In collaboration with Accenture

World Economic Forum

Business on the Edge: Building Industry Resilience to Climate Hazards

INSIGHT REPORT

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A stroke can change the course of a lifetime and hits in less than a minute. In geological terms, the last 100 years is equivalent to a single minute in an average human lifetime. The "stroke" that has hit our planet has heated, polluted and destabilized Earth systems on which our economies and societies depend. Earth's coldest climates are transforming rapidly due to atmospheric heating, with global implications. Polar, glacial and ocean destabilization are cascading risk in the form of climate hazards from extreme weather to deadly heatwaves, droughts and floods.

As with any stroke patient, our planet requires emergency care delivered with evidence-based accuracy. The urgency and quality of our response today will determine the immediate and long-term outlooks for economic, social and planetary stability. It may well determine human survivability too. Short-term global temperatures have breached the 1.5°C warming limit for the first time, a critical threshold outlined both in the Paris Agreement and by Earth system scientists. This is a physical boundary beyond which we exit a safe operating space, not a political target to be negotiated.

Despite ardent efforts from companies such as those in the Alliance of CEO Climate Leaders, who recently reported a 10% reduction in aggregate absolute emissions[1] from 2019 to 2022, global emissions trajectories are not slowing down. In December 2024, the Alliance published *The Cost of Inaction: A CEO Guide to Navigating Climate Risk* highlighting that businesses tend to underestimate the financial impact of inaction in the face of physical and transition risk and showcasing the imperative for action from CEOs. Indeed, corporates will increasingly grapple with significant balance sheet costs and supply chain disruptions that inhibit their ability to function as they have in the past. Corporate leaders will simultaneously need to deliver on rapid decarbonization together with bold civic, political and economic collaboration to support societal and economic resilience and adaptation on a global scale.

Companies are in a unique position to lead the transition to net zero alongside the development of more robust and resilient economies. Investors, consumers and the communities they serve will ultimately reward them for it. An effective response to the nature and climate crisis is in the best interests of far-sighted corporates and the societies in which they operate. Enabled by sound government policy, corporate resilience benefits from close collaboration with experts, local innovators, communities, youth and Indigenous Peoples. These individuals and groups are at the forefront of this crisis and have precious local understanding to support cost-effective and locally tailored solutions.

Companies that fail to build resilience stand to lose their ability to compete, as the consequences of the crisis shift markets and fracture supply chains, degrading and stranding physical infrastructure and compromising lives and livelihoods.

This report is the first of its kind and is mandatory reading for business leaders, boards, risk experts, strategists and investors seeking to understand emerging supply chain risks and best-in-class responses. It builds a bridge between the latest scientific evidence and the direct implications on business costs, supply chain risk and societal disruption. We outline clear actions to safeguard revenue, reduce maintenance and operating costs and protect workforces and local communities while supporting the ecosystems on which our economies and societies depend.

The report builds on the findings of the World Economic Forum's January 2023 white paper, *Accelerating Business Action on Climate Change Adaptation*, and its climate adaptation framework[2] to enhance resilience, capitalize on opportunities and shape collaborative outcomes.

Executive summary

The nature and climate crisis poses a growing threat to business profitability, supply chains and societal stability. This report shows how business leaders can adapt and build resilience.

Fixed asset losses across listed companies by 2035 equate to a drop of 6.6-7.3% in average company earnings every year.

Companies are grappling with the implications of the nature and climate crisis. As tangible business risks rise, they need to make better-informed decisions that safeguard corporate supply chains and secure industries and societies. The stakes are high: a recent study suggests that emissions already in the atmosphere today will lower global GDP per capita by between 11% and 29% by 2050.[3] But where should business leaders and investors focus their attention and resources today?

The urgency to decarbonize is clear. However, to date, little work has been done to connect climate science with even more immediate business risks and the pressing need for resilience and adaptation.[4] This report fills that gap - offering a tangible assessment of climate hazards (specifically extreme heat, wildfires, drought, water stress, tropical cyclones, coastal flooding and fluvial flooding) and the risks they pose to companies' fixed assets (property, plant and equipment) across 20 industries globally. Economies and societies are dependent on these assets to generate returns and drive societal value.

The headlines are stark. Climate hazards could drive $560-610 billion of fixed asset losses per year across listed companies by 2035, depending on the emissions scenario, rising as high as $1.1 trillion by 2055.[5] Without evidence-based resilience strategies, this equates to a drop of between 6.6% and 7.3% in average company earnings every year by 2035.[6] As a comparator, S&P 500 profit margins declined by 15.3% during the depths of the Covid-19 pandemic but quickly recovered thanks to significant government investment and policy interventions.[7] By contrast, recurring annual losses on the scale identified in this report would cause performance shocks that would become increasingly challenging to safeguard against through insurance and offsets. Associated impacts could include lower company valuations, disruption to the financial systems we rely on for trade and investment and ultimately, reduced global social and economic prosperity.

TABLE 1 **Summary of estimated annual fixed asset losses**

Emissions scenario	Total estimated annual fixed asset losses ($ billion, all companies) – Low	Total estimated annual fixed asset losses ($ billion, all companies) – High	Annual fixed asset losses (% EBITA, average per company) – Low	Annual fixed asset losses (% EBITA, average per company) – High
2035	560	610	6.6	7.3
2045	680	850	8.1	10.1
2055	830	1,070	9.9	12.8

Sources: S&P Global Sustainable1, Accenture analysis.

The first chapter of this report explores how seven climate hazards affect fixed assets held by listed companies around the globe. The analysis reveals that extreme heat accounts for 72-73% of the potential losses accruing to these fixed assets over the next decade. These losses are likely to manifest in the form of business interruption, higher repair and operating costs, and lower employee productivity. The most exposed industries - telecommunications and utilities - face losses equivalent to a drop in yearly earnings of more than 20% by 2035. Moreover, given the focus on fixed assets only, and the fact that commercial and scientific climate risk models do not fully account for the scale and scope of cascading threats, the total costs facing businesses from climate hazards are likely much higher.

Moving beyond this analysis, the second chapter of this report looks at the degradation of Earth systems facing irreversible tipping points.[8] Five of these Earth systems may have already reached a point of no return,[9] presenting a more severe outlook for the frequency and severity of climate hazards with a direct impact on business and societies regionally and globally.[10, 11] Even in a world of Paris Agreement-aligned emissions cuts, the natural sources of emissions locked into soil, frozen ground, the ocean and forests continue to be released, adding greater momentum to the nature and climate crisis.

The third chapter explores the broader risks these climate hazards pose within the context of five socio-economic systems relating to food, the built environment, health, technology and financial services. Guidance is offered across these five systems, showcasing solutions-orientated strategies and recommendations to help business leaders and C-suite executives integrate them into routine decision-making to enhance resilience, adapt to capitalize on opportunities and shape collaborative outcomes that benefit investors, economies and societies alike.

BOX 1 **Definitions**

Mitigation

The intervention by humans to reduce emissions or enhance the sinks of greenhouse gases.

Resilience

The ability of a system and its component parts to anticipate, absorb, accommodate or recover from the effects of a dangerous event in a timely and efficient manner.

Adaptation

The process of adjusting to the actual or expected climate and its effects, to moderate harm or exploit opportunities.

Foundational actions to enable resilience and adaptation

Without climate resilience and adaptation, businesses will face disruption and, ultimately, redundancy. Conversely, the business case for investing in adaptation is increasingly clear. The framework presented in the World Economic Forum's January 2023 white paper, *Accelerating Business Action on Climate Change Adaptation*, highlights how business leaders need to focus on enablers for adaptation. The analysis on value at risk in this report spotlights two further actions: integrating climate change adaptation with net-zero transformation and mainstreaming climate risk considerations into business decision-making.

Every business leader should be activating the following array of enablers within the next 24 months to drive better C-suite decision-making:

- **Conduct a detailed audit of core capabilities and processes** to ensure climate resilience and adaptation percolates to every level of the organization and its ecosystem partners.
- **Master the data and strategic intelligence to understand the materiality of new risks and opportunities** presented by the climate crisis. Invest in the required skills, technology and responsible use of AI to accelerate insights and decision-making.
- **Tie climate risk into every capital maintenance and investment decision**, building resilience criteria with cost-benefit analyses to taper stranded asset risk while prioritizing socio-economic opportunity in existing communities across the value chain.
- **Sponsor and integrate evolving scientific insight with commercial models** to improve the quality of analysis and interpretation, shaping strategic and operational decisions to account for cascading exogenous shocks. Work in partnership with the scientific community to develop more useful insights into potential local impacts in key regions.

With increasingly visible signs of disruption across global value chains, much can be done to prepare now for growing risks in the future. Indeed, the gift that science affords us is time. Science helps us understand what is happening now and why, warns us of what is to come and helps us to cultivate opportunities to innovate and build resilience.

Today, bold partnerships are needed across the value chain and with local communities to embed resilience and adaptation to withstand growing climate hazards. Companies will be required to reinvent core products and services and build optionality into supply chains, while supporting a just and inclusive transition for local actors affected by emerging risks. Collaboration to improve foresight of localized risks and their implications on global supply chains will support strategic planning as disruptions gain pace.

In light of a growing nature and climate crisis – and the results of this report – forward-thinking businesses will need to accelerate their learning journey and act on these recommendations today.

Bold partnerships are needed across the value chain and with local communities to embed resilience and adaptation to withstand growing climate hazards.

1 The nature and climate crisis will hit fixed assets and threaten profits

As fixed asset losses rise across industries, company earnings could suffer.

$143 billion – the cost, every year over the past two decades, of extreme events linked to climate change.

The fallout from the nature and climate crisis is evident all around us - and growing. Biodiversity loss, Earth system degradation and extreme weather events threaten the health of humans and other species, as well as the proper functioning of our economies and societies. For businesses too, the tangible costs are rising.

The Intergovernmental Panel on Climate Change (IPCC) states in its Sixth Assessment Report[12] that human-caused climate change has increased the frequency and intensity of extreme weather events globally. A 2023 study estimated the cost of extreme events partly or wholly attributable to climate change at $143 billion per year over the past two decades.[13] In the United States, the cost of large-scale climate disasters has climbed steadily from $21.8 billion per year in the 1980s to $123.2 billion per year over the past five years.[14] In Europe, economic losses from climate-related extremes totalled approximately half a trillion euros over the past 40 years.[15] In Africa, GDP is already 2-5% lower on average every year than it could be due to climate-related hazards.[16]

Climate science is complex and involves many interconnected components, making it challenging to translate its implications into business impacts. The basic dynamics are as follows: Earth's climate responds to increasing greenhouse gases in the atmosphere with changes to Earth systems; these systems support natural ecosystems that provide services, such as climate regulation, that allow societies and economies to flourish. As human production and consumption activities drive greenhouse gas emissions up, Earth systems are pushed closer to collapse, exacerbating climate hazards and placing the entire cycle at risk.

A climate hazard is a climate condition with the potential to harm natural systems or society.[17] To help business leaders understand the tangible risks the nature and climate crisis poses to their operations, this report focuses on seven climate hazards related to extreme weather (see Figure 1).

FIGURE 1 **Seven climate hazards**

Extreme heat

Prolonged period of excessively hot weather above the average high temperature for a particular region for that time of year, often combined with high humidity.

Coastal flooding

A result of storm surges and high winds coinciding with high tides. Occurs when dry and low-lying land is submerged by seawater.

Fluvial flooding

Surface water drained from a watershed into a stream or river that exceeds the channel's capacity, overflowing beyond banks and inundating adjacent low-lying areas.

Tropical cyclone

Rapidly rotating storm (cyclone, hurricane or typhoon) that begins over tropical oceans, with violent winds and torrential rain that can be accompanied by thunderstorms.

Drought

A period of abnormally dry weather sufficiently prolonged for the lack of water to cause serious hydrologic imbalance in water tables and across landscapes.

Water stress

A combination of reduced freshwater availability from reduced rainfall and/or growing demand.

Wildfire

Unplanned, unwanted and uncontrolled fire that burns in a natural area such as a forest, grassland or prairie.

Sources: US Federal Emergency Management Agency (FEMA), US Cybersecurity & Infrastructure Security Agency (CISA), World Meteorological Organization (WMO).

Note: More detail on how climate hazards are defined is available here.[18]

> Climate hazards hit businesses in three ways: direct operational costs, supply chain disruption and instability in nature and society.

Companies can face heavy losses and damage from climate hazards. When multiple businesses are hit simultaneously - a common occurrence during extreme weather events - the ramifications extend far beyond individual organizations, cascading through entire industries and regions. The interconnected nature of the global economy means volatility ripples across markets and sectors. This threatens economic downturns and instabilities in financial markets that could culminate in broader economic and financial global crises. These economic impacts are underpinned by social and natural structures, which climate hazards influence both directly and indirectly.

Although the cascading economic and societal risks for business are complex and interconnected, they can be understood in three ways to guide appropriate and credible responses:

- **Direct operational costs**: The impact of climate hazards on fixed assets (property, plants and equipment) is the most direct risk businesses face. This report explores the scale and magnitude of associated fixed asset losses in the period 2025-2055. The knock-on impact on company earnings is already alarming, but may well be a conservative estimate given the analysis focuses on fixed assets only and did not incorporate emerging Earth system tipping-point science (see Annex 2: Limitations to the approach).
- **Supply chain disruption**: Climate hazards disrupt every stage of supply chains, from sourcing to processing, distribution and consumption patterns. The section on value chain and societal losses explores the broader business risks through the lens of five key socio-economic systems. This section also illustrates how companies are addressing these risks and offers concrete recommendations for building supply chain and societal resilience.
- **Instability in nature and society**: The vitality of businesses and economies is closely tied to the stability of societies and the natural environment in which they operate. Figure 2 illustrates how the impact of climate hazards on people and nature at local, regional and global levels can disrupt business operations, for example, via working hours lost due to employee health issues or resource shortages. These systemic risks should be incorporated into company resilience solutions.

The pace of the climate crisis today means the current temperature statistics in this report will likely be outdated in a year or two. It is critical, therefore, as climate hazards become more frequent and more severe, that business leaders recognize risks not as isolated incidents but as integral components of a complex and moving system that can disrupt economic stability on a macroeconomic scale.

FIGURE 2 **Direct and indirect consequences of climate hazards on economies and societies**

Climate hazards	Local	Regional	Global
Economic	Strain on company earnings Higher repair or replacement costs Stranded assets Higher operational costs Lost revenues Decreased productivity Labour shortages	Economic downturn Reduced economic output Falling retail sales Changes in consumer behaviour Loss of competitiveness Salary freezes Rising unemployment Supply chain disruptions & supply shortages Inflationary pressure	Financial market instability Declining GDP High market volatility Reduction of investment expenditures Decreased investor confidence Lower stock prices & reduced capital inflows High loan defaults Reduced credit rating Strained insurance sector due to increased insurance losses
Societal and natural	Natural resource shortages Workforce health decline Civil disorder Human rights violations Unemployment Misinformation & disinformation	Forced migration Deepening social inequalities Unequal access to resources resulting in conflicts Food insecurity Water insecurity Infectious diseases Humanitarian disasters	Biodiversity loss & ecosystems collapse Chronic health conditions Societal polarization Breakdown of trust in institutions Loss of intellectual property Geoeconomic confrontation Geopolitical risks Cyber insecurity

Sources: Accenture analysis, World Economic Forum *Global Risks Report 2024*.

1.1 Climate hazards are forecast to increase fixed asset losses

Fixed asset losses driven by climate hazards could reach $560-610 billion per year by 2035.

Climate hazards can damage fixed assets or prevent them from working efficiently. Consider factories losing their water supply, data centres which struggle to cool, offices under water or fields hit by floods and drought. Such events are likely to raise business costs through, for example, additional repairs, orders that cannot be fulfilled and less productive workers. Given the strong positive relationship between capital investment and productivity,[19, 20] this is consequential not just for companies themselves but for wider economic and societal prosperity.

Combining data on the fixed assets held by 5,736 large, listed companies with climate risk metrics from the S&P Physical Risk Financial Impact database provides insight into the exposure of businesses at a granular level (see Box 2). The analysis suggests that fixed asset losses driven by climate hazards could reach $560-610 billion per year by 2035, depending on the emissions scenario. This climbs to $680-850 billion by 2045 and $830 billion-$1.1 trillion by 2055 (see Figure 3). For context, global foreign direct investment totalled $1.3 trillion in 2023.[21]

BOX 2

Estimating fixed asset losses

Using the Coupled Model Intercomparison Project 6 (CMIP6) climate models, the S&P Global Sustainable Climate Risk Model dataset provides climate hazard exposure scores across different IPCC future climate-change scenarios. It covers more than 3 million corporate assets, with asset type-specific sensitivity to quantify financial losses associated with each hazard. Costs include those stemming from increased direct operational expenses, revenues lost to business interruption, repairs to physical damage and lower employee productivity.

Fixed asset loss risk is aggregated at the company level as a weighted average of all assets mapped to the company of interest. The analysis combines these individual, aggregated company scores across three emissions scenarios - High: SSP5-8.5, Medium-High: SSP3-7.0 (labelled as Medium in this analysis for simplicity) and Low: SSP1-2.6 - with estimations of the value of fixed assets held by each of 5,736 large, listed companies (from S&P Capital IQ).

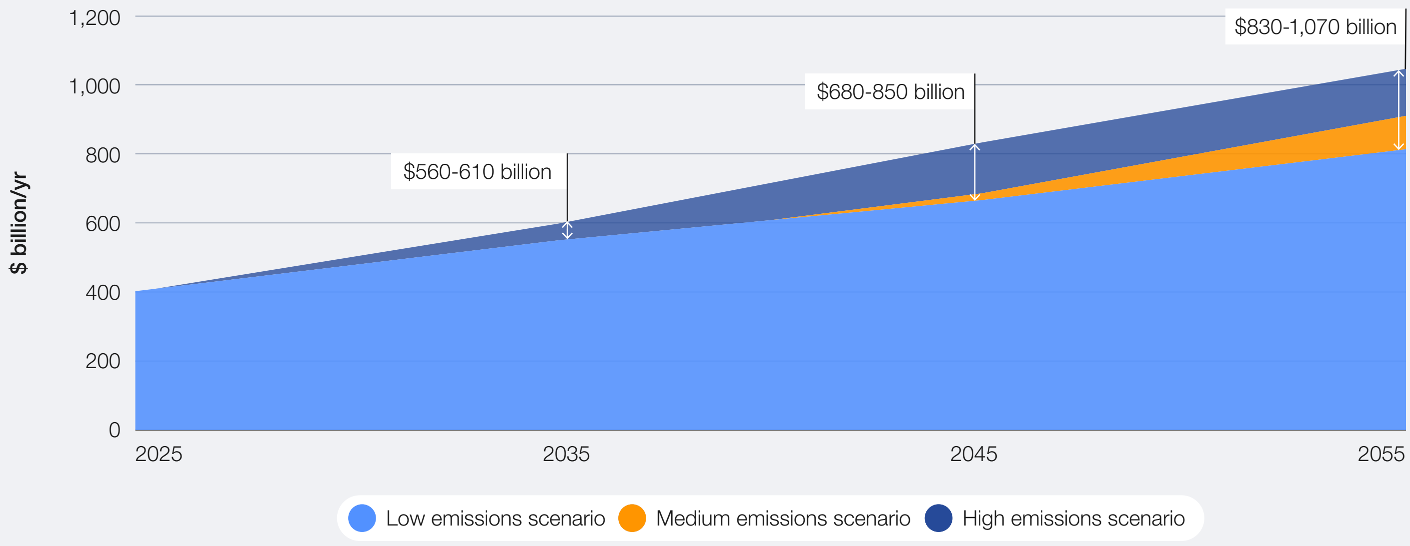
This figure is then extrapolated to 55,515 listed companies using revenue data to estimate the annualized global financial impact of physical climate hazards in US dollars.

The estimated impact represents a conservative baseline for three major reasons:

- Risk metrics do not include emerging tipping point science.
- Non-listed companies are excluded due to data availability.
- Climate hazards beyond the seven considered increase risks (see Figure 1).

For the full methodology, including approach limitations and sources, see Annex 2: Quantifying the impact of the nature and climate crisis on business.

FIGURE 3 **Total estimated fixed asset losses for listed companies under three emissions scenarios** ($ billion per year, 2025-2055)



Note: High emissions scenario = SSP5-8.5, Medium emissions scenario = SSP3-7.0, Low emissions scenario = SSP1-2.6.

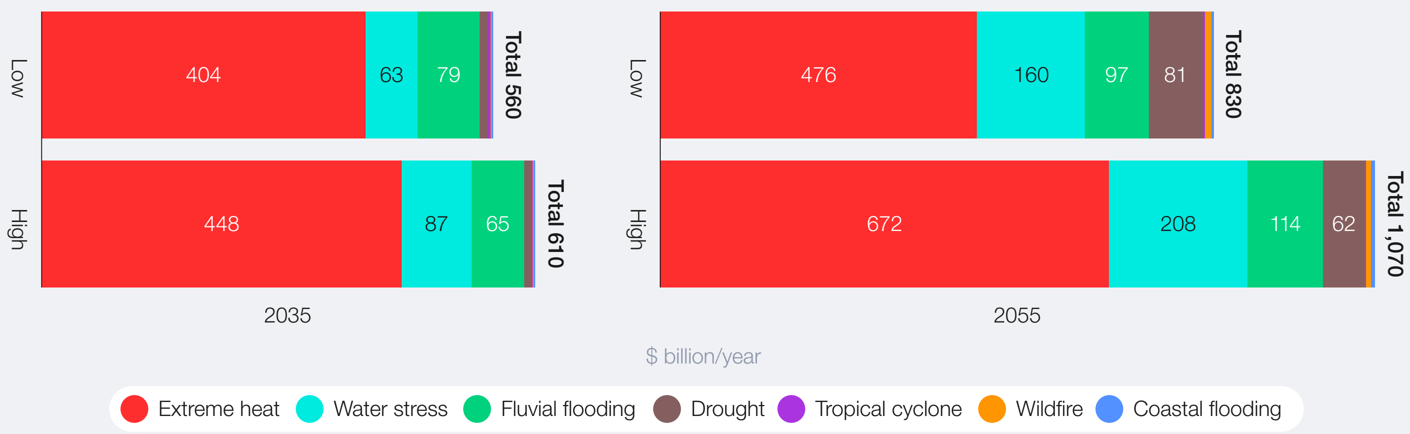
Sources: S&P Global Sustainable1, Accenture analysis.

1.2 Extreme heat is the most potent climate hazard affecting fixed assets across all regions

Corporate fixed assets are likely to be hit primarily by extreme heat. By 2035, this climate hazard alone is expected to drive annual losses of $404-448 billion across all listed companies (72-73% of total estimated losses), depending on the emissions scenario, rising to $476-672 billion by 2055 – although declining as a proportion of the total to 57-63% (see Figure 4).

Water stress is forecast to be the next most potent climate hazard, driving fixed asset losses of $63-87 billion by 2035 and $160-208 billion per year by 2055. Fluvial flooding ($97-114 billion) and droughts ($62-81 billion) are also set to pose serious threats to the efficiency of fixed assets by 2055.

FIGURE 4 **Total estimated fixed asset losses for listed companies under low and high emissions scenarios, by climate hazard** ($ billion per year, 2035-2055)



Sources: S&P Global Sustainable1, Accenture analysis.

Although businesses across the world are exposed to climate hazards, there is some variation by region. Extreme heat is the number one risk across all regions, followed by fluvial flooding (see Table 2).

Water stress ranks next highest in Africa, the Middle East, Asia-Pacific, Latin America and the Caribbean and Europe. Tropical cyclones rank third in Canada and the United States.

TABLE 2 **Top five climate hazard risks under a high emissions scenario** (by region, 2035)

	Canada and US	Latin America and Caribbean	Europe	Africa	Middle East	Asia-Pacific
1	Extreme heat	Extreme heat	Extreme heat	Extreme heat	Extreme heat	Extreme heat
2	Fluvial flooding	Fluvial flooding	Fluvial flooding	Fluvial flooding	Fluvial flooding	Fluvial flooding
3	Tropical cyclone	Water stress	Water stress	Water stress	Water stress	Water stress
4	Water stress	Wildfire	Wildfire	Drought	Coastal flooding	Wildfire
5	Wildfire	Tropical cyclone	Drought	Wildfire	Wildfire	Drought

Sources: S&P Global Sustainable1, Accenture analysis.

1.3 Telecommunications, utilities and energy companies face steepest fixed asset losses in next decade

Industries that provide the plumbing for the modern economy face the sharpest climate hazard risks, according to the analysis (see Figure 5).

