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Environmental Risks – Global

Sectors with heightened credit risk account for twice as much debt as in 2015

Summary

» **Sectors facing heightened environmental credit risk account for more than twice as much rated debt as when the Paris Agreement was announced.** Credit risks associated with environmental considerations are rising as growing awareness of the issues increasingly spurs policy, investor and corporate action across most risk categories. Our newly updated heat map of environmental risk, with rated debt levels as of June 2022, shows an overall increase in credit risk linked to environmental considerations, based on our analysis of 89 global sectors with total rated debt of about $83 trillion. Sectors facing very high or high environmental credit risk now account for $4.3 trillion in rated debt, up 27% from $3.4 trillion in December 2020 and up 109% from $2 trillion in November 2015, at the time of the Paris Agreement's initial unveiling.

» **Debt exposure to heightened environmental risks continues to increase as a share of total rated debt.** Sectors with very high or high environmental credit risk now account for 5.1% of total rated debt outstanding, up from 4.2% in 2020 and 3% in 2015. In our latest heat map, six sectors face very high overall environmental risks: coal mining and coal terminals, chemicals, mining - metals and other materials excluding coal, independent exploration and production (E&P), integrated oil and gas, and refining and marketing. In 2020, only coal mining and coal terminals faced very high environmental credit risk. Ten sectors face high environmental credit risk.

» **Sixteen sectors with $4.9 trillion in rated debt have very high or high inherent exposure to carbon transition risk amid stricter emissions regulation and the expanding availability of low-carbon alternatives.** The exposure increased by about 10% from our 2020 heat map and 55% from 2015. Integrated oil companies and refining and marketing sectors move to very high exposure in this category from high risk in our 2020 heat map, driven mainly by limitations on where they can explore for new resources and the increasing availability and adoption of alternative energy products. Other large sectors that face heightened inherent carbon exposure risks include automobile manufacturers and regulated and unregulated utilities with generation.

» **Fourteen sectors with high inherent exposure to physical climate risks account for $6.4 trillion in rated debt; this exceeds the debt held by sectors with heightened exposure to any other environmental risk category, reflecting the pervasive, broad-based nature of this risk.** The increased frequency and severity of extreme weather events are causing significant economic losses, hazards for local populations and environmental damage. Further, long-term patterns of climate change – such as rising temperatures, changing frequency and intensity of precipitation and rising sea levels – can also affect companies' operations, supply chains and asset values. The largest sectors in terms of rated debt with high exposure include emerging market sovereigns, regulated electric and gas utilities with generation and integrated oil and gas companies.

» **Fourteen sectors with $4.4 trillion in rated debt have very high or high inherent exposure to waste and pollution risk amid tightening regulation of plastic packaging and chemical waste.** Chemicals, refining and marketing, and coal mining and coal terminals have very high exposure. Sectors with the largest exposure by debt are regulated and self-regulated utilities with generation and integrated oil and gas companies. Risks include air pollutants, hazardous and nonhazardous waste, human-made accidents and growing pressure to address "circular economy" issues.

» **Nine sectors with very high or high inherent exposure to natural capital risk hold $1.7 trillion in rated debt, more than twice the debt exposure in 2020, reflecting the increasing prominence of biodiversity, ecosystem health and natural resource management in policy and investor agendas**. Sectors with high exposure include building materials, mining - metals and other materials, excluding coal and protein and agriculture. Natural capital-related credit risk is rising as regulatory and investor interest in the issue increases. The rise in debt exposure stems in part from integrated oil and gas companies, independent E&P and oilfield services moving to high inherent exposure from moderate. Some of these sectors cause damage to natural systems that can lead to direct and indirect loss of revenue. At the same time, sectors that depend on ecosystem services, such as protein and agriculture, are vulnerable to the potential loss of these resources. As public interest in preserving natural assets continues to grow, natural capital risk will become a focal point for investors.

» **Eight sectors with very high or high inherent exposure to water management risk account for $1.9 trillion in rated debt, about double the debt exposure in 2020, reflecting growing regulatory compliance costs and mounting pressure on supplies.** This category, which includes water consumption and reduction, water efficiency and access, and water quality and pollution, is generally centred around management and governance aspects of water. Integrated oil companies and water and wastewater utilities are among the largest sectors with heightened exposure. The rise in rated debt and the number of sectors with heightened exposure to water management considerations was driven in part by the substantial investments needed in the independent E&P, integrated oil and gas and protein and agriculture sectors to comply with increasing environmental regulation of water management and greater societal focus on water issues, moving these sectors to high inherent exposure from moderate.

Sectors facing heightened environmental credit risk account for more than twice as much rated debt as when the Paris Agreement was announced

Credit risks associated with environmental considerations are rising as growing awareness of the issues increasingly spurs policy, investor and corporate action across most risk categories. Our newly updated heat map of environmental risk, with rated debt levels as of June 2022, shows an overall increase in credit risk linked to environmental considerations, based on our analysis of 89 global sectors with total rated debt of about $83 trillion. Environmental considerations pose heightened (very high or high) risk to the credit quality of 16 sectors with about $4.3 trillion in rated debt, up from 13 sectors with $3.4 trillion in debt in December 2020 and 9 sectors with $2 trillion in debt in November 2015, at the time of the Paris Agreement's initial unveiling. (See blue box titled "Assessing sector exposure to environmental risks: our approach" for an explanation of how we assess sector exposure.)

As shown in Exhibit 1, five sectors have moved to very high risk in 2022 from high risk in our 2020 heat map: integrated oil and gas companies, independent exploration and production (E&P), refining and marketing, chemicals and mining - metals and other materials, excluding coal. These sectors accounted for $1.9 trillion in debt. In 2020, only coal mining and coal terminals faced very high credit risk from environmental considerations.

Exhibit 1

Most sectors facing heightened environmental credit risk have seen an increase in risk level since 2015

Changes in environmental risk heat map scores and total rated debt ($ billions) for sectors with very high or high environmental credit risk in 2022

KEY: Very High Risk | High Risk | Moderate Risk | Low Risk | Total Debt ($ Bn)

	2015	2018	2020	2022
Total Debt ($Bn)	**$2,043**	**$2,243**	**$3,352**	**$4,261**
Percentage of Total Debt	**3%**	**3%**	**4%**	**5%**
Coal Mining and Coal Terminals	Very High Risk	Very High Risk	Very High Risk	Very High Risk
Chemicals	High Risk	High Risk	High Risk	Very High Risk
Mining - Metals and Other Materials, excluding Coal	High Risk	High Risk	High Risk	Very High Risk
Oil & Gas - Independent Exploration & Production	High Risk	High Risk	High Risk	Very High Risk
Oil & Gas - Refining & Marketing	High Risk	High Risk	High Risk	Very High Risk
Oil & Gas - Integrated Oil Companies	Moderate Risk	Moderate Risk	High Risk	Very High Risk
Unregulated Utilities and Power Companies	Very High Risk	Very High Risk	High Risk	High Risk
Automobile Manufacturers	High Risk	High Risk	High Risk	High Risk
Building Materials	High Risk	High Risk	High Risk	High Risk
Steel	High Risk	High Risk	High Risk	High Risk
Shipping	Moderate Risk	High Risk	High Risk	High Risk
Surface Transportation and Logistics	Moderate Risk	High Risk	High Risk	High Risk
Airlines	Moderate Risk	Moderate Risk	Moderate Risk	High Risk
Oil & Gas - Midstream Energy	Moderate Risk	Moderate Risk	Moderate Risk	High Risk
Oil & Gas - Oilfield Services	Moderate Risk	Moderate Risk	Moderate Risk	High Risk
Protein and Agriculture	Low Risk	Moderate Risk	Moderate Risk	High Risk

Our 2015 and 2018 heat maps referred to very high and high risk as elevated-immediate and elevated-emerging, respectively.
Source: Moody's Investors Service

Four sectors accounting for $765 billion in debt – airlines, midstream energy, oilfield services and protein and agriculture – have moved to high risk from moderate risk in 2020. The intensifying level of risk facing the protein and agriculture sector is particularly noteworthy because it was assessed as facing low risk in our 2015 environmental risks heat map. The sector is exposed to risks associated with deforestation, land use changes, water usage and potential changes in greenhouse gas regulation given its contribution to climate change.

