
- [Keeping The Lights On: U.S. Utilities’ Exposure To Physical Climate Risks](#)
- [Model Behavior: How Enhanced Climate Risk Analytics Can Better Serve Financial Market Participants](#)
- [Damage Limitation: Using Enhanced Physical Climate Risk Analytics In The U.S. CMBS Sector](#)
- [Scenario Analysis Shines A Light On Climate Exposure: Focus On Major Airports](#)
- [Better Data Can Highlight Climate Exposure: Focus On U.S. Public Finance](#)
- [Sink Or Swim: The Importance Of Adaptation Projects Rises With Climate Risks](#)

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Authors

Dr. Paul Munday | S&P Global Ratings, Global Climate Adaptation and Resilience Specialist
Steven Bullock | S&P Global Sustainable¹, Managing Director and Global Head of ESG Innovation and Solutions
James McMahon | S&P Global Sustainable¹, CEO of The Climate Service, an S&P Global company



Sustainable bond issuance will return to growth in 2023

Green, social, sustainability and sustainability-linked issuance is expected to return to growth in 2023, potentially reaching \$1 trillion in total. This follows a 2022 in which contractionary monetary policy and macroeconomic uncertainty pulled down global bond issuance. Green bonds will likely continue to dominate, though sustainability bonds could become more prevalent. Meanwhile, sustainability-linked bonds are at an inflection point.

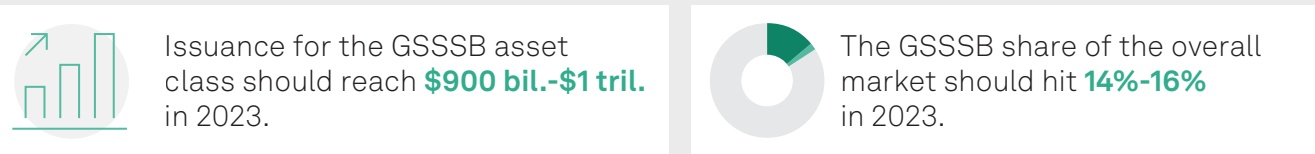
Published on February 7, 2023 by S&P Global Ratings.

This report does not constitute a rating action.

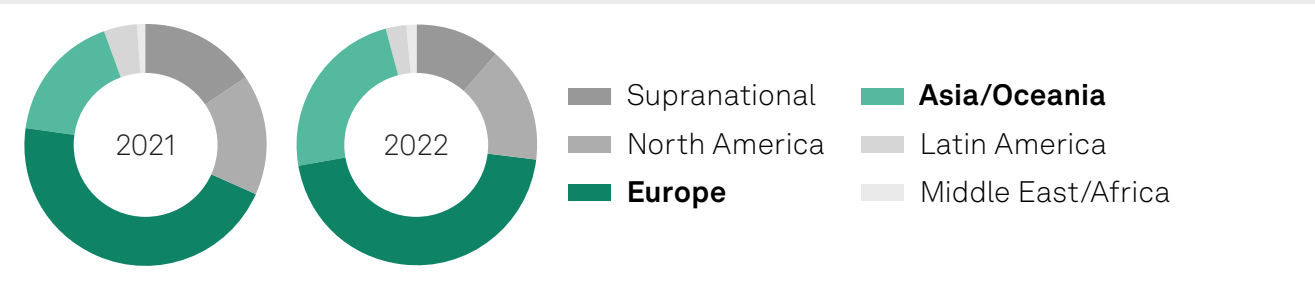
Key takeaways

- Regulation, policy and transparency initiatives may influence investor demand and issuer appetite.
- The need for accelerating climate finance and calls for more investment in climate adaptation and resilience could spur issuance of sustainable bonds.
- Sustainability-linked bonds are at an inflection point as the market grapples with challenging financing conditions and scrutiny on credibility of targets.

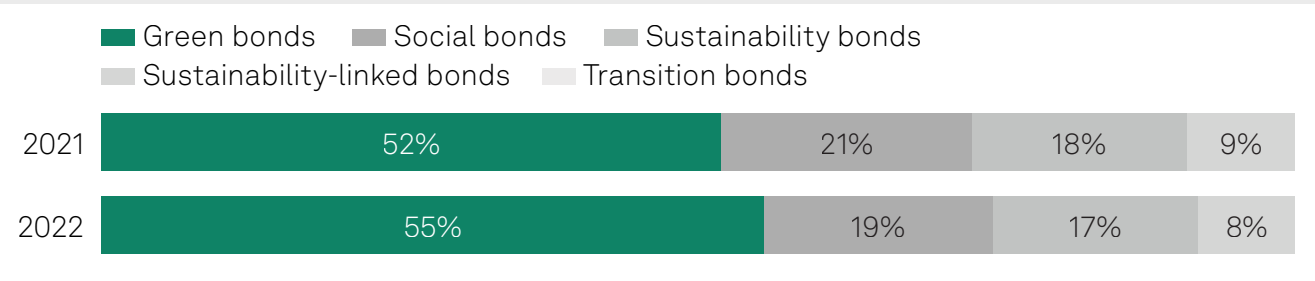
Key figures



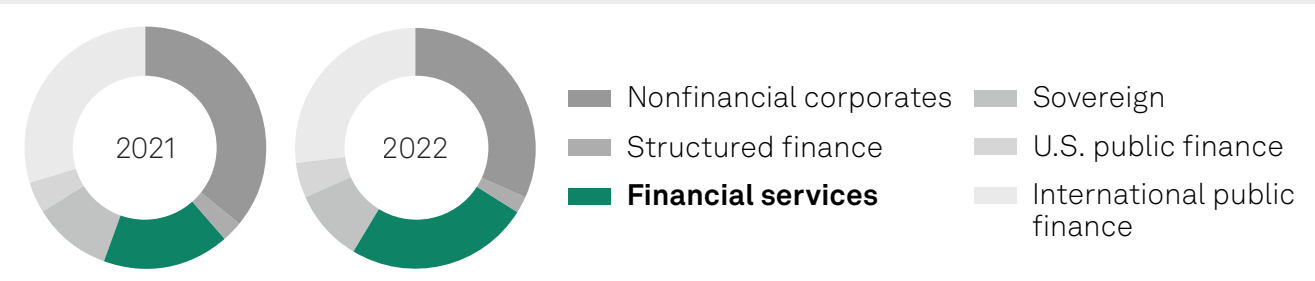
Europe still leads, but Asia-Pacific on the rise.