The average company in these sectors faces the following fixed-asset losses per year by 2035, ranged from low to high emissions scenarios:

Telecommunications

$518-563 million/year

Utilities

$204-233 million/year

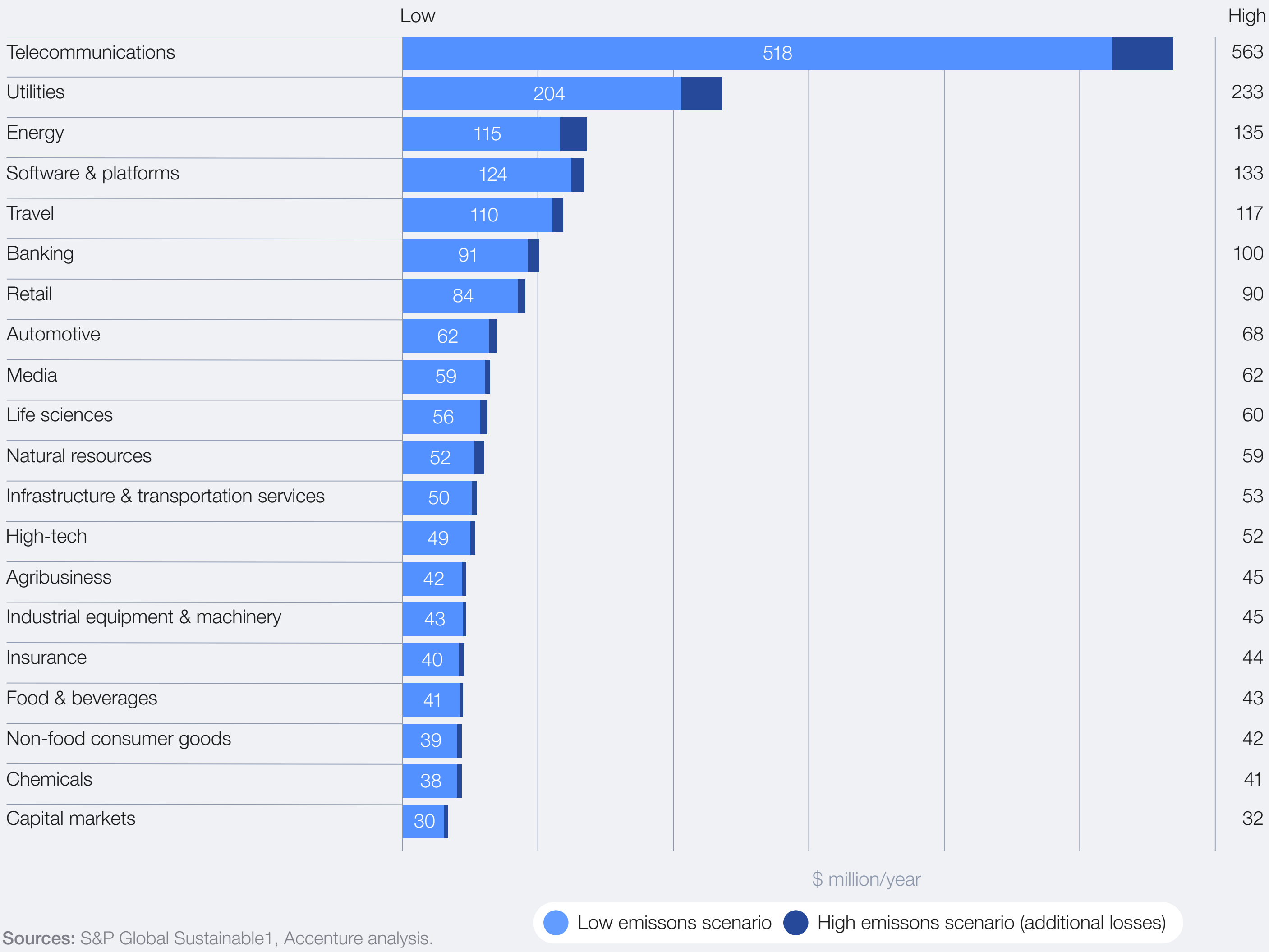
Energy

$115-135 million/year

Telecommunications companies face the highest level of risk, due principally to the sensitivity of data centres and network infrastructure to extreme heat and restricted water access.

FIGURE 5

Fixed asset losses for the average listed company under low and high emissions scenarios, by industry ($ million per year, 2035)



Sources: S&P Global Sustainable1, Accenture analysis.

1.4 Climate-driven fixed asset losses pose a growing threat to corporate profitability

For the average listed company, climate-driven losses equate to a drop in earnings of 8.1-10.1% per year by 2045.

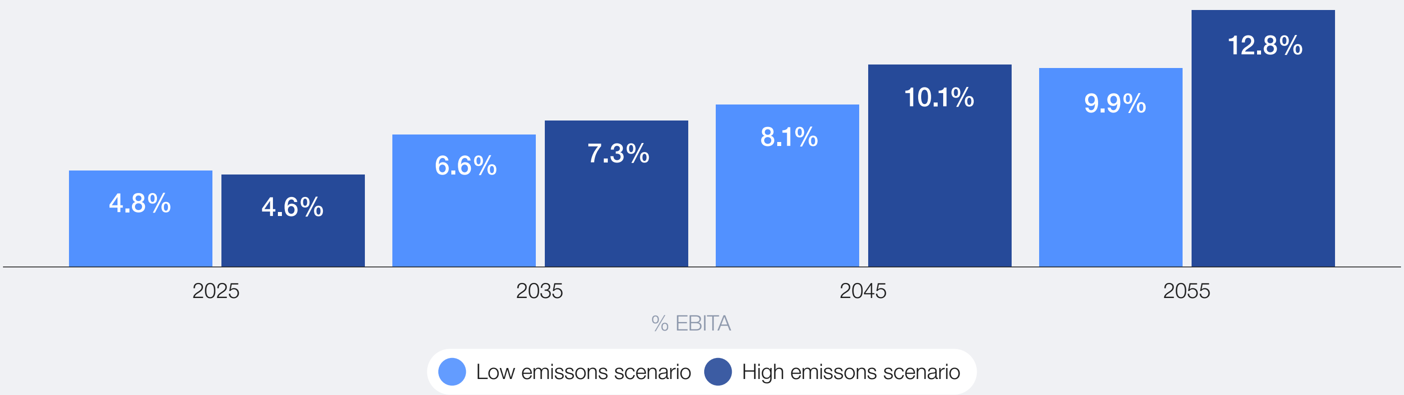
The scale and ubiquity of such figures tends to mask the need for individuals and businesses to act. The picture becomes clearer when translating losses down from the aggregate to the scale of an individual company. To assess business viability in different emissions scenarios, the impact of fixed asset losses was set against company profitability. The analysis finds that for the average listed company, climate-driven losses equate to a drop in earnings of 6.6-7.3% per year by 2035, depending on the emissions scenario, accelerating to 8.1-10.1% by 2045 (see Figure 6).

For comparison, the profit margins of S&P 500 companies declined by 20.0% between Q3-2008 and Q2-2009 through the financial crisis. Profit margins dropped 15.3% in the four quarters to Q2-2020, encompassing the depths of the Covid-19 pandemic.

However, these are imperfect comparisons. The banks were recapitalized during the financial crisis and corporate profit margins had broadly recovered by Q2-2010. Similarly, S&P 500 profitability rebounded to pre-pandemic levels by Q1-2021[22] as successful Covid-19 vaccine rollouts ended the cycle of lockdowns and governments spent heavily to support citizens and economies.

By contrast, the complexity and scale of Earth system tipping points are of a different order of magnitude. By definition, once you pass a tipping point, there is no going back. The damage done is both binding and growing. No financial stimulus or vaccination programme will quickly solve them. The inference is that the risk to company earnings from climate hazards on fixed assets alone may soon rival a global recession or pandemic – a risk that will hit every year with increasing severity.

FIGURE 6 **Fixed asset losses per year as a proportion of EBITA under low and high emissions scenarios** (2025-2055)



Note: Average for 5,043 companies with available data; average EBITA 2021-2023. See methodology at Annex 2 for further detail on 2025 estimate.

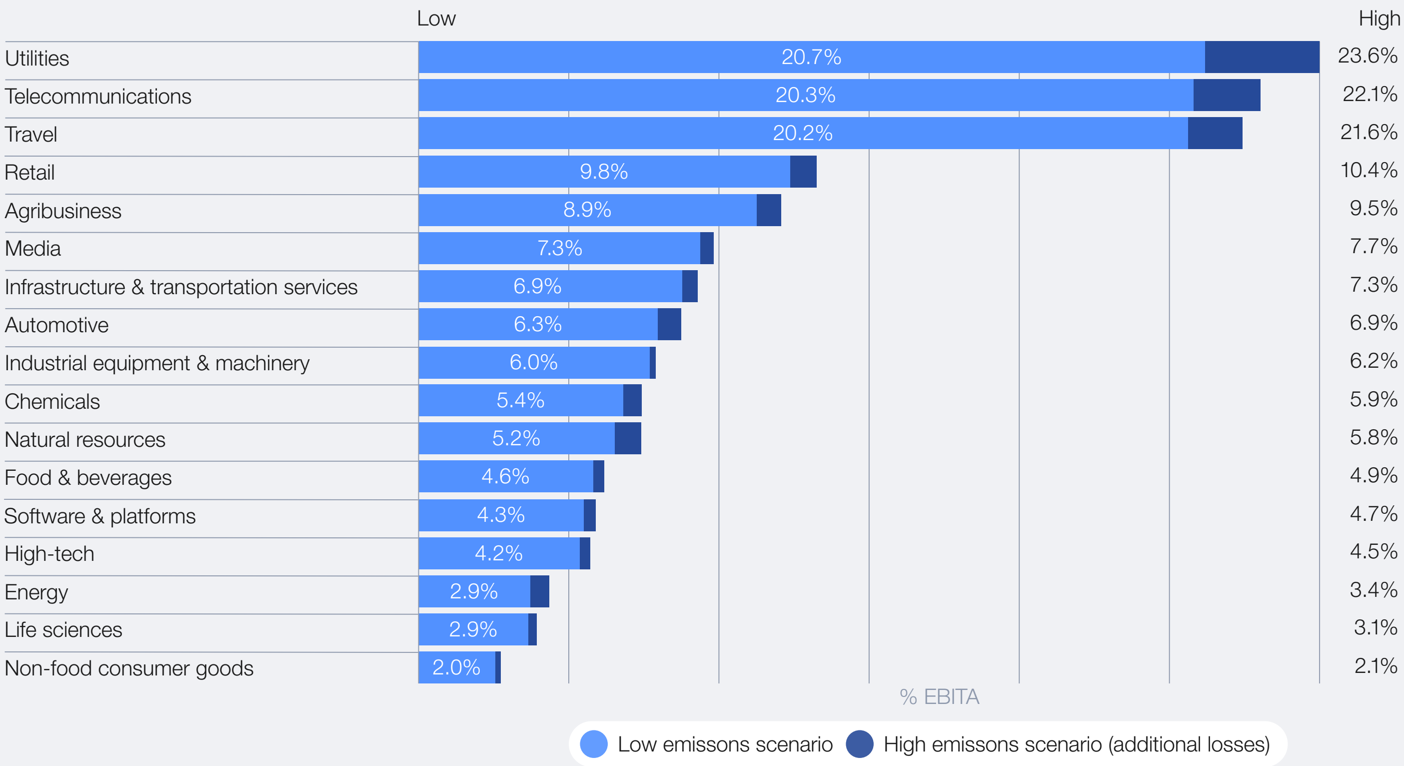
Sources: S&P Global Sustainable1, Accenture analysis.

1.5 Utilities, travel and telecommunications sectors face the highest potential earnings shocks

The threat to profitability from climate hazards is even steeper in some industries. Again, the impact is likely to be highest in utilities (20.7-23.6% under low and high emissions scenarios) and telecommunications (20.3-22.1%), where the scale of fixed asset losses equates to a drop in earnings of more than a fifth over the next decade (see Figure 7). Travel (20.2-21.6%) faces a similar level of risk.

Despite having large stocks of fixed assets, on average, energy companies face a more moderate risk (2.9-3.4%) because their average earnings today are among the highest of industries analysed. However, as energy transition risks amplify over time, potential earnings shocks will likely rise.[23]

FIGURE 7 | **Fixed asset losses per year as a proportion of EBITA under low and high emission scenarios, by industry** (2035)



Note: Industry average for 5,043 companies with available data; average EBITA 2021-2023.

Sources: S&P Global Sustainable1, Accenture analysis.

The scale and magnitude of fixed asset losses should concern business leaders. However, the World Economic Forum's Alliance of CEO Climate Leaders highlights that companies that make adaptation and resilience investments report a very positive business case, ranging from $2 to $19 for every $1 invested across sectors.[24] This prompts an important question as companies consider how fast to adapt: with rising climate hazards threatening to drive fixed asset losses and depress earnings, can they afford not to respond urgently and appropriately now?

Moreover, this analysis paints an incomplete picture of the climate threats facing companies. For one thing, climate hazards pose risks to other areas of business activity such as the supply chain, employee well-being and consumer spending (see Chapter 3). Additionally, the data does not fully account for the increased frequency and severity of climate hazards as tipping points cascade.

This report is accompanied by a series of Industry briefs that provide a more detailed view on the implications and recommendations for some of the most-impacted industries: utilities, telecommunications, travel, retail, agribusiness, media, infrastructure and transportation services.

2 Earth systems on the brink of tipping beyond the point of no return

Five Earth systems are at risk of tipping, triggering higher emissions, global heating, sea-level rise and food insecurity.

2.1 Our planet's life-support systems are severely threatened

While some effects of the nature and climate crisis are already apparent today, other more serious consequences are on the horizon. The science is clear that risks are mounting but the precise timing and magnitude of the impending changes are difficult to specify, given the complexity and interdependencies of Earth systems and their tipping points.

A tipping point is a critical threshold that, when reached, leads to a significant change in the state of the system that is typically irreversible.[25] Given their scale, the degradation and tipping of Earth systems pose grave threats to the future of our species, affecting liveability and survivability in many geographies around the world. Crossing an Earth system tipping point "will severely damage our planet's life-support systems and threaten the stability of our societies", according to the authors of the *Global Tipping Points Report 2023*.[26]

2.2 Five Earth systems are at imminent risk of tipping today

The Greenland and West Antarctic ice sheets – close to crossing their tipping points – represent 10 metres of sea-level rise with unavoidable rises already locked in.

At present levels of global heating, five Earth systems are close to crossing tipping points:[27]

- Greenland ice sheet collapse
- West Antarctic ice sheet collapse
- Warm-water coral reef die-off
- Labrador & Irminger Seas convection collapse
- Boreal permafrost abrupt thaw[28]

Land ice on the Greenland and West Antarctic ice sheets – melting rapidly and close to crossing tipping points – represents 10 metres of sea-level rise[29] with unavoidable rises already locked in.[30] Communities around the world are experiencing the effects of coastal erosion, flooding and storm surges. Some 630 million people live on land lying below projected annual flood levels for the end of the century.[31] The displacement of so many people could lead to a global security crisis, with increased competition for freshwater, land and other resources.

For more information on risks to land ice, the chain of geographic reactions unlocked when it melts and the global consequences of its decline and tipping, refer to Figure 8.

Sea ice is showing marked signs of deterioration. Regardless of emissions scenarios, there is likely to be at least one sea-ice-free summer in the Arctic before 2050. Decreased sea ice extent creates a feedback loop that amplifies warming, because darker water absorbs a greater amount of solar radiation compared with reflective, white sea ice. Amplified Arctic warming destabilizes the polar jet stream which could lead to increased temperature extremes at lower latitudes.

For more information on risks to sea ice, the chain of geographic reactions unlocked when it melts and the global consequences of its decline and tipping, refer to Figure 9.

At 1.5°C of global heating 99% of the world's coral reefs will experience heatwaves that are too frequent for them to recover from, impacting the food security of half a billion people.

In the ocean, the Atlantic's dominant heat-transferring current, known as the Atlantic Meridional Overturning Circulation (AMOC), has slowed by 15% since 1950 and is in its weakest state for more than a millennium.[32] It is showing signs of destabilization on a trajectory towards collapse, partly due to the weakening of the Labrador & Irminger Seas convection current, itself part of the wider North Atlantic Subpolar Gyre and a driver of the bigger AMOC. This vast AMOC current can be likened to an air conditioning system for the planet. It has collapsed in the past. If it were to collapse again, a cold spot in the North Atlantic would emerge while the remainder of the Atlantic Ocean heated. One effect would include shifting the rain belt back to the equator. Tropical forests reliant on this rain would experience unprecedented droughts. As many tropical forests have not evolved the capacity to deal with systemic droughts and their consequential fires, forest systems like the Amazon would be at risk.

For more information on risks to Atlantic Ocean circulation, the chain of reactions its failure would unlock geographically, and the global consequences of their decline and tipping, refer to Figure 10.

At 1.5°C of global heating, 99% of the world's coral reefs will experience heatwaves that are too frequent for them to recover from.[33] Coral reefs offer an effective barrier to extreme weather from coastal storm surges – so the loss of these ecosystems propels higher costs from extreme weather for many seaboard towns and cities. As a quarter of all marine life are dependent on coral reefs at some point in their life cycle, their loss also affects the composition of ocean ecosystems and coastal food security. Coral reef die-off impacts the livelihoods and food security of half a billion people dependent on the ocean for readily accessible protein.[34]

For more information on risks to coral reefs, the chain of reactions their destruction unlocks geographically and the global consequences of their decline and tipping, refer to Figure 11.

Permafrost could be considered the climate crisis wildcard. By definition, permafrost is ground that remains completely frozen (0°C or less) for at least two years in a row. Permafrost accounts for nearly half of all organic carbon stored within the planet's soil.[35] Northern permafrost soils contain approximately twice as much organic carbon as is currently contained in the atmosphere today.[36] With heating in the Arctic, these landscapes are thawing – releasing carbon dioxide and methane into the atmosphere. Permafrost emissions could be anywhere from 30-150 billion tonnes of carbon by 2100 – with upper estimates on a par with cumulative emissions from the US economy at its current rate.[37] These "natural" emissions speed up global warming.

For more information on risks to permafrost, the chain of reactions its thawing unlocks geographically and the global consequences of its decline and tipping, refer to Figure 12.

The figures in this chapter offer briefs for business on the dynamics at play in five critical landscapes: land ice, sea ice, ocean circulation, coral reefs and permafrost. The briefs include: definitions, Earth system tipping points, the way warming leads to climate hazards, select implications, future projections, shocking scientific facts and socio-economic consequences.

Inevitably, these briefs simplify the complex nature of Earth systems and the interdependencies between them to explain the primary drivers of relevant tipping points to non-technical readers. They do not aim to be exhaustive. However they do give corporate decision-makers a sense of the scale of emerging and cascading risks involved, as well as primary considerations to inform credible and appropriate responses, in light of those risks.

FIGURE 8 | LANDSCAPE BRIEF

Land ice

Related climate hazards

Fluvial flooding
Coastal flooding
Water stress

What is it?

The Greenland and Antarctic ice sheets store approximately 99% of the Earth's land ice and have a profound impact on global climate, sea levels and ecosystems. Ice sheets are in danger of collapsing in response to both atmospheric and oceanic warming, which affect their surface mass balance and ice dynamics.

Mountain (extrapolar) glaciers are receding rapidly due to rising temperatures, diminishing snowfall and increased meltwater runoff. The Himalayan glaciers are invaluable sources of freshwater for approximately 800 million people.

What are the implications?

Loss of land ice results in **sea level rise**, which leads to coastal floods, coastal erosion and saltwater intrusion into groundwater.

Melting of mountain glaciers causes moraine dams to fail, leading to **glacial-lake outburst floods (GLOFs)**.

Subsequent glacier retreat reduces river flows and worsens downstream droughts.

Increased freshwater from land ice enters the oceans and **disrupts global ocean circulation** and **salinity**.

Shocking scientific fact

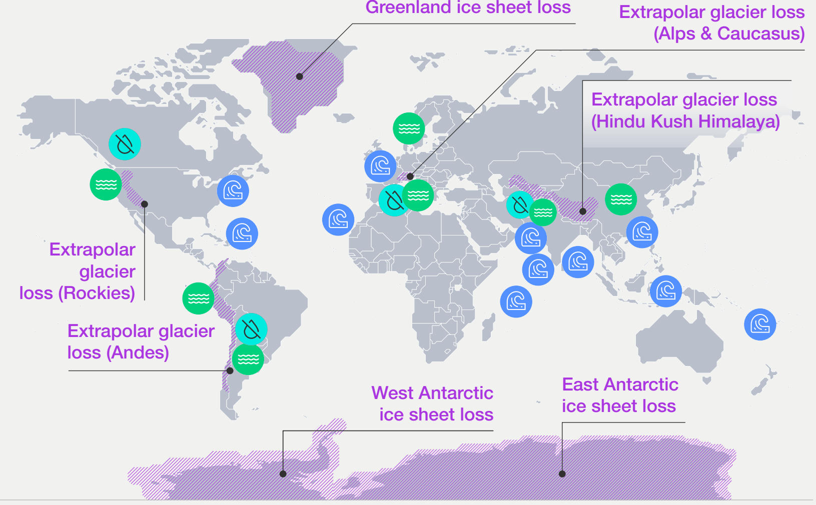
Some of the latest estimates suggest that 630 million people may live on land below projected annual flood levels for the end of the century. The displacement of so many people could lead to a global security crisis, with increased competition for freshwater, land and other resources.

Related Earth system tipping points

Related Earth system tipping points	Temperature scenario	Scientific confidence
Greenland ice sheet collapse*	0.8 – 3.0°C	High
West Antarctic ice sheet collapse	1.0 – 3.0°C	High
East Antarctic ice sheet collapse	>5.0°C	Medium
Extrapolar glacier retreat	1.5 – 3.0°C	Medium

* See endnote on Greenland ice sheet.[38]

Where does it occur?



What could happen?

Accelerated sea level rise

IPCC sea level rise projections by 2100:

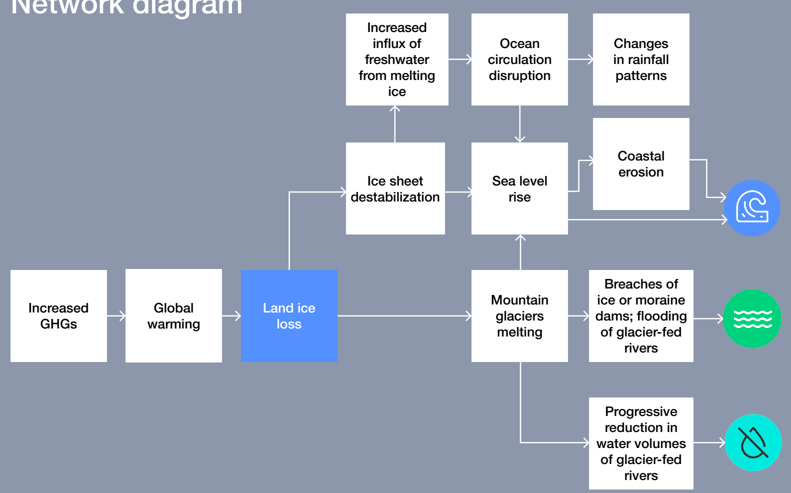
- 0.28 – 0.55 metres (RCP2.6** scenario).
- 0.61 – 1.10 metres (RCP8.5 scenario).
- These do not account for the full range of possible ice sheet instabilities, which could add centimetres to metres of sea level rise by 2100 and multi-metre increases towards 2300.

Increased water levels and fluvial floods

- The majority of Himalayan glaciers are losing mass at an accelerating rate. Peak water is likely to be reached in the Ganges, Indus, Tarim and Brahmaputra rivers by 2050.
- The frequency and magnitude of glacial lake outburst floods (GLOFs) are expected to increase in the future due to climate change.

** RCP2.6 is the IPCC's lowest-emissions/warming scenario; RCP8.5 is the highest-emissions/warming scenario.

Network diagram



Socio-economic consequences

1. Sea level rise acts as a threat amplifier for extreme weather events in coastal areas. It could damage coastal infrastructure, compromise port operations, contaminate farmland and groundwater, and lead to increased coastal erosion. Sea level rise is among the most costly and permanent future consequences of climate change.
2. Latest estimates suggest that 630 million people may live on land below projected annual flood levels for the end of the century. This could lead to displacement, loss of property and other socio-economic challenges.
3. Loss of glaciers will lead to greater water stress during droughts, with implications for downstream communities' municipal, industrial and agricultural sectors that rely on those water sources.
4. Glacial-lake outburst floods destroy settlements and infrastructure in mountain regions, including hydroelectric power installations and transport links.

FIGURE 9 | LANDSCAPE BRIEF

Sea ice

Related climate hazards

Extreme heat · Wildfire

Drought · Coastal flooding

What is it?

Sea ice is frozen sea water that floats on the surface of the polar oceans. It reflects solar radiation and moderates heat exchange to maintain Earth's temperature balance. It also provides habitat for marine organisms fostering biodiversity and affects ocean circulation and carbon and nutrient cycles.