Among the sectors that faced very high or high environmental credit risk in our 2020 heat map, only automotive suppliers declined to moderate credit risk, helped by less exposure to carbon transition risk than their automaker customers, customer diversity that helps mitigate risk exposure to any one automaker and the fact that many auto parts are used in both traditional combustion engines and alternative fuel vehicles. Two sectors – the beverage industry and semiconductors and technology hardware – moved to moderate risk from low risk. Beverage companies face rising exposure to natural capital considerations, which pose a risk to the availability of key ingredients. Makers of semiconductors and technology hardware face increasing exposure to carbon transition, water management and waste and pollution considerations related to their manufacturing processes. (For a complete list of sectors scored by level of overall environmental risk, see Appendix B.)

Environmental credit risk will continue to grow as the transition to a low-carbon economy proceeds apace and the adverse effects of physical climate change become more evident. Sectors with $8.3 trillion in rated debt have heightened exposure to climate risk, given their very high or high inherent exposure to carbon transition or physical climate risks (see Appendix A).

This is our first in-depth analysis of sector exposure to environmental risk – and our first update of total rated debt exposure – since the publication of our December 2020 environmental risk heat map. Since then, we have published four updates to our heat map to reflect changes in our assessment of the credit materiality of environmental risk by sector following periodic reviews. Unlike our ESG credit impact and issuer profile scores, our heat map does not differentiate the risk level of issuers within a given sector (or subsector), nor does it capture regional deviations within a sector. Still, it serves as a consistent starting point for a more granular evaluation of environmental considerations at an issuer level.

Our environmental risk classification

Environmental risks can arise from regulatory and policy issues, hazards or a combination of both. As shown in Exhibit 2, the five environmental categories we consider most material to credit are carbon transition, physical climate risks, water management, waste and pollution and natural capital. We identified these categories, which apply to both public and private-sector issuers, based on their alignment with evolving market standards and conventions (see Revised classification of environmental considerations reflects evolving standards).

Exhibit 2

Environmental considerations most relevant to credit quality

Carbon transition
- Current positioning for carbon transition
- Technology, market and policy risk
- Actions to mitigate risk
- Long-term resilience to risk of accelerated carbon transition

Physical climate risks
- Current and future effects of climate change
- Exposure to heat stress, water stress, floods, hurricanes, sea level rise and wildfires

Water management
- Non-climate-related risks
- Impact of economic activity
- Availability, access and consumption
- Innovations to enhance water use efficiency
- Risk of pollution-related regulatory violations

Waste and pollution
- Non-GHG air pollutants
- Land-based accidents, spills and leaks
- Hazardous and non-hazardous waste
- Circular economy

Natural capital
- Impact on natural systems (soil, biodiversity, forest, land, oceans, etc.)
- Dependency on goods and services derived from nature (agriculture, fiber, fish, etc.)

Source: Moody's Investors Service

Debt exposure to heightened environmental risks continues to increase as a share of total rated debt

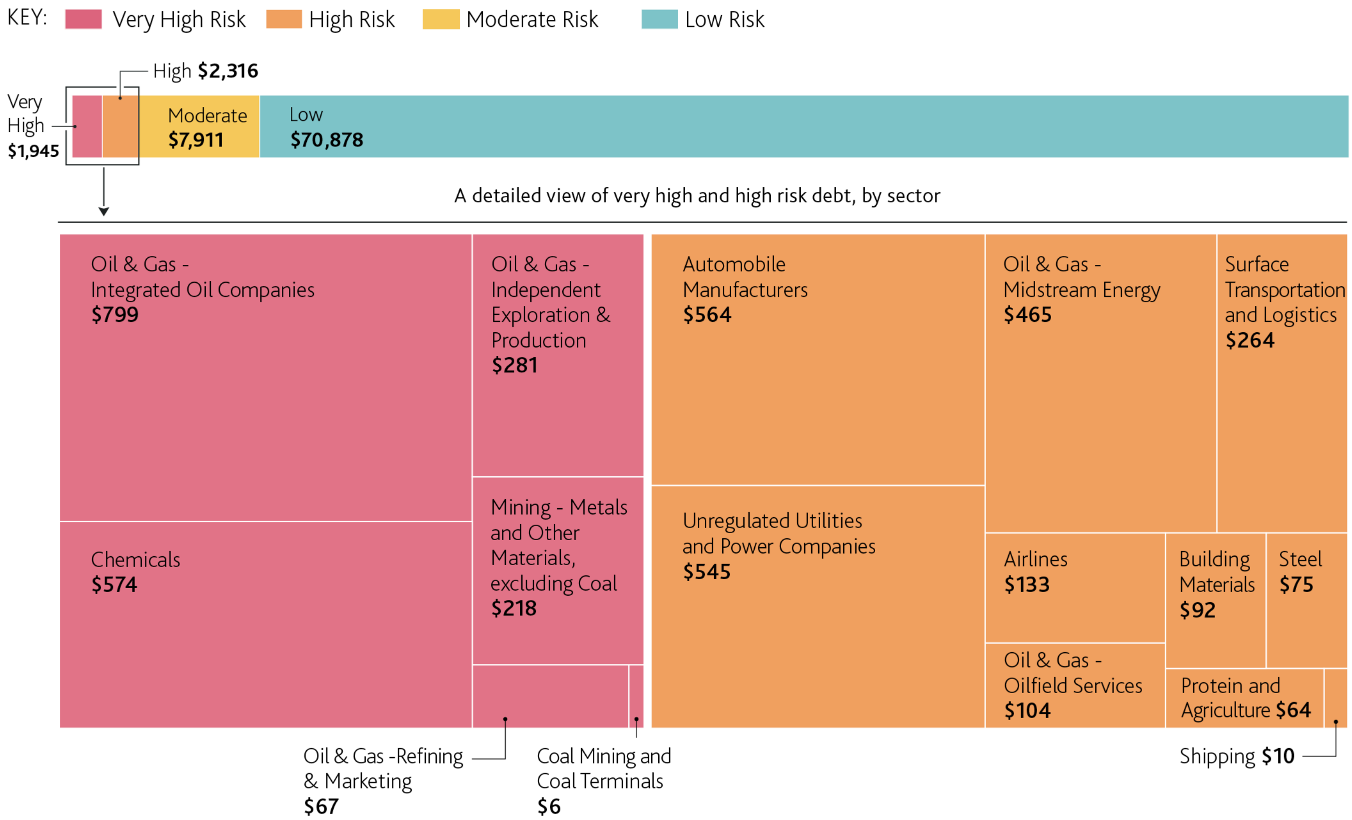
Sectors with very high or high environmental credit risk now account for 5.1% of total rated debt outstanding, up from 4.2% in 2020 and 3% in 2015 (these percentages are also subject to change based on fluctuations in debt issuance). As shown in Exhibit 3, six sectors – coal mining and coal terminals, chemicals, mining - metals and other materials excluding coal, independent E&P, integrated oil and gas, and refining and marketing – face very high credit risk from environmental considerations, indicating that environmental considerations are already pressuring issuer credit profiles or that these pressures are likely to emerge in the future. These sectors account for more than $1.9 trillion in rated debt, about two-thirds of which is held by integrated oil and gas and chemicals companies.