Green bonds look set to remain the leading category.



Financial services was the only sector to grow in 2022, and looks to continue gaining market share in 2023.



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► **S&P Global Ratings recently published its** global bond forecast for 2023 (see: “[Credit Trends, Global Financing Conditions: Bond Issuance Is Set To Expand Modestly In 2023, With Stronger Upside Potential](#),” published Jan. 30, 2023). In that report, we estimated modest growth of 2.5% in global bond issuance. Below, we provide our outlook for the green, social, sustainable and sustainability-linked bond (GSSSB) market for 2023. In addition, we explore some of the key drivers of overall global issuance, as well as for sectors and regions.

This research draws on Environmental Finance’s Bond Database of global GSSSB issuance for nonfinancial corporates, sovereigns, financial institutions and international public finance issuers; Bloomberg for structured finance issuers; and for U.S. public finance issuers, we leverage our proprietary dataset that we have maintained for 10 years and which we believe best captures the nuances of the U.S. municipal bond markets. Our GSSSB forecasts in this research are informed by S&P Global Ratings’ global bond forecasts,

issuer surveys and market intelligence gathered by our sustainable finance and credit ratings analysts.

GSSSB issuance to grow 5%-17%

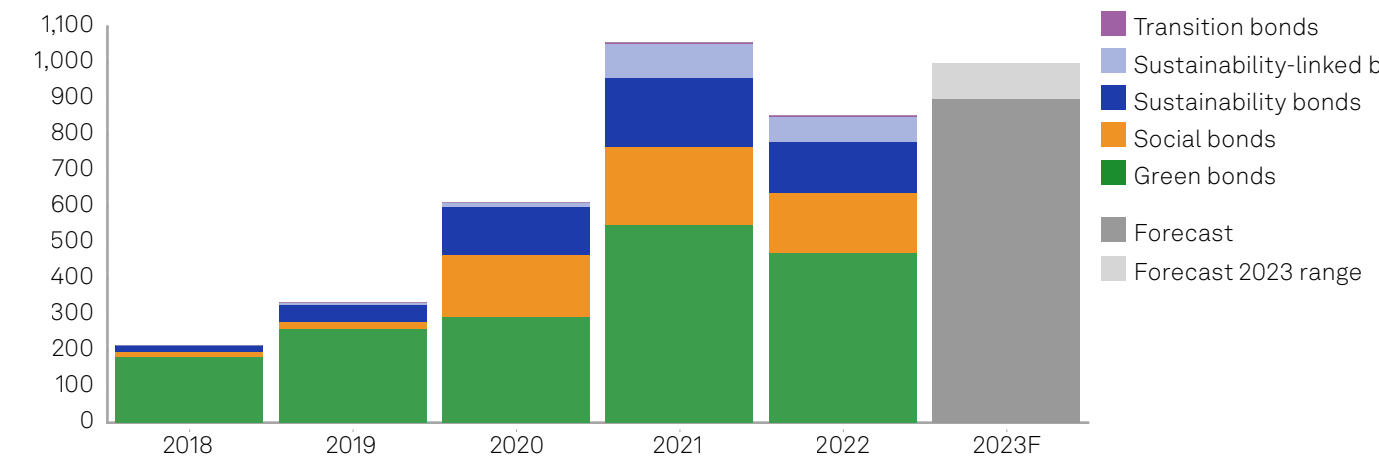
We believe in 2023, global GSSSB issuance will return to growth, reaching \$900 billion-\$1 trillion, nearing the record \$1.06 trillion in 2021. This follows a 2022 in which contractionary monetary policy and macroeconomic uncertainty pulled down global bond issuance.

Three factors could drive growth or drag it down. Broadly, these are policy initiatives, levels of investment in climate adaptation and resilience, and the ability of issuers to address concerns about the credibility of certain types of GSSSB debt.

Green bonds will likely continue to dominate. However, we expect to see sustainability bonds become more prevalent. Meanwhile, sustainability-linked bonds (SLBs) are at an inflection point. Skepticism and questions around the

Chart 1: **Global GSSSB issuance forecast to reach \$900 billion to \$1 trillion in 2023**

Annual GSSSB issuance by instrument type (US\$B)



Excludes structured finance issuance.
F = S&P Global Ratings forecast; GSSSB = green, social, sustainability and sustainability-linked bonds.
Sources: Environmental Finance Bond Database; S&P Global Ratings.
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credibility of the asset class's ability to achieve meaningful sustainability targets are increasing, weighing on the minds of investors and issuers.

In our view, total global bond issuance will grow only moderately in 2023. However, we think faster growth for GSSSB issuance will lead to a larger market share for this asset class across all regions and sectors. We believe GSSSB issuance from nonfinancial corporates, financial services, and the U.S. and international public finance sectors is likely to account for 14%-16% of all bond issuance in 2023. In our view, issuance data are the most comparable in these sectors.

Drivers could boost or pressure issuance

As always, conditions in the global bond market will underlie issuance of GSSSB. With global bond issuance forecast to resume modest growth in 2023, we believe momentum is on GSSSB's side.

