

# Critical industries have substantial exposure to physical climate risks

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## ABOUT

Moody's is committed to helping market participants advance strategic resilience, responsible capitalism, and the greening of the economy. Our offerings span across credit, ESG, sustainable finance, and climate risk solutions and help our customers identify risks and opportunities and provide meaningful performance measurements and insights.

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## Climate Solutions – Global

# Critical industries have substantial exposure to physical climate risks

## Summary

**Physical climate hazards threaten business operations across all sectors globally.** Based on an analysis of over 5,000 publicly-listed companies and their roughly 2 million underlying facilities, heat stress and water stress threaten the largest proportion of assets across sectors, with multifaceted impacts on human health, resource demand and operations.

**The manufacturing industry has the largest proportion of assets exposed to climate hazards.** The most exposed manufacturing segments include electronic and electrical product manufacturing (mostly semiconductor manufacturing companies), as well as the manufacturing of petroleum and coal, nonmetallic mineral products, food and chemicals.

**Computer and electronic manufacturing companies have 17-22% of assets exposed to floods.** This presents significant industry risks, particularly due to supply chain impacts. Exposure is particularly acute for facilities based in Asia, where many companies operate.

**Utilities have significant exposure to heat stress and water stress.** The risk is concentrated in the Americas, with 88-93% of assets exposed in Latin America and the Caribbean and 80-85% of assets exposed in North America. However, utilities across several European countries, such as Italy and Austria, have large concentrations of assets exposed to heat stress.

**Real estate and construction are particularly vulnerable to acute climate risks.** Within the sector, we find 17-22%, 15-20% and 11-16% of facilities are exposed to wildfires, floods and hurricanes & typhoons respectively. Hurricane & typhoon risk is concentrated in Asia and – to a lesser extent – the East coast of the US, while other hazards are more distributed globally.

**The water and air transportation industry has among the most significant exposure to sea level rise of all sectors,** with between 5-10% of assets exposed. This exposure is driven by the proximity of transportation nodes to the coast. Exposure is spread between Asia, Europe and North America, with broad implications for supply chains and communities.

**Chemical manufacturing companies have 54-59% and 45-50% of their assessed assets exposed to heat stress and water stress respectively, with 18-23% exposed to floods.** In addition to heat stress, water stress presents significant risks to the chemical manufacturing sector due to its reliance on clean water for inputs into its products.

**Retail trade has 24-29% and 22-27% of assets exposed to heat stress and wildfires respectively.** While this will likely reduce business at brick and mortar retailers, stores with a strong online presence have thrived during the COVID-19 pandemic and are well-positioned to benefit as climate hazards may encourage people to continue shopping from home.

# Rising prevalence of extreme weather calls for increasing understanding of companies' physical climate risk

The [year 2020 tied with the year 2016 as the hottest year on record](#) and the past seven years have been the hottest seven years on record. The [latest Intergovernmental Panel on Climate Change \(IPCC\) report](#) shows that greenhouse gas (GHG) emissions from human activities are responsible for approximately 1.1°C of warming since 1850-1900, and finds that global temperature is expected to reach or exceed 1.5°C of warming over the next 20 years.

This increase in atmospheric temperatures will increasingly manifest in a range of extreme weather events and chronic stresses, with significant impacts on businesses, supply chains and economies. Indeed, we are already seeing more frequent extreme weather. [2020 saw a record-breaking \\$50 billion of weather-driven disasters](#), with combined economic losses (insured and uninsured and including earthquakes) of \$268 billion – the fifth costliest year on record for weather-related disasters. Monsoon flooding in Asia caused \$35 million in damage for China. Furthermore, wildfires caused \$12 billion of insured damage globally in 2020.

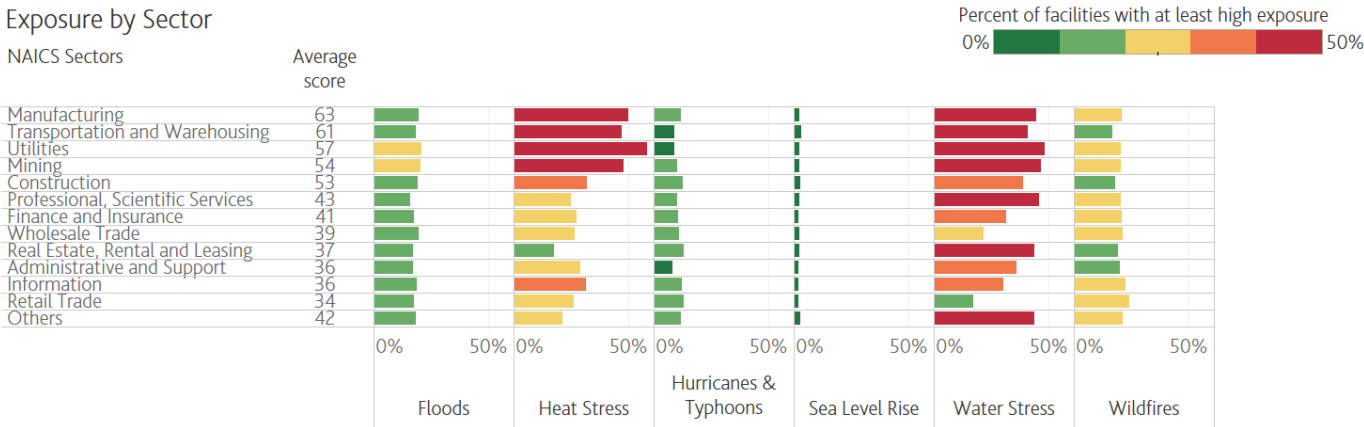
Managing the physical risks of climate change requires an understanding of which organizations are exposed to climate hazards and how this will change over time. Investors and lenders are primarily exposed to climate risk through the entities in their portfolios. Companies, meanwhile, will primarily face risk driven by the location of their operations and whether or not manufacturing plants, storage facilities, data centers and other assets are exposed to damage and disruption from climate hazards. A detailed view on exposure to physical risks can inform targeted investment in adaptation, thereby supporting the economies and communities that underpin corporate operations and resilience.