Ten sectors face high environmental credit risk, indicating that credit pressures from environmental considerations are also present or are likely to crystallise in the future, but are less influential for issuers' credit profiles than sectors scored as very high risk. These sectors account for about $2.3 trillion in rated debt, led by auto manufacturers, unregulated utilities and power companies and midstream energy companies.

Exhibit 3

Sixteen sectors with $4.3 trillion in rated debt face heightened credit risk from environmental considerations

Very high and high risk sectors in our environmental risk heat map sized relative to value of rated debt ($ billions)



Note: Risk levels as of the date of publication of this report
Source: Moody's Investors Service

Three oil and gas sectors, chemicals and metals and mining (excluding coal) have moved to very high risk in 2022 from high risk in 2020

Integrated oil and gas companies, chemicals, independent E&P, mining - metals and other materials, excluding coal and refining and marketing moved to very high risk from high risk in 2020.

Integrated oil and gas companies ($799 billion in rated debt) face a combination of upstream (E&P) and downstream (refining and marketing) operational and regulatory risks. Such companies have complex offshore drilling operations and are the most visible and scrutinised by industry participants. Substantial investment is needed over a number of years to adapt business models and transition to a low-carbon economy. Their upstream operations face increasing environmental regulation of their operations and restrictions on access to new resources. Their downstream operations face stricter regulation of fuel quality and content and air and water emissions from their refining facilities.

Independent E&P companies ($281 billion in rated debt) contend with the effects of increasing environmental regulations on their operations, as well as limitations on where they can explore for new resources. Regulations have gradually increased operational and investment costs in recent years. While we do not foresee meaningful product substitution in the near-to-medium term, carbon transition risk will reduce demand over the longer term through the increasing availability and adoption of alternative energy products.

The global **refining and marketing** industry ($67 billion in rated debt) has been subject to increasing environmental regulations and mandates that require companies to make substantial investments in their assets, often without compensation in the form of higher product prices. The trend toward stricter regulation of airborne and water emissions, as well as product specifications such as lower sulphur content, is likely to continue. Pressure to decarbonise the global economy is likely to dampen demand for refined products over the long term, which could pose an existential threat for some refiners.

Many companies in the **chemicals** sector ($574 billion in rated debt) utilise or create toxic/hazardous feedstocks, intermediates or by products during the production process. Increasingly stringent soil, air and water pollution regulations are likely to remain the key sources of environmental risk for the sector, but regulations and legal liability vary considerably from country to country.

For **mining - metals and other materials excluding coal** ($218 billion in rated debt), very high environmental risk is largely driven by the sector's very high inherent exposure to natural capital risk because of the physical degradation related to mining operations and risks relating to successful reclamation following the completion of mining-related activities. Inherent exposure to physical climate risks, water management and waste and pollution considerations is high.

Airlines, protein and agriculture, midstream energy and oilfield services have moved to high risk in 2022 from moderate risk in 2020

Future carbon emission regulations will increase the operating costs of **airlines** ($133 billion in rated debt), particularly on international routes. The extent of competition across an airline's international network will influence its ability to pass higher costs on to passengers.

Protein and agriculture sector's ($64 billion in rated debt) move to high risk from moderate risk in 2020 stands out because we had assessed it as facing low risk in 2015. The sector's inherent exposure to carbon transition and water management considerations has moved to high from moderate in 2020. The sector continues to have high inherent exposure to natural capital and physical climate risks, including deforestation, land use changes and potential changes in greenhouse gas regulation given its contribution to climate change.

Midstream energy and **oilfield services** face heightened exposure to carbon transition risk as economies pivot away from oil and natural gas and to waste and pollution considerations given the substantial financial liability they could face in the event of a catastrophic spill.

Assessing sector exposure to environmental risks: our approach

Our environmental risk heat map was developed by Moody's analytical teams and reviewed independently by our Credit Strategy and Standards and Environmental, Social and Governance groups. Our heat map provides a qualitative assessment of the overall credit materiality of environmental risks for each sector globally. We regard environmental risks as material if they result in visible pressure on the credit profiles of a broad set of issuers, either today or in the foreseeable future. In assigning an overall score, we considered a sector's exposure to environmental risks in their totality, as well as industrywide mitigants to these risks. Sector classifications are based on our rating methodologies and reflect only Moody's rated entities within a given sector.

To assess a sector's environmental credit risk, we first considered each sector's inherent (unmitigated) exposure to different categories of environmental risk and assigned a category score of very high, high, moderate or low to describe the sector's exposure to each risk category. We then took these category scores and any applicable sectorwide mitigating factors into consideration to assign an overall environmental risk credit score to each sector: very high risk, high risk, moderate risk or low risk (see Exhibit 4).

Exhibit 4

Our environmental risk scoring definitions

Overall Sector Environmental Risk Scoring

Our overall scores provide a qualitative assessment of the credit materiality of environmental risks for 89 sectors globally. In this context, we regard environmental risks as material if they result in visible pressure on the credit profiles of a broad set of issuers, either today or in the foreseeable future. In assigning a score, we consider a sector's exposure to environmental risks I their totality, as well as sector-wide mitigants to these risks.

VERY HIGH RISK	For sectors scored red overall, the credit materiality of environmental risks is considered "very high risk". As such, material pressures from environmental risks are visible for issuers' credit profiles currently, or there is a very high likelihood that these will crystallise in the future. There is also limited scope for most issuers to adjust to or manage these risks in the near term without major structural, financial and/or policy realignment.
HIGH RISK	For sectors scored orange overall, the credit materiality of environmental risks is considered "high risk". As such, credit pressures from environmental risks are present, or are likely to crystallise in the future, but are less influential for issuers' credit profiles compared to sectors scored red. There is also typically greater scope for issuers to adjust to or manage environmental risks; for example, by adapting business models, changing policies (in the case of governments), or by passing on expected cost increases to customers or taxpayers.
MODERATE RISK	For sectors scored yellow overall, the credit materiality of environmental risks is considered "moderate risk". As such, credit pressures from environmental risks are less pronounced, or are less likely to develop in a way that is influential in the future compared with sectors scored orange. Sectors have inherent exposure to one or more environmental risks, but there is a reasonable expectation that most issuers can adapt to or manage these risks over the medium term in a way that substantially mitigates the overall impact on credit quality.
LOW RISK	For sectors scored blue overall, the credit materiality of environmental risks is considered "low risk". As such, there is little pressure on issuers' credit profiles currently, and a low likelihood that they will manifest in the future. Low risk sectors may have some exposure to one or more environmental risks, but there is significant scope to adjust or manage these risks. Remediation is generally routine, costs can easily be passed along to customers or taxpayers, and/or regulations are unlikely to become meaningfully stricter over the foreseeable future.

ENVIRONMENTAL RISKS

Carbon transition | Physical climate risks | Water management | Waste and pollution | Natural capital

Source: Moody's Investors Service

The debt amounts referred to in this report represent the total face amount of debt publicly rated by Moody's in each sector as of June 2022. They include both long-term obligations and commercial paper. We allocate debt instruments to sectors on the basis of the primary methodology/methodologies used in the rating process. For debt rated under multiple methodologies that fall within different sectors, we evenly distribute the face amount to each sector accordingly.

