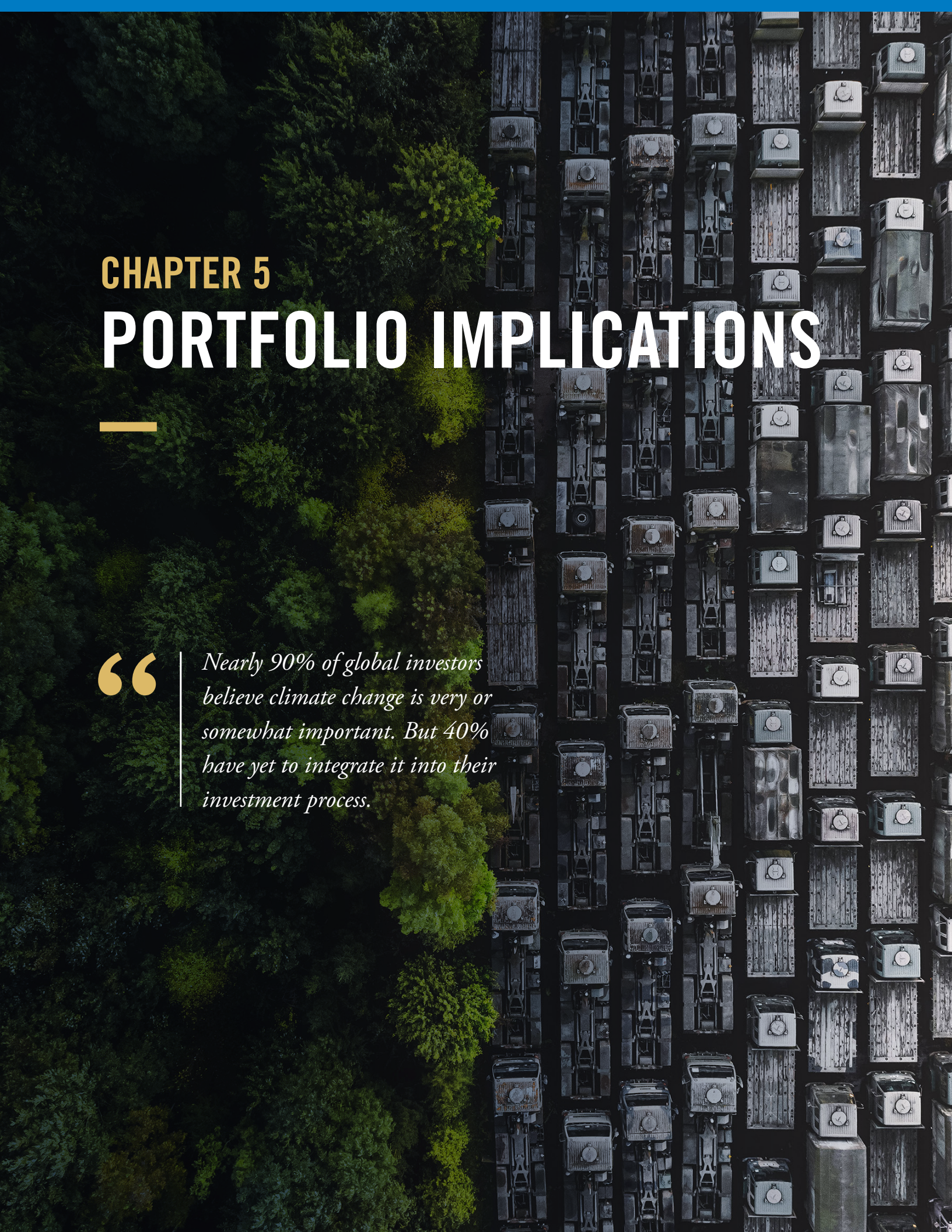
PGIM
India Mutual Fund

MEGATRENDS

WEATHERING CLIMATE CHANGE

Opportunities and risks in an altered investment landscape



CHAPTER 5

PORTFOLIO IMPLICATIONS

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PORTFOLIO IMPLICATIONS

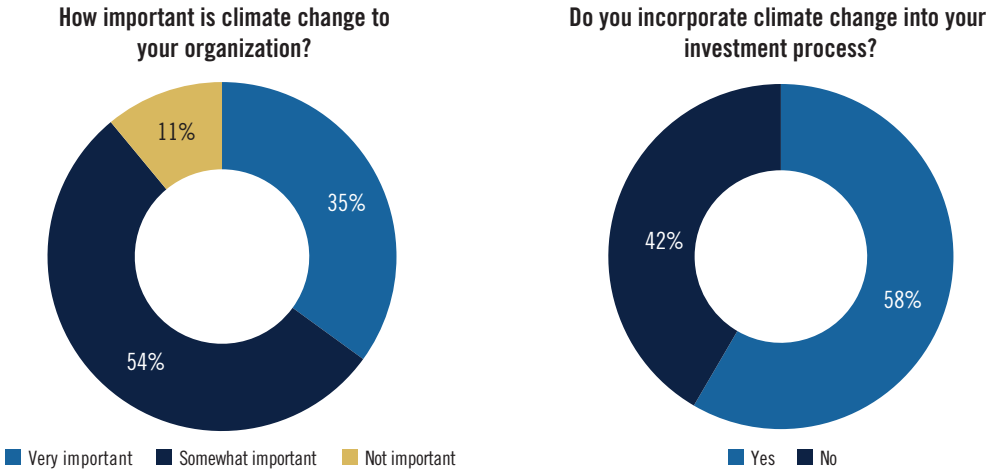
Investors can no longer ignore climate change in their portfolio. Yet, many investors don't have a comprehensive plan for addressing it. According to PGIM's proprietary survey of over 100 institutional investors, nearly 90% of global investors believe climate change is very or somewhat important. However, 40% have done little to integrate it into their investment process (Exhibit 19).

Overall, climate change presents a set of multi-dimensional risks that are difficult to capture and empirically analyze using historical data and linear models. The potential impact of rising sea levels and flooding on coastal cities like Mumbai and Miami is apparent. What is less evident are the hidden risks embedded in individual companies and