As air and ocean temperatures rise, sea ice thins, covers a smaller extent and becomes more vulnerable to storms and waves.

What are the implications?

Decreased sea ice extent creates a feedback loop that **amplifies warming at the poles,** due to darker water absorbing a greater amount of solar radiation.

Amplified Arctic warming **destabilizes the polar jet stream** which could lead to increased temperature extremes at lower latitudes.

Changes in polar ecosystems **threaten livelihoods** of Arctic people **and unique species** (e.g. seals, walrus, polar bears) that depend on sea ice as a primary habitat.

Shocking scientific fact

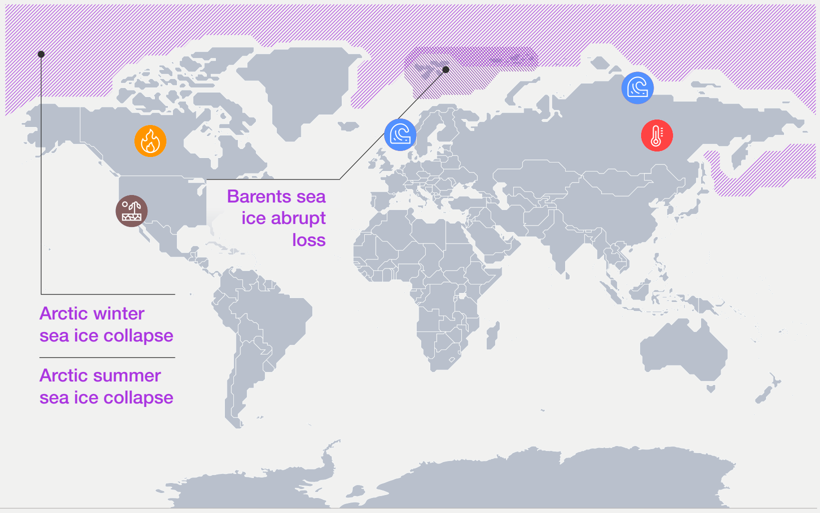
Regardless of emissions scenarios, there is likely to be at least one sea-ice-free summer in the Arctic before 2050.

Related Earth system tipping points

Related Earth system tipping points	Temperature scenario	Scientific confidence
Arctic summer sea ice collapse*	1.5 – 2.0°C	High
Arctic winter sea ice collapse	>6.0°C	High
Barents Sea ice abrupt loss*	1.5 – 1.7°C	Low

* Not expected to show tipping behaviour but can trigger tipping events in the ocean-atmosphere-cryosphere system.

Where does it occur?



What could happen?

Ice-free summer in the Arctic

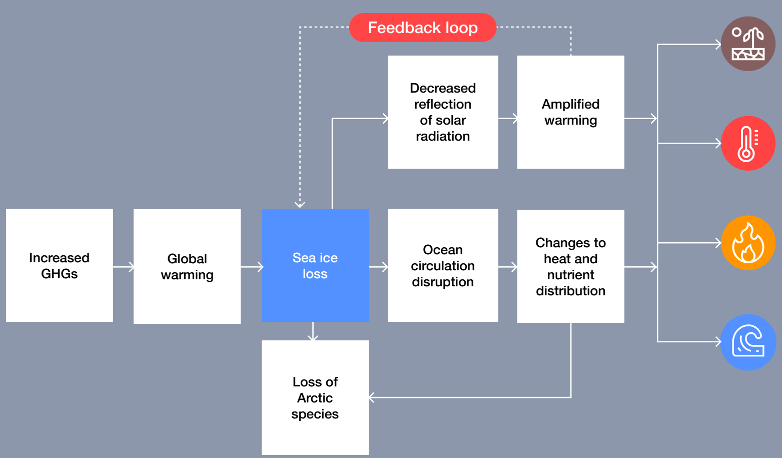
- Regardless of future emissions, there is likely to be at least one sea-ice-free summer in the Arctic by 2050.
- The Arctic Ocean is expected to remain ice-covered in winter throughout the century, but the ice will become thinner and more vulnerable to storms and waves.

Continuation of sea ice decline

Future projections under the IPCC's emission scenarios:

- assume a continuation of sea ice decline.
- project an ice-free-year-round Barents Sea by the end of this century.

Network diagram



Socio-economic consequences

1. Thawing Arctic permafrost and melting sea ice will cause extra economic losses.
2. Amplified Arctic warming could alter the jet stream and increase the frequency and intensity of extreme weather events, including heatwaves in North America and cold winter extremes in the northern continents. These changes may lead to more persistent and prolonged adverse weather patterns globally.
3. Sea ice loss can have a profound impact on Indigenous communities in the Arctic, affecting their traditional ways of life and making it harder for them to access food.
4. The extent and seasonality of Arctic sea ice determines the viability of shipping routes as well as oil and gas exploration and exploitation. Concerns about associated geopolitical tensions and conflicts over access to more economic shipping routes and offshore hydrocarbons have been raised.

FIGURE 10 | LANDSCAPE BRIEF

Ocean circulation

Related climate hazards

- Extreme heat
- Water stress
- Drought
- Coastal flooding
- Wildfire
- Fluvial flooding

What is it?

Deep ocean currents are driven by differences in the density of ocean water. This is controlled by temperature and salinity. The input of freshwater from melting land ice, the reduction in sea ice extent and the warming of ocean water all change the density of ocean water, affecting the rate at which deep ocean water circulates.

The Labrador-Irminger Seas convection is at particular risk of collapse due to warming polar regions. If global temperatures continue to increase, the Atlantic Meridional Overturning Circulation (AMOC) will also be at risk of collapse, with global implications.

What are the implications?

Increased frequency and intensity of extreme weather events in Europe.

Drop in temperature in northern Europe, but **extreme heat** elsewhere.

Possible **disruption of precipitation** patterns, which have an impact on food productivity (e.g. in India, South America, West Africa).

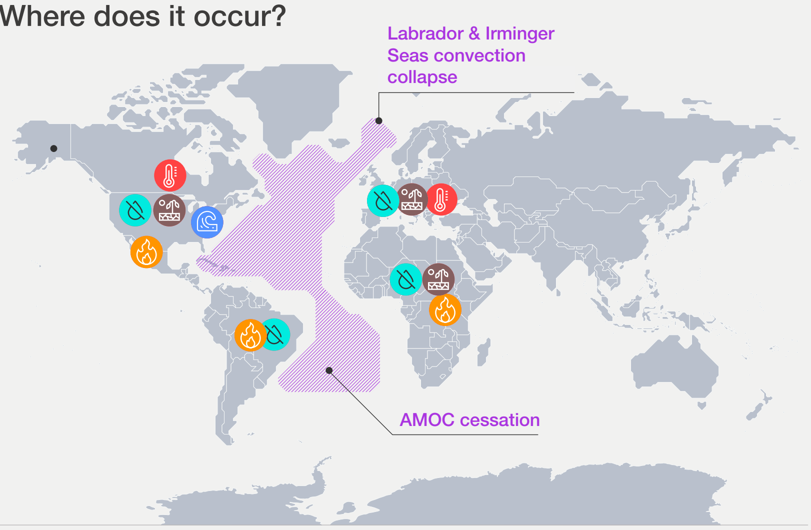
Rising sea levels on the eastern coast of North America, leading to **coastal flooding.**

Shocking scientific fact

The circulation of the Atlantic Ocean is heading towards a tipping point: AMOC has declined 15% since 1950 and is in its weakest state in more than a millennium – it has the potential to collapse, with catastrophic consequences.

Related Earth system tipping points	Temperature scenario	Scientific confidence
Labrador & Irminger Seas convection collapse	1.1 – 3.8°C	High
Atlantic Meridional Overturning Circulation (AMOC) collapse	1.4 – 8.0°C	Low

Where does it occur?



What could happen?

Further currents weakening

– Under continued high emissions, the AMOC would decline 74% by 2290–2300, with a 44% likelihood of outright collapse.

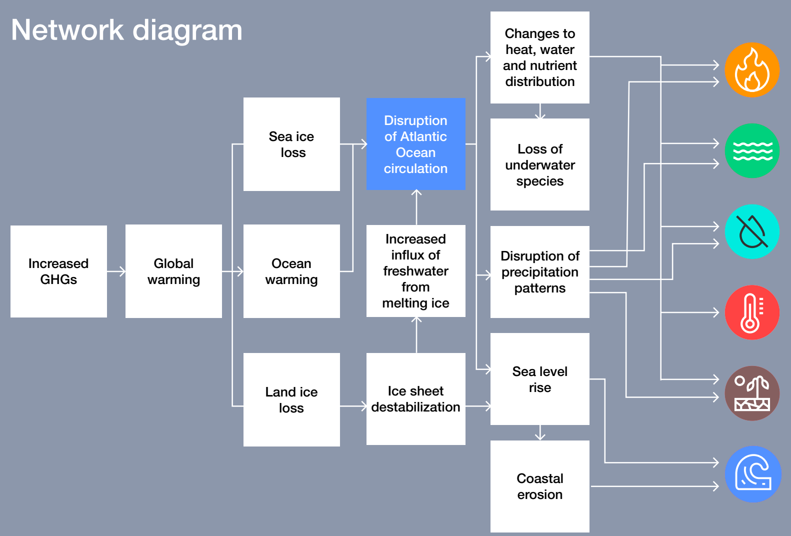
– This would amplify regional consequences, such as sea level rise, disruption of rainfall patterns, increased storms and temperature drops.

Shift of the rainfall zone

– Major rainfall zones would shift due to AMOC collapse, leading to less rainfall over Europe, North and Central America, North and Central Africa and Asia, causing drought conditions.

– AMOC collapse would return the rain belt to the equator, causing droughts and fires in tropical forests.

Network diagram



Socio-economic consequences

1. A weak AMOC will not only affect food security but also the livelihoods of communities dependent on these industries. AMOC collapse will therefore lead to a substantial reduction in global economic output and exacerbate global economic inequalities.

2. Instability of the AMOC would have a huge impact on agriculture, especially in Europe. If the AMOC weakened or collapsed in the coming decade, Europe's seasonality would strongly increase. This, in turn, would lead to harsher winters, and hotter and drier summers. This shift in Europe's climate is projected to reduce agricultural productivity and render most land unsuitable for arable farming.

3. In the tropics, collapse of the AMOC would cause a shift of the monsoon rains in central/southern America, West Africa, South Asia and India. This will have major impacts on vegetation productivity, including crop productivity, with significant decreases in these regions.

FIGURE 11 | LANDSCAPE BRIEF

Coral reefs

Related climate hazards

Coastal flooding

What is it?

Coral reefs are underwater ecosystems, which serve as natural barriers against storm surges and extreme wave events.

Reefs are threatened by multiple stressors at a range of scales. Local human impacts on reefs include overfishing and destructive fishing, nutrient pollution and urban runoff, and coastal development. On a global scale, climate change threatens coral reefs via marine heatwaves (which cause coral bleaching), tropical storms (which damage coral structure) and ocean acidification (which reduces coral growth). Ocean warming has already triggered multiple global coral bleaching events and it is estimated that 50% of coral cover has already been lost.

What are the implications?

Loss of coral reef 3D structure could lead to increased coastal erosion and damage from tropical storms, particularly as sea levels rise.

The loss of reef-building corals could lead to the collapse of marine ecosystems, significantly impacting **food security.**

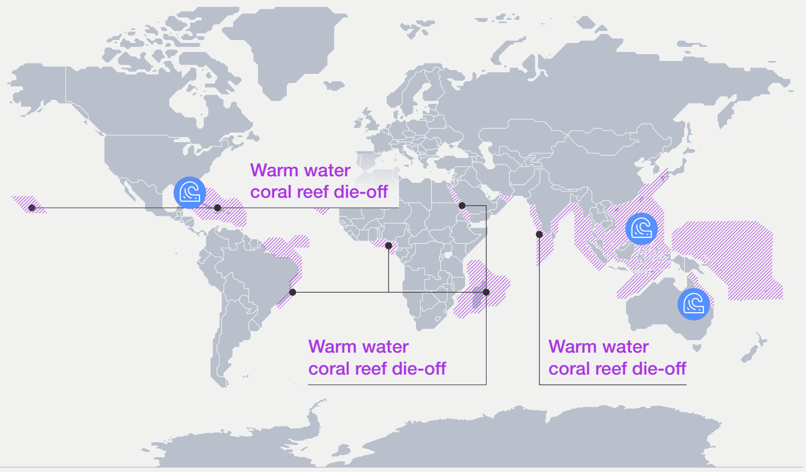
Shocking scientific fact

Approximately one quarter of all marine species depend on coral reefs in some way, making these ecosystems cornerstones of marine biodiversity.

Related Earth system tipping points

	Temperature scenario	Scientific confidence
Warm water coral reef die-off	1.0 – 1.5°C	High

Where does it occur?



What could happen?

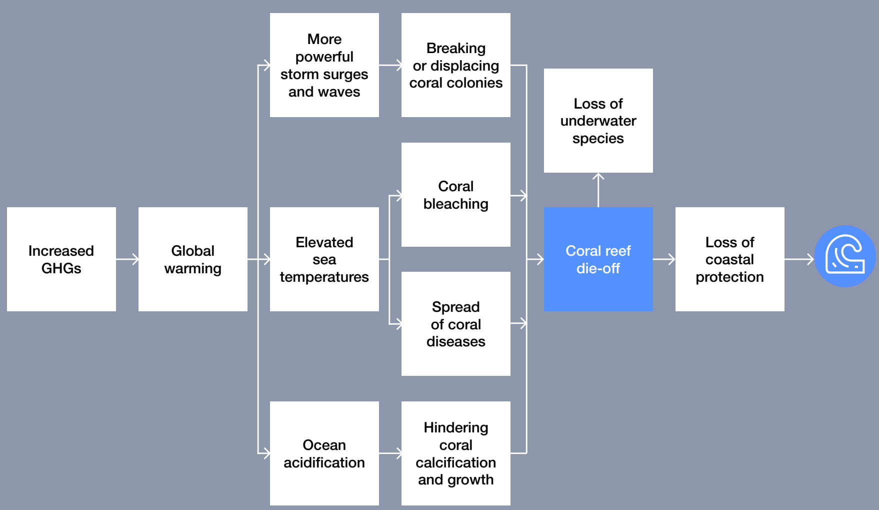
Severe coral reef loss

- At 1.5°C of warming 99% of the world's reefs will experience heatwaves that are too frequent for them to recover from.
- 70% – 90% loss of tropical and subtropical coral reefs at 1.5°C.
- Near total coral reef loss at 2°C.

Flooding risk amplification

- Future sea level rise paired with coral reef loss will amplify flooding risks.
- By 2100, land flooded under a 100-year storm event increases by 64% under continued high emissions *with no reef loss.*
- In the same scenario *with a 1m loss in reefs,* land flooded increases by 116%.

Network diagram



Socio-economic consequences

1. One billion people globally live within 100km of a coral reef and depend on coral reefs for their food and livelihoods. This includes one quarter of small-scale fishers globally.
2. Shorelines would be vulnerable to erosion, while rising sea levels would push coast-dwelling communities out of their homes.
3. From the Great Barrier Reef to the Caribbean Sea, coral reefs attract tourists to over 100 countries and territories worldwide. Coral reef tourism is estimated to generate $36 billion in economic revenue per year, from both on-reef (e.g. diving) and reef-adjacent activities (e.g. hotel stays). Each hectare of coral reef habitat also provides an average of $350,000 in ecosystem services per year.
4. By researching corals' natural chemical defences, scientists are able to develop medicines to treat all sorts of human diseases, from cancer and arthritis to Alzheimers and heart disease.

FIGURE 12 | LANDSCAPE BRIEF

Permafrost

Related climate hazards

- Water stress
- Coastal flooding
- Wildfire
- Extreme heat

What is it?

Permafrost is named after ‘permanently frozen’ land. It is ground that remains completely frozen (0°C or less) for at least two years in a row. It accounts for nearly half of all organic carbon stored within the planet’s soil.

Arctic permafrost is a home to 5 million inhabitants. As the climate warms permafrost begins to thaw, resulting in number of socio-economic consequences.

What are the implications?

When permafrost begins to thaw, carbon dioxide and methane are released into the atmosphere. This could further **speed up global warming** and permafrost thawing.

Thawing permafrost causes softening of the frozen land and its erosion. This eventually causes the ground to move, leading to slumping, landslides and **damage to local infrastructure.**

Ancient bacteria and viruses, as well as toxic waste hidden in the ice and soil, are released when permafrost thaws. These newly-unfrozen microbes could unleash major **disease outbreaks.**

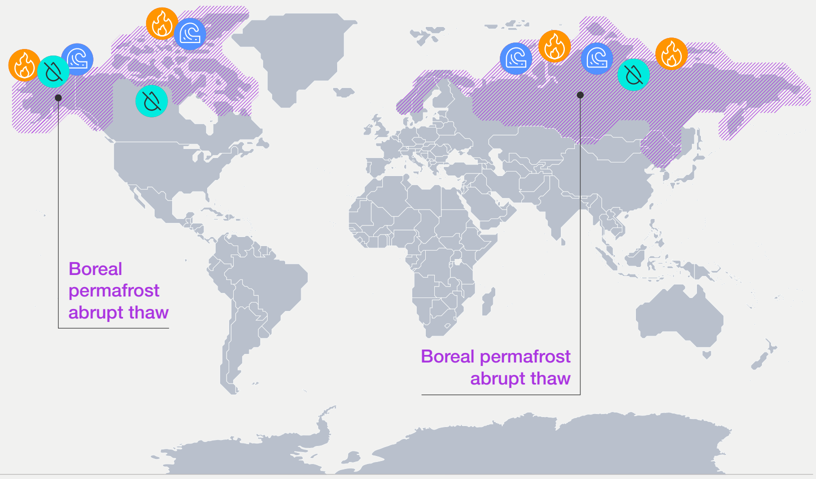
Shocking scientific fact

Permafrost emissions could consume 25-40% of our remaining carbon budget within the next 80-100 years.

Related Earth system tipping points

Related Earth system tipping points	Temperature scenario	Scientific confidence
Boreal permafrost abrupt thaw	1.0 – 2.3°C	Medium
Boreal permafrost collapse	3.0 – 6.0°C	Low

Where does it occur?



What could happen?

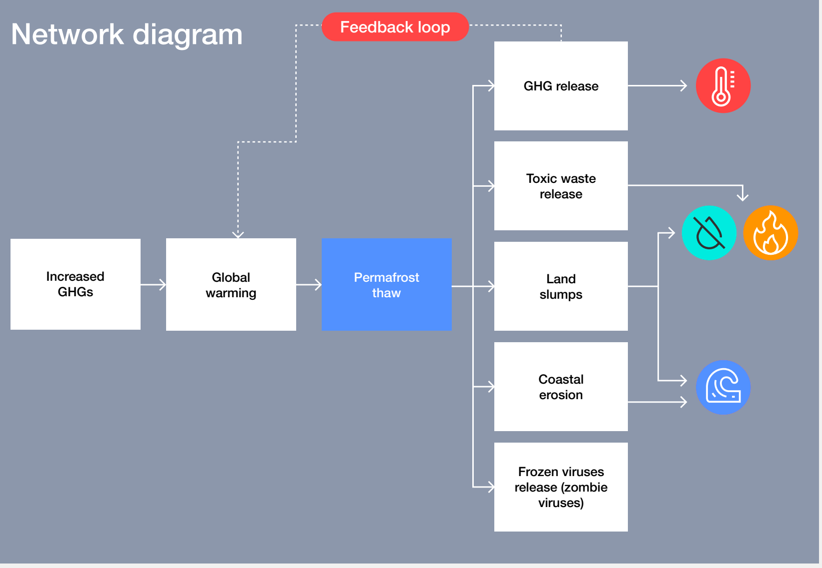
Loss of near surface permafrost

- High emissions scenario leads to the cumulative release of tens to hundreds of billions of tonnes of permafrost carbon as CO_2 and methane to the atmosphere by 2100.
- If the climate were stabilized at 2°C warming, 40% of near-surface permafrost area would be lost.
- However, stabilizing the climate at 1.5°C warming would save approx. 2 million km² of permafrost.

Damage to infrastructure

- An estimated 70% of infrastructure in the Arctic, particularly oil & gas-related, is located in areas where thawing of permafrost is expected to intensify by 2050.
- Risk of damage to infrastructure is especially pronounced in Russia, which produces 80% of its natural gas in the Arctic.

Network diagram



Socio-economic consequences

1. Thawing permafrost has led to slumping ground, which damages infrastructure.
2. Toxic industrial contaminants, which include lead, mercury and arsenic, could be released from thawing permafrost.
3. Permafrost thaw is a challenge for many of the 907 Arctic communities living on permafrost. Impacts include destabilization of infrastructure, reduction in food accessibility and declining human health.
4. A 2015 study found that greenhouse gas emissions from thawing Arctic permafrost could result in an additional $43 trillion in economic impacts by 2200.
5. Permafrost is a potential reservoir of pathogens. Permafrost thaw could lead to the release of viruses and microorganisms that may be harmful to humans, animals and plants.

2.3 Over 20 other Earth systems could be destabilized

As up to 80% of boreal forests are underlaid with permafrost, they are particularly prone to the effects of permafrost thaw, drought and fires.

The demise of these five Earth systems will have a knock-on effect on over 20 others. For instance, three Earth systems become vulnerable to tipping at 1.5-2.0°C of 10-year average warming: boreal forests, mangroves and seagrass meadows, and the Amazon rainforest.[39]

Boreal forests

Boreal forests form a ring around the North Pole, just south of the Arctic circle. As up to 80% of boreal forests are underlaid with permafrost,[40] they are particularly prone to the effects of permafrost thaw, drought and fires. Boreal wildfires are also a driver of permafrost thaw.[41] Some fires burn through the year. Known as “zombie fires” they emit carbon from boreal forests in the summer and go underground in winter, thawing permafrost.[42]

Mangroves and seagrass meadows

Mangroves and seagrass meadows are breeding and nursery grounds for sea life. They trap organic matter, preventing its decomposition and allowing for the long-term storage of carbon in the ocean. Their health is compromised by rising ocean temperatures. In some regions, the health of their ecosystems is also dependent on coral reefs.[43]

Amazon rainforest

Risks to Earth systems do not only come from higher temperatures. For example, the savannization of the Amazon rainforest is likely to be triggered by the compound impacts of both global heating and deforestation. As outlined above, the Amazon’s future is also contingent on the positioning of the tropical rain belt which could shift towards the equator due to disruption of the Atlantic Ocean’s circulation systems.

2.4 Economic models fail to encompass the full scope of Earth system tipping point risks

Many models do not account for the latest peer-reviewed observational science, which reveals worrying trends that standard models fail to predict.

Earth systems operate on a planetary scale and their degradation is unfolding at unprecedented rates. This makes it difficult to estimate precisely the full scope of shifts and their reverberating impacts.[44] Some scientific models only account for temperature impacts, not volatility of temperatures or reinforcing impacts such as nature loss.[45] Most models are not sufficiently able to incorporate the non-linear processes and existential shocks that are characteristic of Earth system tipping points.[46] Many do not account for the latest peer-reviewed observational science, which reveals worrying trends that standard models fail to predict.[47]

Meanwhile, economic models often fail to accurately encompass the full scope of climate risks.[48] They tend to focus primarily on the most likely climate scenarios and exclude significant parts of the economy from their estimates, thereby underestimating the potential for systemic shocks.[49] This exclusion leads to a disconnect between the models and the real-world economic risks posed by Earth system tipping points.[50]

Despite the shortcomings in scientific and economic models, it is clear that impacts are likely to accelerate. This places additional responsibility on business leaders to move beyond rapid decarbonization. Successful business leaders will increasingly need to implement appropriate risk management and resilience strategies whilst investing in nature and the foresight tools that enable an evidence-based and real-time response to hazards as they emerge. Those ahead of the game will have a unique and long-lasting comparative advantage.

3 How climate hazards threaten socio-economic systems

Systems highly impacted by the climate crisis include agriculture, built environment, technology, health and financial services.

3.1 Five socio-economic systems: building blocks of a prosperous and inclusive world

Climate hazards disrupt operations and essential services, damage infrastructure, increase costs across industries, trigger jobs and income losses, and threaten workforce health and productivity.

This section illustrates the direct consequences of seven climate hazards across five socio-economic systems that businesses globally contribute to and depend on. The consequences are clearly visible in the value chain of any business engaged in each of these systems and extend beyond fixed asset losses. The five socio-economic systems are:

- Agriculture, food and beverages
- Built environment
- Technology
- Health and well-being
- Financial services

The societal implications of climate hazards are far-reaching, affecting economies, businesses and communities on a global scale. Climate hazards disrupt operations and essential services, damage infrastructure, increase costs across industries, trigger jobs and income losses, and threaten workforce health and productivity. These disruptions extend beyond businesses, undermining societal well-being by causing direct physical health impacts and jeopardizing essential services such as healthcare, housing, food and water. The mental health toll is significant, as communities face the stress of environmental instability, displacement and the uncertainty of future climate risks.