Moody's ESG Solutions' methodology to assess physical risk for companies is based on the exposure of companies' operations to climate hazards (see Box 1). The database covers over 5,000 large public companies and more than 2 million underlying corporate facilities globally. This paper explores the key findings from our analytics.

## Almost all sectors face significant exposure to heat stress and water stress

We leverage global climate change data integrated into proprietary models to provide asset-level risk assessments of the physical risk exposure of companies over the 2030-2040 horizon. Our physical climate risk scoring methodology for companies assesses three types of risk: Operations Risk, Supply Chain Risk, and Market Risk. Each indicator for the 5,000-plus corporations covered is scaled by percentile to derive a risk score between 0 (low risk) and 100 (high risk).

Figure 1 Exposure to physical climate hazards by sector.



Source: Moody's ESG Solutions



An analysis of assets within our database shows that all sectors carry significant exposure to water stress and heat stress, with around 33-38% of assets highly exposed to each of those hazards (Figure 1).<sup>1</sup> Heat stress and water stress represent a major threat to companies through their effects on human health, water consumption and energy demand. The risk is particularly acute for resource-intensive activities such as manufacturing, transportation, utilities, mining and agriculture. These sectors' operations tend to be energy intensive and require clean water and/or large amounts of water. Floods and wildfires represent a high risk for around 18-23% of the assets within our database. They can lead to severe damages and repeating loss for assets across all sectors, as well as operational disruptions. While sea level rise and hurricanes and typhoons threaten a lower percentage of assets, they can have far-reaching and long-term consequences on assets, corporations and regional economies.

Manufacturing stands out with the highest risk exposure overall. Half of the companies in the sector are among the most exposed in our total universe.<sup>2</sup> Manufacturing is also the largest sector in our universe, covering a wide range of manufacturing activities (Table 1).

**Table 1** Manufacturing subsectors' exposure to physical climate hazards.

NAICS MANUFACTURING SUBSECTORS <sup>3</sup>	COMPANY COUNT	FACILITY COUNT	PERCENT OF ASSETS WITH AT LEAST HIGH EXPOSURE					
			FLOODS	HEAT STRESS	HURRICANES & TYPHOONS	SEA LEVEL RISE	WATER STRESS	WILDFIRES
Computer and Electronic Product	290	60,183	17-22%	40-45%	11-16%	0-5%	45-50%	23-28%
Petroleum and Coal Products	41	21,433	16-21%	48-53%	10-15%	1-6%	45-50%	21-26%
Electrical Equipment, Appliance, and Component	55	17,789	18-23%	49-54%	12-17%	0-5%	44-49%	19-24%
Nonmetallic Mineral Product	69	31,858	19-24%	50-55%	7-12%	0-5%	43-48%	21-26%
Food	137	40,765	18-23%	55-60%	7-12%	0-5%	44-49%	17-22%
Chemical	346	92,643	18-23%	54-59%	12-17%	1-6%	45-50%	18-23%
Primary Metal	76	19,778	21-26%	45-50%	13-18%	1-6%	39-44%	18-23%
Plastics and Rubber Products	41	14,726	18-23%	54-59%	8-13%	0-5%	42-47%	17-22%
Transportation Equipment	185	75,385	18-23%	44-49%	9-14%	1-6%	42-47%	17-22%
Beverage and Tobacco Product	70	29,385	17-22%	37-42%	6-11%	0-5%	31-36%	15-20%
Machinery	147	13,906	17-22%	36-41%	10-15%	0-5%	44-49%	17-22%

Source: Moody's ESG Solutions

Among the most exposed manufacturing segments are electronic and electrical product manufacturing, mostly composed of semiconductor manufacturing companies, as well as the manufacturing of petroleum and coal, nonmetallic mineral products, food and chemicals. In our database, most companies within these industries are headquartered in Asia, where there is significant exposure to multiple physical hazards, and many companies have facilities in the US which also has significant exposure. These industries are also highly exposed within their market and their supply chains. They generate an important part of their revenues in countries with high exposure to physical risks. Their supply chains are typically dependent on resources and countries threatened by climate change.