portfolios. In fact, these hidden risks are material for a range of industries not commonly thought of as highly exposed to climate risk. Likewise, the best opportunities for investors may not be conveniently branded as "green." In other words, a simplistic strategy that divides the investment world into "brown" villains and "green" heroes is not the most effective approach to achieve environmental or fiduciary objectives. Below we present an action plan for institutional investors considering the holistic impact of climate change across their portfolios.

1. Use alternative data sources and techniques to better understand cross-portfolio climate risk

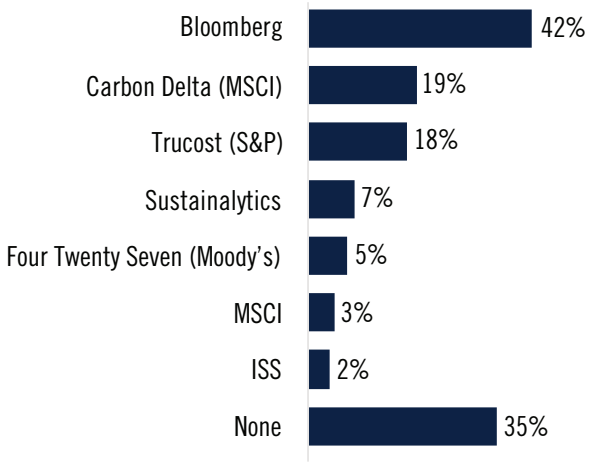
Measuring portfolio-level climate risk can be daunting given the complexity of the risks and the inconsistency in data quality and granularity. Risk managers accustomed to standard, uniform measures of risk they can apply across asset classes are bereft with regard to climate risk. High-quality data and metrics are simply not available across all asset classes.