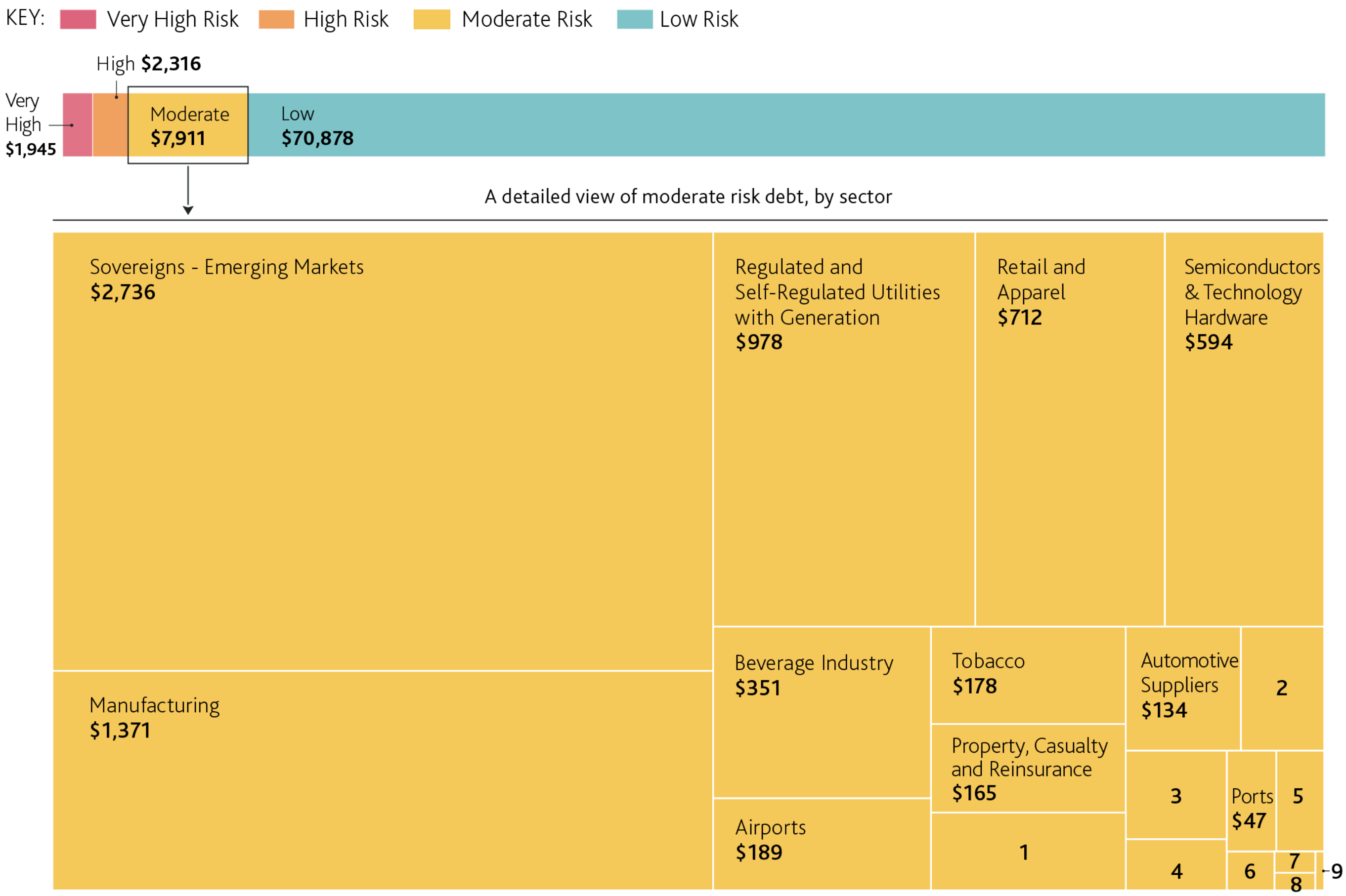
Twenty sectors with $7.9 trillion in rated debt face moderate environmental credit risk

We have identified 20 sectors, with $7.9 trillion in rated debt, whose credit quality is at moderate risk from environmental issues (see Exhibit 5). Compared with sectors with heightened risk, credit pressures from environmental risks are less pronounced or are less likely to develop in a way that will hurt credit quality. Moderate-risk sectors have inherent exposure to one or more environmental risks, but there is a reasonable expectation that most issuers can manage or adapt to these risks in a way that substantially mitigates the overall impact on credit quality.

Exhibit 5

Environmental considerations pose a moderate risk to the credit quality of 20 sectors

Moderate risk sectors in our environmental risk heat map sized relative to value of rated debt ($ billions)



1. Packaging Manufacturers: Metal, Glass, and Plastics **$143**
2. Environmental Services and Waste Management **$98**
3. Paper and Forest Products **$84**
4. Power Generation Projects **$50**
5. Equipment and Transportation Rentals **$45**
6. Regional and Local Governments - Emerging Markets **$17**
7. Asset Backed Securities - Aircraft **$8**
8. Collateralised Debt and Loan Obligations -Project Finance and Infrastructure Assets **$7**
9. Asset Backed Securities - Tobacco Settlement **$3**

Note: Risk levels as of the date of publication of this report
Source: Moody's Investors Service

The three largest sectors by total debt outstanding with moderate credit risk are **emerging market sovereigns** ($2.7 trillion of rated debt), **manufacturing companies** ($1.4 trillion in rated debt) and **regulated and self-regulated utilities with generation** ($978 billion in rated debt). Environmental risks do not pose a material credit burden to advanced economy sovereigns as they do to their emerging market counterparts. Although environmental factors may have an adverse impact on quality-of-life issues and other concerns, advanced economies typically have the financial resources and governance capacity to facilitate the transition to a low-carbon future and to mitigate the impact of, or reduce exposure to, physical climate risks.

Semiconductors and technology hardware ($594 billion in rated debt) and the **beverage industry** ($351 billion in rated debt), both moved to moderate from low environmental credit in our 2020 heat map. Semiconductor and technology companies face exposure to physical climate risk inherent in large manufacturing operations that include supply chains and physical assets across the globe; to carbon transition and water management risks because of the water- and energy-intensive production process of semiconductor chip manufacturing and the assembly and test process; and to waste and pollution risks because of the hazardous byproducts produced by the manufacturing process and the long-term hazards posed by electronics waste. Natural capital considerations are a growing risk for beverage companies, particularly alcoholic-beverage producers, which rely on specific ingredients, some of which are difficult to obtain or substitute.

Environmental considerations pose low risk to the credit quality of most sectors

For the remaining 53 sectors, representing $71.0 trillion in rated debt, the overall credit risk materiality of environmental risks is low. These sectors include **advanced economy sovereigns** ($31.7 trillion in rated debt) and **banks** ($13.0 trillion in rated debt).

There are typically four main reasons why sectors are scored low credit risk:

» They have fundamentally low business exposure to environmental risks. Most of the 53 sectors facing low environmental credit risk fall into this category. The media and broadcasting sector has a small carbon footprint and major publishing and printing companies have transitioned to digital offerings, resulting in declining exposure to environmental risks related to paper products. Telecommunication companies may face physical climate risk, but diversified operators can reallocate resources and restore services.