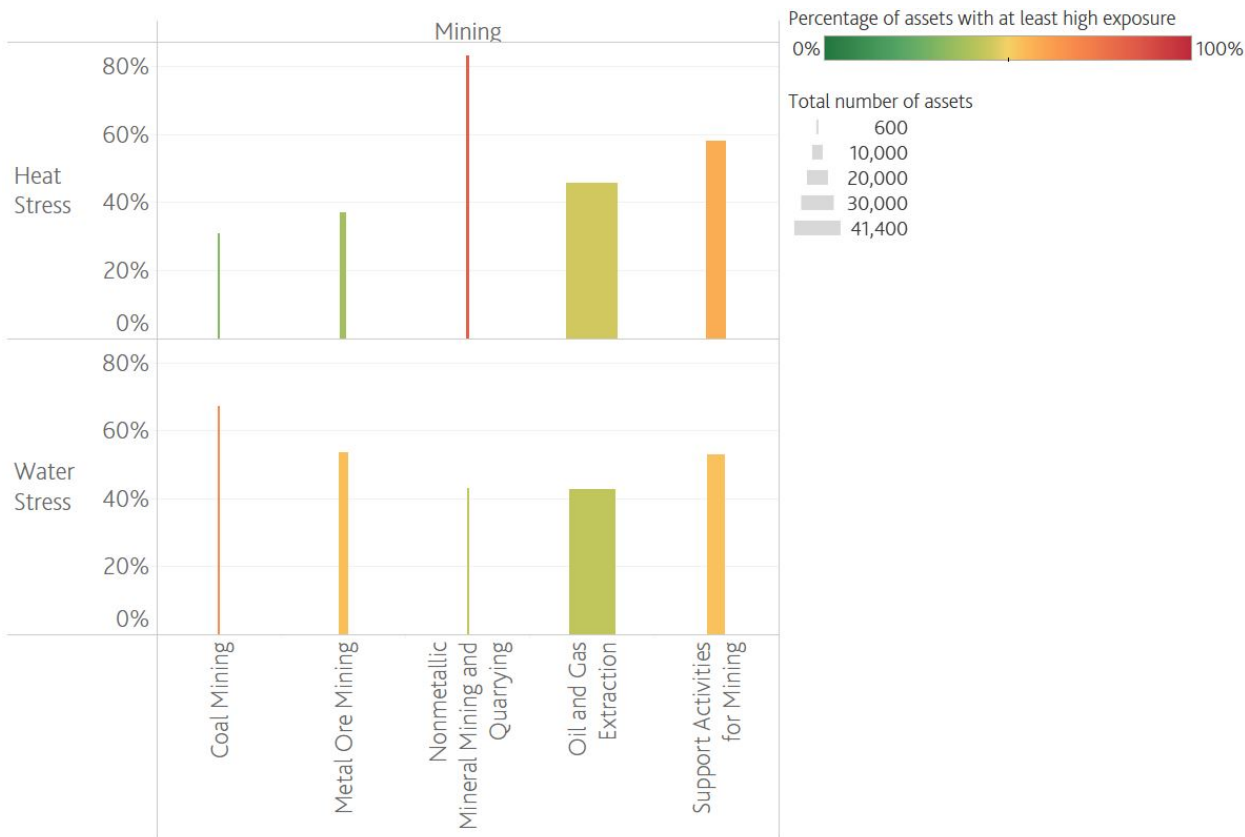
Outside of manufacturing, our data shows high exposure of the utilities, mining and transportation industries. These sectors have similar market and supply chain risk exposure when compared to manufacturing. On the operations side, mining companies tend to have significant operations in dry regions with exposure to water stress and wildfires, such as Australia, South China and the South West of the US. Exposure to water stress is particularly high for coal and metal ore mining activities (Figure 2), which presents challenges due to their reliance on water for their operations and dependence on outdoor labor which could be affected by wildfire smoke.

<sup>1</sup> We use the North American Industry Classification System (NAICS) for sectors throughout this report, which is one of the standard classification systems for industries. Further, as information about facility ownership is not public information we rely on public and private sources to compile our database of corporate facilities and we rely largely on their quality control measures. We use ranges to refer to facility exposure throughout this report to reflect the uncertainty that stems from these limitations. See box 1 for more information.

<sup>2</sup> Half of the companies from the manufacturing sectors are amongst the 35% most exposed companies in our universe.

<sup>3</sup> This table only includes results for the largest subsectors within the manufacturing sector (i.e. sectors for which we have the highest number of companies in our database).

Figure 2 Mining exposure to Heat and Water Stress by subsectors.

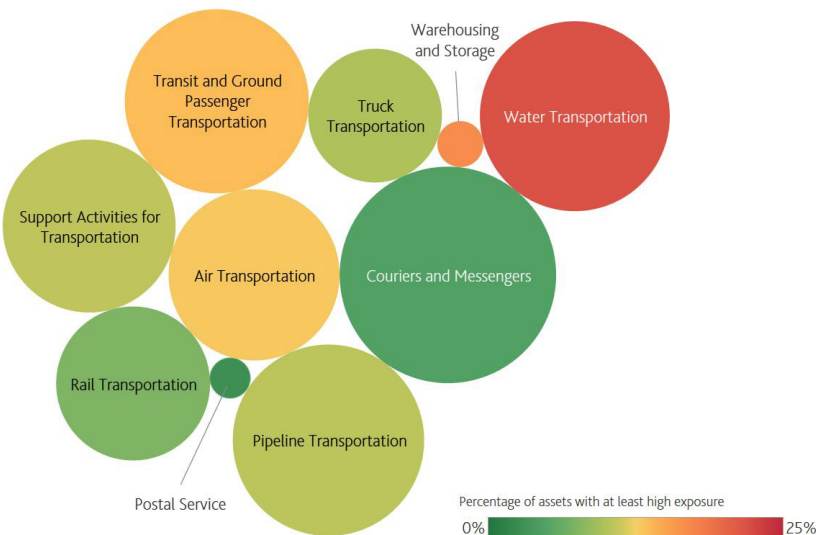


Note: Total number of assets is rounded to the nearest 100.

Source: Moody's ESG Solutions

Assets in the transportation sector have a high exposure to the risk of sea level rise and hurricanes, due to the concentration of key transportation nodes adjacent to the coast, such as airports and ports. Hurricane risk is particularly high for water transportation, air transportation, and transit and ground passenger transportation with between 10-25% of their assets exposed (Figure 3).

Figure 3 Exposure of Transportation companies to hurricanes & typhoons by subsector.