Exhibit 19: **PGIM Survey of Global CIOs**



Source: PGIM 2020 Climate Change Investor Survey

Exhibit 20: **Investors Use a Range of Vendors for Climate-Related Data and Analytics**



Source: PGIM 2020 Climate Change Investor Survey

To evaluate the full extent of their portfolio's exposure to both transition and physical risk, CIOs will need to go beyond conventional data resources and methodologies and adopt an unorthodox approach. According to PGIM's survey of global CIOs who already incorporate climate change, fewer than one in five utilize alternative data such as satellite imagery, flooding maps, drought data and air quality data.

Transition risk

For publicly listed companies, detailed data availability around transition risks – such as carbon emissions and carbon footprint – has increased significantly in the last few years. Sustained stakeholder pressure has led to many public companies reporting at least basic carbon emission data, albeit inconsistently. In parallel, a wide array of climate data analytics companies has emerged that use data to devise rating systems and metrics for virtually all publicly traded companies (Exhibit 20).

When considering climate risk at the individual security level, it is important for investors to remember that the absolute rating for a firm matters less than its relative rating against its peers. That is, the individual rating for Volkswagen in a particular rating methodology is less important than how it compares to Toyota and Ford. For this reason, investors may be better served to choose a single provider with a consistent methodology who can cover ratings across the widest swath of geographies, sectors and firms rather than selecting the best player in each sector or region.

By aggregating the corporate-level data, climate analytics firms can provide some basic portfolio-level metrics enabling CIOs to get a clear picture of the embedded carbon exposure across their public debt and equity portfolios. This also enables CIOs to get a feel for the embedded transition risk, or which portions of their portfolio are at greatest risk from environmental policy changes such as carbon pricing schemes. Once they have a sense of their carbon exposure, CIOs can consider hedging strategies using environmental commodities like carbon offsets.

> *Climate analytics firms can provide some portfolio-level metrics so CIOs can get a feel for their embedded carbon exposure.*

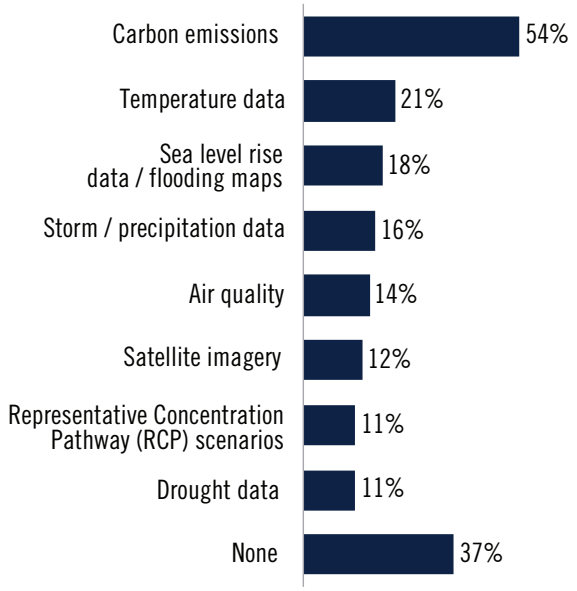
For private markets, visibility into company-level climate risk is limited. Privately held companies face few of the public pressures listed firms face to measure and publish their carbon footprint and other relevant metrics. With little to no data available it is much more challenging to assess transition risk for private equity (PE) investments, for instance, and CIOs will need to invest the time to get comfortable with the methodologies deployed by climate data providers and be aware of the significant data limitations.

Physical risk

When it comes to physical risk, the geolocation of critical real assets can be overlaid with predictive scenarios for drought, extreme heat and flooding. While sophisticated infrastructure and real estate investors have been doing this for some time, new capabilities in geolocation technology and climate analytics enable even equity and debt investors to assess their portfolio's exposure to physical risk (Exhibit 21). The very same geolocation and forecast overlay techniques can be applied to assess physical risk around the critical real assets of companies – including production facilities, data centers, assembly plants, distribution centers and even key suppliers.