As ecosystems degrade and climate risks escalate, social inequalities widen, with marginalized communities often facing the worst impacts. The compounded effects of climate hazards make it clear that business resilience and long-term economic prosperity are deeply intertwined with the health and well-being of the communities in which they operate.

Businesses large and small will face growing consequences from climate hazards in the form of supply chain costs and reduced financial performance, economic instability, and risks to societal well-being and cohesion. A recent study quantifying the impact of global heatwaves on health, labour productivity and other indirect supply chain losses, including crop failures, projected net economic losses of between $3.75 and $24.7 trillion by 2060, depending on the emissions scenario studied.[51]

Extreme heat is expected to lead to decreased worker productivity in heat-stressed zones, with certain occupations especially vulnerable due to outdoor exposure and significant physical exertion – for example, growing and harvesting crops, hauling and building with heavy materials for construction, and unloading crates for shipping.[52] In 2022, heat exposure resulted in an estimated 490 billion lost labour hours, nearly 42% higher than losses in the 1990s.[53] This corresponded to $863 billion in potential loss of income, with agriculture most severely affected.[54] The World Economic Forum estimates that heatwaves alone will depress productivity by $7.1 trillion by 2050.[55]

Investing in climate adaptation not only protects business assets but also helps sustain the societal systems that underpin stable and thriving economies.

The following sections in this chapter provide high-level recommendations for each of the five socio-economic systems, building on the framework introduced in the Forum's January 2023 white paper, *Accelerating Business Action on Climate Change Adaptation*.

3.2 Agriculture, food and beverages socio-economic system

BOX 3 **Data overview – agriculture, food and beverages system**

Global food production

Increased 54% from 2000-2021 and grew 29% faster than the number of people in the world.[56]

Single largest cause of biodiversity loss on land.

Major driver of greenhouse gas emissions.

Food systems

Cause 80% of deforestation.[57]

Use around half of all habitable land and consume over 70% of available fresh water.

Drive one-third of all human-made greenhouse gases[58] – of which half attributed to livestock and fisheries.[59]

Global agrifood market

Employs 40% of the world's workers.

Accounts for ~12% of global GDP.[60]

Projected to be worth ~$12 trillion by 2027.[61]

Drought weakens crop yields and supply chains

Droughts typically impact crop yields more severely than other climate hazards, due to their direct effect on soil moisture and plant health. Over 34% of crop and livestock production losses in low and middle-income countries can be traced to drought, costing the sector $37 billion overall.[62]

Moreover, prolonged lack of water can hinder global supply chains. The Panama Canal, crucial for 5% of global maritime trade, experienced more than a 30% decrease in rainwater during the rainy season of 2023 compared to the usual average.[63] Daily access restrictions have resulted in delays that particularly affect perishable goods, causing food losses and driving material commodity price inflation.

Tropical cyclones cause crop and livestock losses

High winds and flooding from tropical cyclones cause crop and livestock losses and the destruction of food processing and distribution facilities. Soil degradation, higher insurance premiums and insufficient resourcing of disaster responses all damage food security and livelihoods. Extreme storms cost billions of dollars in crop and livestock losses globally.[64]

Cyclones can also damage energy grids and water systems. Power shortages at processing plants after a storm hit Texas in 2021 forced dairies to dump 14 million gallons of milk, causing a breakdown in supply.[65]

Extreme heat affects cold chains, staples and fish

Extreme heat impacts the continuity and effectiveness of cold chains,[66] increasing energy costs and food waste. In India, where only 6% of food is managed through cold chains, up to 35% of harvested food is lost due to inadequate storage and refrigeration.[67] Globally, failure to provide appropriate temperature conditions results in the loss of 12-13% of the food supply, valued at approximately $379 billion annually[68] – enough to feed around 1 billion people; more than the 750 million suffering from hunger in the world today.[69,70]

Warming temperatures diminish the efficiency of key staple foods, such as rice – a vital carbohydrate source for over half the global population – which can lose yield with a night-time temperature increase.[71] Similarly, higher ocean temperatures are harming fish populations, causing shifts in species distribution and reproductive challenges, further undermining food security. By 2050, ensuring access to nutritious and affordable diets will be a major challenge, as extreme weather events heighten the risks of malnutrition[72] and exacerbate social inequalities.

FIGURE 13 | **Consequences of climate hazards to the agriculture, food and beverages system**

Sourcing	Formulation, processing & packaging	Logistics & distribution	Sales & consumer preferences
Land maintenance for crops, horticulture, cattle farming, animal welfare and productivity, fisheries and water sourcing	Industrial food and beverage formulation, processing and packaging	Transportation models and infrastructure	Retail and consumer choice
Dominant hazards			
Crop losses	Damage to production infrastructure & machinery	Cold chain disruptions & food losses	Damage of physical assets
Livestock exhaustion & losses	Water shortages & treatment interruptions	Livestock exhaustion & losses	Reduced access to food
Fish & seafood losses	Higher energy use for cooling	Transport disruption	Reduced nutritional quality
Soil degradation	Supply chain delays		
Reduced labour productivity			Increased toxins in perishable goods
Threats to worker safety, health & well-being			Food waste
Reduced pesticide effectiveness	Changes in formulation due to reduced availability of ingredients, materials & resources		Deterioration of packaging quality
Water scarcity			Increased demand for beverages
Feed shortages for livestock			Changing consumer preferences

Extreme heat · Wildfire · Tropical cyclone · Coastal flooding · Fluvial flooding · Water stress · Drought

Combined climate impacts on agriculture and food security

The combined impacts of droughts, floods and heatwaves damage crops, reduce yields and disrupt the growing season. These hazards cause food waste and insecurity as well as economic losses, driving up prices and disrupting supply chains worldwide. In Honduras in 2020, a combination of drought, excessive rainfall and flooding caused catastrophic crop losses with a 50% drop in agricultural output. This led to increased food insecurity and compelled many people to migrate within and outside the country.[73]

Due to its significance and scale, the agriculture, food and beverages system has great potential to influence sustainable development on many levels, if it is resilient and effectively adapted to climate hazards. Supporting resilient food systems can help eliminate hunger, regional nutrient deficiencies and nature degradation.

> Annual financial losses caused by climate hazards on agricultural land in one of the world's largest food producers, Brazil, could reach $23.3 billion by 2035, rising to $42.8 billion in 2055 under a high emissions scenario.[74]

Recommendations to build industry and societal resilience in the agriculture, food and beverages system

The following recommendations give agriculture, food and beverages companies an array of solutions where they can take the lead and manage growing risks from climate hazards in agriculture, food and beverages supply chains:

Integrate local business continuity and crisis management planning to mitigate exposure to extreme weather events

– Develop five- and 10-year strategies for locations and commodities at high risk from climate hazards, including operational resilience and recovery planning at key processing and production facilities.

– Invest in new agriculture techniques, climate-resilient crop variations, diversifying supply chains, securing physical infrastructure and mitigating water stress.

Reinvent core products and packaging for flexible ingredient and raw material formulations

– Rethink product design to allow for flexible sourcing of raw materials and new formulations to incorporate more resilient and climate-adapted ingredients.

Engage with consumers to raise awareness and promote sustainable consumption preferences

– Shape demand by engaging with consumers to create new markets for innovative, sustainable and climate-smart products at affordable price points.

Collaborate across the value chain to improve productivity per hectare and water efficiency

– Agriculture systems need investment in regenerative practices to increase capacity without consuming more land and to build long-term resilience to climate hazards.

– Depending on the location and specific needs, these interventions could include topsoil regeneration, enhancing local biodiversity, intercropping and agroecology.

– Additional practices like minimizing soil disturbance, rotational grazing and cover cropping are crucial to restoring soil structure and vitality.

– By investing in regenerative methods, companies not only protect their supply chains but also enhance ecosystem services, sequester carbon and contribute to biodiversity conservation that builds societal resilience.

– Business will need to work with local government and financial institutions to de-risk the transition of farming communities to new production methods.

FIGURE 14 **Adaptation case studies in the agriculture, food and beverages system**

1 Unilever

Unilever expects typhoons and floods to disrupt operations, so they partnered with renewable energy developers to install solar plants at six Indian factories.

2 Cargill

Cargill is working to help scale and support farmer adoption of regenerative agriculture, with a vision of making regenerative agriculture common place across the company's global supply chains. This includes a commitment to advancing regenerative agriculture practices across 10 million acres of North American agricultural land by 2030. Regenerative farming practices focus on building resilience and delivering positive outcomes such as improved soil health and water quality, enhanced biodiversity, and increased productivity.

3 Bayer

Bayer developed the Arize hybrid rice variety, which is disease-resistant, high-yielding, and more tolerant to salty water. This innovation helps farmers in Vietnam's Mekong Delta protect their rice harvests from reduced rainfall and rising sea levels pushing saltwater further inland. They build strong partnerships with governments, foundations, institutes and NGOs to address rice production challenges with innovative and sustainable solutions. The company is also working on developing new parental lines with greater tolerance to extreme temperatures.

4 Louis Dreyfus Company

Louis Dreyfus Company (LDC) grants LDC Climate Resilience Prize of CHF 100,000 cash award for startups enhancing climate resilience in agriculture and food value chains. LDC aims to support sustainable solutions through its corporate venture capital program which invests in early-stage companies with transformative products and technologies.

Sources: Unilever, Cargill (press release), Cargill (website), Bayer, Louis Dreyfus Company.

3.3 Built environment socio-economic system

BOX 4 **Data overview – built environment system**

Cities support over 80% of global GDP and house 56% of the global population.[75]	Physical investment and economic activities in cities account for 70% of global GHG emissions.[76]	Buildings and transport are among the largest emitters.[77]	By 2050, built environments are set to double in size.	14 of the world's 17 largest cities are coastal.

Built environments are predicted to double in size by the middle of this century and climate-driven migration will further intensify urbanization.[78] With such high demand and increasing pressure on resources,[79] cities will struggle to provide adequate living conditions for expanding and shifting populations.

Climate hazards threaten the construction, use and lifetime value of built environments. As extreme weather events such as tropical cyclones, wildfires and floods intensify, the costs to build, maintain and recover infrastructure rise.[80] These hazards have direct financial consequences, including supply chain disruption and material scarcity, declining net asset values, increased costs, revenue losses and higher capital expenses, all of which undermine long-term returns.

FIGURE 15 **Consequences of climate hazards to the built environment system**

Materials, manufacturing & logistics	Construction	Usage, maintenance & renovation	Insurance & reinsurance, financing	End of use
Materials extraction, processing and production; collaboration with suppliers, equipment arrangement	Construction process	Usage, maintenance and renovation	Purchasing insurance and acquiring funds	Reuse, redesign, recycling, incineration, landfill
Dominant hazards				
Wildfire, Fluvial flooding, Coastal flooding, Water stress, Tropical cyclone	Tropical cyclone, Fluvial flooding, Coastal flooding, Extreme heat, Water stress	Tropical cyclone, Wildfire, Coastal flooding, Extreme heat, Drought, Water stress	Tropical cyclone, Wildfire, Fluvial flooding, Coastal flooding	Tropical cyclone, Wildfire, Fluvial flooding, Coastal flooding
Disturbance of raw materials extraction	Supply chain & logistics delays	Physical damage to property & infrastructure	Reduced insurance coverage or refusal to insure	Increased risk of damage & collapse
Raw materials scarcity	Direct damages to equipment & construction site	Power outages	Higher insurance premiums	Higher waste-management costs
Disruption of raw materials processing	Increased risk of construction disaster	Increased energy demand & inefficiency	Reduced funds	
Transportation disruption due to physical obstacles	Impaired performance of building materials	High maintenance frequency & repair costs	Higher interest rates	
Threat to workers' safety, health & well-being	Threat to workers' safety, health & well-being	Threat to residents' safety, health & well-being	Increased risk of default or insolvency	
Supply chain & logistics delays			Property devaluation	

Extreme heat · Wildfire · Tropical cyclone · Coastal flooding · Fluvial flooding · Water stress · Drought

Tropical cyclones and floods threaten infrastructure

Tropical cyclones and flooding pose a significant and growing threat to life and infrastructure. High winds from cyclones can destroy buildings, kill thousands and cause massive economic losses. Hurricane Katrina, one of the most devastating US disasters, led to nearly 2,000 deaths and the destruction of over 200,000 homes.[81] Elevated rainfall can trigger fluvial and pluvial flooding,[82] damaging property, cutting off utilities and even causing hidden landslides. The after-effects, such as weakened foundations and costly repairs, can push communities into financial crises long after the water recedes.[83]

Annual financial losses accruing to retail properties from climate hazards across China could reach $21 billion by 2035, rising to $33.7 billion by 2055 under a high emissions scenario.[84]

Coastal hazards threaten 14 of the world's largest cities

Coastal cities are particularly vulnerable to climate hazards. Fourteen of the world's 17 largest cities are coastal,[85] making them susceptible to rising sea levels, intense storms, storm surges and erosion.[86] Additionally, continued seaside development weakens natural defences such as mangroves and coral reefs, exacerbating the risk from extreme weather.[87]

Extreme heat will affect eight times more urban residents by 2050

Urban areas face escalating risks from extreme heat. Urban heat islands, caused by heat-absorbing surfaces, elevate temperatures in cities and other built-up areas.[88] The number of cities experiencing extreme heat will nearly triple, exposing eight times more people to the impacts.[89] By 2050, 1.6 billion urban residents will be more vulnerable to heat-related illnesses.[90]

Furthermore, high temperatures can reduce the efficiency of power transmission lines and transformers, leading to power outages.[91] Extreme heat can cause roads to buckle, rail lines to warp and runways to soften or melt.[92] It can also cause bridge materials to expand, leading to dangerous conditions and transport disruptions.[93]

Climate hazards drive up cost of insurance

Climate hazards are driving up the cost and availability of insurance and financing. Extreme weather events can reduce the availability of funds or lead to higher borrowing costs due to increased risk of default or insolvency.[94] Insurance becomes less accessible and more expensive, with insurers withdrawing from high-risk areas.[95] This trend is creating "insurance deserts",[96] further threatening the economic stability of affected communities.[97]

Recommendations to build industry and societal resilience in the built environment system

The following recommendations give built environment companies an array of solutions where they can take the lead and manage growing risks from climate hazards in the built environment:

Integrate local climate risk analysis into capital maintenance and investment decisions, while supporting societal transitions

- Develop a process and a partner ecosystem to map climate risks at the asset level.
- Invest in the necessary nature and climate expertise, data, skills and technology to support better decision-making and maintain the expected return on invested capital in the face of evolving local risks.
- In the event that investments in high-risk locations no longer remain viable, allow for long-term planning with local and regional stakeholders and safeguards to ensure a just and fair transition for communities most affected.

Invest in resilient materials design and nature-based solutions to withstand and maintain efficiency through extreme weather

- Create building, factory and asset designs that can endure extreme weather events.
- Invest research and development into more resilient raw materials that support energy and water efficiency, to help avoid operational shocks and overheads.
- Avoid further habitat conversion and leverage nature-based solutions to contribute to natural resilience against hazards such as coastal and fluvial flooding.

Foster cross-sector collaboration on mutual recovery programmes to build regional resilience

- Establish mutual recovery and assistance programmes with operators of comparable infrastructure facing common climate threats.
- Form alliances to boost shared resources, expertise and recovery capabilities in the event of extreme weather or natural disasters, reducing downtime and expediting recovery.

FIGURE 16 **Adaptation case studies in the built environment system**

1 Hitachi

Hitachi collaborates with Japanese local governments to develop smart sewer systems to prevent flooding during periods of intense rainfall. Using AI, they automate decisions for pumping stations that manage rainwater flow into rivers. The AI predicts inflow amounts based on rainfall data and pipe water levels, then creates operation plans for rainwater pumps.

2 CEMEX

CEMEX promoted their permeable concrete PERVIA™ for infrastructure resilient to extreme weather events. Partnering with the Water Utility Company in Bogota, PERVIA™ was applied for pedestrian paths near wetlands prone to flooding. Digital simulations and on-site tests demonstrated its effectiveness in permeating rainwater while providing a durable surface. This initiative led to replacing asphalt with permeable concrete, securing benefits like flood protection and recreational use, and cost savings.

3 Exelon

Exelon is enhancing adaptation planning to build resilience against changing weather patterns by investing in maintaining infrastructure, such as poles and vegetation trimming, and conducts storm drills. They participate in mutual assistance programmes for quicker power restoration post major storms.

Sources: World Economic Forum, CEMEX, Exelon.

3.4 Technology socio-economic system

BOX 5 **Data overview – technology system**

Demand for computing power is doubling every three to four months.

70% of critical mineral extraction may be exposed to droughts by 2050.

Majority of mines and production sites for lithium and copper are concentrated in areas facing water stress (50% and 80%, respectively).

Lithium and copper extraction consumed over 65% of local water supply in Salar de Atacama, Chile, depriving Indigenous farming communities of resources on which their livelihoods depended.

In 2027, global AI demand could lead to withdrawal of 4.2-6.6 billion cubic metres of water – about half UK's annual withdrawal.

Global market for AI expected to expand by 169% in the next three years, with AI data centre capacity growing at 40+% a year.

Telecommunications, internet and digital devices have changed the way the world works and interacts. Today, there are more mobile phones than people[98] and two-thirds of the world's population has access to the internet, 93% of whom use social media every month.[99] As global living standards rise and innovation continues at pace, a continued surge in demand for devices and connectivity is likely.

However, communications and digital technologies are resource- and fixed asset-intensive to develop and operate. With innovations such as generative AI, the demand for computing power is doubling every three to four months.[100]

Extreme heat and tropical cyclones threaten infrastructure and devices

Due to the reliance on fixed assets and complex networks, climate hazards threaten the stability and continuity of the technology socio-economic system. Hardware manufacturers, telecommunications providers and data centre operators rely on capital-intensive fixed assets that can be difficult to relocate. These facilities are integral to corporate operations, yet they are highly vulnerable to climate hazards such as floods, tropical cyclones and extreme heat, which pose risks to service delivery and operational continuity.

Heatwaves themselves have a profound impact on the lifespan of electronic devices and components as well. For example, cell phones with lithium-ion batteries stop working above 35°C to avoid overheating, while exposure to prolonged extreme temperatures above 30°C can cause premature lithium-ion battery degradation, accelerating depleting corrosion reactions. This is particularly important for electric vehicles, as degraded batteries can cause cars to lose up to 20% of their range.[101]

FIGURE 17 | Consequences of climate hazards to the technology system

Raw materials extraction	Hardware operations	Technology end-user products	Data centres and AI	Connectivity
Mining, extraction and separation of raw metals & minerals and rare earth elements	Production, assembling and transport of electronic devices, EVs, renewable energy technology, batteries and semi-conductors	Electronic devices, EVs, renewable energy technology, batteries	Operation and maintainance of data transfer and storage infrastructure	Infrastructure: base transceiver stations (BTS), baseband units (BBU), submarine communication cables
Dominant hazards				
Lack of water for extraction	Power outages	Overheating of electronic devices	Overheating of data centres	Infrastructure damage
Conflicts over water supply	Infrastructure damage	Reduced battery efficiency	Increased demand for water for cooling	Service interruptions
Threats to worker safety, health & well-being	Lack of water for production	Battery degradation	Conflicts over water supply	
Spills of hazardous waste	Loss of valuable materials from e-waste		Competition for renewable energy resources	
	Danger to hazardous waste-management infrastructure			

Extreme heat · Wildfire · Tropical cyclone · Coastal flooding · Fluvial flooding · Water stress · Drought

The impact of extreme heat on data centres already installed in London could result in annual financial losses of $472 million by 2035, rising to $695 million by 2055 under a high emissions scenario.[102]

Water stress impacts mining and manufacturing

The technology sector is also exposed to concentrated supply chains for scarce resources. As much as 70% of critical mineral extraction may be exposed to droughts by 2050.[103] The majority of mines and production sites for lithium and copper are concentrated in areas already facing water stress (50% and 80%, respectively). Methods used to mine critical minerals require huge amounts of water for separating, cooling machinery and controlling dust.

A severe drought in Taiwan in 2021 jeopardized nearly two-thirds of the world's semiconductor manufacturing capacity, leading to increased costs and extended lead times for vital components across various tech sectors.[104] Water scarcity will become a threat not only to manufacturers but to all stakeholders. History demonstrates how conflicts over water resources can disadvantage local communities in places like Chile's Salar de Atacama, where lithium and copper extraction consumed over 65% of the local water supply and deprived local Indigenous farming communities of resources that their livelihoods depended on.[105]

Severe drought in Taiwan in 2021 jeopardized nearly two-thirds of the world's semiconductor manufacturing capacity, leading to increased costs and extended lead times for vital components.

AI data centres drive up water demand

The rapid growth of AI amplifies pressure on clean energy and water sources. Over the next three years, the global market for AI is expected to expand by 169%, driving AI data centre capacity to grow at over 40% a year.[106] This demand for data centres not only increases the need for reliable and renewable energy but also puts a strain on local water supplies, including potable water.

Water is used in data centres both to generate power and as a liquid coolant. In 2021 data centres were already ranked in the top ten water-consuming industrial and commercial sectors of the United States.[107] The largest data centres in development today could use up to 600 million litres of water a year. In 2027, global AI demand could lead to the withdrawal of 4.2-6.6 billion cubic metres of water – about half the annual withdrawal of the United Kingdom.[108]

The power of AI to accelerate solutions the world needs is increasingly clear but competition for limited resources in local communities underscores the need for the technology sector to continue to innovate on efficiency, resilience and adaptation strategies. For example, through energy efficient hardware design, data selection criteria, efficiencies in AI model training and tuning, new cooling solutions such as immersion or direct-to-chip cooling and water recycling, the resource footprint of AI can be significantly reduced.

Recommendations to build industry and societal resilience in the technology system

The following recommendations give technology businesses an array of solutions where they can take the lead and manage growing risks from climate hazards in the technology system:

Conduct end-to-end assessments across the value chain to identify systemic risks from climate hazards

- Prioritize the development and implementation of energy efficient infrastructure, such as communications networks and data centres that are also designed to withstand extreme weather conditions.
- Cloud, AI and internet of things (IoT) technologies can support the industry to develop risk assessments and build their own supply chain resilience to ensure operational continuity and sustainability in the long-term.

Partner with technology providers to develop circular business models that reduce pressure on scarce resources

- Work closely with technology suppliers to create circular business models that prioritize resource efficiency and sustainability. This includes establishing reverse logistics for the reuse and recycling of electronic devices and components.
- Enhance resilience against supply chain disruptions caused by climate hazards, by reducing reliance on scarce resources and creating more decentralized refurbishment operations.

Invest in and collaborate on technologies and approaches to enhance community and supply chain resilience

- Focus on developing and implementing early warning systems and visualization tools to educate and inform societies.
- By doing so, provide critical information to the communities served by technology, enabling better local preparedness to emerging climate hazards.

FIGURE 18 **Adaptation case studies in the technology system**

1 Huawei

Huawei's trade-in and recycling initiatives promote sustainability by recycling electronic devices and offering economic benefits to consumers. By the end of 2021, Huawei's global recycling system included 2,000 centres in nearly 50 countries, processing over 8,600 metric tons of e-waste. Huawei extracts raw materials from discarded devices, significantly reducing e-waste and conserving resources.

2 Aveva

AVEVA is involved in developing circular business models that reduce pressures on scarce resources. The company focuses on creating connected data ecosystems for industries like batteries and electric vehicles (EVs), which include reverse logistics and the reuse of components. For example, AVEVA's solutions help manage the lifecycle of EV batteries, from production to recycling, ensuring efficient use of materials and minimizing waste.

3 Cisco

The Cisco Foundation has committed $100 million over 10 years to fund non-profit grants and impact investments in climate solutions. This funding supports innovative projects aimed at building resilient ecosystems, promoting clean energy and advancing sustainable infrastructure.

Sources: Huawei, AVEVA, Cisco.

3.5 Health and well-being socio-economic system

BOX 6 **Data overview – health and well-being system**

Global spending on health reached $9.8 trillion in 2021, a new high equivalent to 10.3% of global GDP.[109]

Healthcare systems account for an average 4.6% of global CO_2 emissions.[110]

Climate crisis will lead to an additional ~14.5 million deaths by 2050 – 79% in low-and middle-income countries.

Floods are expected to cause 8.5 million deaths by 2050.

By 2050, an additional 500 million people may be at risk of exposure to vector-borne diseases.

Risk of damage to hospitals from extreme weather events has increased by 41% since 1990.