We've identified three key themes that we believe could determine whether GSSSB issuance hits \$900 billion-\$1 trillion this year:

- **Policy, regulation and transparency initiatives:** These will influence investor demand and issuer appetite.
- **Calls for investment in climate adaptation and resilience:** These could spur more GSSSB issuance, particularly green and sustainability bonds, to address the growing gap between the cost of adapting to climate change and what has been invested to date.
- **Sustainability-linked bonds' inflection point:** If questions surrounding the credibility of these bonds are not addressed to the satisfaction of investors and other critics, this could hamper issuance in what has been a segment of growth for GSSSB.

Policy, regulation and transparency initiatives should drive GSSSB issuance over time

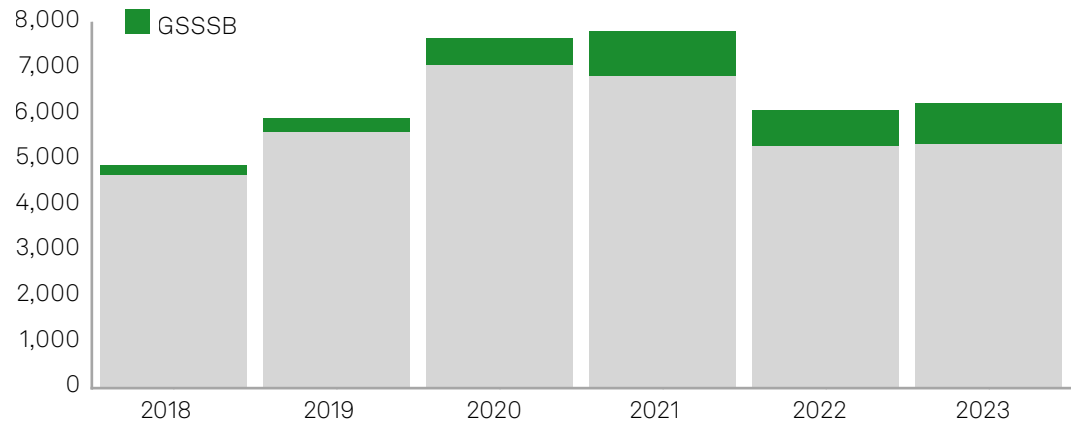
The impact on investor demand and issuer appetite for GSSSB from sustainability-related policies, regulations and transparency initiatives will be mixed in 2023. Development and implementation in these areas is likely to gather pace globally over the next few years.

Take the Inflation Reduction Act, which passed in the U.S. in August 2022. We believe this is already driving issuance. However, EU initiatives such as the EU Taxonomy and the EU Green Bond Standard are unlikely to significantly influence issuance levels this year. This is because we think most issuers are likely to continue to follow the International Capital Market Association (ICMA) principles.

Over the next five years, regulatory initiatives could be a key driver of whether the GSSSB market grows. National directives on electric vehicles or national building standards, for example, could provide direction or signals for further sustainable finance flows. The content of initiatives could inform corporate and government decisions on financing research and development, infrastructure projects, and plants and equipment.

The Inflation Reduction Act, for instance, could further boost GSSSB issuance in the U.S. by incentivizing certain corporate behavior. It can do so through mechanisms, such as tax credits, that encourage investment in green projects, particularly in the energy sector (see "[Inflation Reduction Act Update: Between Cheap, Firm, And Clean Power--Pick Any Two,](#)" published Sept. 8, 2022).

Chart 2: GSSSB looks set to continue increasing its share of global bond market in 2023 (US\$B)



Excludes structured finance and sovereign issuance.
GSSSB = green, social, sustainability and sustainability-linked bonds.
Sources: Environmental Finance Bond Database; S&P Global Ratings.
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Transparency initiatives, such as the EU Taxonomy, will drive issuers to take stock of the impact of their activities on the environment and related risks. Understanding and reporting on issuers' environmental profiles may help reduce the burden of pulling together this information for GSSSB issuances, which in turn could facilitate future issuance.

Reporting requirements for investors, such as the EU's Sustainable Finance Disclosure Regulation (SFDR), are also spurring demand for credible sustainable bonds and investments. The effects of this regulation could be felt beyond the EU. Issuers looking to broaden their investor base may voluntarily adopt these reporting standards and practices. Doing so would make it easier for Europeans to invest in their sustainable bonds.

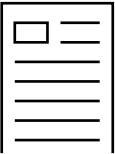
GSSSB may contribute to financing adaptation and resilience

COP27 again emphasized the need for more investment in adaptation and resilience to the physical risks of climate change. The GSSSB market could contribute to answering

that call from the November 2022 event, formally known as the U.N. Climate Change Conference. This could boost issuance in the years ahead, particularly of green and sustainability use-of-proceeds bonds.

The focus on adaptation and resilience is likely to increase, and interest should trickle down from the public sector to the private sector. This interest could be a source of growth for the GSSSB asset class in 2023 and beyond.

However, the adaptation finance market faces several challenges, including long time horizons for realizing benefits. In fact, actual investment in adaptation finance has lagged the needs identified by the U.N. It represents less than 8% of global climate finance, according to the Intergovernmental Panel on Climate Change, and less than 4% of climate-related GSSSB issuance. Further challenges include identifying benefits and cash flows, and the potential for mismatch between those financing projects and those who benefit from them (see "[Crunch Time: Can Adaptation Finance Protect Against The Worst Impacts From Physical Climate Risks?](#)" published Jan. 13, 2023).



Reporting requirements for investors, such as the EU's Sustainable Finance Disclosure Regulation, are also spurring demand for credible sustainable bonds and investments.

We expect the public sector to remain the leader in financing adaptation and resilience. It may begin using GSSSBs more to achieve its aims in this area, in our view. This is in part because the public sector, especially local governments, are on the front lines in terms of the rising costs of climate impacts. In addition, some of the challenges mentioned above often leave the public sector holding the bag.

That said, we see signs that adaptation and resilience are increasingly on the radar of the private sector. Multilateral lending institutions, in our view, will continue to explore and scale up the use of blended finance. Such finance uses funds for public development to mobilize additional commercial capital, primarily from private sources, to help achieve sustainability goals. The institutions may bolster risk-sharing facilities, particularly in low- and middle-income countries that could attract further private capital via GSSSB issuance. Blended finance may make institutions looking to invest private capital more

confident about deploying it in developing countries (see “COP27: Top 5 Takeaways That Matter,” published Nov. 23, 2022).