Once again, CIOs will need to be thoughtful about the methodologies employed by their analytics

Exhibit 21: **Few Investors Go Beyond Carbon Emissions When Incorporating Alternative Data**



Source: PGIM 2020 Climate Change Investor Survey

providers, seeking providers that deploy transparent, peer-reviewed models rather than proprietary "black-box" models. The field of climate research is evolving rapidly, with new research being published almost daily. CIOs will also want to ensure their analytics providers continuously update their models using new, cutting-edge research. Analytics firms that monitor and incorporate the most current thinking will be able to develop the most useful models for investors.

CIOs and risk managers can't rely on off-the-shelf risk data metrics when assessing the climate risk of a multi-asset portfolio. This demands a more dynamic approach that involves different techniques and metrics for each asset class.

2. Integrate climate change into portfolio risk management analytics

There are three distinct choices that CIOs will want to consider when incorporating climate change into portfolio risk management.

First, the most basic – and perhaps the most useful – climate risk analysis recognizes the next decade of climate change is largely predetermined. This approach does not require complex climate scenario modeling stretching into the distant future. Rather, it simply looks at every holding in the portfolio in terms of its exposure to near-term, fairly predictable climate-driven risks to assess the degree and nature of climate exposure. In the case of real assets, for example, this would require overlaying the location of real estate, infrastructure and agricultural holdings on top of maps that specify areas with elevated risk of flooding, severe storms, water stress and extreme heat. This fundamental geographic analysis can be extended to public equity and debt securities where data on location of key production facilities is available. This analysis should, in particular, highlight assets with lengthy lock-up periods or long maturities.

> *The geolocation of critical real assets can be overlaid with predictive scenarios for drought, extreme heat and flooding.*

In a similar fashion, a heat map can be constructed for debt and equity exposures to sectors with high climate risk – as well as sectors with upside associated with the transition to renewables. The resulting climate risk and opportunity heat map can provide CIOs with a multi-asset view on the portfolio's vulnerability to climate risk as well as exposure to opportunities resulting from a transition to greener energy sources and technologies. From a practical standpoint, the output from a rigorous climate risk analysis can inform decisions on reducing (or increasing) exposures to regions, sectors or companies.

Second, institutional investors may want to conduct targeted climate stress tests. These tests could be at the issuer or asset class level for a specific parameter – like a potential policy response (e.g., higher carbon prices)

or a specific future physical risk (e.g., water stress) in a specified region. By keeping the scope of climate stress tests focused on a specific policy or risk, investors can often generate actionable results that can concretely inform investment decisions. A note of caution here: to the extent this analysis relies on incomplete or unstandardized data, or the requisite data has long lags (like carbon emissions data) the results need to be interpreted with an appropriate margin of error. Nevertheless, as data quality and transparency improve, there is clearly an opportunity for investors to explore targeted climate stress testing. Of the investors who currently do incorporate climate change into their investment and asset allocation processes, fewer than 10% utilize predictive climate modeling.

> *It is becoming more apparent that physical risks from climate change extend well beyond infrastructure, buildings and other real assets.*

Third, investors can conduct top-down, comprehensive climate scenario stress tests across their entire portfolio. These sweeping climate scenario models are quite elaborate and incorporate policy actions as well as societal responses to them. This complexity leads to a very wide range of results from the stress tests. While the results from these broad climate scenario tests may help provoke internal discussions on the impact of climate change, in most cases they are not granular enough to be easily actionable or guide specific investment decisions.

Despite the current complexity and challenges in translating broad multi-decade climate scenarios into investment decisions, it remains a worthwhile aspiration for the industry, which will only improve as data quality gets better and methodologies and approaches become more standardized. As that happens, climate scenario analysis will increasingly become an important tool for financial regulators aiming to analyze the systemic effects that arise from climate change or CIOs looking to better understand the multidimensional climate risks woven into their portfolios.

As broad climate scenario stress testing becomes more useful for investors in the future, there are several important considerations. For starters, scenario analysis is not a standalone process. It needs to be integrated into investors' governance, risk management and investment processes. This kind of analysis touches upon a broad swath of functions and disciplines within an investor's organization, including the board, investment strategy, reporting and risk management. CIOs need to have a clear plan for coordinating this cross-functional engagement.