Climate risks threaten societal health and healthcare

Health and well-being are at the heart of society's ability to prosper and thrive. However, climate hazards pose significant risks to global healthcare systems, increasing death and disease while exacerbating inequalities. Extreme heat, droughts, tropical cyclones and floods threaten healthcare by damaging infrastructure, disrupting supply chains and raising operational costs.

Climate hazards also undermine preventive health by limiting physical activity, worsening nutrition and increasing mental health issues, driving up healthcare demands. Additionally, declining biodiversity threatens the discovery of new drugs, with one potential breakthrough lost every two years as natural sources of medicines disappear.[111]

FIGURE 19 | Consequences of climate hazards to the health and well-being system

Impacts on human health

Dominant hazards

Respiratory diseases	Infectious diseases	Cardiovascular diseases	Heat-related diseases	Malnutrition	Fatalities & injuries	Mental health

Health & well-being service fulfilment

Dominant hazards

Prevention		Diagnostics		Treatment	
Vaccine supply chain disruptions	Challenges to sustain the cold chain	Medical devices supply chain disruptions	Challenges to sustain the cold chain	Higher operating costs of facilities	Increased asset management costs
Decreased vaccine potency	Reduced quantity & quality of crops	Medical devices lifespan & functionality shortages	Increased energy demand	Overwhelmed response capacity	Medicine production delays & shortages
Storage disruptions due to power outages	Food supply chain disruptions	Impact on sterilization processes	Decreased sensor reliability of wearable devices	Equipment failure due to power outages	Decreased medicine efficacy
Decreased personal investment in physical & mental health		Equipment disruptions due to power outages	Reduced test result accuracy	Cancellation of surgeries	Disruptions in raw materials sourcing

Infrastructure damage leading to increased asset management & maintenance costs, repairs & retrofits on fixed assets

Threat to workers' safety, health & well-being, resulting in staff shortages & service disruptions

Extreme heat · Wildfire · Tropical cyclone · Coastal flooding · Fluvial flooding · Water stress · Drought

Extreme weather and flooding impact lives and infrastructure

Extreme weather events pose a fundamental direct threat to human health, disproportionately impacting the most vulnerable populations. It is estimated that the climate crisis will lead to an additional 14.5 million deaths by 2050,[112] 79% of which will be in low-and middle-income countries.[113] Floods alone are expected to cause 8.5 million deaths by 2050.[114]

Healthcare infrastructure is particularly vulnerable. Storms and flooding cause significant damage to hospitals, medical devices and capacity for critical procedures.[115] Cooling-dependent equipment (such as ventilators, MRI machines or refrigerators for storing biological samples) and cold chains for medication and vaccine storage are highly susceptible to power outages and logistics disruptions. Extreme weather events lead to substantial repair costs and increased healthcare expenses, placing long-lasting pressure on the entire system.

Risk of damage to hospitals from extreme weather events has already increased by 41% since 1990.[116] By 2100, 1 in 12 hospitals globally will be at risk of a shutdown due to climate hazards, particularly in low- and middle-income countries, increasing mortality rates.[117] Damage to hospital structures forces evacuations and closures that overstretch other hospitals, lowering the quality of care they can provide and restricting access to preventive healthcare.[118]

Extreme heat and air pollution exacerbates disease

Elevated temperatures and changes in precipitation patterns will increase the spread of infectious diseases, such as malaria, dengue, West Nile virus and Zika.[119] By 2050, an additional 500 million people may be at risk of exposure to vector-borne diseases.[120]

Rising temperatures in the poles increase the risk of releasing pathogens trapped in permafrost for millennia (zombie viruses), raising the likelihood of dangerous outbreaks, which health systems are not prepared to manage.[121] Extreme heat and air pollution are also likely to exacerbate cardiovascular, respiratory and mental health diseases.[122] This will further strain healthcare systems, disrupt labour productivity and necessitate significant investments in public health.

Water risk and cold chain failure affect manufacture of and access to medicines

Health-related industries, including pharmaceuticals and life sciences, will face escalating production delays, costs and distribution challenges. The pharma industry's reliance on water makes it highly vulnerable to water-related risks and may result in disrupted medicine production.[123]

Disruptions to cold-chain storage and transit[124] may cause active medical ingredients to degrade and become ineffective,[125] which not only leads to financial losses for the companies but also undermines the adequate provision of healthcare.[126] Failures in the cold chain have been linked to outbreaks of vaccine-preventable diseases, particularly in developing countries, which further increases healthcare costs and damages public health outcomes.[127]

The average life sciences company could see annual fixed asset losses of $60 million by 2035 due to climate hazards under a high emissions scenario.[128]

Recommendations to build industry and societal resilience in the health and well-being system

The following recommendations give life sciences businesses an array of solutions where they can take the lead and manage growing risks from climate hazards in the health and well-being system:

Build flexibility into service networks and implement regional plans for business continuity during extreme weather

- Ensure operations are equipped to handle greater exposure to extreme weather risk by developing storage, logistics, back-up power, mobile healthcare units and recovery solutions that build distributed service networks and continuity.

Develop strategies to maintain workforce productivity during periods of extreme heat

- Consider long-term strategies to protect employee well-being and productivity during short- and long-term heatwaves.
- For example, working practices can be adapted to accommodate more flexible working hours and workplace guidelines and regulations can better suit regional considerations.

Pivot R&D to develop climate-resilient products and services for vulnerable populations

- Focus on a growing market to support greater resilience through precision medicine, wearables for remote diagnostics and more durable medical devices.
- Collaborate with suppliers to ensure equipment is mobile and long-lasting, while anticipating climate-induced disease vectors by region, to help healthcare companies stay ahead of growing climate hazards.

Invest in public health campaigns and collaborate on disaster response plans to raise awareness and prevent patient surges

- Educate the public about climate risks and necessary precautions to help reduce the strain on healthcare systems during extreme events.
- Collaborate with local healthcare providers, government agencies and NGOs to ensure that organizations are well-prepared to respond to disasters as they emerge.

Prioritize preventative healthcare

- This will increase capacity to manage the consequences of the nature and climate crisis.

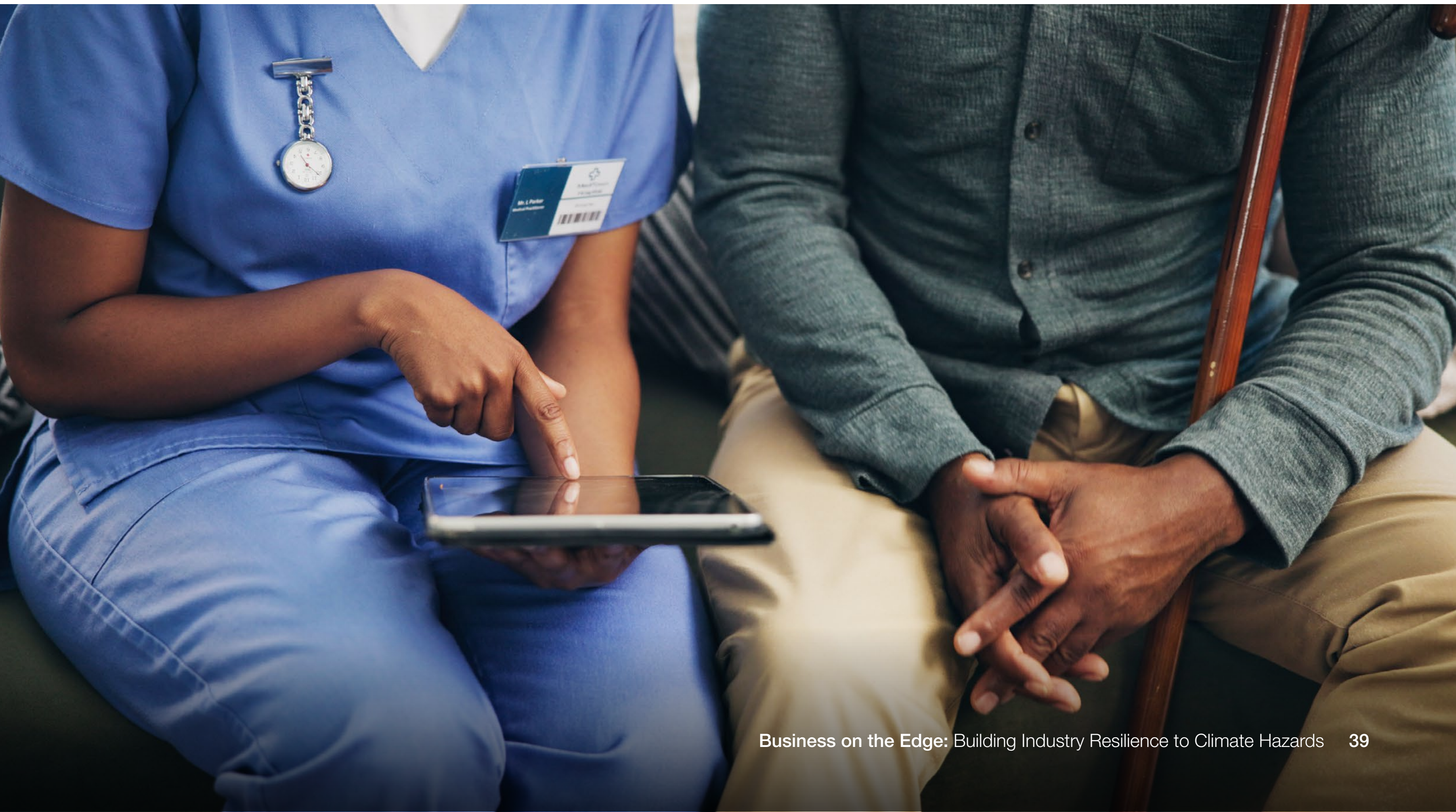


FIGURE 20 | **Adaptation case studies in the health and well-being system**

1 Cigna & Accredo

Cigna, in response to the risk of tropical cyclones, has partnered with Accredo, a specialized pharmaceutical provider for patients with complex medical conditions, which has business continuity and disaster recovery plans in place. Accredo has invested in stockpiles of products such as critical life-sustaining drugs at multiple locations to ensure that in the event of a disaster, the company will not rely on a single location to deliver types of therapies to patients.

2 Sanofi

Sanofi develops treatments against vector-borne diseases in response to extreme heat and increased precipitation that promote an array of infectious diseases. They are working on several research and development programmes for climate-sensitive diseases including:

- a new vaccine against yellow fever (innovative on cell culture) specifically for Latin America.
- the development of an oral treatment for sleeping sickness.
- the promotion of affordable treatment and prevention programmes in the areas most affected by malaria.

3 Burjeel Holdings

Burjeel Holdings has launched the Burjeel Holdings Center for Climate and Health to proactively tackle the pressing health impacts of climate change. The centre will introduce advanced screening and consultation protocols to identify climate-sensitive triggers, such as air pollution and extreme heat, ensuring patients receive personalized care. Healthcare professionals at Burjeel will incorporate climate risk assessments during patient consultations, providing patients with counseling on how to mitigate the impact of environmental stressors.

4 Kaiser Permanente

Kaiser Permanente is investing in innovative research to better understand the health impacts of climate change, particularly on vulnerable populations like children, older adults and low-income communities. They are actively studying the relationships between extreme climate events and health outcomes, focusing on conditions exacerbated by rising temperatures, such as cardiovascular diseases.

Sources: Cigna, Sanofi, Burjeel Holdings, Kaiser Permanente.

3.6 Financial services socio-economic system

BOX 7 | **Data overview – financial services system**

Financial institutions' portfolio emissions are on average over 700 times larger than direct operational emissions.

Residential properties in flood-risk areas of the US were overvalued by $121-237 billion in 2023.

Since the 1970s, extreme weather-related damage has increased sevenfold – reaching $313 billion in global economic losses in 2022.

In 2023, only 38% of global economic losses due to natural catastrophes were insured.

Reinsurers' estimates of their exposure to natural catastrophe risk could be underestimated by 33-50%, according to S&P Global.

Financial services underpin global economic stability and growth by spreading financial risk and allocating resources efficiently. Financial institutions bear financial risk through the loan, investment and underwriting portfolios they hold. Through their portfolio emissions – which are on average over 700 times larger than their direct operational emissions – financial institutions can have a material impact on climate change.[129] This underscores the need for more comprehensive management of financed emissions.

The financial services system is currently confronted with macroeconomic pressures of high interest rates, inflation, economic slowdown and a global debt crisis. The interconnectedness of financial institutions implies that risks, including climate risks, can be transmitted throughout the entire system, and feedback loops with other sectors can cause risk to spread rapidly and uncontrollably if not identified, managed and mitigated.[130]

Physical and transition climate risks affect business models

Physical and transition climate risks are likely to affect the strategies, business models and financial performance of financial services companies, impacting lending, investment, insurance and reinsurance products. As extreme weather events such as tropical cyclones, coupled with rising sea levels, render coastal properties uninsurable, mortgages and loans are likely to be written off as default rates rise. As physical and transition risks intensify, contagion could spread beyond financial markets and cause broader economic disconnections and dislocations, transmitted for example via global supply chains.[131]

A cycle of more expensive financing and higher insurance premiums would reduce the ability of consumers and businesses to spend and invest. Stranded assets[132] would move beyond the fossil fuel industry to other sectors as climate risks intensify.[133] While diversification provides a degree of risk management, particularly in the short- to medium-term, more work is needed to understand how different climate scenarios, and the physical and transition risks that arise, may translate into financial impacts for companies and financial firms.

Climate hazards pose systemic risk to entire finance sector

The systemic risk posed by climate hazards threatens the entire financial services sector. The materialization of physical risks could lead to system-wide shocks and high volatility of financial markets, causing sharp asset price corrections that simultaneously affect multiple financial institutions holding these assets.[134] This can lead to cascading failures across the entire system.[135] International financial institutions such as the World Bank and International Monetary Fund play a crucial role in maintaining financial security by coordinating capital flows in regions facing climate risks and providing risk-sharing arrangements.[136] These institutions should continue to lead on adaptation and resilience finance, using tools including guarantee products, co-financing and catastrophe bonds.

FIGURE 21 | Consequences of climate hazards to the financial services system

Financial services					
Banking			Insurance & reinsurance		
Retail	Commercial	Investment	Retail	Commercial	Reinsurance
Dominant hazards					
Tropical cyclone, Wildfire, Fluvial flooding, Coastal flooding	Tropical cyclone, Wildfire, Fluvial flooding, Coastal flooding	Tropical cyclone, Wildfire, Fluvial flooding, Coastal flooding	Tropical cyclone, Wildfire, Fluvial flooding, Coastal flooding, Extreme heat	Tropical cyclone, Wildfire, Fluvial flooding, Coastal flooding, Extreme heat	Tropical cyclone, Wildfire, Fluvial flooding, Coastal flooding, Extreme heat
Property devaluation		Decreased financial asset values	Higher costs for insurance providers due to extreme weather events		
Decreased demand for mortgages & loans		Impaired portfolio performance due to lower stock prices	Smaller customer base due to higher premiums, limited coverage or withdrawal from risk-prone areas		
Increased credit risk (default or insolvency)		Higher losses due to business interruptions	Increase in claims due to weather-related damage to real estate, automobile & company's tangible assets		Increasing exposure to severe losses
Increased risk for the mortgage portfolio		Increased risk for the investment portfolio	Higher losses for life & health insurance due to human health impacts	Higher losses due to business interruptions	Rising demand for reinsurance offerings
Decreased revenue due to higher rejection rate for loan applications		Poorly informed investment decision-making			
Threat to financial stability					

Extreme heat | Wildfire | Tropical cyclone | Coastal flooding | Fluvial flooding | Water stress | Drought

Floods and tropical cyclones depreciate property values

Commercial and retail mortgages are highly exposed to climate-related risks, particularly in flood-prone areas. Floods and tropical cyclones will likely cause a depreciation of property values and limit the availability and affordability of insurance. According to empirical research, residential properties in flood-risk areas were overvalued by $121-237 billion in 2023.[137] Banks that hold significant stakes in these properties may incur increased loan losses if too many of the properties they back are affected.[138] Less immediate hazards such as drought and extreme heat could lead to a permanent market shift away from certain real estate areas, impacting banks' loan portfolios.[139]

Climate risk disrupts cash flows and market valuations

Corporate investments are increasingly vulnerable to shrinking margins due to climate hazards. Climate hazards can significantly affect business performance through asset damage, operational disruptions and reduced cash flows, ultimately impacting the ability to repay debt and company valuations.[140] Financial markets may rapidly reprice assets exposed to climate risks, negatively affecting the market valuations of these investments.[141]

Consider hydroelectric plants in Sub-Saharan Africa, which provide approximately 40% of power in the region: asset valuations are likely to suffer if climate hazards drive annual financial losses estimated at $2.1 billion by 2035, rising to $3.7 billion by 2055 under a high emissions scenario.[142]

Leading insurers in California have restricted coverage for both residential and commercial real estate due to increased frequency and severity of wildfires.

Extreme weather prompts pullback from insurers

The insurance industry faces rising natural catastrophe losses, widening the protection gap. Since the 1970s, extreme weather-related damage has increased sevenfold, with 2022 alone witnessing $313 billion in global economic losses.[143] In 2023, only 38% of global economic losses due to natural catastrophes were insured[144] and the protection gap is widening further,[145] putting additional financial burden on individuals, businesses and governments.[146]

The strains are already showing. Leading insurers in California have restricted coverage for both residential and commercial real estate due to increased frequency and severity of wildfires, reflecting a wider trend of firms pulling back from risk-prone areas[147] and a subsequent pullback of bank lending due to un-insurability. Furthermore, liability insurance is becoming increasingly unavailable for companies, especially those implicated in climate-related incidents like wildfires, exposing them to significant uninsured litigation risks, such as class actions.[148] This could severely affect corporate valuations and financial stability as legal challenges from climate events continue to rise.

Reinsurers face rapidly increasing exposure to severe losses due to the climate crisis. Research conducted by S&P Global indicates that reinsurers' estimates of their exposure to natural catastrophe risk – and therefore physical climate risk - could be underestimated by 33-50%.[149] The increased volatility and growing demand for reinsurance products could result in both higher risk exposure for the reinsurers and increased costs for reinsurance buyers.[150]

Recommendations to build industry and societal resilience in the financial services system

The following recommendations give financial institutions an array of solutions where they can take the lead and respond to growing risks from climate hazards in the financial services system:

Sponsor and support the alignment of commercial and scientific climate models to better assess climate risk in financial valuations – current models are inadequate

- Invest further to improve the integration of evolving climate science into asset, debt and equity valuation processes.

- Align commercial practices with evolving climate models and local expertise, to enable better interpretation of risk premiums and discounting factors, allowing for more accurate pricing of climate risks and enhancing decision-making across portfolios.

- Use the outputs of these models to identify hotspots for adaptation and resilience finance, allowing capital to be provided in a way that reduces climate risks.

- Ensure appropriate controls are in place to mitigate environmental and social risks and avoid any unintended consequences of maladaptation.

Build portfolio strategies to capitalize on risk-mitigating investments in addition to the energy transition

- Seize clear opportunities to invest in the infrastructure required for the clean energy transition.

- Investing in climate resilience and adaptation across related or regionally located assets – which currently receives a fraction of global sustainable financing – could enhance short- and medium-term portfolio returns.

Innovate with the public sector to develop financial solutions that protect natural assets and safeguard vulnerable communities

- Work closely with governments and local stakeholders to create financial products, such as parametric insurance, and strategies that safeguard ecosystems and the populations that depend on them.

- Develop green bonds, sustainable insurance solutions and financing mechanisms that incentivize nature-based solutions and climate adaptation efforts, ultimately reducing systemic social and financial risk tied to environmental degradation.

FIGURE 22 **Adaptation case studies in the financial services system**

1 Barclays

Barclays integrated climate risk into the company's broader Enterprise Risk Management Framework, aligning with other Principal Risks and ensuring a holistic approach to risk identification, assessment and management. Barclays' Climate Risk Framework facilitates a structured integration of climate risk considerations into the bank's operations. It undergoes regular reviews and updates – including changes to risk taxonomy, definitions and methodology – to align with changing regulatory expectations and external developments.

2 AXA

AXA employs and adjusts sophisticated Nat Cat models that combines exposure, hazard and vulnerability to assess climate-related natural disaster risks. Nat Cat models integrate these three crucial components of the P&C insurance risk equation, when evaluating potential portfolio impacts over various time horizons, climate pathways and resolutions.

3 SwissRe

Swiss Re developed a parametric insurance solution to help protect the coral reef off the coast of Mexico's Yucatan Peninsula. In partnership with The Nature Conservancy and regional governments of Mexico, the insurer designed a solution that would issue payouts to a trust consisting of public and private actors that maintain reefs. To ensure the rapid disbursement of funds, payouts are triggered by wind speed measurements rather than the assessment of damage following an incident.

4 Standard Chartered Bank

Standard Chartered Bank believes immediate action on adaptation is essential, with at least $317 billion of investment required between now and 2040. A recent report by the bank shows that every $1 spent on adaptation in low-income markets could generate $12 of economic benefit. The bank's Guide for Adaptation and Resilience Finance defines key terms and lists over 100 investable activities, including climate-resilient crops, public hospital infrastructure and mangrove conservation.

Sources: Barclays, AXA (portfolio catastrophe loss modelling), AXA (natural hazards risk consulting), Swiss Re, World Economic Forum, Standard Chartered Bank.

Conclusion and recommendations

With five of Earth's systems on the brink of tipping irreversibly, business leaders must act swiftly and collaboratively to decarbonize operations, safeguard nature, build resilient value chains and adapt to climate risks.

Commitments and investment to decarbonize economies and mitigate further global heating remain an urgent priority and efforts need to intensify. However, Earth systems are already on the move and face irreversible tipping points. Five of these systems may already have passed the point of no return, presenting a new outlook for the frequency and severity of climate hazards with a direct impact on business and societies globally.

Increased awareness and action to build resilience and adapt to climate hazards becomes more urgent by the day, with material business, economic and social losses growing in the coming decade. As illustrated in this report, fixed asset losses alone equate to a drop in earnings for the average company of approximately 7% every year by 2035 – rising to over 20% in some capital-intensive industries.

The implications for the economic, social and financial systems humanity depends on are far-reaching. The science behind climate hazards and Earth system tipping points can be difficult to translate into direct business and societal risks against which C-suites can make informed decisions to safeguard, sustain and grow stakeholder value. This report helps businesses to understand the uncertainties and opportunities, and to navigate from climate risk towards sustained commercial and societal prosperity. It serves as a starting point from which to improve governance, decision-making and collaboration for resilience and adaptation – in support of not only company valuations but also the communities that companies serve.

The interconnectedness of highlighted Earth systems and the cascading nature of climate hazards necessitates a holistic approach – a conclusion also reached by the Forum's December 2024 report, *The Cost of Inaction: A CEO Guide to Navigating Climate Risk*. This report has reviewed the consequences of climate hazards across five socio-economic systems to help identify system-specific recommendations, supported by examples of what progressive companies are already doing.

Using the framework developed in the World Economic Forum's January 2023 white paper *Accelerating Business Action on Climate Change Adaptation*, these recommendations can be summarized into three universal pillars:

1. Avoid economic loss through enhancing resilience.

2. Increase revenues and sustainability through adaptation.

3. Collaborate to protect communities and ecosystems, through resilience and adaptation.

Pursuing such recommendations will require new enablers that every business leader should be activating within the next 24 months to drive better C-suite decision-making (see Figure 23).

As companies review enterprise risk management strategies and investment decisions, collaboration and effective solutions for the communities in which they already operate can still be the fastest route to safeguarding returns, goodwill and continued growth.

FIGURE 23 | **Key recommendations and business enablers**

Avoid economic loss

Enhance resilience

1. Develop a process and partner ecosystem to understand and map exposure to climate hazard risk at an asset level (including IT and IoT estates).
2. Integrate site-specific continuity, crisis management and recovery planning to mitigate exposure to water stress and extreme weather events.
3. Address single points of failure by increasing service delivery and supply chain options.
4. Develop contingency plans and practices to maintain workforce well-being and productivity through periods of extreme heat.

Increase revenue, cost savings & sustainability

Capitalize on opportunities

5. Understand long-term trends and evolve local propositions to capture adjustments in consumption preferences and emerging needs.
6. Pivot R&D to reinvent core products, services and infrastructure with new materials, formulations and circular business models.
7. Build climate smart portfolio strategies to capitalize on climate risk mitigation opportunities as a strategic advantage, alongside deep decarbonization.

Protect communities & ecosystems

Shape collaborative outcomes

8. Work across the value chain with private, public and grassroots stakeholders to develop system value frameworks that elevate economic, environmental and social interdependencies, engaging in local advocacy and assistance programmes.
9. Collaborate across the value chain to realize breakthrough solutions, for instance:
   - Circular business models to recycle, reuse and reduce scarce resources and extend product life.
   - Productivity and regenerative practices to increase food yields per unit of land and water that mitigate extreme weather risk.
   - Shared industry data and technologies to build and implement early warning systems that identify and mitigate damage.
   - Public-private financial models to protect natural assets and communities they support.
10. Take responsibility for tackling biodiversity loss and promote nature-based solutions and business models that help reduce climate-related risks.