Some corporate sectors, such as the building sector, could begin to embed adaptation and resilience into their issuance more clearly. Doing so could help support projects that boost the resilience of their assets. For example, there are instances of corporates looking to raise funding to invest in building materials or manage supply chain risk in areas where they have faced significant costs from climate impacts such as flooding and heat stress. In addition, there are examples of private equity firms and large institutional investors entering the fray.

Sustainability-linked bonds reach an inflection point

To get back to growth in 2023 and beyond, issuers of SLBs will have to find ways to address concerns flagged by market participants about the credibility

of SLBs, namely surrounding issuer ambitions and incentives to achieve sustainability targets.

SLBs can offer flexibility that isn’t available in other types of GSSSB. This flexibility has led to the bond type being widely used by issuers who may have business models that are not suited to use-of-proceeds bonds. Companies in the consumer discretionary and healthcare sectors, and in hard-to-abate sectors such as industrials or materials, are among those that would find issuing green or social investments difficult. SLBs allow access to sustainable financing for those in this situation still wishing to participate in GSSSB markets. During the last two years, the market for such bonds has grown dramatically: Issuance volume has grown seven-fold since 2020, reaching a total of \$70 billion. SLBs accounted for 9% of GSSSB global issuance during their 2021 peak.

Returning to growth is now the challenge for issuers. In 2022, SLB issuance levels dropped significantly, by 25%, compared with 2021. This was in large part due to difficult market conditions for nonfinancial corporates. They have represented about 90% of SLB issuers in recent years. However, increasing scrutiny from stakeholders such as investors and policymakers on the credibility of the asset class – that is, whether SLBs help companies achieve meaningful sustainability targets also contributed to the decline.

We continue to believe that given the greater flexibility in proceed use, SLBs have the potential to broaden the base of issuers of sustainable debt. Recent geopolitical events, including the Russia-Ukraine war, are a reminder that countries face challenges in balancing energy security and the energy transition to meet national decarbonization goals. This paves the way for some traditional energy

GSSSB Defined

Green, social, sustainability and sustainability-linked bonds fall into two main categories:

Sustainability-linked bonds: Any type of instrument for which the financial or structural characteristics can vary depending on whether the issuer achieves predefined sustainability objectives.

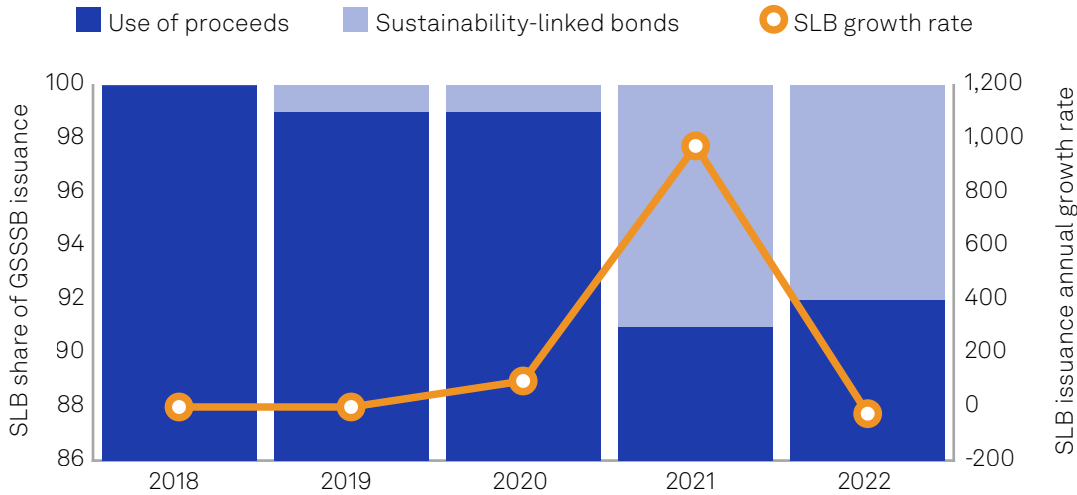
Use-of-proceeds bonds: Any type of instrument where the net proceeds (or an equivalent amount to the net proceeds) are exclusively used to finance or refinance, in part or in full, new and/or existing eligible green and/or social projects. The three main subcategories of use of proceeds instruments are:

- **Green bonds:** Instruments that raise funds for projects with environmental benefits including renewable energy, green buildings and sustainable agriculture.
- **Social bonds:** Instruments that raise funds for projects that address or mitigate a specific social issue and/or seek to achieve positive social outcomes, such as improving food security and access to education, healthcare and financing, especially but not exclusively for target populations.
- **Sustainability bonds:** Instruments that raise funds for projects with both environmental and social benefits.

companies to participate in the transition to net-zero. These companies should be well-positioned to maintain consistency of supply and demonstrate their efforts to reduce carbon emissions. The sustainability-linked bond market is an important avenue for financing emissions reduction. But first, credibility issues need to be addressed.

Chart 3: Sustainability-linked bonds share of GSSSB declines for first time in 2022

Percentage breakdown of use of proceeds and SLB issuance

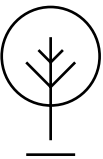


Excludes structured finance issuance.
GSSSB = Green, social, sustainability and sustainability-linked bonds.
Sources: Environmental Finance Bond Database; S&P Global Ratings.
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Table 1: GSSSB issuance by type of bond

(US\$B)	Green bond	Social bond	Sustainability bond	Sustainability-linked bond	Transition bond	Total
2018	182.51	14.29	17.80	0.00	0.00	214.60
2019	261.53	18.01	48.06	4.46	1.05	333.11
2020	294.96	169.90	135.62	8.79	2.43	611.71
2021	548.71	217.56	191.70	94.38	4.26	1,056.61
2022	473.06	164.95	141.55	70.45	3.50	853.51

Note: Excludes structured finance data. Sources: Environmental Finance Bond Database; S&P Global Ratings. Copyright © 2023 by Standard and Poor’s Financial Services LLC. All rights reserved.