» The diversity and flexibility of their business mitigates the environmental risks they may face. Environmental risks to banks are indirect, undertaken through financing clients' operations. Such risk exposure is unlikely to translate into a significant credit impact because banks companies typically benefit from portfolio diversification and lending is typically short to medium term. This provides these entities with the flexibility to shift the composition of their portfolio away from clients highly exposed to environmental risks. For structured finance transactions, these mitigants include structural mitigants such as subordination, reserve funds and over-collateralisation.

» They have the economic, policy or financial flexibility to adapt to environmental risks they cannot avoid. While climate change is a global phenomenon, advanced economy sovereigns and regional and local governments typically have ample financial resources, economic resilience and institutional capacity to deal with the potential credit implications of climate risk.

» They are positioned to benefit from emerging environmental trends. For example, the overall credit risk materiality of environmental risks for the mass transit sector is low because mass transit is an energy-efficient mode of transportation whose ridership is likely to increase as government policies and public preference shift away from carbon-intensive travel.

Breakdown of sectors with heightened inherent exposure to individual environmental risk categories

The degree of inherent exposure to the environmental risk categories of carbon transition, physical climate risks, waste and pollution, natural capital and water management varies widely by sector. Sectors with heightened exposure to these risks face specific challenges in terms of regulatory and policy issues, environmental hazards, or a combination of both.

While some sectors may face inherent exposure to specific environmental risks, sector-wide mitigants can limit their overall environmental credit risk to moderate or low. For instance, while all power producers face high inherent exposure to carbon transition, physical climate and waste and pollution risks, regulated companies face a lower level of overall environmental credit risk than their unregulated counterparts because they have the ability to recover related costs under their respective regulatory frameworks.

Our environmental categories are not mutually exclusive. For example, water risks, such as reduced or excess supply, can be exacerbated by the impact of physical climate risks, such as declining precipitation or flooding. Waste discharges can pollute water supplies, inhibit usage and endanger the health of the local population. Deforestation can lead to the loss of natural capital by damaging the ecosystem and accelerate global warming by releasing previously sequestered carbon dioxide.

Environmental considerations also increasingly influence consumer preferences and hence market demand for a company's products and services. Below we identify the sectors with heightened exposure to the five risk categories of our environmental classification.

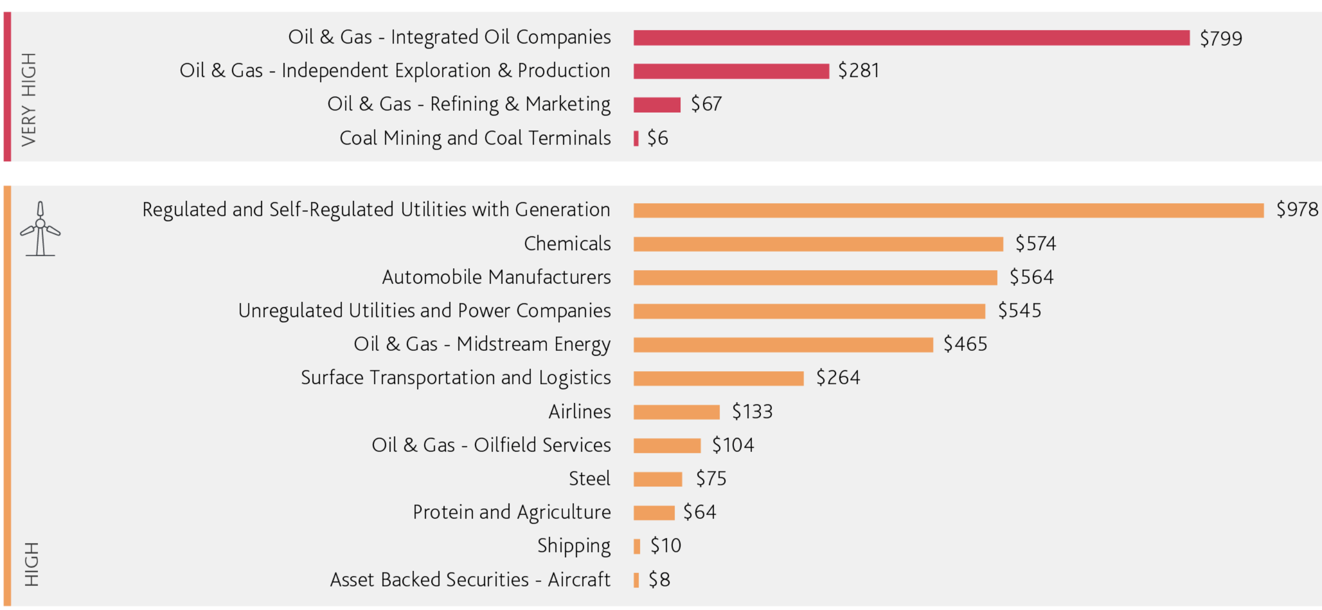
Sixteen sectors with $4.9 trillion in rated debt have very high or high inherent exposure to carbon transition risk amid stricter emissions regulation and the expanding availability of low-carbon alternatives

Amid signs of an acceleration in the transition to a low-carbon economy, we have identified 16 sectors with $4.9 trillion in rated debt that are exposed to very high or high carbon transition risk, up from $4.5 trillion in 2020 and $3.2 trillion in 2015. These sectors include oil and gas, regulated and unregulated electric utilities, automotive manufacturers, chemicals, steel, shipping and airlines (see Exhibit 6).

Exhibit 6

Oil and gas sectors and coal mining and coal terminals are the most exposed

Sectors with very high or high inherent exposure to carbon transition risk (rated debt in $ billions)



Source: Moody's Investors Service

Integrated oil companies and refining and marketing sectors move to very high exposure in this category from high risk in our 2020 heat map, driven mainly by limitations on where they can explore for new resources and the increasing availability and adoption of alternative energy products. Other large sectors that face heightened inherent carbon exposure risks include automobile manufacturers and regulated and unregulated utilities with generation.

Russia's invasion of Ukraine (Caa3 negative), will likely slow near-term efforts to cut carbon emissions, especially in Europe, as economic imperatives spur many countries to prioritise energy security and affordability over decarbonisation (see Energy security needs will slow emissions reductions, but long-term targets still intact). However, increasingly ambitious national and corporate climate commitments and the long-term drive to reduce dependence on fossil fuels will ensure that plans to reduce carbon emissions will remain intact. And the credit implications of this temporary loss of momentum are likely to be limited.

Fourteen sectors with $6.4 trillion in rated debt have high inherent exposure to physical climate risks; this exceeds the debt held by sectors with heightened exposure to any other environmental risk category, reflecting the pervasive, broad-based nature of this risk

Fourteen sectors with a collective $6.4 trillion in rated debt have high exposure to physical climate risks, down from 18 sectors with $7.2 trillion in rated debt in 2020. Physical climate risk is particularly acute among sectors with fixed assets in locations with exposure to climate change, heat stress, water stress and flooding, which can lead to operational and supply chain disruptions and hurt asset values. Out of the fourteen sectors that have high inherent exposure to physical climate risks, seven have very high or high environmental credit risk, while the rest are scored as having moderate credit risk (see Exhibit 7).

The physical effects of climate change are manifesting themselves through the increased frequency and severity of extreme weather events (see Physical climate risk assessment: so much more than geographic location). According to the NASA Goddard Institute for Space Studies' Global Land Ocean Temperature Index, 2016 and 2020 were the warmest years on record. Rising global mean temperatures can contribute to more extreme weather events, including heat waves and cyclones.