The size of the bubble represents the number of assessed facilities. Source: Moody's ESG Solutions

While relative exposure varies across sectors, climate change will likely impact every large company in the world if appropriate adaptation measures are not implemented. We also provide data on companies' management of physical risks based on their disclosures. Based on publicly-available data and direct interaction and engagement, we provide scores and performance levels assessing the awareness of companies, disclosure on exposure to physical impacts and measures implemented to mitigate these risks. These datasets show that 80-85% of companies analyzed exhibit a weak performance in physical risk management, despite high exposure to physical climate risks.

**Box 1: Our physical climate risk methodology**

**Operations Risk** measures the overall climate hazard exposure associated with the facilities a company owns or operates, from manufacturing sites and warehouses to offices and retail stores. We assess exposure to six climate hazards, including floods, heat stress, hurricanes & typhoons, sea level rise, water stress and wildfires, leveraging data from the Intergovernmental Panel on Climate Change (IPCC), National Aeronautics and Space Administration (NASA), The National Oceanic and Atmospheric Administration (NOAA), the World Resources Institute (WRI) and other organizations. The scoring process accounts for the fact that facilities will be affected differently by climate hazards based on their activities. For example, a manufacturing plant that has heavy water and energy inputs will be more sensitive to heat stress and water stress than an office in the same location. In addition to the six climate hazards, the Operations Risk score for a corporation also includes a measure of socioeconomic risk, sourced from Moody's ESG Solutions' Sovereign Sustainability Rating.

The Operations Risk component of our physical risk scoring methodology assesses the climate risk exposure of companies' facilities based on our database of around 2 million global corporate facilities. The company facility database includes facilities for which a company has indirect or ultimate ownership of at least 50%, including subsidiaries and joint ventures. For this analysis we use a snapshot of company facilities as of September 2020, so it may not capture recent changes in corporate ownership. Information on a company's facility locations and activities is not public information. Our global database of corporate facilities leverages data from public and private industry sources, mapped to the corporate owner and relevant financial instrument issuers. Our primary vendor is Moody's Analytics Bureau van Dijk, who, along with our other vendors, maintains its own set of information sources, quality control procedures, and limitations. It should be noted that our database is largely subject to the same quality strengths and limitations as our vendors.

**Supply Chain Risk** captures upstream climate risks for corporations. It includes two indicators measuring climate risk in countries that export commodities that a company depends on for production (Country of Origin), and the industry-level dependence on climate-sensitive resources such as water, land and energy across the supply chain (Resources Demand). Supply Chain and Market Risk data comes from several sources including the World Bank.

**Market Risk** captures downstream climate risks for companies. It also includes two indicators looking at climate risk exposure in the countries a company depends upon for its sales (Country of Sales) and the sensitivity of economic output to climate variability based on the company's industry (Weather Sensitivity).