Green bond issuance decreased less than any other bond type in 2022, demonstrating resilience to challenging market conditions.

Market composition: Green bonds will continue to set the pace

In 2023, we anticipate that green bonds will continue to drive the GSSSB market. Issuers across sectors are likely to look to finance projects that allow them to align themselves with nationally determined contributions and individual net-zero commitments.

As for social bonds, it is our view that issuance growth here will be the slowest among the GSSSB types in 2023. Tremendous growth in 2020 and 2021 was driven by local and national governments, as well as supranational entities. All looked to the capital markets to finance pandemic relief programs. However, issuance contracted by 24% in 2022, largely because the need for pandemic relief financing tailed off.

In 2023, we see two trends that could drive growth in social and sustainability bond issuance. The first is affordable housing. We observe more interest from public finance entities seeking social bonds to fund affordable housing projects as interest rates rise and housing stocks struggle to keep pace with demand. Similarly, access to affordable finance has become increasingly difficult for many in the current economic environment.

Financial institutions, including banks and nonbank lenders, are therefore exploring ways to secure financing that can support lending to underserved segments of the population through social bonds.

As issuers explore using GSSSB to finance these social projects, they may increasingly look to combine them with green financing. We consider this synergy to be a second possible growth driver because it could lead to increased issuance of sustainability bonds in 2023. For instance, issuers in the public housing sector may look to develop green social housing options. Banks, in addition, could look to combine access to affordable finance with existing green lending initiatives. Further, public finance and supranational entities may look to the sustainability bond market to finance more environmentally friendly social infrastructure such as schools, municipal buildings, hospitals, roads and energy.

The composition of the GSSSB market didn’t change much in 2022. Green bonds continued to account for over half of issuance (55%), while social (19%), sustainability (17%) and SLBs (8%) each made up a marginally smaller proportion of the market compared to the year before. Green bond issuance decreased less than any other bond type in 2022, demonstrating resilience to challenging

market conditions. Social bond issuance in 2022 was largely dominated by international public finance entities. These bonds were the only type for which issuance declined below 2020 levels in 2022.

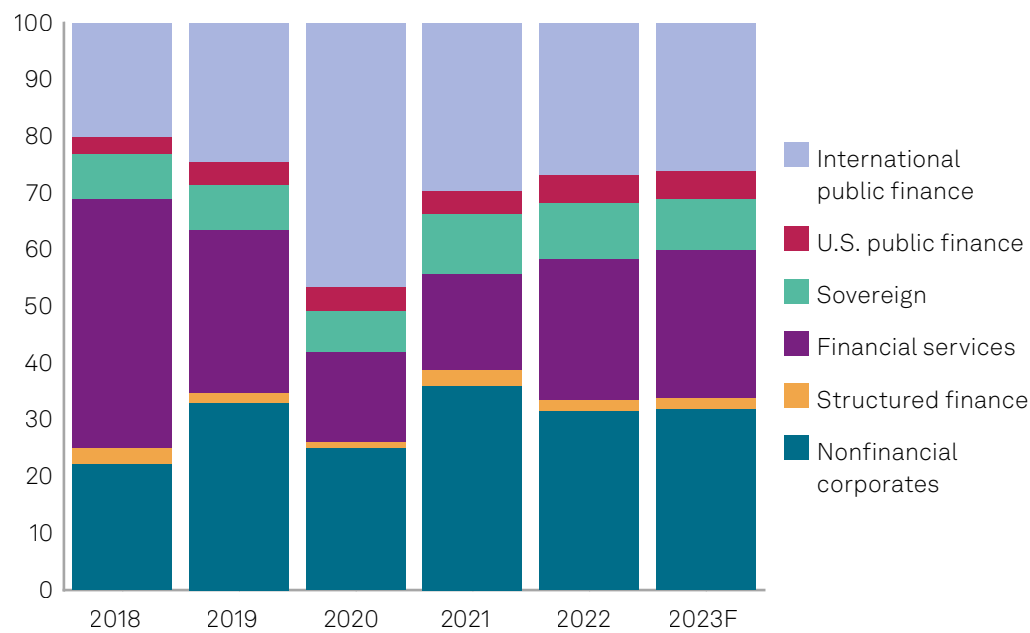
Key drivers by sector

In 2023, we anticipate a return to growth in all sectors. We forecast each sector will grow at least in line with, and in many cases exceed, the expected respective growth in overall bond issuance. Financial services look poised to grow the most in 2023, increasing its share again this year. Nonfinancial corporate issuers, meanwhile, should continue to be the leading contributor to GSSSB issuance. In 2022, most sectors contracted. Nonfinancial corporate issuance led the decline, down 28% year over year. However, issuance in the financial services sector increased by 14%.

Nonfinancial corporates

We anticipate a return to growth for the nonfinancial corporate sector in 2023 partly because of the growing maturity of issuers’ sustainability funding strategies. However, there are likely to be continued challenging market conditions generally. For example, GSSSB issuance levels may remain tempered by the tradeoff between the speed to market offered by standard bonds and the additional resources and time required to bring a sustainable bond to market. Nonfinancial corporate issuers saw the largest contraction in GSSSB issuance in 2022, down 28% compared to 2021. Another constraining factor in 2022 was limited expansion toward smaller issuers. Such issuers may face challenges to provide historical sustainability indicators and confidently track them going forward.

Chart 4: Financial services gain ground in 2023 (%)



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In 2023, the nonfinancial corporate category should see more diversification in terms of sector, geography and size of issuers. We also believe the energy sector could play an important role in the growth of this issuer type in 2023. This trend is supported by the unprecedented energy transition financing needs fostered by government plans. These include the Inflation Reduction Act in the U.S. and Europe’s REPowerEU, the bloc’s plan to boost energy independence and accelerate the green transition.