Exhibit 7

Inherent exposure to physical climate risk is high across multiple industries

Distribution of the five risk categories scores of sectors with high exposure to physical climate risk

KEY: Very High Risk, High Risk, Moderate Risk, Low Risk

Sector	Overall Sector Risk Score	Carbon transition	Physical climate risks	Water management	Waste and pollution	Natural capital
Chemicals	Very High Risk	High Risk	High Risk	Moderate Risk	Very High Risk	Moderate Risk
Coal Mining and Coal Terminals	Very High Risk	Very High Risk	High Risk	High Risk	Very High Risk	High Risk
Environmental Services and Waste Management	Moderate Risk	Moderate Risk	High Risk	Moderate Risk	Moderate Risk	High Risk
Mining - Metals and Other Materials, excluding Coal	Very High Risk	Moderate Risk	High Risk	High Risk	High Risk	Very High Risk
Oil & Gas - Integrated Oil Companies	Very High Risk	Very High Risk	High Risk	High Risk	High Risk	High Risk
Oil & Gas - Refining & Marketing	Very High Risk	Very High Risk	High Risk	High Risk	Very High Risk	Moderate Risk
Ports	Moderate Risk	Moderate Risk	High Risk	Low Risk	Moderate Risk	Moderate Risk
Power Generation Projects	Moderate Risk	Moderate Risk	High Risk	Moderate Risk	Moderate Risk	Moderate Risk
Property, Casualty and Reinsurance	Moderate Risk	Low Risk	High Risk	Low Risk	Low Risk	Low Risk
Protein and Agriculture	High Risk	High Risk	High Risk	High Risk	Moderate Risk	High Risk
Regional and Local Governments - Emerging Markets	Moderate Risk	Low Risk	High Risk	High Risk	Low Risk	Low Risk
Regulated and Self-Regulated Utilities with Generation	Moderate Risk	High Risk	High Risk	Moderate Risk	High Risk	Moderate Risk
Sovereigns - Emerging Markets	Moderate Risk	Moderate Risk	High Risk	Moderate Risk	Low Risk	Moderate Risk
Unregulated Utilities and Power Companies	High Risk	High Risk	High Risk	Moderate Risk	High Risk	Moderate Risk

Source: Moody's Investors Service

The increased frequency and severity of extreme weather events are causing significant economic losses, hazards for the local population and environmental damage. Further, long-term patterns of climate change such as rising temperatures, the changing frequency and intensity of precipitation and rising sea levels can also affect companies' operations, supply chains and asset values, becoming increasingly material credit considerations.

The largest sectors in terms of rated debt with high exposure include emerging market sovereigns, regulated and self-regulated utilities with generation and integrated oil and gas companies. Total debt exposure decreased because of lower debt issuance in some sectors in 2022. For example, emerging markets sovereign debt issuance was $3.1 trillion in 2020, versus $2.7 trillion in 2022. Furthermore, rated debt exposure declined as **shipping** ($9.7 billion in rated debt), **midstream energy** ($465 billion in rated debt) and **oilfield services** ($104 billion in rated debt) moved to moderate inherent exposure from high exposure. While extreme weather poses risks for ports, they tend to cause temporary delays for shipping companies rather than significant, lasting disruptions. Midstream and oilfield services companies generally have limited geographic concentration of assets, which in some cases are also portable or situated underground, limiting their vulnerability to severe weather events.

Fourteen sectors with $4.4 trillion in rated debt have very high or high inherent exposure to waste and pollution risk amid tightening regulation of plastic packaging and chemical waste

Fourteen sectors with $4.4 trillion in rated debt have very high or high inherent exposure to waste and pollution risk, down from 18 sectors with $5.2 trillion in rated debt in 2020. This environmental risk encompasses air pollutants, hazardous and nonhazardous waste and accidents (such as spills, leaks and related incidents). As shown in Exhibit 8, these sectors include oil and gas, chemicals, coal mining and coal terminals, regulated electric utilities and packaging manufacturers.

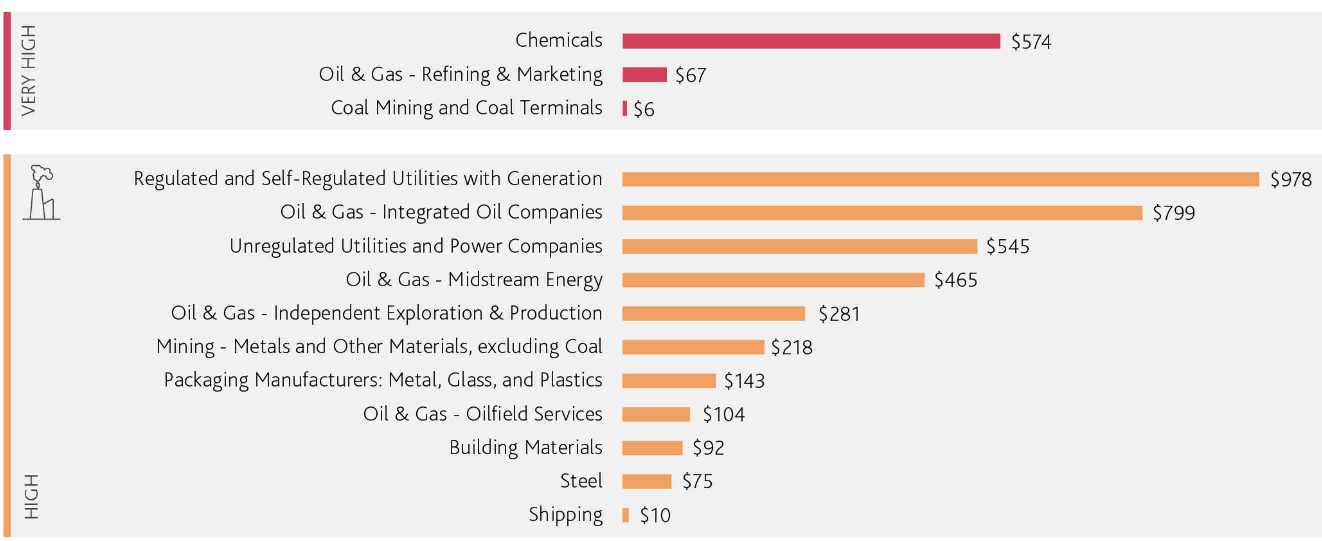
Waste and pollution considerations include the intentional or accidental release of air pollutants and hazardous or nonhazardous waste and the growing pressure to address "circular economy" issues. For example, the World Bank warns that global waste will surge 70% by 2050 (from a 2016 base) without urgent action. This will likely increase market and policy pressure on companies to become more circular in their operations – such as by improving production efficiency, creating more durable goods, encouraging circular partnerships and ramping up recycling efforts.

The decline in rated debt and the number of sectors with heightened exposure to waste and pollution risk was driven by our reassessment of relative sector exposures and our consolidation of specialty chemicals and commodity chemicals into one sector. Sectors no longer deemed to have heightened exposure include airlines, auto manufacturers and surface transportation and logistics.