**Figure 4** Moody's ESG Solutions physical climate risk scoring methodology for companies.



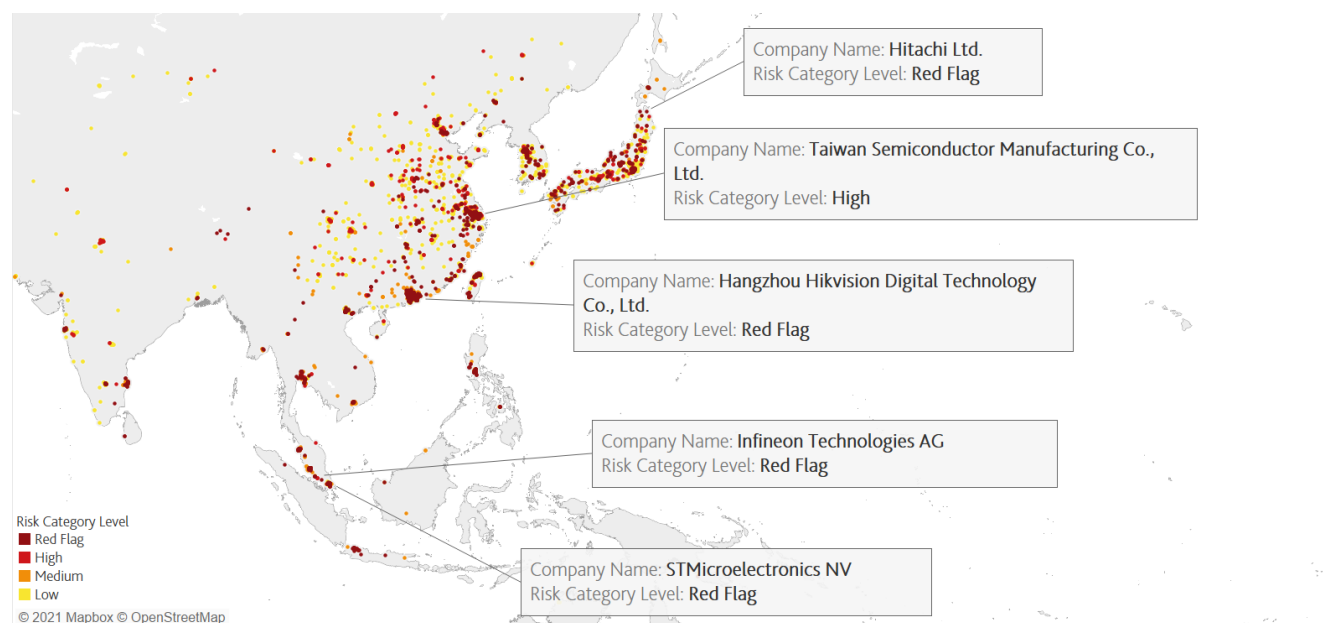
Source: Moody's ESG Solutions

## Manufacturing of computer and electronics products faces significant exposure to floods in Asia

Computer and electronic manufacturing companies are particularly exposed to water stress, heat stress and wildfires. However, with 17-22% asset exposure, floods also present significant risk to the industry, particularly due to the supply chain impact. We find heightened exposure for facilities based in Asia, where many companies in the sector operate. Roughly 19-24% of assets located within Asia from the sector have high exposure to the risk of floods. Severe flooding can lead to damages to materials, losses of expensive machinery and products and temporary shutdown of operations. Semiconductors facilities contain costly and water sensitive equipment. If damaged, the repair costs can be prohibitive as shown by the example of ON Semiconductors, which permanently shut down one of its production sites after the 2011 Thailand floods because of the ["excessive cost required to recover and reconstruct."](#)

Roughly 59-64% of companies manufacturing computers and other electronic products have more than 30% of their facilities exposed to high risk of floods. Among them are several Asian companies such as Taiwan Semiconductor Manufacturing Co., Ltd. with 36-41% of its facilities exposed, but also a few US based companies like Western Digital Corp.

Figure 5 Computer and electronic manufacturing companies' exposure to floods.



Note: Dots represent facilities. They are colored based on their flood risk with the darker red dots being the most exposed.

Source: Moody's ESG Solutions.

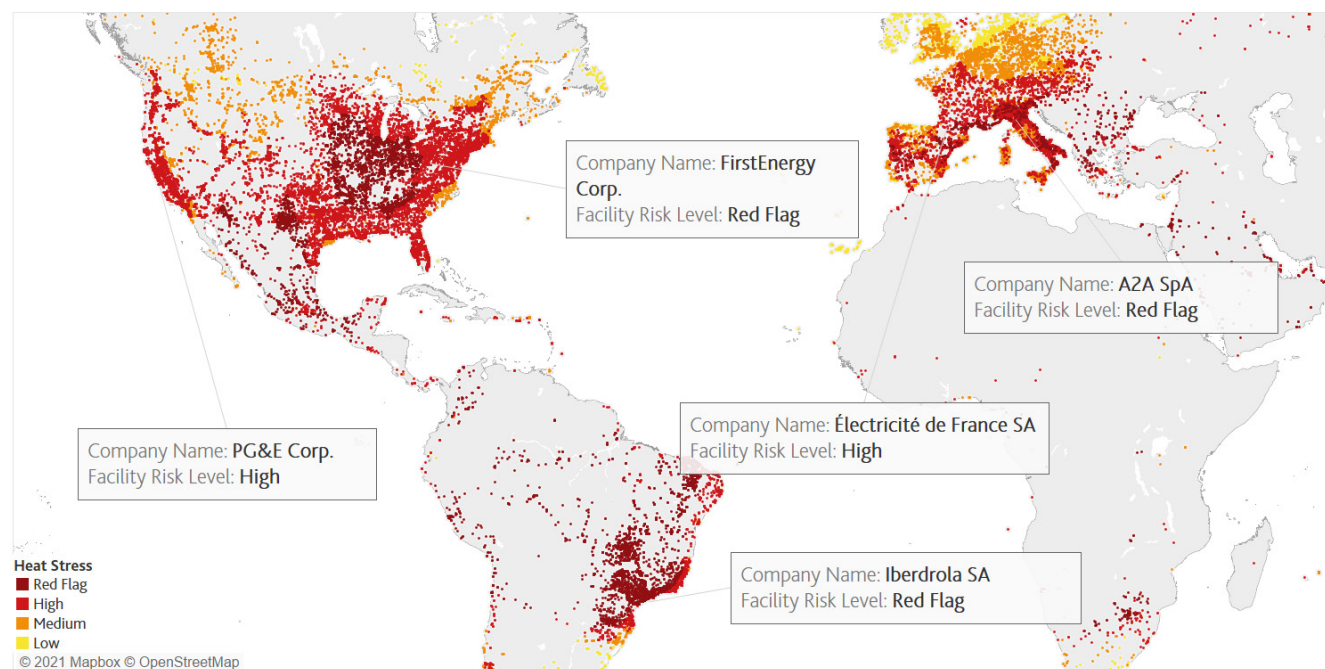
## Utilities are highly exposed to heat and water stress, particularly in the Americas

Utilities have significant exposure to heat stress and water stress, which poses risks to their operations. In total, 56-41% of the utilities' assets have high exposure to heat stress risk. The risk is concentrated in the Americas, with 88-93% of assets exposed in Latin America and the Caribbean and 80-85% of assets exposed in North America. However, there is also significant risk in a few European countries, such as Italy and Austria, where 79-84% of utilities' assets are highly exposed to increased frequency and intensity of extreme heat events.

In a report, [Moody's Investors Service identified rising temperatures as a risk for US based utilities](#). Extreme heat events can reduce the efficiency of electrical grids. Increasing temperatures can make it challenging to cool power plants, potentially leading to temporary shutdowns. Heat stress also leads to greater losses in energy transmission. Utilities' operations rely on outdoor workers, which means employees may be vulnerable to adverse health conditions from extreme heat if their working hours aren't adapted. Lastly, energy demand for cooling tends to increase during heat waves which can add pressure to the distribution network and can potentially lead to power cuts, exposing companies to reputation and litigation risk.