U.S. public finance

For 2023, we anticipate the themes underscoring growth in the GSSSB market will continue for U.S. public finance. This should lead to a fifth consecutive year of increase in the share of GSSSB issuance as a proportion of overall U.S. public finance issuance. It will likely reach a range of 13%-15%. For U.S. public finance, GSSSB issuance fared relatively well in 2022, declining by 10% compared with a 20% contraction for municipal bonds overall. The share of GSSSB of total USPF bonds rose to 11%.

For 2023 we anticipate that GSSSB issuance in the international public finance sector will increase slightly compared with 2022.

Two factors should combine to drive further GSSSB growth in 2023. First, public finance issuers serve the public, naturally aligning their activities with environmental and social purposes. Second, a number of large issuers are coming to market with GSSSB and building momentum for the asset class.

Challenges, however, are likely to endure. The U.S. municipal market’s smaller and more fragmented nature makes it difficult to measure any pricing advantage for

GSSSB issuance. At the same time, we expect that GSSSB issuance may be tempered by some issuers’ and investors’ preference not to offer or invest in bonds falling under the label of GSSSB. This could hinder growth. Finally, while progress toward disclosure of best practices or post-issuance regulatory guidance may help bring clarity to the market and solidify demand from certain investors, there are drawbacks. Stricter rules in these areas could sideline some potential GSSSB issuers if they would be burdened with additional financing costs or disclosure expectations.

International public finance

For 2023 we anticipate that GSSSB issuance in the international public finance sector will increase slightly compared with 2022. However, it isn’t likely to reach the highs of 2021. Supranational agencies and multilateral lending institutions (MLIs) make up the bulk of GSSSB issuance in the international public finance sector, along with government-related entities. After record issuance in 2020 and 2021, led by social and sustainability bonds, issuance contracted by 26% in 2022. Health problems and economic fallout associated with COVID-19 drove issuance in 2020 and 2021. The need for financing pandemic relief receded in 2022.

We expect national government related entities such as the French social security fund Caisse d’Amortissement de la Dette Social (CADES) to modestly increase labeled issuance. They will do so, in our view, to try to advance national and EU policy objectives, particularly around decarbonization. Meanwhile, the share of green bonds should increase given MLIs’ commitments to address climate change, as suggested by their increasing lending targets for green and climate finance.

Furthermore, many MLIs continue to deepen their commitments to the U.N.’s 2030 Agenda for Sustainable Development and integrate these targets into their institutional and lending directives. This should support social and sustainable bond issuance. Calls for the sector to shoulder more of the burden of investment in climate adaptation and resilience could lead to growth in GSSSB issuance from this segment over the next two to three years.

Structured finance

We do not expect structured finance issuance to materially increase in 2023. However, issuance in the GSSSB segment should be relatively stronger than the 7% decline we forecast for total structured finance issuance in 2023. GSSSB issued by structured finance issuers contracted 39% in 2022 from a year earlier.

We believe developments around the ICMA green and social bond principles (GBP and SBP) in June 2022 will help support the sustainable securitization market. Use-of-proceeds securitizations in which not all collateral is sustainable may be aligned with ICMA’s set of sustainable finance principles if the proceeds are deployed on eligible projects in line with ICMA’s GBP or SBP. Meanwhile, questions remain over how the EU Green Bond Standard (GBS) will be applied to securitizations and whether further flexibility may be needed. Until there is more clarity, issuers may grapple with the benefits of issuing labeled bonds under ICMA’s GBP if there are concerns about future alignment with the EU GBS.

We think the electrification of light vehicle fleets will likely fuel growth for green collateral that can be securitized. Solar equipment and energy efficient commercial and residential properties should also see from growth in collateral that can be

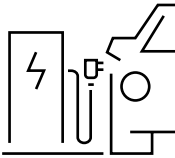
securitized. However, while progress has been made, challenges that are slowing issuance of sustainable securitizations continue. These challenges include a lack of sustainable collateral originations and the absence of standardized ESG data, disclosures and definitions.

Sovereigns

A continued policy focus on climate resilience in 2023 will likely support modest growth in sovereign GSSSB issuance compared with 2022, particularly for EU states. This is largely in line with our preliminary expectation for gross sovereign long-term commercial borrowing this year. Sovereigns issued 28% less GSSSB in 2022 compared with 2021. This was largely in line with an overall reduction of 18% in sovereign borrowing. The EU accounted for nearly 50% of sovereign GSSSB issuance in 2022. Outside the EU, the U.K. (10%), Chile (9%) and Canada (5%) were the largest sovereign issuers of debt labeled either green or social last year.

Continued use of sustainability-linked instruments for sovereigns in 2023 looks likely. This is despite lingering questions about the effectiveness of SLBs in advancing meaningful progress toward global targets in particular, we expect to see more issuance from emerging market sovereigns, following Uruguay’s successful \$1.5 billion SLB issuance in October 2022.

It remains to be seen whether SLB issuance among sovereigns will take off more broadly this year. This is because of the credibility challenges the asset class faces. Thus far, SLBs have found favor primarily in emerging markets. In these markets, investor interest in the instruments’ sustainability features can expand sovereigns’ access to capital markets beyond what would be the case if they issued conventional bonds.



We think the electrification of light vehicle fleets will likely fuel growth for green collateral that can be securitized.

SLBs’ simplicity and flexibility versus green- and social-labeled issuance may also appeal to emerging market sovereigns. Compared with SLBs, green and social bonds come with heavier reporting burdens, particularly those using the EU taxonomy. At the same time, many developed market countries prefer green- or social-labeled debt due to its high liquidity and appeal to a large segment of investors.