In addition, investors need to select a practical set of scenarios from a dizzying array of choices. For investors, optimal scenarios should include both transition and physical risks and focus on pathways as well as outcomes. In this way, investors can consider orderly and disorderly pathways under a diverse set of technology and policy assumptions.

Finally, climate scenarios should stretch beyond the typical investment and analysis horizon, focus on externalities not yet incorporated into the portfolio's value and will likely need to be supported by a comprehensive and transparent climate data strategy and models.

3. Look beyond obvious physical risks to uncover embedded climate risks across the portfolios

It is becoming more apparent that physical risks from climate change extend well beyond infrastructure, buildings and other real assets. These underappreciated, "hidden" risks are in industries not typically associated with climate change exposure (Box 2). Investors don't often think of Swiss pharmaceutical companies and Japanese chip manufacturers as being highly exposed to physical risk from climate change like extreme heat, flooding and drought. Indeed, these exposures are not readily apparent. They lurk far from corporate offices and are embedded within complex global supply chains.

As the coronavirus pandemic has laid bare, supply chains represent key vulnerabilities for manufacturers. Climate change has the potential to unleash the same kind of disruptive impact that reverberates through

Box 2: **Climate Analytics Reveal Material Risks to Unsuspecting Companies and Investors**

Semiconductors

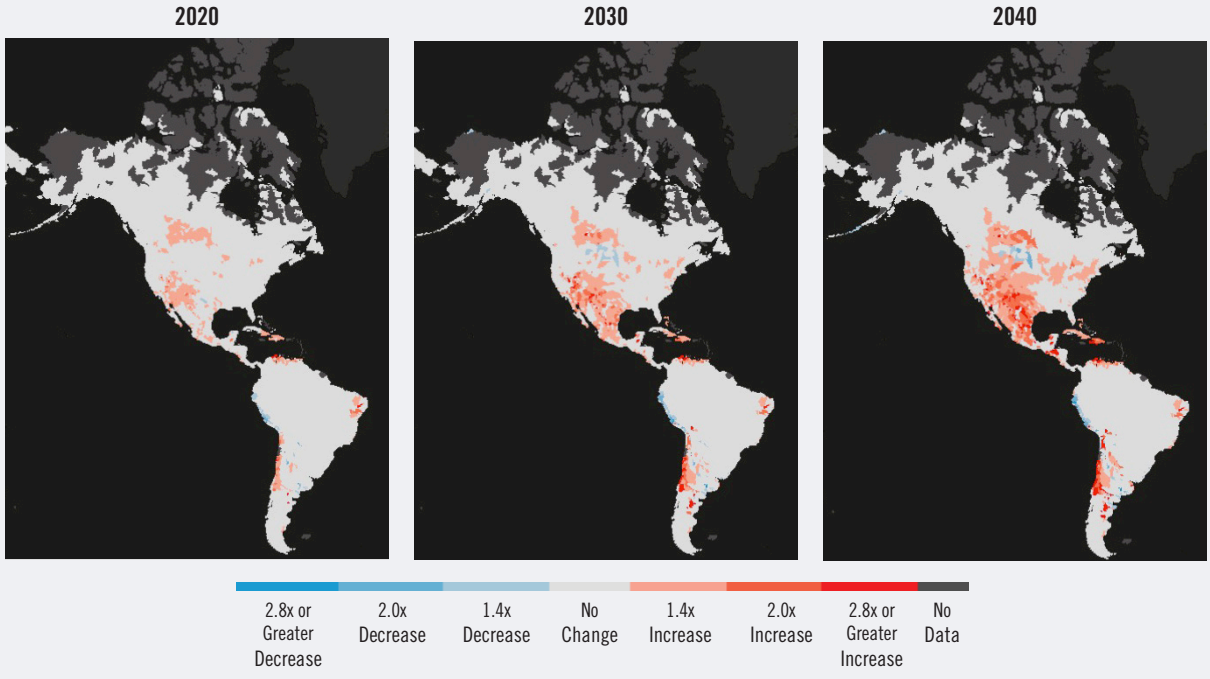
Semiconductors are an essential component of the 21st century economy. The supply chain for the industry is quite geographically dispersed, with major production centers in the US, East Asia and Europe. Importantly, the industry faces an array of climate risks which vary by region and offer illustrative examples of industrywide climate risks that are often overlooked.