Business enablers
– Activate within 24 months

Integrate climate change adaptation with net-zero transformation, and mainstream climate risk considerations into business decision-making

Make it the responsibility of the entire C-suite to understand the double materiality challenge and to establish it as a foundational element of systemic enterprise risk management.

Conduct a detailed audit of core capabilities and processes

Ensure climate resilience and adaptation percolates to every level of the organization and its ecosystem partners.

Master the non-financial data for ESG intelligence and strategic foresight to understand new risks and opportunities presented by the climate crisis

Invest in the required skills, technology and responsible use of AI to accelerate insights, decision-making and portfolio reinvention.

Tie climate risk into every capital maintenance and investment decision

Build resilience criteria with cost-benefit analysis into every capital investment decision to taper stranded asset risk, while promoting socio-economic opportunity at local levels.

Sponsor and integrate evolving scientific insight with commercial models

Improve the quality of analysis and interpretation shaping strategic and operational decisions, to account for cascading exogenous shocks.

Work in partnership with the scientific community to develop more useful insights into potential local impacts in key regions.

The pathway to sustainable economic and social prosperity amid changing Earth system demands international alignment, sound government policy, public awareness, advocacy, innovation, financing and collaboration involving those affecting and affected by climate hazards.

The nature and climate crisis directly threatens the performance and valuation of the world's largest companies. Therefore, global businesses have a unique opportunity and responsibility to lead this effort, taking a central role in shaping cross-border investment decisions, driving market innovation and supporting policies that enable long-term resilience. Companies are also uniquely positioned to safeguard and improve their communities - employees, customers and beyond - on whose trust and well-being they depend.

Now, more than ever, corporate leadership must build on net zero and nature-positive goals to foster deep, forward-looking industry and societal resilience and adaptation. The ability of businesses to address emerging climate risks today will directly affect the lives and livelihoods of millions, underscoring the urgent need for credible and proactive action.

Annexes

A1 Industry briefs

Agribusiness

Sector overview

The agribusiness industry encompasses commercial farming, fishing and related activities. It includes producers and suppliers of agricultural inputs, farmers, fisherman, breeders, agro-processors, distributors, traders, exporters and retailers.

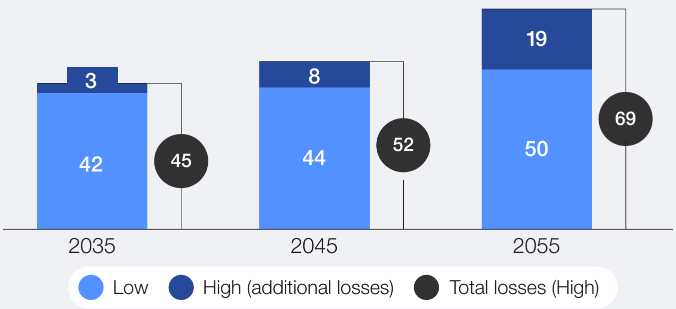
Financial overview

Average company EBITA margin (2023)	6.3%
Total industry fixed assets value (2023)	$92.85 billion
Average company fixed assets value (2023)	$2.65 billion

Financial implications of climate hazards

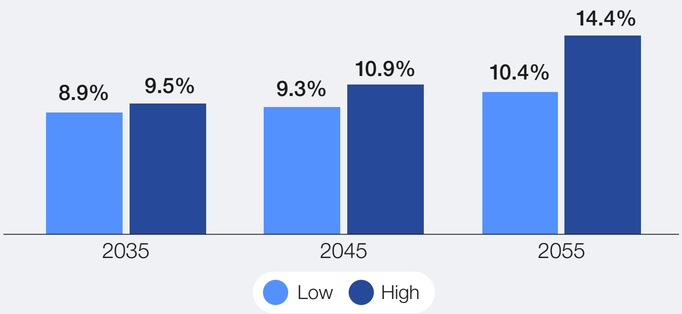
The impact of climate hazards is set to climb steadily

Average fixed business asset losses for agribusiness companies under low and high emissions scenarios ($ million per year; 2035, 2045, 2055)



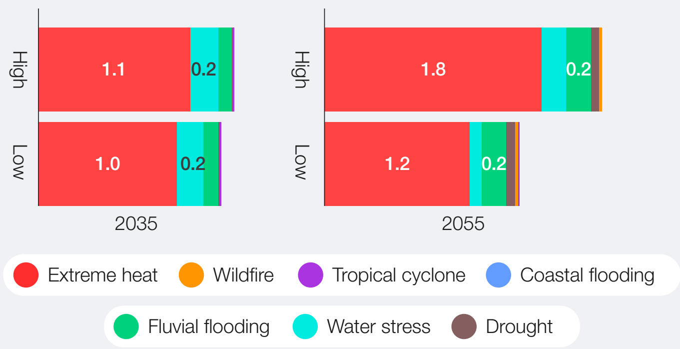
Fixed asset losses pose a major risk to profitability

Fixed asset losses as a proportion of EBITA under low and high emissions scenarios (% EBITA per year; 2035, 2045, 2055)



Threat of extreme heat set to grow

Estimated fixed asset loses for all listed agribusiness companies under high and low emissions scenarios, by climate hazard ($ billion per year; 2035, 2055)



By 2035, an average agribusiness company is expected to face fixed asset losses of **$42–45 million per year** due to climate hazards, increasing to **$44–52 million by 2045** and **$50–69 million by 2055,** depending on the emissions scenario. Building resilience in the sector is critical to protecting food security.

The losses to property, plant and equipment are set to equate to **8.9–9.5% of earnings by 2035,** potentially leading to higher food prices for consumers and reduced funds for agricultural innovation.

Extreme heat is expected to be the primary driver of fixed asset losses, accounting for **$1–1.1 billion** (71–76%) of the industry total in 2035, highlighting the need for heat-resistant crops. **Water stress** is set to account for 14–15% of annual losses in 2035, underscoring the importance of efficient water management practices and drought-resistant crop varieties.

Societal implications of climate hazards

Rising food prices

Disruptions to agribusiness supply chains affect local and global food markets. Rising operational costs for farmers will be passed on to consumers in the form of higher food prices. This impacts household budgets worldwide and contributes to inflation and reduces levels of disposable income.

Malnutrition and hunger

Climate hazards reduce agricultural output, resulting in food shortages and a decline in nutritional quality, leading to malnutrition and hunger. This a particular concern for subsistence farmers who may be forced to migrate to seek and cultivate new land and fishing grounds, potentially causing social strife.

Reduced smallholding competitiveness

Smallholder farmers, who typically work with limited margins, will suffer if crop failures and fish shortages lower incomes, hindering their ability to purchase essential inputs. This financial strain and lack of economies of scale may make smallholder farmers less competitive in the market.

Notes: Analysis of n=35 listed agribusiness companies.

Source: S&P Global Sustainable1, Accenture analysis.

Value chain implications of climate hazards

Cultivation & livestock farming

Tropical cyclones and flooding increase vulnerability to diseases and pathogens leading to **substantial losses in crop yields.**

Extreme heat causes accelerating ripening which leads to **reduced yield quality and quantity.**

Extreme heat poses challenges to livestock and marine life, **decreasing animal and fish health, productivity and overall welfare.**

Harvesting

Extreme heat leads **to less availability of water** from freshwater sources.

Tropical cyclones and floods pollute freshwater sources needed for harvesting, leading to **additional water treatment costs.**

Extreme heat threatens agricultural workers' health and safety, leading to health problems, **decreased productivity and increased absenteeism from work.**

Storage & transport

Climate hazards physically damage storage facilities, leading to **direct loss of stored crops and creating conditions for mould and decay.**

Extreme heat undermines the efficiency of cold chain transportation, resulting in **increased shipping costs.**

Climate hazards disrupt transportation networks, **delaying food supplies and increasing logistics costs,** due to detours and additional labour.

Extreme heat · Wildfire · Tropical cyclone · Coastal flooding · Fluvial flooding · Water stress · Drought

Recommendations

Avoid economic loss

Enhance resilience

Integrate climate risk management tools. Boost resilience via enhanced forecasting and supply chain vulnerability assessments.

Introduce precision agriculture. Reduce climate-related crop loss through predictive weather analytics, soil monitoring, irrigation management and optimized planting.

Adapt logistics. Adjust the time of transport and place of storage according to heat conditions.

Strenghten critical infrastructure. Reinforce roofs, install storage shutters and storm defence systems.

Implement nature-based solutions. Create sustainable farm management strategies (e.g. through vegetated buffer zones and restoring ponds and wetlands).

Increase revenue, cost savings & sustainability

Capitalize on opportunities

Introduce climate-resilient agricultural products. Boost R&D into climate-resilient and especially drought-tolerant varieties; develop water-efficient products.

Drive food innovation. Scale-up plant-based and food bio-technology such as precision fermentation, to decarbonize, drive resilience and diversify ingredient sourcing across the value chain.

Drive efficiencies. Consider solutions such as controlled environment agriculture to optimize land use, shorten supply chains, enable year-round cultivation, limit water use and reduce exposure to unpredictable weather conditions.

Protect communities & ecosystems

Shape collaborative outcomes

Drive regenerative agriculture. Help local communities adopt restorative farming practices and foster value chain collaboration to boost long-term yields.

Incentivize farmers to adapt. Support new management practices such as adjusting planting schedules, enhancing irrigation methods and implementing intercropping techniques.

Address perverse incentives. Bake biological diversity into decision-making by implementing natural capital accounting to evaluate costs and benefits. Support community-led initiatives and sustainability certification to promote land restoration.

Food and beverages

Sector overview

The food & beverages industry includes all sectors from primary production to retail and food services level. It involves the processing of raw ingredients, food and beverages manufacturing, packaging, storage, distribution and sales of ready-to-eat products.

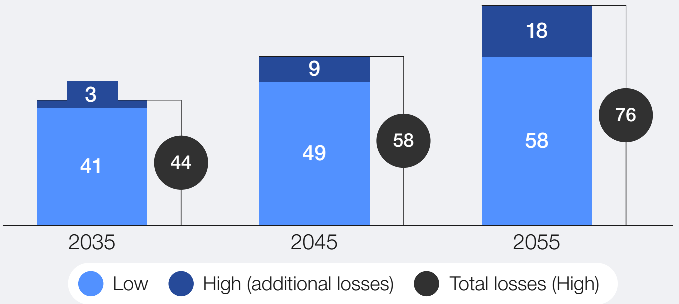
Financial overview

Average company EBITA margin (2023)	10.7%
Total industry fixed assets value (2023)	$647.84 billion
Average company fixed assets value (2023)	$2.36 billion

Financial implications of climate hazards

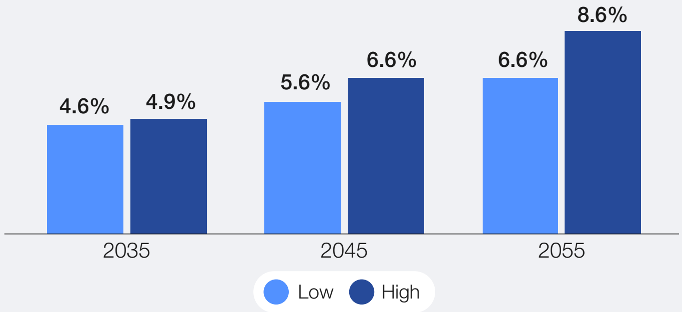
Fixed asset losses set to rise steadily over coming years

Average fixed business asset losses for food & beverages companies under low and high emissions scenarios ($ million per year; 2035, 2045, 2055)



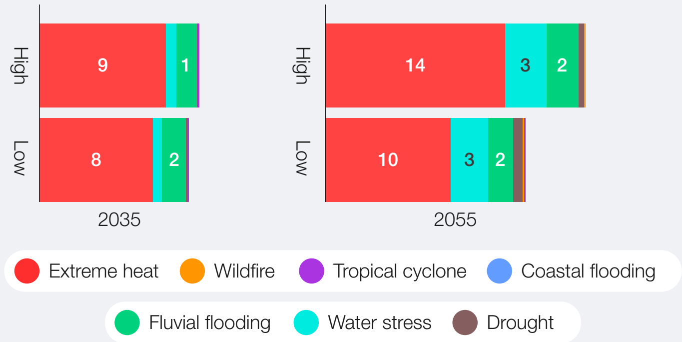
Fixed asset losses equate to a growing proportion of earnings

Fixed asset losses as a proportion of EBITA under low and high emissions scenarios (% EBITA per year; 2035, 2045, 2055)



Extreme heat the major threat, with water stress risks growing

Estimated fixed asset losses for all listed food & beverages companies under high and low emissions scenarios, by climate hazard ($ billion per year; 2035, 2055)



By 2035, the average food & beverages company is expected to face fixed asset losses of **$41–44 million per year** due to climate hazards, increasing to **$49–58 million by 2045** and **$58–76 million by 2055**, depending on the emissions scenario. These losses highlight the urgent need for protection of production facilities and supply chains.

The losses to property, plant and equipment are set to equate to **4.6–4.9% of earnings by 2035,** potentially leading to higher food and beverages prices and reduced funds for product innovation and quality improvements.

Extreme heat is expected to be the primary driver of losses, accounting for **$8–9 billion** (77–80%) of the industry total in 2035, emphasising the need for heat-resistant storage and processing facilities. **Fluvial flooding** is set to contribute 12–16% to these losses in 2035, highlighting the importance of resilient supply chain logistics.

Societal implications of climate hazards

Food shortages and price increases

Climate-related disruptions result in decreased agricultural output and increased food spoilage, reducing market supply. This causes volatility in food prices, making it more challenging for low-income consumers to access nutritious foods and alters household budget expenditure.

Reshaped dietary patterns

Prices typically rise when crops fail or supply contracts. This can lead consumers to shift their preferences toward cheaper, but less nutritionally dense foods. As a result, dietary diversity may decrease, causing a reliance on easily accessible but nutritionally poor processed foods, which contribute to obesity and diet-related disease, further increasing healthcare costs.

Sector redundancies

Rising commodity costs and inflationary pressures driven by climate hazards may result in mass layoffs as companies implement cost-saving measures. This can significantly impact entire communities that depend on the food production industry, leading to a rapid increase in unemployment in certain regions.

Notes: Analysis of n=274 listed food & beverages companies.

Source: S&P Global Sustainable1, Accenture analysis.

Value chain implications of climate hazards

Processing & packaging

Tropical cyclones and extreme heat cause power outages that halt production lines in processing and packaging facilities, resulting in **operational downtime.**

Extreme heat and moisture may change the physicochemical properties of packaging, posing **a threat to consumer health.**

Water stress limits availability of water for food processing which may force **investment in alternative water sources.**

Logistics & distribution

Extreme heat **undermines the efficiency of cold chain transportation,** resulting in **spoilage of perishable goods.**

Climate hazards disrupt transportation networks, **delaying food supplies and increasing logistics costs** due to detours and additional labour.

Flooding damages storage facilities and introduces harmful contaminants and pathogens into food storage areas, **posing serious health risks to consumers.**

Sales & consumer preferences

Flooding and extreme heat affect marketability by reducing food's shelf life and nutritional value, ultimately leading to **increased food waste** as unsold products are discarded.

Extreme heat may shift consumer preferences and purchasing behaviour towards lighter, more hydrating food and beverages, **prompting brands to adjust product offerings** accordingly.

Climate hazards affect the availability and quality of certain products and when combined with price volatility, they discourage consumers, ultimately leading to **decreased demand.**

Extreme heat | Wildfire | Tropical cyclone | Coastal flooding | Fluvial flooding | Water stress | Drought

Recommendations

Avoid economic loss

Enhance resilience

Invest in efficiency and waste minimization technologies.

For example:

- Early warning systems and temperature and humidity sensors to anticipate and mitigate food spoilage.
- Energy-efficient infrastructure to support temperature-controlled storage and help reduce GHG emissions.
- Renewable energy-powered devices to decrease dependence on fossil fuels.

Strengthen early warning systems and disaster-resistant infrastructure. Use climate-resilience practices such as storing goods on pallets and building warehouses with sustainable standards. Install rainwater collection systems and maintain storm drains regularly.

Increase revenue, cost savings & sustainability

Capitalize on opportunities

Adjust energy usage to real needs. Lowering temperatures in freezers can maintain frozen food safety and quality, lowering energy costs within supply chains.

Drive portfolio reinvention through alternative ingredients. Plant-based and novel food bio-technologies such as precision fermentation and cell-cultivation are advancing fast and, once at scale, will be able to provide radically decarbonized and consistent ingredient solutions for consumer packaged goods.

Collaborate throughout the value chain for new market opportunities. Engaging with producers, suppliers, bio-innovation start-ups and retailers drives innovation, supply chain resilience and mutually beneficial solutions to climate issues

Protect communities & ecosystems

Shape collaborative outcomes

Foster genuine partnerships. Work with local communities to learn from grassroots innovations. This collaboration enhances product development, helps meet community needs and empowers local solutions.

Collaborate on data use. Partner with all stakeholders to collect and share climate hazard data, to inform new insurance and loan products for the food and beverages industry.

Adopt blockchain. Blockchain technologies can create a transparent, traceable and trustworthy supply chain. Benefits include accurate labelling, fraud reduction, product origin details, removing intermediaries and enabling quick recall responses, enhancing food system integrity.

Infrastructure and transportation

Sector overview

The infrastructure and transportation industry comprises public and private structures such as roads, railways, bridges, tunnels and air systems. It encompasses the services and facilities necessary for economies, households and companies to function.

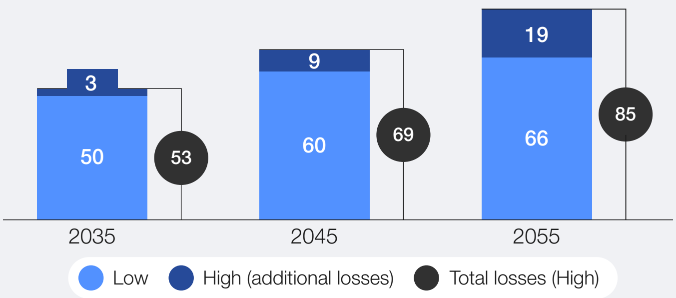
Financial overview

Average company EBITA margin (2023)	10.7%
Total industry fixed assets value (2023)	$1,833.2 billion
Average company fixed assets value (2023)	$3.07 billion

Financial implications of climate hazards

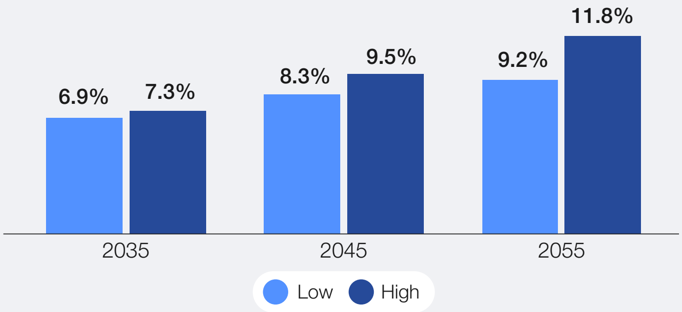
Fixed asset losses set to climb steadily

Average fixed business asset losses for infrastructure and transportation companies under low and high emissions scenarios ($ million per year; 2035, 2045, 2055)



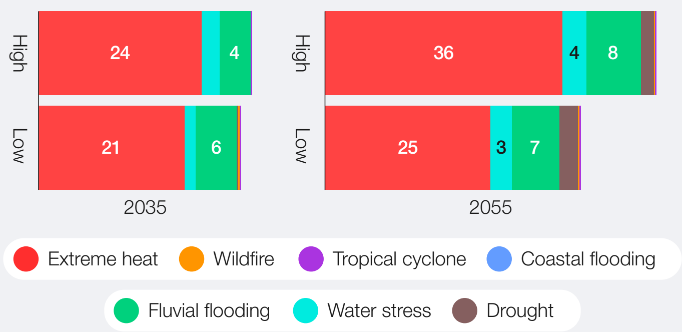
Rising climate-related losses could significantly lower profitability

Fixed asset losses as a proportion of EBITA under low and high emissions scenarios (% EBITA per year; 2035, 2045, 2055)



Extreme heat & fluvial flooding will drive fixed asset losses

Estimated fixed asset losses for all listed infrastructure and transportation companies under high and low emissions scenarios, by climate hazard ($ billion per year; 2035, 2055)



By 2035, the average listed infrastructure and transportation company is expected to face fixed asset losses of **$50–53 million per year** due to climate hazards, increasing to **$60–69 million by 2045** and **$66–85 million by 2055,** depending on the emissions scenario. This highlights the urgent need for adaptation of critical infrastructure to ensure operational continuity.

The losses to property, plant and equipment are set to equate to **6.9–7.3% of earnings by 2035,** potentially leading to higher transportation costs and reduced funds for maintenance.

Extreme heat is expected to be the primary driver of these losses, accounting for **$21–24 billion** (73–76%) of the industry total in 2035, emphasising the need for heat-resistant materials and cooling technologies. **Fluvial flooding** is set to account for 14–20% of losses in 2035, underscoring the importance of robust flood defences and drainage systems.

Societal implications of climate hazards

Loss of critical services

Destruction of roads, bridges and public transit systems impacts access to healthcare, education and emergency services, hindering recovery efforts. Prolonged service outages threaten public safety and wellbeing.

Climate migration and displacement

Repeated climate events force entire communities to migrate from areas prone to hazards such as flooding and fires. This may result in housing shortages, strained public services and social tension in receiving areas. Displacement can also fracture communities, disrupting social ties and local economies.

Employment instability

Disruption across key transportation networks hinders the flow of goods and services. This could lead to slower growth and increased unemployment, especially in sectors reliant on infrastructure, such as logistics, retail and tourism.

Notes: Analysis of n=598 listed infrastructure & transportation companies.

Source: S&P Global Sustainable1, Accenture analysis.

Value chain implications of climate hazards

Materials manufacturing & construction	Usage, maintenance & renovation	Insurance & financing	End-of-life
Wildfires and floods disrupt resources value chains, reducing the **supply of crucial construction materials.**	Wildfires, floods & tropical cyclones cause physical damage, leading to **higher maintenance frequency and repair costs.**	Frequent wildfires, tropical cyclones & floods lead to **higher insurance** premiums, reduced coverage or retreat from risk-prone areas.	Wildfires, tropical cyclones & floods amplify the risk that **ageing infrastructure** will be damaged or collapse, posing **health risks.**
Extreme heat and tropical cyclones **reduce the performance of building materials** and result in construction site **damage** or **accidents.**	Tropical cyclones lead to power outages and extreme heat causes **increased energy demand and reduced energy efficiency.**	Wildfires, tropical cyclones & floods drive **lower funds availability** and **higher financing cost** due to risk of default or insolvency.	Wildfires, tropical cyclones & floods **require safe handling of materials** in hazard-prone areas, increasing waste management costs.
Tropical cyclones, floods & wildfires disrupt materials and equipment transportation, leading to **supply chain and logistics delays.**	Extreme heat and droughts lead to soil subsidence, which **reduces pavement and bridge integrity and weakens rail systems.**	Tropical cyclones cause disruptions to transportation networks, resulting in **increased financing needs for repairs and upgrades.**	Floods can cause contamination of waste disposal sites, resulting in **higher clean-up costs and potential environmental penalties.**

Extreme heat · Wildfire · Tropical cyclone · Coastal flooding · Fluvial flooding · Water stress · Drought

Recommendations

Avoid economic loss

Enhance resilience

Integrate climate risks into planning and design. Conduct due diligence to identify climate-related vulnerabilities and prioritize investments. Incorporate resilient design principles and technologies.

Integrate adaptation into maintenance regimes. Use resistant materials for structure reinforcement.

Enhance communication and preparedness. Ensure that residents know how to shelter or evacuate during disasters. Use hazard maps, text alerts and evacuation routes.

Develop alternative routes and renewable power systems for critical infrastructure. Use digital twins to simulate performance during disruptions.

Increase revenue, cost savings & sustainability

Capitalize on opportunities

Develop green infrastructure projects, which minimize urban heat island effects and absorb rainwater to prevent flooding.

Promote renewable energy integration. Invest in solar, wind and hydropower and energy storage solutions to ensure a stable energy supply for critical infrastructure.

Develop smart transportation networks. Examples include electric vehicle infrastructure, intelligent traffic management systems and public transportation enhancements.

Develop new expertise. Invest in training programmes and educational initiatives to develop new skills in climate-resilient infrastructure.

Protect communities & ecosystems

Shape collaborative outcomes

Foster cross-sector coordination. Collaborate with energy, water and telecommunications sectors to identify interdependencies. Work with government agencies on policies that incentivize infrastructure retrofitting.