All assessed facilities of some highly concentrated utilities companies, such as Ameren and Arkansas Electric Cooperative Corp, have high exposure to the risk of heat stress. The percentage of assets with high exposure decreases for global utilities that have geographically diversified assets, but the risk is still high with around 55-60% of Iberdrola's assets highly exposed to heat stress, and 76-81% of Enel's assets.

Figure 6 Utility company facilities' exposure to heat stress.



Note: Dots represent facilities. They are colored based on their heat stress risk with the darker red dots being the most exposed.

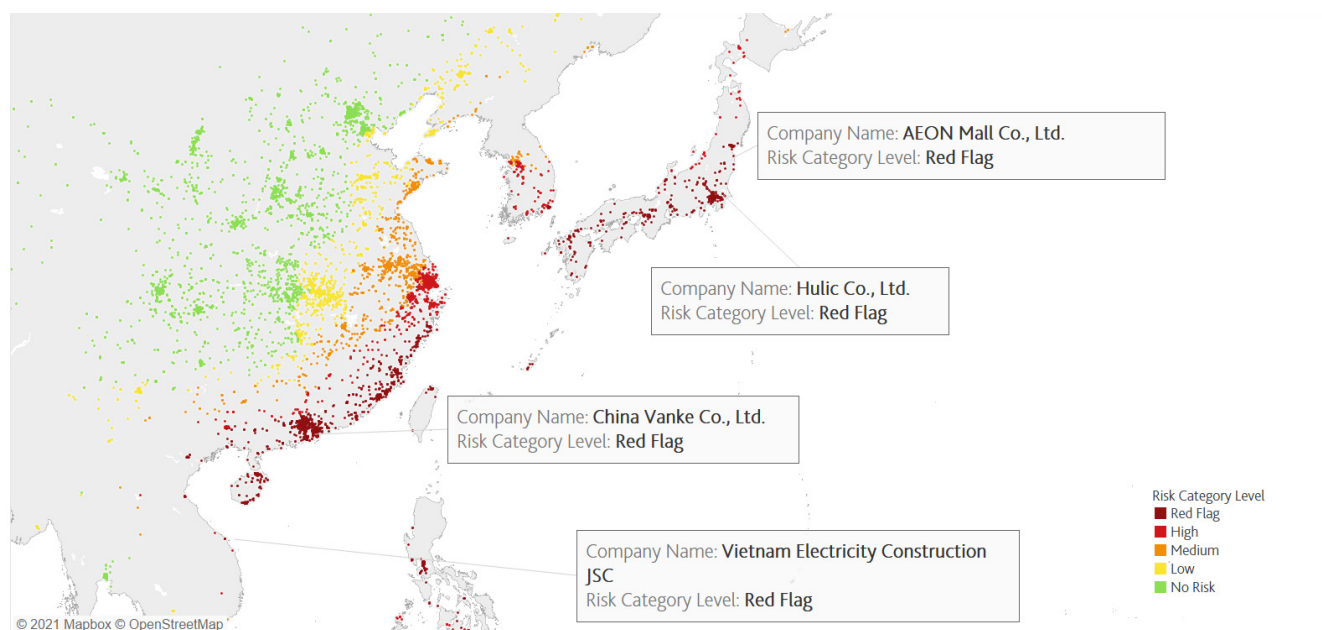
Source: Moody's ESG Solutions.

## Real Estate and construction face exposure to acute climate hazards like wildfires, floods and hurricanes & typhoons

Real estate and construction are particularly affected by acute climate hazards. Within the sector, we find that 17-22%, 15-20% and 11-16% of facilities are exposed to wildfires, floods and hurricanes & typhoons respectively. Hurricane & typhoon risk is concentrated in Asia and – to a lesser extent – the East coast of the US, while other hazards are more distributed globally. Wildfires, floods and storms can critically damage assets and infrastructure and lead to costly delays for construction. [Studies have also](#) demonstrated the impact of hurricanes on commercial property values, with figures showing that areas affected by the costliest hurricanes found a decrease in value of almost 6% one year after the hurricanes and by 10.5% two years after. However, while the construction sector can suffer from hurricane damage, [companies can also experience some benefits](#) from reconstruction efforts post-disaster.



Figure 7 Real estate and construction company facilities exposure to hurricanes & typhoons



Note: Dots represent facilities. They are colored based on their hurricanes & typhoons risk with the darker red dots being the most exposed.