Exhibit 8

Oil and gas sectors, chemicals and mining among the most exposed

Sectors with very high or high inherent exposure to waste and pollution risk (rated debt in $ billions)



Source: Moody's Investors Service

Nine sectors with very high or high inherent exposure to natural capital risk hold $1.7 trillion in rated debt, more than twice the debt exposure in 2020, reflecting the increasing prominence of biodiversity, ecosystem health and natural resource management in policy and investor agendas

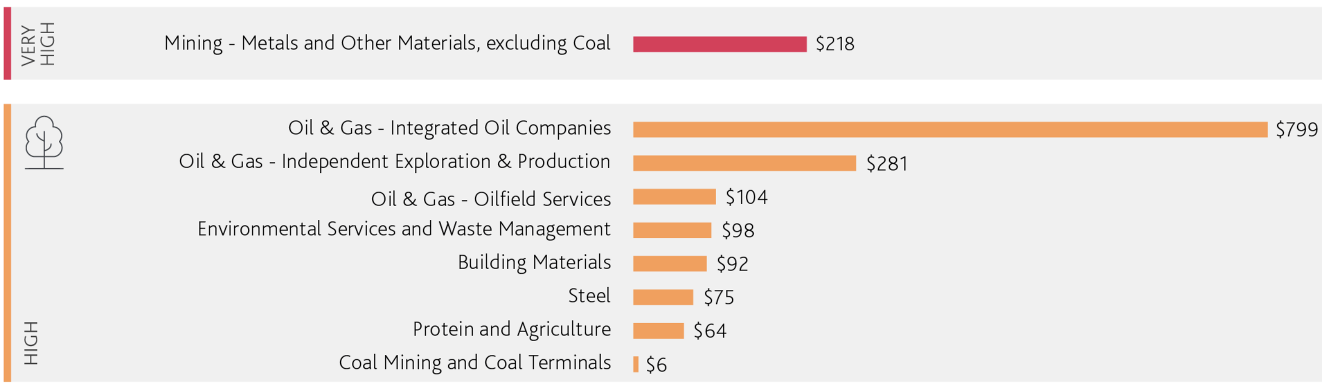
Nine sectors with $1.7 trillion in rated debt have very high or high inherent exposure to risks related to natural capital, up from eight sectors with $747 billion in rated debt in 2020. Natural capital risk refers to assets provided by nature that are essential for human habitation and economic activity. These sectors include mining, some oil and gas subsectors, environmental services and waste management, building materials, steel and protein and agriculture, as shown in Exhibit 9.

The rise in debt exposure stems largely from integrated oil and gas companies, independent exploration and production and oilfield services moving to high inherent exposure from moderate. The move effectively aligns our assessment of natural capital exposure across all extractive industries. These industries may cause damage to natural systems that can lead to material financial costs for these companies, as well as consumer backlash (see FAQ on the credit implications of natural capital).

Exhibit 9

Metals and mining is the most exposed sector

Sectors with very high or high inherent exposure to natural capital (rated debt in $ billions)



Source: Moody's Investors Service

Natural capital risk is driven by two dynamics – the damage that companies, governments and other entities cause to natural systems, which can lead to loss of revenue, consumer backlash or regulatory penalties; and the dependency of these entities on ecosystem services (i.e., goods and materials) that are derived from the natural world, such as agricultural products, pulp and paper, fisheries, ecotourism and raw materials. The loss of natural resources can impact economic and health outcomes, or in a more extreme scenario, fuel socioeconomic instability in countries or regions where natural capital is a significant source of income.

Eight sectors with very high or high inherent exposure to water management risk account for $1.9 trillion in rated debt, about double the debt exposure in 2020, reflecting growing regulatory compliance costs and mounting pressure on supplies

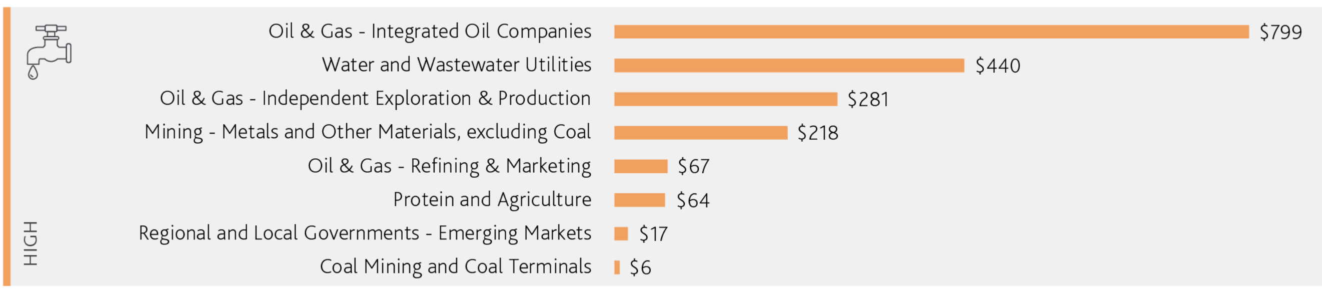
Eight sectors with $1.9 trillion in rated debt have very high or high inherent exposure to water management risks, up from six sectors with $925 billion in rated debt in 2020. This risk which encompass non-climate-related issues associated with water, including water availability, consumption, efficiency of use, access, quality, treatment, pollution, innovation, regulation and mispricing. These sectors, are mainly water-intensive private sectors include mining, protein and agriculture and integrated oil and gas, as shown in Exhibit 10.

Population growth, improved living standards, industrial growth, urbanisation and changing consumption patterns can heighten water stress for regional and local governments. The risk is particularly acute in emerging-market urban areas. Urbanisation increases water consumption by providing access to piped water, showers, washing machines and dishwashers. Economic development and improving living standards lead to other changes in consumption as well, including a transition from mainly plant-based, low water-intensity diets to more water-intensive protein-based diets.

Exhibit 10

Oil and gas sectors, water and wastewater utilities and metals and mining are the most exposed

Sectors with very high or high inherent exposure to water management risk (rated debt in $ billions)



Source: Moody's Investors Service

The rise in rated debt and the number of sectors with heightened exposure to water management considerations was driven in part by substantial investments needed in the independent E&P and integrated oil and gas sectors to comply with increasing environmental regulation of water issues, moving these sectors to high inherent exposure from moderate.

Appendix A: Sectors with heightened climate risk exposure

We see climate risk as an increasingly material credit risk to be assessed and considered in our credit ratings. Exhibit 11 shows the rated debt held by sectors that we have identified as having very high or high inherent exposure to carbon transition or physical climate risks. Debt held by sectors with heightened exposure to both risk categories is counted only once.

Exhibit 11

Sectors with $8.3 trillion in rated debt have heightened exposure to climate risk

Rated debt of sectors with very high or high exposure to carbon transition or physical climate risks ($ billions)

KEY: Very High Risk High Risk

Sector	Carbon transition	Rated debt ($ billion)	Physical climate risks	Rated debt ($ billion)	Debt exposed to heightened climate risk
Airlines	High Risk	$133			$133
Asset Backed Securities - Aircraft	High Risk	$8			$8
Automobile Manufacturers	High Risk	$564			$564
Chemicals	High Risk	$574	High Risk	$574	$574
Coal Mining and Coal Terminals	Very High Risk	$6	High Risk	$6	$6
Environmental Services and Waste Management			High Risk	$98	$98
Mining - Metals and Other Materials, excluding Coal			High Risk	$218	$218
Oil & Gas - Integrated Oil Companies	Very High Risk	$799	High Risk	$799	$799
Oil & Gas - Independent Exploration & Production	Very High Risk	$281			$281
Oil & Gas - Midstream Energy	High Risk	$465			$465
Oil & Gas - Oilfield Services	High Risk	$104			$104
Oil & Gas - Refining & Marketing	Very High Risk	$67	High Risk	$67	$67
Ports			High Risk	$47	$47
Power Generation Projects			High Risk	$50	$50
Property, Casualty and Reinsurance			High Risk	$165	$165
Protein and Agriculture	High Risk	$64	High Risk	$64	$64
Regional and Local Governments - Emerging Markets			High Risk	$17	$17
Regulated and Self-Regulated Utilities with Generation	High Risk	$978	High Risk	$978	$978
Shipping	High Risk	$10			$10
Sovereigns - Emerging Markets			High Risk	$2,736	$2,736
Steel	High Risk	$75			$75
Surface Transportation and Logistics	High Risk	$264			$264
Unregulated Utilities and Power Companies	High Risk	$545	High Risk	$545	$545
Total debt exposed to heightened climate risk					**$8,268**