Financial services

We anticipate that the financial services sector will continue to expand GSSSB issuance in 2023. Banks, insurers and other financial institutions are still increasing transparency around their sustainability strategies. Many are working toward implementing net-zero ambitions and Paris-aligned targets. In 2022, financial services issuers are the only issuer type to have increased bond issuance volumes year on year in 2022. Their total issuance value reached nearly \$215 billion in 2022, a 14% increase.

We believe that use-of-proceeds bonds will continue to be the most prevalent form of GSSSB from financial services issuers. This is because increasingly demanding regulatory environments should allow banks to quickly identify sustainable assets in their portfolios that can be financed using such bonds. We expect green bonds to continue to be the leading category of GSSSB issued by financial services issuers. However, sustainability bonds will grow in stature in 2023, in our view. Issuers are likely to look to complement their green lending with projects focused on social objectives.

Key drivers by region

We expect Europe, the Middle East and Africa (EMEA) to retain the leading share of issuance across regions. However, Asia-Pacific and Latin America look likely to continue increasing their share of global issuance as they have done in recent years.

Asia-Pacific

We anticipate that GSSSB in Asia-Pacific (APAC) will grow 20% in 2023, outpacing other regions. In 2022, the market for GSSSB in APAC maintained momentum. Issuance was up by 10%. In addition, its share of the global GSSSB market increased to 23%, up from 17% in 2021. The region proved more resilient to global macroeconomic uncertainties than others: Global GSSSB issuance contracted 19% in 2022.

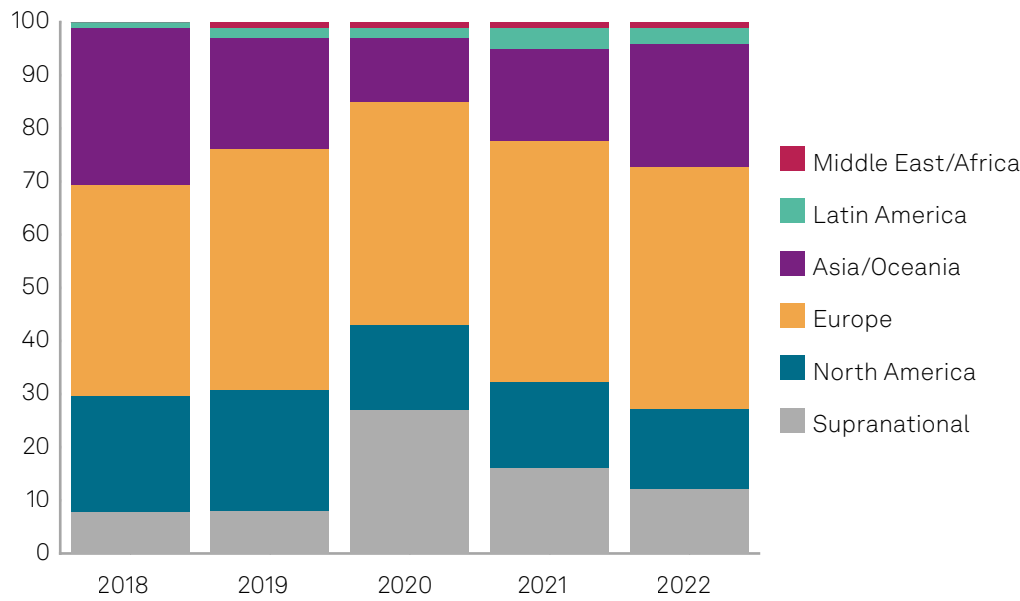
In terms of GSSSB growth in 2023, APAC starts from a lower existing base. However, there is also growing awareness of calls for sustainable economic development across the region, especially regarding decarbonization. China, South Korea and Japan will drive the region’s issuance, in our view. Some other countries are starting to catch up. The continued development of local regulations will also instill discipline and credibility into the GSSSB market. This could potentially lead to additional issuance in some places.

Europe, the Middle East and Africa

We expect Europe to retain its leading share of issuance in 2023. In addition, there is likely to be a strong pipeline of issuance coming from the Middle East this year. GSSSB issuance from EMEA continued to lead the way among global regions in 2022. However, some ground was lost as issuance in the Middle East and Africa slowed significantly.

Green bonds in the use-of-proceeds category will continue to lead issuance in EMEA in 2023, in our view. This should be driven by the focus on credible net-zero plans by issuers, the European Central Bank’s intent to green its bond-buying program, and the implementation of the EU Taxonomy and EU green bond standards. In addition, we see signals that issuers are increasingly looking to finance projects

Chart 5: Asia-Pacific issuance grows while supranationals' steadily declines (%)



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related to biodiversity enhancement and preservation. The supply of social bonds declined in 2022, as needs related to funding pandemic relief subsided relative to 2021.

Sustainability bonds in the use-of-proceeds category may see an uptick in 2023. This is particularly the case among financial services issuers looking to complement existing green frameworks with social projects. Despite the challenges faced by the SLB asset class, we envision a strong pipeline of sustainability-linked frameworks coming to market in Europe during the first half of 2023.

Latin America

We anticipate that 2023 will see a return to growth for GSSSB in Latin America. At least one-third of all bonds issued in the region are likely to be labeled as GSSSB. Latin American GSSSB issuance contracted 48% in 2022 compared with the previous year. While this contraction was more pronounced than in other regions, the asset

class held up well relative to the 60% contraction experienced in total bond issuance in the region. In our view, sovereigns will continue leading issuances in 2023, particularly in green bonds. They will do so as they work toward achieving the National Determined Contributions (NDCs) set out in the Paris Agreement.

Financial institutions, meanwhile, should gradually increase participation in the GSSSB market. A number of large banks in the region are likely to set interim greenhouse gas emissions reduction targets and decarbonization agendas for their lending and investment portfolios before the end of 2023.