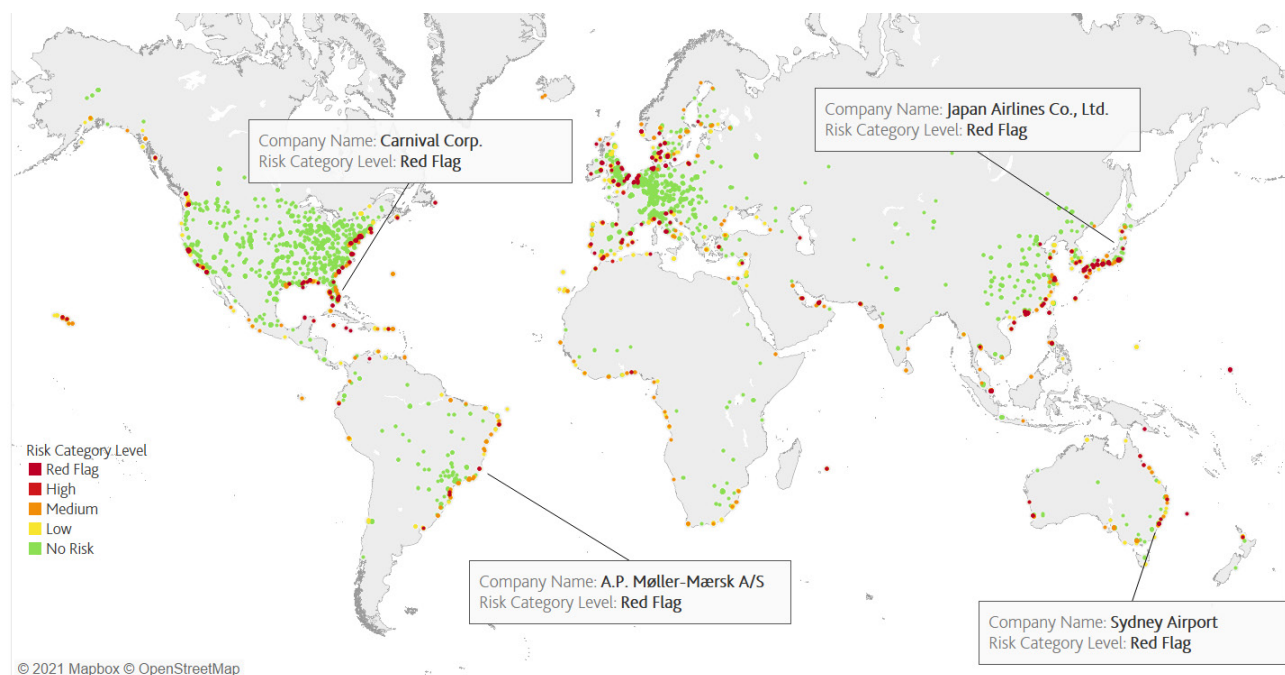
Source: Moody's ESG Solutions.

### Transportation industries have among the highest exposure to sea level rise, with widespread implications

The water and air transportation industries have among the most significant exposure to sea level rise of all sectors, with between 5-10% of assets exposed. The risk is linked to the proximity of activities to the coast and exposure is spread between Asia, Europe and North America. The risk of sea level rise threatens transportation companies due to increased likelihood of coastal flooding and storms surges, potentially leading to disruptions in operations and material damages. Amongst the most exposed companies in our universe are numerous airports and airline companies such as Japan Airlines and EVA airways Corp., with 18-21% and 14-19% of their assets exposed to sea level rise, respectively. On the water transportation side, the shipping company A.P. Moller - Maersk has around 13-18% of its assets highly exposed to sea level rise.

There are also many assets that are both highly exposed to sea level rise and hurricanes & typhoons, particularly in East Asia and the Eastern coast of the US. Sea level rise will lead to more intense coastal flooding linked to tropical storms events. [In 2018, typhoon Jebi flooded one of Japan's major airports](#), the Kansai International Airport of Osaka. The airport was forced to close for several days and was significantly damaged. [As many of the world's largest airports are located in coastal areas, the threat of sea level rise is much more than an individual risk for assets and companies](#), but rather it represents a risk for the whole industry.

Figure 8 Air and water transportation company facilities' exposure to sea level rise



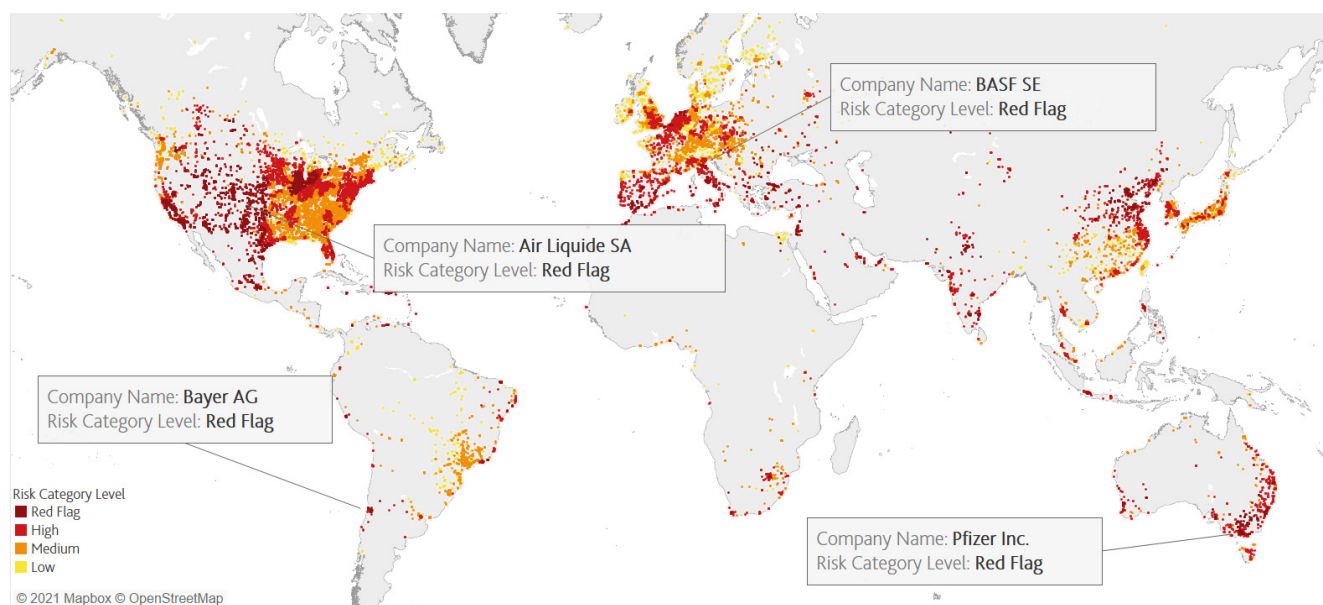
Note: Dots represent facilities. They are colored based on their sea level rise risk with the darker red dots being the most exposed.