Support environmental justice. Co-develop community infrastructure and ensure that climate resilience efforts, such as cooling centres or transportation routes, prioritize vulnerable populations and underserved areas.

Address unique challenges and opportunities faced by developing countries through knowledge sharing, technical assistance and investment in climate-resilient infrastructure projects through multilateral development banks.

Life sciences

Sector overview

The life sciences industry consists of companies operating in the research, development and manufacturing of medicines and pharmaceuticals, biotechnology, medical devices, biomedical technologies, nutraceuticals, cosmeceuticals and other products that improve the lives of organisms.

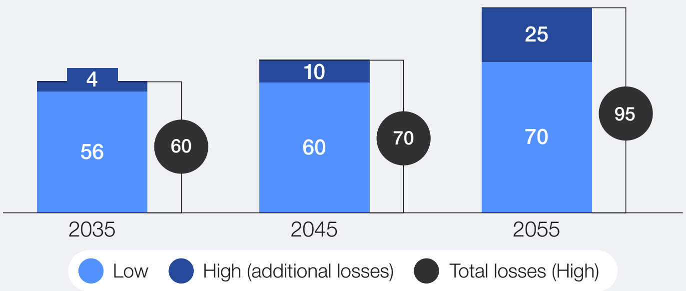
Financial overview

Average company EBITA margin (2023)	16.7%
Total industry fixed assets value (2023)	$605.5 billion
Average company fixed assets value (2023)	$2.3 billion

Financial implications of climate hazards

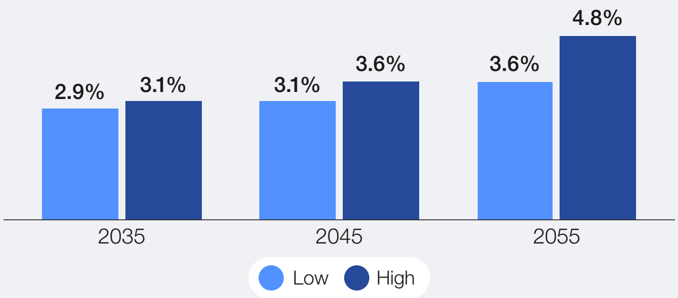
Financial losses driven by climate hazards set to climb steadily

Average listed life sciences company fixed asset losses under low and high emissions scenarios ($ million per year; 2035, 2045, 2055)



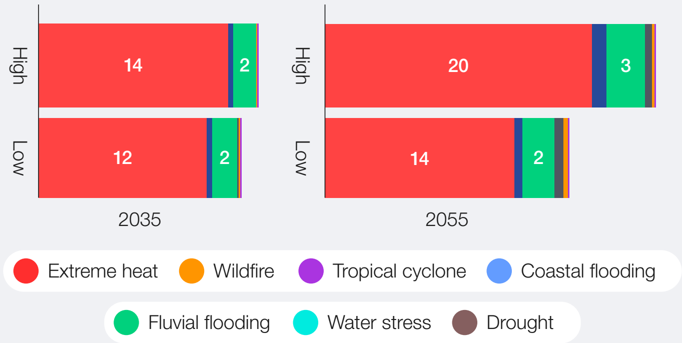
Rising climate-related losses could significantly dent profitability

Fixed asset losses as a proportion of EBITA under low and high emissions scenarios (% EBITA per year; 2035, 2045, 2055)



Extreme heat is the major driver of financial losses

Estimated fixed asset losses for all listed life sciences companies under high and low emissions scenarios, by climate hazard ($ billion per year; 2035, 2055)



By 2035, the average listed life sciences company is expected to face fixed asset losses of **$56–60 million per year** due to climate hazards, increasing to **$60–70 million by 2045** and **$70–95 million by 2055,** depending on the emissions scenario. This growing financial burden underscores the need for resilience strategies to protect production facilities and research.

The losses to property, plant and equipment are set to equate to **2.9–3.1% of earnings by 2035,** potentially affecting strategic planning.

Extreme heat will be the primary driver of these losses, accounting for **$12–14 billion** (83–86%) of the industry total in 2035, highlighting the need for advanced cooling technologies and heat-resistant infrastructure. **Fluvial flooding** is expected to drive 10–12% of annual losses in 2035, emphasizing the importance of robust flood defences and water management.

Societal implications of climate hazards

Impacts on healthcare access

Climate hazards lead to disruptions in the supply of critical medications, vaccines and medical equipment. As a result, healthcare facilities may experience shortages, hindering access to critical treatments. This can leave populations unable to receive essential medical care, further straining public health systems.

Widening social and health inequalities

Climate hazards disproportionately affect marginalized communities, worsening pre-existing social and health inequalities. Socio-economic disparities in healthcare are expected to grow and bridging the gaps to vulnerable communities will become more difficult to achieve.

Strain on mental health

Communities facing repeated climate-related disasters experience heightened stress, trauma and anxiety. The provision of equitable access to mental health resources for communities facing the destabilizing effects of climate change remains a key societal challenge.

Notes: Analysis of n=262 listed life sciences companies.

Source: S&P Global Sustainable1, Accenture analysis.

Value chain implications of climate hazards

Drug discovery & research	Manufacturing	Distribution	Dispensing
Extreme heat, droughts and wildfires lead to biodiversity loss, which **compromises the discovery of new pharmaceuticals.**	Tropical cyclones and wildfires damage manufacturing facilities and equipment resulting in **business interruption and repair costs.**	Tropical cyclones and floods **disrupt distribution networks,** requiring repairs and extending downtime, leading to **financial losses.**	Tropical cyclones and wildfires push healthcare systems to **shift to emergency-focused, lower-margin products,** reducing revenues.
Tropical cyclones and extreme heat cause power outages, which leads to **disruptions to medical equipment and laboratories.**	Tropical cyclones and extreme heat cause power outages, **disrupting manufacturing processes and plant operations.**	Extreme heat **disrupts the cold chain** for safe storage and transportation, which can result in **high wastage costs.**	Tropical cyclones and floods disrupt delivery routes, causing **delays in dispensing medications and higher logistics costs.**
Tropical cyclones lead to laboratory and clinical trial site closures, which **extend R&D process timelines and increase costs.**	Water stress **threatens drug production** as it involves water-intensive processes to ensure product safety.	Climate hazards create demand for medicines in new markets, requiring companies to **ensure adequate resources and logistics**	Climate hazards place stress on healthcare systems, **diverting resources away from sales and marketing** activities.

Extreme heat · Wildfire · Tropical cyclone · Coastal flooding · Fluvial flooding · Water stress · Drought

Recommendations

Avoid economic loss

Enhance resilience

Develop climate-resilient infrastructure. Reinforce and upgrade manufacturing facilities, research labs and distribution centres to withstand climate impacts.

Introduce climate intelligence. Use science-backed climate intelligence to forecast climate risk and improve transparency and traceability to ensure robust supply chains during climate disruptions. Use big data and AI to predict disease outbreaks and manage healthcare resources more efficiently.

Invest in renewable energy sources. Transition away from fossil fuels to reduce direct emissions and enhance energy security against climate-related disruptions.

Increase revenue, cost savings & sustainability

Capitalize on opportunities

Boost innovation in emerging diseases. Increase R&D into emerging infectious diseases to develop vaccines and reduce the likelihood of outbreaks.

Innovate in product development. Develop more heat-stable medications and packaging to ensure products reach remote locations without deteriorating. Improve cold-chain supply networks in low- and middle-income countries.

Leverage digital health technologies. Expand the use of telemedicine and remote monitoring technologies to provide healthcare access in climate-affected regions.

Protect communities & ecosystems

Shape collaborative outcomes

Incentivize suppliers to enhance climate resilience. Engage upstream and downstream partners in climate risk assessments. Co-develop adaptation and resilience strategies to strengthen the value chain.

Collaborate with governments to protect vulnerable populations. Ensure underserved populations have affordable access to essential medicines, particularly in regions most affected by the climate crisis.

Support community resilience. Invest in public health campaigns to make people aware of the climate risks, helping to safeguard against potential patient surges.

Telecommunications

Sector overview

The telecommunications sector is made up of three categories of companies: telecom services, including voice services (traditional & mobile) and data services (internet access); telecom equipment, such as hardware manufacturers (fibre optics, switches, satellites); and infrastructure providers that maintain the physical networks.

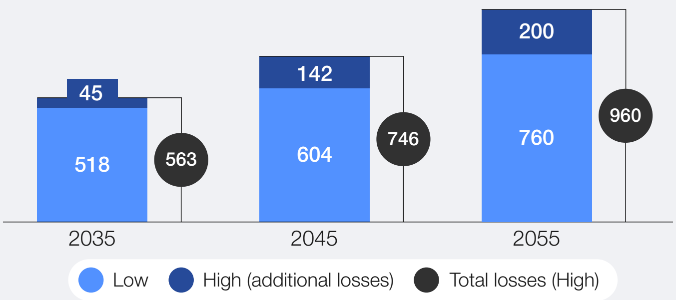
Financial overview

Average company EBITA margin (2023)	19.2%
Total industry fixed assets value (2023)	$1,579.9 billion
Average company fixed assets value (2023)	$13.4 billion

Financial implications of climate hazards

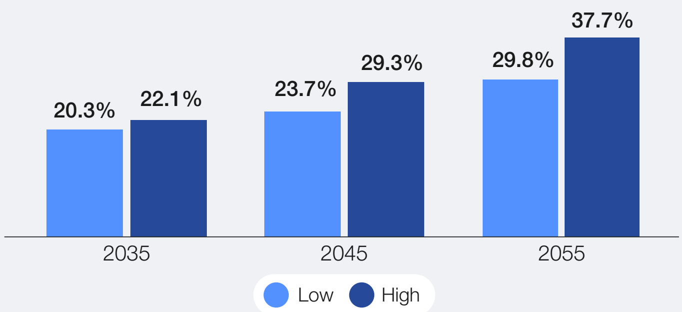
Fixed asset losses are significant and growing

Average fixed business asset losses for telecommunications companies under low and high emissions scenarios ($ million per year; 2035, 2045, 2055)



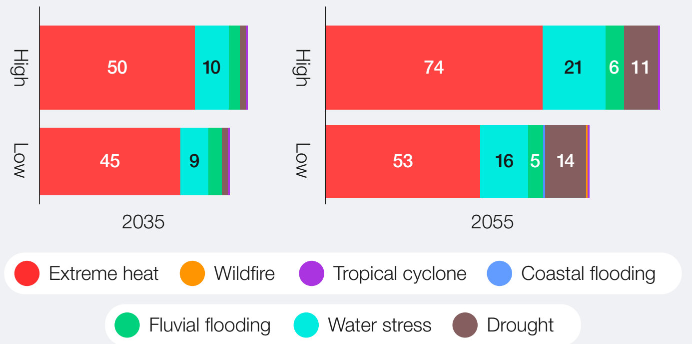
Estimated losses climb to roughly a third of earnings by 2055

Fixed asset losses as a proportion of EBITA under low and high emissions scenarios (% EBITA per year; 2035, 2045, 2055)



Extreme heat is the major threat; water stress & drought growing

Estimated fixed asset losses for all listed telecommunications companies under high and low emissions scenarios, by climate hazard ($ billion per year; 2035, 2055)



By 2035, the average telecommunications company is expected to face fixed asset losses of **$518–563 million per year** due to climate hazards, increasing to **$604–746 million by 2045** and **$760–960 million by 2055,** depending on the emissions scenario. This underscores the need for adaptation measures to protect critical infrastructure and ensure uninterrupted service.

The losses to property, plant and equipment are set to equate to **20.3–22.1% of earnings by 2035,** potentially leading to higher service costs and reduced funds for network expansion or technological advancements.

Extreme heat is expected to be the primary driver of losses, accounting for **$45–50 billion** (74–75%) of the industry total in 2035, emphasizing the need for heat-resistant equipment and cooling technologies. **Water stress** is set to contribute 15–16% to these losses in 2035, highlighting the importance of sustainable water management practices to maintain cooling systems and data centres.

Societal implications of climate hazards

Connectivity during disasters

Climate hazards can harm essential telecommunications infrastructure, causing major service interruptions. Such outages obstruct communication during emergencies, affecting public safety and disaster response and raising the likelihood of misinformation.

Augmented cybersecurity risks

Climate hazards can exacerbate cybersecurity vulnerabilities. Outages caused by climate hazards may damage critical infrastructure, including data centres and communication networks; this leads to failures in security systems, making them more susceptible to cyberattacks during periods of crisis.

Declines in jobs and economic prospects

Unreliable telecommunications infrastructure can limit educational and work opportunities. Communities with unreliable connectivity may struggle to attract businesses and investment, which can cause a cycle of economic decline and further impact residents' ability to seek employment.

Notes: Analysis of n=153 listed travel companies.

Source: S&P Global Sustainable1, Accenture analysis.

Value chain implications of climate hazards

Telecom equipment manufacturing	Infrastructure operations & maintenence	Service provisioning
Tropical cyclone, Extreme heat, Fluvial flooding, Coastal flooding	Tropical cyclone, Fluvial flooding, Coastal flooding, Extreme heat	Extreme heat, Wildfire, Tropical cyclone, Fluvial flooding, Coastal flooding
Tropical cyclones and extreme heat cause power outages and physical damage, causing downtime that results in **lower productivity** and **financial losses.**	Tropical cyclones and floods **damage transmission towers,** cables and other vital infrastructure resulting in immediate **repair costs.**	Extreme heat disrupts data centre cooling systems, causing **power outages, equipment failures and connectivity issues,** which affects service delivery and customer satisfaction.
Increased frequency and intensity of tropical cyclones and floods leads to **infrastructure damage** and **logistics disruptions.**	Extreme heat leads to **increased energy consumption** for cooling systems of telecom towers and data centres, **raising operational costs.**	Smoke and ash from wildfires can **scatter or absorb signals,** especially in high-frequency bands, leading to **reduced signal strength,** coverage and **increased latency.**
Climate hazards **interrupt the supply of critical components** sourced or assembled in vulnerable regions, **delaying production timelines** and **limiting product availability.**	Drought conditions **affect the structural integrity of cables** and underground wiring if soil becomes too dry and shifts, increasing the risk of **cable damage or disconnections.**	Climate hazards lead to **inconsistent service delivery,** which impairs usage and could lead to **penalties or compensation claims** from affected customers.

Extreme heat | Wildfire | Tropical cyclone | Coastal flooding | Fluvial flooding | Water stress | Drought

Recommendations

Avoid economic loss

Enhance resilience

Conduct comprehensive risk assessments. This includes identifying and evaluating climate risks to fixed assets by location; mapping supply chain vulnerabilities and understanding disruption potential; and estimating likely losses to company infrastructure and supply chains due to climate hazards.

Diversify network pathways. Ensure back-up equipment and alternative routes for data transmission at critical locations to maintain connectivity when components fail due to extreme weather events.

Increase revenue, cost savings & sustainability

Capitalize on opportunities

Develop tech-powered solutions. Leverage AI and other emerging tech to create products and services tailored to climate-related challenges; for example, early warning systems, remote monitoring, telehealth, real-time alerts, satellite mobile telephony and remote working support.

Strengthen infrastructure. Upgrade infrastructure by climate-proofing above-ground transmission components – such as masts, antennas and overhead wires – to meet growing demand for connectivity even as climatic events increase in severity.

Protect communities & ecosystems

Shape collaborative outcomes

Engage with stakeholders. Work with customers, regulators and others to understand different climate risk perspectives.

Collaborate with local governments and utility companies. Enhance the resilience of key infrastructure in climate-impacted areas.

Develop monitoring capabilities. Use technology to improve climate monitoring in vulnerable regions.

Collaborate with industry partners. Share cross-sector resources and expertise to improve overall disaster preparedness. Invest in shared infrastructure to boost connectivity in remote and underserved areas.

Travel

Sector overview

The travel industry encompasses a broad range of businesses and services that facilitate travel experiences. It involves sectors such as airlines, accommodation, tour operators and travel agencies. The industry stimulates investment in infrastructure and fosters the conservation of cultural and natural heritage.

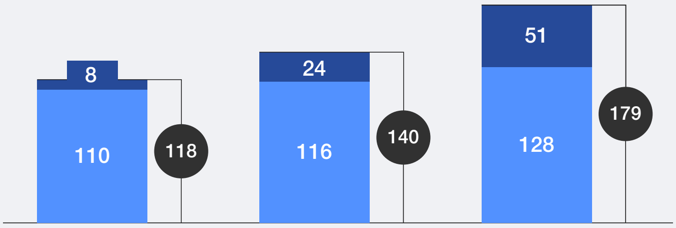
Financial overview

Average company EBITA margin (2023)	15.6%
Total industry fixed assets value (2023)	$969.7 billion
Average company fixed assets value (2023)	$6.3 billion

Financial implications of climate hazards

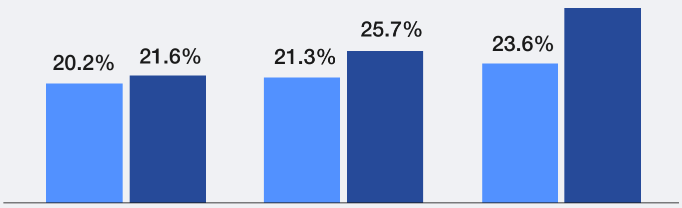
Climate-driven fixed asset losses set to climb steadily

Average listed travel company fixed asset losses under low and high emissions scenarios ($ million per year; 2035, 2045, 2055)



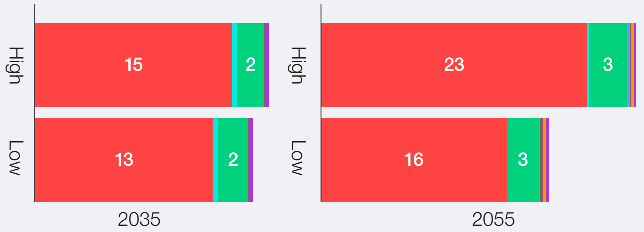
Estimated losses equate to a drop in earnings of one fifth by 2035

Fixed asset losses as a proportion of EBITA under low and high emissions scenarios (% EBITA per year; 2035, 2045, 2055)



Fluvial flooding an emerging threat beyond extreme heat

Estimated fixed asset losses for all listed travel companies under high and low emissions scenarios, by climate hazard ($ billion per year; 2035, 2055)



By 2035, the average listed travel company is expected to face fixed asset losses of **$110–118 million per year** due to climate hazards depending on the emissions scenario, increasing to **$116–140 million by 2045 and $128–179 million by 2055.** This highlights the need for climate adaptation measures to protect travel infrastructure and ensure business continuity.

The losses to property, plant and equipment are set to equate to **20.2–21.6% of earnings by 2035,** potentially leading to higher travel costs for consumers and reduced funds for service improvements and expansion.

Extreme heat is expected to be the primary driver of these losses, accounting for **$13–15 billion** (82–84%) of the industry total in 2035, emphasizing the need for heat-resistant facilities and cooling technologies. **Fluvial flooding** is set to contribute 11–14% to the annual losses in 2035, underscoring the importance of resilient travel infrastructure.

Societal implications of climate hazards

Compromised livelihoods

The increased frequency of climate hazards constrains tourism-dependent destinations and residents that depend on travel-related income. Climate hazards risk cultural disconnection and economic isolation as the attractiveness of destinations shifts and local populations are forced to find alternative sources of income.

Destruction of cultural heritage

Climate hazards can lead to the destruction of cultural heritage sites, diminishing the historical and cultural identity of communities. This destruction negatively impacts the travel sector by diminishing cultural experiences that attract visitors and reducing tourism revenue in local communities.

Increased health risks

Climate hazards can cause heat-related illnesses, respiratory problems and the spread of vector-borne diseases, putting a strain on local healthcare systems and discouraging travel to affected areas. These hazards are transforming many tourist destinations and associated health risks are already prompting some travellers to reconsider their plans.

Notes: Analysis of n=153 listed travel companies.

Source: S&P Global Sustainable1, Accenture analysis.

Value chain implications of climate hazards

Research & inspiration	Pre-trip experience	At destination	Post-trip experience
Extreme heat and floods reduce location attractiveness, **changing travel behaviour and increasing marketing costs.**	Tropical cyclones, floods & wildfires cause **travel cancellations, reducing asset utilization** and compromising customer experience.	Wildfires, floods & tropical cyclones cause **physical damage** to infrastructure and assets, leading to **financial losses.**	Disruption caused by tropical cyclones, floods & wildfires leads to increased **compensation payouts** and **insurance claims.**
Tropical cyclones, floods & wildfires **lower travel demand, reducing revenue** for tourism destinations.	Climate hazards cause transportation delays and schedule disruptions, leading to **increased demand for flexible trip options.**	Extreme heat, floods & tropical cyclones **restrict certain tourism activities, lowering associated revenue streams.**	Tropical cyclones, floods & wildfires damage travel infrastructure, leading to **higher maintenance frequency** and **repair costs.**
Extreme heat, floods & tropical cyclones **reduce the availability of travel destinations.**	Climate hazards drive demand for additional trip insurance, **increasing the overall cost of travel** and therefore **decreasing the demand.**	Tropical cyclones, floods & wildfires pose **health risks to travellers,** leading to **medical emergencies** and costly **evacuations.**	Tropical cyclones cause delays in return trips, leading to additional **accommodation expenses** and a **loss of future bookings.**

Extreme heat | Wildfire | Tropical cyclone | Coastal flooding | Fluvial flooding | Water stress | Drought

Recommendations

Avoid economic loss

Enhance resilience

Increase resilience of fixed assets and infrastructure. Reinforce and upgrade travel-related fixed assets and infrastructure to better resist climate-related events. For example, adding heat-resistant materials to cope with extreme heat and moving passenger-facing operations to higher levels to cope with flooding.

Introduce climate intelligence. Use science-backed climate intelligence to understand and forecast risks, so as to reduce disruption and minimize negative impacts on customer experience.

Increase revenue, cost savings & sustainability

Capitalize on opportunities

Develop sustainable travel products. Attract eco-conscious consumers, for example through flights using sustainable aviation fuel, or zero-waste and renewably powered accommodation.

Promote local resilience-building experiences. For example, visits to coastal communities restoring mangroves to protect against sea-level rise.

Create flexible booking and cancellation policies. Accommodate customer concerns around climate-related disruptions. For example, rescheduling trips without penalties could attract new customers and increase loyalty.

Protect communities & ecosystems

Shape collaborative outcomes

Collaborate with local communities. Co-develop tourism experiences that incorporate local adaptation strategies.

Cultivate partnerships on the ground. Work with local environmental organizations and government bodies to fund and implement resilience projects that benefit both the community and the tourism sector.

Develop integrated travel packages that combine flights with ground transportation, accommodation and activities to decrease the risk of disruption and delays, while promoting climate-resilient options.

Utilities

Sector overview

The utilities industry is responsible for generating, transmitting and distributing electric power and natural gas, as well as water supplies and sewage disposal. The sector provides essential public services and is integral to economic infrastructure and the built environment.

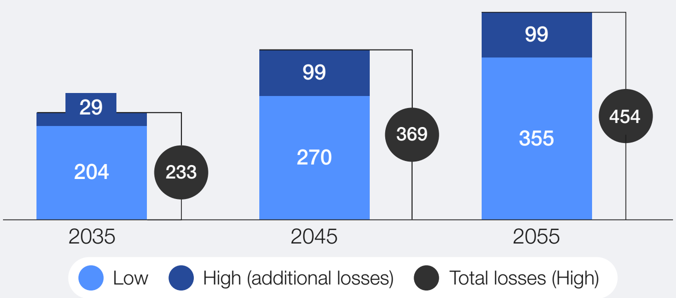
Financial overview

Average company EBITA margin (2023)	17.8%
Total industry fixed assets value (2023)	$4,100.52 billion
Average company fixed assets value (2023)	$14.2 billion

Financial implications of climate hazards

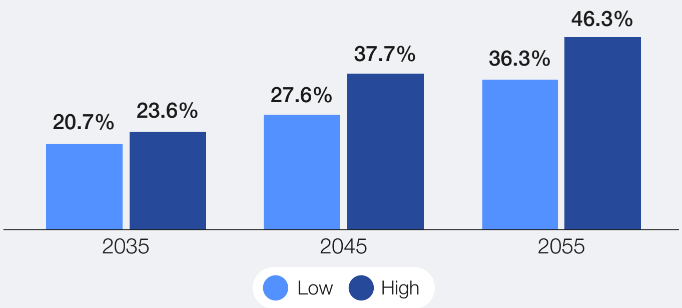
Financial losses driven by climate hazards set to climb steadily

Average listed utilities company fixed asset losses under low and high emissions scenarios ($ million per year; 2035, 2045, 2055)



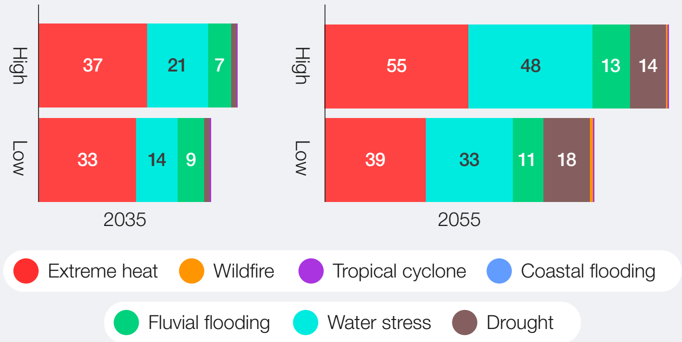
Losses climb above a quarter of earnings by 2045

Fixed asset losses as a proportion of EBITA under low and high emissions scenarios (% EBITA per year; 2035, 2045, 2055)



Extreme heat & water stress set to be the major drivers of losses

Estimated fixed asset losses for all listed utilities companies under high and low emissions scenarios, by climate hazard ($ billion per year; 2035, 2055)



By 2035, the average utility company is expected to face fixed asset losses of **$204–233 million per year** due to climate hazards, increasing to **$270–369 million by 2045** and **$355–454 million by 2055,** depending on the emissions scenario. These projected losses underscore the need to invest in reinforcing infrastructure and ensuring service continuity.