Four Twenty Seven analyzed the geolocation of over 2,300 production facilities either owned by or supplying components to the 50 largest chip makers, and overlaid detailed regional maps of locations at high risk for drought, flooding, extreme heat and severe storms. Their research revealed that nearly half of these chip production facilities were exposed to water stress. This represents a critical threat to semiconductor manufacturers who rely on ultrapure water during every step of the manufacturing process.[116] In addition, greater severity and frequency of drought would likely increase the costs of both procuring and purifying water and potentially limit production. Competition with local citizens and businesses for scarce water resources could also adversely impact companies' reputations and hurt their sustainability ratings. Virtually all the companies analyzed were exposed to water stress in at least a quarter of their facilities. Water stress is especially prominent in the southwestern US where almost two-thirds of facilities face this potential climate risk (Exhibit 22).

Investors need to be aware of how companies manage these risks as it can make a material difference in earnings performance. For example, some companies in Asia and the US have developed innovative production techniques that recycle water.[117] Others have invested in conservation projects or partnered with local authorities to develop water treatment facilities.[118] These measures have already paid off for some Taiwanese chip manufacturers whose production was more resilient despite stringent water restrictions during the 2015 drought.[119]

Water stress is not the only climate threat to semiconductor manufacturers. Some chip manufacturers also face considerable risk from typhoons and floods, especially fabrication plants and subcontractor facilities in East Asia, a key region for the industry's supply chain. According to Four Twenty Seven's analysis, two-thirds of East Asian facilities are exposed to elevated risk from strong winds associated

Exhibit 22: **Water Stress Is Forecast to Rise in North America**



Source: Luck, Landis, and Gassert "Aqueduct Water Stress Projections: Decadal Projections of Water Supply and Demand Using CMIP5 GCMs," World Resources Institute, 2015, accessed through prepdata.org in 2020

Note: Water stress is measured by evaluating water demand (withdrawal and consumptive use), water supply, the ratio of water withdrawal to supply, and intra-annual (seasonal) variability for the periods centered on 2020, 2030, and 2040. The baseline is defined as the period between 1950 to 2010. This exhibit captures the business-as-usual scenario.

with typhoons and a third are exposed to flood risk. This risk is not merely hypothetical either. The 2011 floods in Thailand, for example, led to local disruptions in chip manufacturing and triggered global interruptions in the communications and automotive sectors as well. The flood disrupted about 10% of one firm's chip production and was estimated to cost hundreds of millions of dollars in lost revenue and damages.[120]

Pharmaceuticals

Pharmaceutical manufacturers are also especially vulnerable to water stress because purified water is an essential component in their manufacturing process. Based on the analysis of publicly traded pharmaceutical companies conducted by Four Twenty Seven, 85% of companies reviewed are exposed to water stress in at least a quarter of their facilities. For example, exposure to water stress is prevalent across 88% of the production facilities located in India and more than half the facilities in the US.

Additionally, many pharmaceutical drugs and key ingredients can degrade quickly and must be stored at precise temperatures to maintain their efficacy. Episodes of extreme heat can lead to increased energy costs for cooling and lost product should heat waves lead to power outages or other disruptions. More than half the facilities in North America and 95% of those located in Brazil are exposed to heat stress.

supply chains and impacts a wide range of industries. For investors, companies that manage these risks more effectively may build a competitive advantage in their industry and provide more resilient production for customers and revenues for investors. Overlaying the geolocation of key production and supplier facilities with climate data and analytics can reveal which facilities are in high stress regions and which operations are exposed to physical climate risk. This kind of analysis enables investors to assess the latent risk embedded in the value chains of individual firms.