Note: Heightened refers to sectors with very high or high inherent risk exposure

Source: Moody's Investors Service

Appendix B: Environmental risk heat map

Exhibit 12
Overall environmental risk scores for sectors

KEY: Very High Risk, High Risk, Moderate Risk, Low Risk

Sector	Overall Environmental Risk Score
Airlines	High Risk
Airports	Moderate Risk
Asset Backed Securities - Aircraft	Moderate Risk
Asset Backed Securities - Auto Loans, Auto Leases, Floorplan, Car & Truck Rental	Low Risk
Asset Backed Securities - Credit Cards	Low Risk
Asset Backed Securities - Equipment Leases and Loans	Low Risk
Asset Backed Securities - Other (Solar)	Low Risk
Asset Backed Securities - Personal Loans	Low Risk
Asset Backed Securities - Railcar Leasing	Low Risk
Asset Backed Securities - Small and Medium Enterprises	Low Risk
Asset Backed Securities - Student Loans	Low Risk
Asset Backed Securities - Tobacco Settlement	Moderate Risk
Asset Backed Securities - Utility Cost Recovery Charges	Low Risk
Asset Backed Securities - Wireless Towers	Low Risk
Asset Managers	Low Risk
Asset-Backed Commercial Paper	Low Risk
Automobile Manufacturers	High Risk
Automotive Suppliers	Moderate Risk
Banks	Low Risk
Beverage Industry	Moderate Risk
Building Materials	High Risk
Business and Consumer Services	Low Risk
Chemicals	Very High Risk
Coal Mining and Coal Terminals	Very High Risk
Collateralised Debt and Loan Obligations - Project Finance and Infrastructure Assets	Moderate Risk
Collateralised Loan and Bond Obligations	Low Risk
Commercial Mortgage Backed Securities	Low Risk
Construction	Low Risk
Consumer Goods	Low Risk
Covered Bonds	Low Risk
Distribution and Supply Chain Services	Low Risk
Education and Not-for-Profits	Low Risk
Electric and Gas Transmission and Distribution	Low Risk
Environmental Services and Waste Management	Moderate Risk
Equipment and Transportation Rentals	Moderate Risk
Finance Companies	Low Risk
Gaming and Gambling Industry	Low Risk
Health Insurance Companies	Low Risk
Healthcare Services - Acute Care and Specialty Services	Low Risk
Homebuilding and Property Development	Low Risk
Insurance Brokers and Service Companies	Low Risk
Life Insurance	Low Risk
Manufacturing	Moderate Risk
Mass Transit	Low Risk
Media & Entertainment	Low Risk
Medical Products and Devices	Low Risk
Mining - Metals and Other Materials, excluding Coal	Very High Risk
Mortgage Insurance	Low Risk
Multilateral Development Banks	Low Risk
Not for Profit Hospitals	Low Risk
Oil & Gas - Independent Exploration & Production	Very High Risk
Oil & Gas - Integrated Oil Companies	Very High Risk
Oil & Gas - Midstream Energy	High Risk
Oil & Gas - Oilfield Services	High Risk
Oil & Gas - Refining & Marketing	Very High Risk
Packaging Manufacturers: Metal, Glass, and Plastics	Moderate Risk
Paper and Forest Products	Moderate Risk
Passenger Railways	Low Risk
Pension Funds	Low Risk
Pharmaceuticals	Low Risk
Ports	Moderate Risk
Power Generation Projects	Moderate Risk
Privately Financed Public Infrastructure Projects (PPPs)	Low Risk
Property, Casualty and Reinsurance	Moderate Risk
Protein and Agriculture	High Risk
Public Sector Housing	Low Risk
Publishing	Low Risk
Real Estate Trusts & Other Commercial Property Firms	Low Risk
Regional and Local Governments - Advanced Economies	Low Risk
Regional and Local Governments - Emerging Markets	Moderate Risk
Regulated and Self-Regulated Utilities with Generation	Moderate Risk
Residential Mortgage Backed Securities	Low Risk
Restaurants	Low Risk
Retail and Apparel	Moderate Risk
Securities Firms and Market Infrastructure Providers	Low Risk
Semiconductors & Technology Hardware	Moderate Risk
Shipping	High Risk
Sovereigns - Advanced Economies	Low Risk
Sovereigns - Emerging Markets	Moderate Risk
Steel	High Risk
Surface Transportation and Logistics	High Risk
Technology Services and Software	Low Risk
Telecommunications	Low Risk
Title and Trade Credit Insurance	Low Risk
Tobacco	Moderate Risk
Toll Roads	Low Risk
Trading Companies	Low Risk
Unregulated Utilities and Power Companies	High Risk
Water and Wastewater Utilities	Low Risk

Note: Risk levels as of the date of publication of this report
Source: Moody's Investors Service

Moody's related publications

Assessment Frameworks

» For a complete list of our carbon transition assessment frameworks and scoring reports, click here.

Sector research

» Emerging Markets – Global: Sovereigns' readiness for a "just transition" varies, as does associated credit impact, 20 October 2022

» Environmental Risks – Global: Climate-adaptation plans are critical, but demonstrating effectiveness and accessing funding are key barriers, 20 October 2022

» Carbon Transition – Global: Green hydrogen may help carbon transition, but implementation risks are high, 10 October 2022

» Carbon transition and physical climate risks shape corporates' credit profiles - Infographic, 3 October 2022

» Carbon Transition – Southeast Asia: Commodity reliance challenges transition, while regional cooperation supports green finance potential, 3 October 2022

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» Environmental Risks – Latin America & Caribbean: Physical climate risks highest for energy and extractive sectors, lower for banks, 15 September 2022

» Power – Korea: Rebalancing of power mix and support are key for coal-driven power companies, 15 September 2022

» Environmental Risks – Global: Physical climate risk assessment: so much more than geographic location, 13 September 2022

» Carbon Transition - UK: Buildings, utilities and autos are most exposed to the UK's net-zero strategy, 11 May 2022

» Cross- Sector - Global: Are emerging market companies ready for carbon transition? (Slides), 11 May 2022

» Coal Mining - Indonesia: Diversification is inevitable because of increasing risks associated with thermal coal, 25 April 2022

» Carbon Transition - Europe: Energy security needs will slow emissions reductions, but long-term targets still intact, 21 April 2022

» Chemicals - North America: Producers raise climate goals and efforts amid heightened carbon transition risks, 18 April 2022

» ESG - Global: Credit impact of urban flood adaption costs offset by reduction in long-term risks, 13 April 2022

» Financial Institutions - Global: ISSB's proposed climate disclosures add momentum for improving climate risk data, 12 April 2022

» ESG - US: SEC's proposed climate-risk disclosures will benefit investors, but implementation will be challenging, 28 March 2022

» ESG - Asia Pacific: Carbon transition, natural capital risks will pose uneven credit challenges in 2022, 10 March 2022

» Sovereigns – Hydrocarbon exporters: Strengthening global commitment to carbon transition increases longer-term credit risks, 11 January 2022

» Financial Institutions – Global: Financial firms' rising climate commitments will support accelerated carbon transition, 18 November 2021

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» Sovereigns – Global: Water management risks curb economic strength in South Asia, Middle East, Africa, may create wider long-term pressures, 4 August 2021

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