Source: Moody's ESG Solutions.

### Chemical companies face significant exposure to physical climate hazards, with operations vulnerable to disruption

Chemical manufacturing companies in our database have 54-59% and 45-50% of their assets exposed to heat stress and water stress respectively, with 18-23% exposed to floods. In addition to heat stress, water stress presents significant risks to the chemical manufacturing sector due to its reliance on clean water for inputs into its products. In its answer to the CDP Water Questionnaire 2019, BASF reported that the European drought of 2018 highly impacted the corporation's largest site. The site is dependant on the Rhine river for cooling purposes as well as for transportation of raw materials and final products. In a 2018 heat wave, the Rhine river water level was so low that it decreased production and [led to negative earnings impacts of around EUR 250 million](#). Our data shows that BASF has between 39-44% of its assets exposed to the risk of water stress, with a large majority of its exposed manufacturing plants located in the US. While a few companies like BASF do provide public disclosure on their exposure to the impacts of climate change and the adaptation measures implemented, our data on physical climate risk management shows that around 68-73% of chemical companies analyzed have a poor level of disclosure regarding their physical risk exposure and management.

**Figure 9** Chemical manufacturing company facilities' exposure to water stress



Note: Dots represent facilities. They are colored based on their water stress risk with the darker red dots being the most exposed.

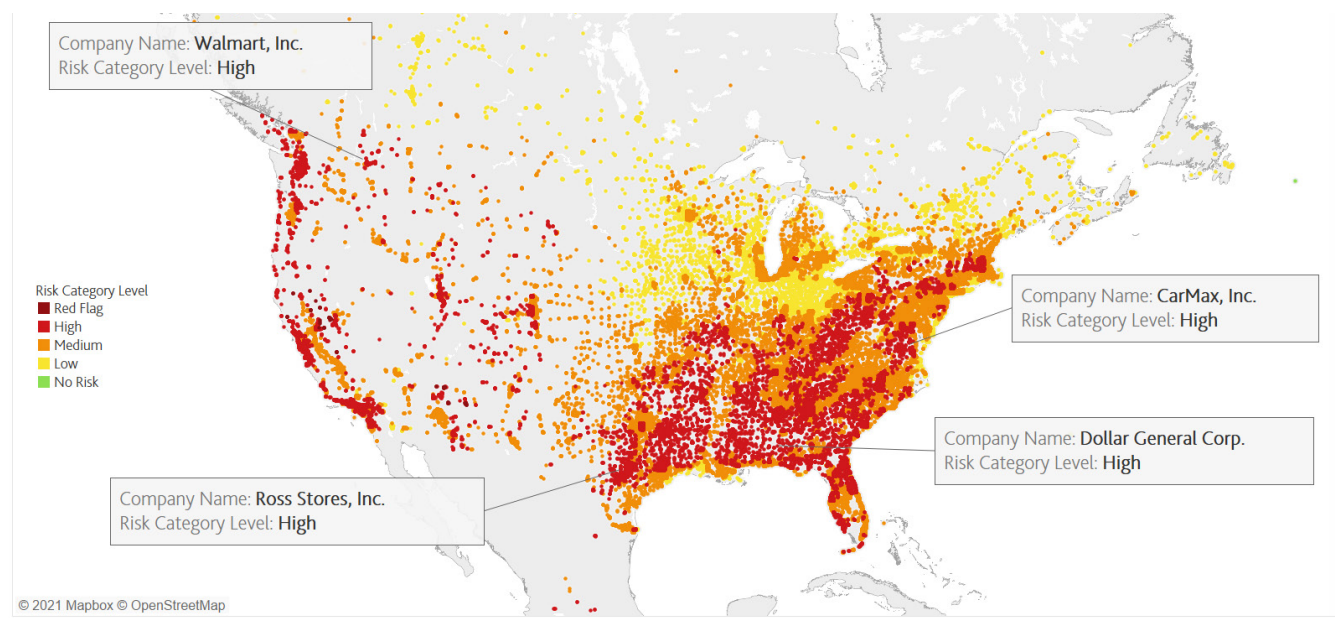
Source: Moody's ESG Solutions.

### Retail trade is highly exposed to wildfires, particularly in the US, Australia and Brazil

The two hazards to which the retail trade sector is most exposed are heat stress and wildfires, with 24-29% and 22-27% of assets exposed respectively. Retail is among the most exposed sectors to wildfires, and the risk is concentrated in the US, Australia and Brazil. In the US, our database contains more than 44,000 facilities from the Retail trade sector with high exposure to the risk of wildfires. This hazard presents significant risks to the retail trade industry, by [damaging or destroying assets or products and temporarily limiting traffic to shops and shopping centers](#). In the long term, wildfire potential can also affect the demography of exposed areas and therefore change potential demand for retail goods in these same regions. However, for heat stress in particular, there is also an opportunity for retail trade to benefit while serving the community as cooling centers, as seen in some instances with indoor, air-conditioned shopping malls.

The retail trade industry has been significantly affected by the COVID-19 pandemic, during which many consumers shifted their habits to online shopping when possible. Retailers with a strong online presence and established distribution networks have thrived during the pandemic and will likely continue to benefit over the long term, as hazards such as wildfires and associated smoke may make it less safe or appealing for consumers to leave their homes, even as their activity picks up again with the ongoing vaccination efforts.

Figure 10 Retail trade company facilities exposure to wildfires



Note: Dots represent facilities. They are colored based on their wildfire potential with the darker red dots being the most exposed.

Source: Moody's ESG Solutions.



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