North America

For 2023, we expect a return to GSSSB issuance growth in North America, as economies in the region begin to recover in the second half of 2023. Nonfinancial corporate issuance in particular may rebound, and issuance volumes will likely

increase to new highs as entities look to take advantage of tax credits offered by the Inflation Reduction Act. Issuance of GSSSB in North America contracted 22% in 2022. This was because of rising interest rates and investor skepticism toward the effectiveness of SLBs. Issuers also don’t want to go to market with issuances that may be accused of greenwashing. Many entities in hard-to-abate sectors have preferred to wait to gauge investor demand before issuing. The region lost ground in terms of its contribution to global GSSSB issuance, being surpassed by APAC.

U.S. municipal issuers have demonstrated resilience in the face of wider bond market headwinds, and we expect this trend to continue in 2023. There is sizeable demand for GSSSB bonds in municipal markets. Canada issued its inaugural sovereign green bond in early 2022. Meanwhile, some high-emitting corporates in the country are in the process of developing transition bond frameworks. This could increase nonfinancial corporate GSSSB issuance in the region.

Skepticism around the effectiveness of SLBs, particularly in North America, has caused some issuers and investors to take

an apprehensive approach to GSSSB issuance in general, and the U.S. Federal Reserve looks likely to continue raising rates, as it did with a 0.25% hike on Feb. 1,, until the second quarter of 2023 (see [“Economic Outlook U.S. Q1 2023: Tipping Toward Recession,”](#) published Nov. 28, 2022). Both of these factors could pull down issuance volumes in the region in the first half of the year.

Beyond 2023

Global GSSSB issuance is likely to resume growth in 2023, and we think this expansion can continue for years to come. We anticipate 2023’s growth will outpace that of the overall global bond market. Our observation, based on the data we have collected and analyzed, is that the GSSSB asset class remains an important tool to help drive investment in meeting climate and sustainability goals, and we think issuers and investors are keen to utilize the tools. However, we also believe that GSSSB is at an important juncture. Questions are increasing about its credibility in truly helping issuers to achieve meaningful sustainability outcomes. Future growth will likely depend on how sufficiently the asset class addresses these concerns. ■

Authors

Dennis Sugrue | S&P Global Ratings, Ratings Analytical Senior Director
Bryan Popoola | S&P Global Ratings, Sustainable Finance Associate

Research Contributors

Florence Devevey | S&P Global Ratings, Sustainable Finance Analytical Manager
Lai Ly | S&P Global Ratings, Global Head of ESG Research
Nora Wittstruck | S&P Global Ratings, Senior Director
Emmanuel Volland | S&P Global Ratings, Credit Analysis Analytical Leader

Editor

Richard Smart | S&P Global Ratings, Senior Editor

Digital Designer

Halie Mustow | S&P Global Ratings, Senior Digital Content Producer



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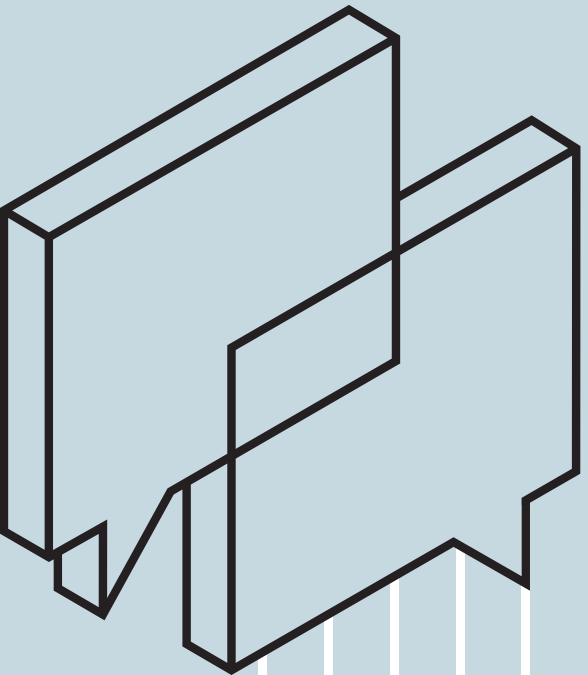
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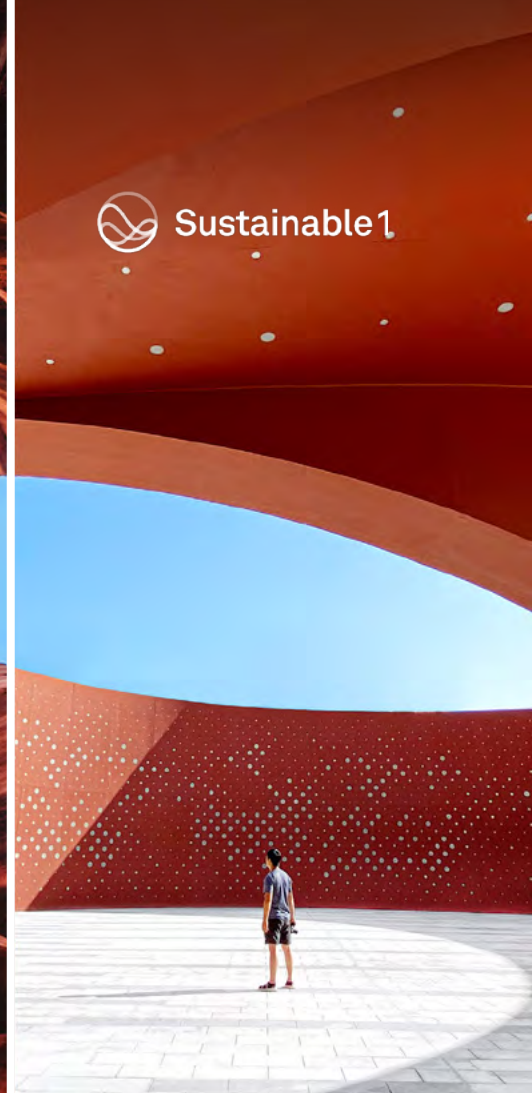
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