> *New green investment opportunities are emerging to fund climate-related activities of households, firms and governments.*

Even green assets assumed to benefit from climate change mitigation and adaptation efforts face underappreciated climate risk. For example, insurance coverage for hail has become either unavailable or prohibitively expensive for some solar projects. For infrastructure equity holders, this can make it difficult to maintain insurance coverage requirements with their lenders. This can also leave infrastructure debt holders with unexpected risk if their borrowers aren't able to maintain the protections included in the original underwriting. Given that investments in assets such as solar projects are typically held for 10-20 years, infrastructure investors are at particular risk from annual insurance renewals.

4. Monitor emerging climate change-related asset classes for scale, viability and returns

A range of new "green" investment opportunities are emerging to fund climate-related activities and investments by individuals, companies, and governments (Table 3). However, many are at a very early stage and may not currently be at the scale required for institutional investors. It will be important for CIOs to monitor these developing markets as they mature and determine when and if they might become viable investment opportunities for their portfolios.

However, these less mature markets offer sophisticated investors willing to engage with them a unique opportunity. Early institutional investors can shape the market and investment structures for these new climate change-oriented asset classes.

Table 3: **Green Investment Key Facts and Considerations**

	Key Facts	Considerations
Green Bonds	■ **What are they?** Fixed income securities that raise capital for projects believed to have environmental benefits ■ **Sizable market:** Total market size of over $1 trillion[121] ■ **Steady issuance:** 2019 saw issuance of $270 billion and 2020 was on pace to exceed that[122] ■ **Maturing market:** Multiple issuers across the curve enable robust portfolio construction	■ **Few standards are universal or mandatory:** Lack of clear guidelines for what constitutes a green investment has led to instances of "greenwashing"
Carbon Emissions Allowances	■ **What is it?** Rights to carbon emissions that are traded on regulated exchanges in Europe, China and North America ■ Potential way for investors to offset climate transition risk ■ **Sizable market:** European and American markets have aggregate market value over $50 billion[123] ■ Emissions trading expanding into China will see volumes grow	■ **Limitations:** Does not hedge against physical risk ■ Need to access market through specialized managers ■ Not a truly global market and trading is largely at regional level ■ **Volatile markets:** Market prices can fluctuate greatly according to changes in regulatory regime ■ Market prices can fluctuate wildly during recession as supply of credits does not adjust lower quickly (e.g., early 2020)
Solar ABS	■ **What is it?** Securities backed by loans made to individuals to finance solar panels for their homes ■ Loans are repaid in part by a tax credit that comes later as well as savings from lower utility costs	■ **Unusual structure:** Tax credit prepays a portion of the loan which adds complexity and makes it difficult to value for investors ■ **Nascent market:** Issuance reached $2.5 billion in 2020 as demand from investors soared[124] ■ **Poor underwriting:** Concerns that many loans are based on simple FICO scores rather than cash flow or ability to pay ■ **Inconsistent standards:** Limited verification whether solar panels were installed correctly or in the optimal location to generate electricity
Resiliency Bonds	■ **What are they?** Hybrid of insurance and resilience projects to monetize avoided losses or reduced costs through a rebate structure ■ Attractive objectives and structures for foundations that need to put funds to work annually	■ **Nascent market:** Relatively small market compared to others ■ Constraint on scaling up may be availability of projects ready to finance

Conclusion

There is no doubt that climate change is and will continue to have profound implications for how long-term institutional investors build and protect their portfolios. Across public and private markets investors must position their investments and overall portfolios for the accelerating climate transformations in our economy and markets. No one can perfectly predict the dynamics of asset price adjustments as climate risks get internalized – or whether the adjustment will be smooth or abrupt – but a repricing will occur, and investors will need to be prepared.

At PGIM, we believe active investors must be on the front foot, predicting and responding to the impact of climate change on the economies and our markets in which investors operate. This will create both immense uncertainty and opportunity. Only forward-looking, long-term investors will have the nimbleness and foresight to seize the opportunities and navigate the risks of our changing climate.

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