The losses to property, plant and equipment are set to equate to **20.7–23.6% of earnings by 2035,** which could lead to higher charges for consumers.

Extreme heat is expected to be the primary driver of these losses, accounting for **$33–37 billion** (55–57%) of the industry total in 2035, emphasizing the need for heat-resistant infrastructure and cooling technologies. **Water stress** is set to drive 24–32% of annual losses in 2035, highlighting the importance of sustainable water management practices.

Societal implications of climate hazards

Power outages exacerbate threats

Power outages during extreme events disrupt essential services such as healthcare, water supply and sewage treatment. This can prevent individuals from meeting their basic needs, including cooking food, maintaining hygiene and accessing information.

Public health risks

Electricity and water supply disruptions can affect heating, cooling and sanitation systems. This increases exposure to health complications – for example, heat-related illnesses, infections, dehydration or water-borne diseases – especially for the elderly, children and other vulnerable groups.

Rising utilities costs

As infrastructure damage from climate hazards increases, utilities may pass on the costs of repairs, upgrades and resilience measures to consumers, leading to higher bills. Vulnerable populations may struggle to afford rising costs, exacerbating energy poverty and widening social inequality.

Notes: Analysis of n=290 listed utilities companies.

Source: S&P Global Sustainable1, Accenture analysis.

Value chain implications of climate hazards

Energy generation, water treatment & gas processing

Tropical cyclones, wildfires and floods cause **physical damage** to facilities and other infrastructure, leading to **disruptions in supply and higher operational costs.**

Water stress and drought **reduce the operational efficiency** of the plants, particularly those relying on water for cooling. Droughts can **reduce** hydropower plant **generation capacity.**

Extreme heat leads to **overheating of equipment** and increased demands for cooling systems, **limiting gas processing efficiency.**

Utilities transmission

Wildfires and tropical cyclones combined with extreme heat cause **physical damage** to transmission lines, substations and pipelines, leading to **power interruptions** or **gas leaks.**

Flooding and tropical cyclones **disrupt** gas and fuel **supply chains,** leading to **reduced gas availability** and **grid shortages.**

Flood damage to water pipelines and pumping stations **contaminates water supplies.** Coastal floods drive saltwater pipeline intrusion, raising **rates of corrosion.**

Utilities distribution

Tropical cyclones and floods lead to power outages, with droughts and water stress further **increasing the risk of blackouts** and **reducing access** to essential services.

Extreme heat leads to increased demand for cooling, **straining distribution networks and** leading to potential **system overloads.**

Tropical cyclones, wildfires and floods **require infrastructure repair** and upgrades to withstand extreme weather events, which leads to **increased utility prices.**

Extreme heat | Wildfire | Tropical cyclone | Coastal flooding | Fluvial flooding | Water stress | Drought

Recommendations

Avoid economic loss

Enhance resilience

Upgrade infrastructure to withstand climate hazards. Reinforce transmission and distribution infrastructure to prevent or minimize damage. Improve vegetation management to reduce contact with power lines.

Decentralize power generation. Locate smaller, renewable utility-scale facilities closer to population centres to reduce transmission interruptions and reliance on long transmission lines.

Implement technology-enabled advanced solutions. For example, weather monitoring and forecasting, or dynamic line rating, to cope with extreme heat.

Increase revenue, cost savings & sustainability

Capitalize on opportunities

Invest in climate-resilient renewable energy projects. For example, integrating solar panels with battery storage systems can provide reliable power when the grid is under strain from climate hazards.

Support the development of microgrids. These can operate independently from the main grid during emergencies.

Develop nature-based solutions. Natural barriers, such as restored mangroves and salt marshes, act as effective buffers against storm surges. They can significantly reduce the impact of flooding on critical infrastructure such as power plants and substations situated along coastlines.

Protect communities & ecosystems

Shape collaborative outcomes

Engage in industry alliances. Share best practice and drive collective progress towards climate adaptation and resilience. As a platform for collaboration and knowledge sharing, alliances help utilities align their efforts with global nature and climate initiatives.

Foster cross-sector collaboration. Work with banks to assess climate risk and adaptation strategies; with insurers to provide innovative products tailored to climate-related risks, such as parametric insurance with predefined payout triggers; and with reinsurers to help underwrite climate risks following agreed-upon investments in modernizing infrastructure.

A2 Fixed asset loss quantification method

Quantifying the impact of the nature and climate crisis on business

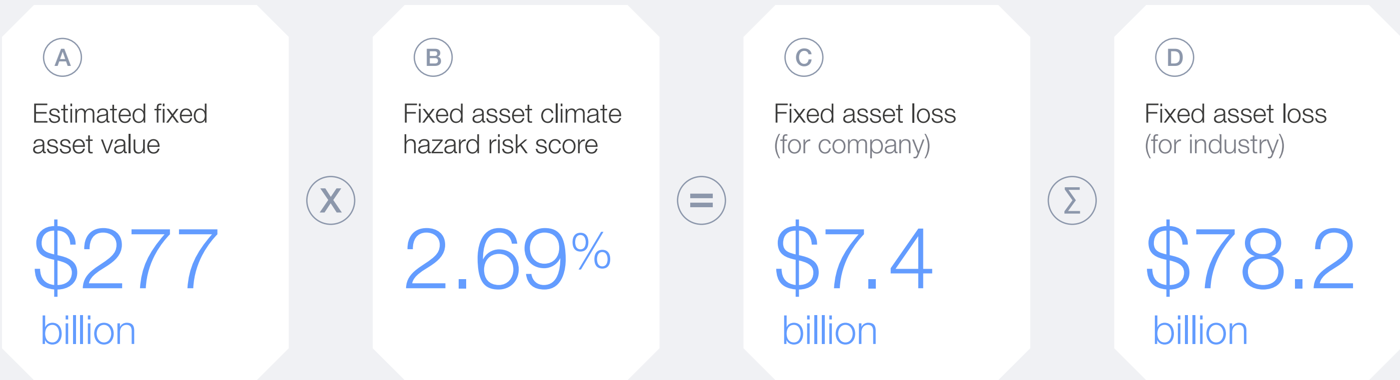
To estimate the financial risk to fixed company assets of failing to adapt to rising frequency and severity of climate hazards, the following approach was used:

1 Estimate fixed asset losses by company and industry due to seven physical climate hazards

To estimate financial losses due to physical climate hazards, the value of fixed assets held by 5,736 large, listed companies (2023 or latest year available; accessed May 2024) was sourced from S&P Capital IQ (see A in Figure 24). The companies selected all had annual revenues of more than $1 billion, a threshold employed to maximize data availability.

These fixed asset values were then multiplied by a company-level fixed asset climate hazard risk score sourced from S&P Global Sustainable1 – a weighted average of financial losses due to climate hazards reflected as a percentage of asset value for all known assets owned by a company and its subsidiaries (B). This produced an overall fixed asset loss estimate in US dollars (C), with the value of fixed assets assumed to be constant across the forecast period (see Section 6: Limitations to the approach). The results were then aggregated by industry (D) and can be seen in Figure 5 of the report. An illustrative example for a large retailer is shown below:

FIGURE 24 **Illustrative annual fixed asset loss calculation for a large retailer**



S&P Global Sustainable1 Physical Risk Financial Impact dataset

The S&P Global Sustainable1 Physical Risk Financial Impact dataset estimates the financial losses arising from changing climate hazard exposure. Data is presented as a percentage of each company's fixed assets for over 250 unique asset types across 3.1 million corporate assets and different future climate-change scenarios.

The climate-change scenarios used in this analysis are based on IPCC Representative Concentration Pathways and Shared Socio-economic Pathways and are informed by the TCFD technical guidelines.

The impact of climate hazards is simulated relative to a baseline time period before the impact of climate change was apparent; for example, for extreme heat, the baseline period is 1980-2000. The three scenarios used in this analysis are:

- **High Climate-Change Scenario (SSP5-8.5):** Low mitigation scenario in which total greenhouse gas emissions triple by 2075 and global average temperatures rise by 3.3-5.7°C by 2100.
- **Medium-High Climate-Change Scenario (SSP3-7.0):** Limited mitigation scenario in which total greenhouse gas emissions double by 2100 and global average temperatures rise by 2.8-4.6°C by 2100. This is labelled as Medium in the analysis for simplicity.

- **Low Climate-Change Scenario (SSP1-2.6):** Aggressive mitigation scenario in which total greenhouse gas emissions reduce to net zero by 2050, resulting in global average temperatures rising by 1.3-2.4°C by 2100, consistent with the goals of the Paris Agreement.

Data is available by decade, from the 2020s to the 2090s. For simplicity, this analysis refers to the decade midpoint for each datapoint (for example, 2035 for the 2030s). Metrics are not intended to represent the percentage of a company's fixed asset value that will be lost but rather reflect the magnitude of those costs relative to the value of the company's total fixed assets. Losses include: increased operational expenses, lost revenues due to business interruption, physical damage and costs incurred to repair assets. They exclude other costs, such as value chain disruptions, insurance premium rises or lower consumer spending power. As such, the total climate hazard losses facing companies are likely to be much higher than those presented in the analysis.

Note: Climate risk modelling is a rapidly evolving field. The parameters and assumptions used influence both the direction and magnitude of change and can therefore be contested. S&P Global, which is ranked as industry-leading for physical climate data capabilities and a category leader overall for physical risk modelling solutions,[151] uses multiple sources to estimate the impact of physical climate hazards on fixed assets. For example, extreme heat is modelled using metrics including annual occurrences of warm days (TX95p), NOAA's Heat Stress Index, duration-and-intensity heatwave metrics, and extreme values generalized extreme value (GEV) analysis.

The data is downscaled using techniques embedded in the NASA NEX-GDDP downscaled data set, augmented with corrections and adjustments. A different downscaling approach could produce different results. In the early forecast period (2025), risk in the high emissions scenario is below that in the low emissions scenario because of the time taken for net increases in longwave radiation caused by higher emissions to manifest as signal above a background natural climate variability when looking at aggregate weather patterns at a local level (see Figure 6). More detail on the methodology behind this dataset – including how the physical climate hazards are defined – is available on the S&P Global website.[152]

2 Extrapolate analysis to all listed companies

To provide a more comprehensive estimate of fixed asset losses, the results were extrapolated to all listed companies. Data on 2023 (or latest available year) business revenues for 55,515 listed companies was sourced from S&P Capital IQ in May 2024, of which the revenues held by the 5,736 large, listed companies analysed in Step 1 already account for a large majority (78.7%). To estimate the financial losses for all listed companies, the extrapolation coefficient is calculated using the formula below:

Total 2023 revenues for all listed companies (n=55,155) / Total 2023 revenues for all large, listed companies (n=5,736)

The calculation assumes the fixed asset to revenue ratio of all listed companies (n=55,155) is the same as that of the subset (n=5,736). The extrapolation coefficient is assumed to be constant across industries to smooth out the dominance of large companies in specific industries that could skew the results. The results are shown in Figure 3 and Figure 4.

Note: Unlisted companies – including small and medium-sized enterprises, start-ups, scale-ups and unicorns – account for a significant proportion of business output across the world and will face climate-related losses, depending on their fixed asset needs and exposure. However, these companies were excluded from the analysis for data availability reasons (see Annex 2: Limitations to the approach).

3 Explore geographic implications

Geolocation was used to identify where specific fixed assets held by the 5,736 large businesses are located. The six regions into which fixed assets were geolocated are: United States and Canada, Latin America and the Caribbean, Europe, Middle East, Africa and Asia-Pacific. The analysis calculates the average expected risk to fixed assets in each region from each hazard. The top five are presented in Table 2.

Note: Calculating fixed asset losses in US dollars is not possible because companies often hold fixed assets in regions beyond where they are headquartered. Overall fixed asset value data is currently only available at the broader company level. Calculations that assumed all company fixed assets were situated in the same country as their headquarters would have been misleading and were therefore not calculated.

4 Compare fixed asset losses with earnings

To contextualize the magnitude of the costs relating to physical climate hazards, fixed asset losses (under different emissions scenarios, across different decades) are compared with earnings (average EBITA 2021-23) across 5,043 companies using the formula below. These companies are a subset of the 5,736 from Step 1 for which sufficient EBITA data is available. The results of this analysis are shown in Figure 6 and Figure 7.

∑ Fixed asset losses for all companies / ∑ EBITA for all companies

Note: As the analysis explores the accelerated depreciation of fixed assets due to physical climate hazards, EBITA (earnings before interest, taxes and amortization), as opposed to EBITDA (earnings before interest, taxes, depreciation and amortization), was selected as the most relevant profit metric for comparison. EBITA for every company is averaged from 2021 to 2023 and assumed to be constant across the forecast period. For companies in the travel industry, EBITA is averaged across 2022 and 2023 only to prevent the impact of the Covid-19 pandemic skewing the data and driving misleadingly high results. Financial services companies were excluded from this analysis as they do not typically report on this metric.

5 Fixed asset category loss estimations

In each of the five socio-economic systems, a worked example of losses to a particular fixed asset category, in a specific location, is given. These include farmland in Brazil and data centres in the United Kingdom. The assumptions and sources underpinning each example are shown in Table 3 below. For data availability reasons, the calculations assume that the risk of physical climate hazards to fixed asset categories is uniform across geographies. Results should be considered directional only.

TABLE 3 **Assumptions and source data underpinning asset category estimations**

Socio-economic system	Asset category	Geography	Scale	Value
Agriculture, food and beverages	Agriculture	Brazil	**239.4m²:** hectares of agricultural land (Source)	**$4,183:** cost per hectare (Source)
Built environment	Retail	China	**412.46m²:** sales area of retail stores in China (Source)	**9,934 yuan ($1,366):** cost per m² of commercial real estate (Source)
Technology	Data centre	United Kingdom	**1062.3 MW:** Data centre inventory (Source)	**$10.19:** Data-centre construction cost per watt (Source)
Health and well-being	Health and healthcare	United States	**356,946 square feet:** average hospital size (Source)	**$430.85:** cost per square foot (Source)
Financial services	Utilities	Sub-Saharan Africa	**42 GW:** total hydropower installed capacity (Source)	**$2,608:** hydropower installation costs per kW (Source)

6 Limitations to the approach

Future research on this topic might seek to gain a deeper understanding of the costs to business of Earth system tipping points that are channelled through physical climate hazards by addressing several limitations to the approach:

1. The full impact of Earth system tipping point breaches: The analysis does not fully account for the frequency and severity of physical climate hazards that reverberate through Earth systems as tipping points cascade. These risks are challenging for financial analysts and natural systems scientists to model with accuracy. Moreover, as Earth system tipping points reinforce global warming beyond human-caused warming, they could propel global heating beyond the High Climate-Change Scenario (SSP5-8.5). Further research could study the impact fully including these tipping point breaches would have on fixed asset (and other business) losses.

2. Losses beyond fixed assets: The analysis focuses on fixed asset losses for data availability reasons. However, as discussed in the socio-economic systems section, climate hazards pose risks to other areas of business activity such as the supply chain, employee well-being and consumer spending. If future studies included the full range of risks to business activity, expected losses would likely increase.

3. Limited scope of physical climate hazards: The analysis looks at seven climate hazards (see Figure 1). However, other climate hazards were not included in the analysis, such as: pluvial flooding (when the amount of rainfall exceeds the capacity of urban storm water drainage systems or the ground to absorb it) and extreme cold (which can occur, for instance from jet-stream disruptions, which pull Arctic air into lower latitudes). Were future studies to include more hazards, fixed asset loss estimations might well be higher than those presented.

4. Inclusion of non-listed companies: Privately held companies account for a large proportion of business output across the world, especially in low- and middle-income economies. These unlisted companies include small and medium-sized enterprises, start-ups, scale-ups and unicorns. As they typically face less stringent reporting requirements, data on key metrics, such as the value of fixed assets held, location of assets and climate hazard exposure is not as robust as for listed companies. These companies were therefore excluded from the analysis. If non-listed companies were included in future studies, total fixed asset loss estimations would likely be significantly higher.

5. Assumption of constant assets: The fixed asset loss estimations assume that the value of fixed assets is constant. The value of the property, plant and equipment companies hold clearly fluctuates over time depending on factors such as depreciation and investment; indeed, some assets could become stranded due to climate hazards. Forecasting this trajectory could be included in future studies.

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1. World Economic Forum. (2024, 26 September). *World's Leading CEO Climate Alliance Slashes Emissions by 10% While Achieving 18% Revenue Growth in Three Years* [Press release]. https://www.weforum.org/press/2024/09/world-s-leading-ceo-climate-alliance-slashes-emissions-by-10-while-achieving-18-revenue-growth-in-three-years/.
2. World Economic Forum. (2023). *Accelerating Business Action on Climate Change*. https://www3.weforum.org/docs/WEF_Climate_Change_Adaptation_2023.pdf.
3. Kotz, M. et al. (2024). The economic commitment of climate change. *Nature,* no. 628, 2024, pp. 551-557. https://www.nature.com/articles/s41586-024-07219-0.

   Note – this is a rapidly developing area of research and scenario modelling:

   – Kotz et al's research, published in April 2024, estimates an income (per capita) reduction of 11-29% (with a midpoint of 19%) by 2050, based on current emissions levels (RCP2.6).

   – The World Economic Forum's December 2024 report, *The Cost of Inaction: A CEO Guide to Navigating Climate Risk*, cites different research which finds that "overall, the net cost of inaction amounts to approximately 10% to 15% of lost global GDP by 2100." Source: Benayad, A. et al. (2024). *Why Investing in Climate Action Makes Good Economic Sense*. Boston Consulting Group (BCG). https://www.bcg.com/publications/2024/investing-in-climate-action.

   – Benayad et al's analysis is based on a review of recent literature, expert engagement and macroeconomic modelling by Network for Greening the Financial System (NGFS), Phase IV, as of November 2023.

   – On 5 November 2024, NGFS published new analysis which assesses that GDP losses by 2050 could be two to four times greater than previously estimated. For instance, they increase significantly for both the "current policies" scenario (from 5% to 15%) and the net-zero 2050 scenario (from 2% to 7%). Source: Network for Greening the Financial System (NGFS). (2024, 5 November). *NGFS publishes latest long-term climate macro-financial scenarios for climate risks assessment* [Press release]. https://www.ngfs.net/en/communique-de-presse/ngfs-publishes-latest-long-term-climate-macro-financial-scenarios-climate-risks-assessment-2024.
4. Williams, A. & Whiteman, G. (2021). A call for deep engagement for impact: Addressing the planetary emergency. *Strategic Organization*, vol. 19, no. 3, 2021, pp. 526-537. https://doi.org/10.1177/14761270211011703.
5. Accenture analysis. See Figure 3 and methodology at Annex 2 for more detail.
6. Earnings = EBITA (earnings before interest, tax and amortization); see Figure 6 and methodology at Annex 2 for more detail.
7. Accenture analysis of S&P 500 EBITA margins between Q3-2019 and Q2-2020; data sourced from S&P Capital IQ (accessed 9 September 2024).
8. Hoegh-Guldberg, O. et al. (2022). 3. Impacts of 1.5 ºC Global Warming on Natural and Human Systems. *IPCC Special Report on Impacts of Global Warming of 1.5°C above Pre-industrial Levels in Context of Strengthening Response to Climate Change, Sustainable Development, and Efforts to Eradicate Poverty,* pp. 175-312. Cambridge University Press. doi:10.1017/9781009157940.005.
9. Lenton, T. M. et al. (2023). *Global Tipping Points Report 2023.* University of Exeter. https://report-2023.global-tipping-points.org/.
10. S&P Global. (2020). *66% of major global companies have at least one asset at high risk of physical risk under the high impact climate change scenario in 2050.* https://www.spglobal.com/esg/education/essential-sustainability/climate/physical-risks.
11. Lenton, T. M. et al. (2023). *Global Tipping Points Report 2023.* University of Exeter. https://report-2023.global-tipping-points.org/.
12. Intergovernmental Panel on Climate Change (IPCC). (2023). *Sixth Assessment Report.* https://www.ipcc.ch/assessment-report/ar6/.
13. Newman, R. & Noy, I. (2023). The global costs of extreme weather that are attributable to climate change. *Nature Communication,* vol. 14, no. 6103, 2023. https://www.nature.com/articles/s41467-023-41888-1.
14. National Centers for Environmental Information. (2024). *Billion-Dollar Weather and Climate Disasters.* https://www.ncei.noaa.gov/access/billions/.
15. European Environment Agency. (2022). *Economic losses and fatalities from weather- and climate-related events in Europe.* https://www.eea.europa.eu/publications/economic-losses-and-fatalities-from/economic-losses-and-fatalities-from.
16. World Meteorological Organization. (2024, 2 September). *Africa faces disproportionate burden from climate change and adaptation costs* [Press release]. https://wmo.int/media/news/africa-faces-disproportionate-burden-from-climate-change-and-adaptation-costs.
17. Intergovernmental Panel on Climate Change (IPCC). (2023). *Sixth Assessment Report - Frequently Asked Questions.* https://www.ipcc.ch/report/ar6/wg1/downloads/faqs/IPCC_AR6_WGI_FAQ_Chapter_12.pdf.

18. S&P Global, Sustainable 1. (2023). *Physical Risk Scores and Financial Impact Data – Methodology.* https://portal.s1.spglobal.com/survey/documents/SPG_S1_Physical_Risk_Methodology.pdf.

19. Chadha, J. & Venables, T. (2024). *Boosting productivity: why doesn't the UK invest enough?* Economics Observatory. https://www.economicsobservatory.com/boosting-productivity-why-doesnt-the-uk-invest-enough.

20. Szymanska, E.J. & Dziwulski, M. (2021). The Impact of Fixed Investments on the Productivity of Production Factors in Agriculture. *European Research Studies Journal,* vol. XXIV, no. 1, 2021, pp. 382-394. https://ersj.eu/journal/1968.

21. UN Trade & Development (UNCTAD). (2024). *World Investment Report 2024.* https://unctad.org/publication/world-investment-report-2024.

22. Accenture analysis. Historical S&P 500 EBITA margin data sourced from S&P Capital IQ (accessed 9 September, 2024).

23. For more information on transition risks, refer to: World Economic Forum. (2025). *The Cost of Inaction: A CEO Guide to Navigating Climate Risk.*

24. World Economic Forum. (2024). *The Cost of Inaction: A CEO Guide to Navigating Climate Risk.*

25. Hoegh-Guldberg, O. et al. (2022). 3. Impacts of 1.5 ºC Global Warming on Natural and Human Systems. *IPCC Special Report on Impacts of Global Warming of 1.5°C above Pre-industrial Levels in Context of Strengthening Response to Climate Change, Sustainable Development, and Efforts to Eradicate Poverty,* pp. 175-312. Cambridge University Press. doi:10.1017/9781009157940.005.

26. Lenton, T. M. et al. (2023). *Global Tipping Points Report 2023.* University of Exeter. https://report-2023.global-tipping-points.org/.

27. Armstrong McKay, D.I. et al. (2022). Exceeding 1.5°C global warming could trigger multiple climate tipping points. *Science,* vol. 377, no. 6611, 2022. https://www.science.org/doi/10.1126/science.abn7950.

28. Lenton, T. M. et al. (2023). *Global Tipping Points Report 2023.* University of Exeter. https://report-2023.global-tipping-points.org/.

29. Lenton, T. M. et al. (2023). *Global Tipping Points Report 2023.* University of Exeter. https://report-2023.global-tipping-points.org/.

30. Box, J.E. et al. (2022). Greenland ice sheet climate disequilibrium and committed sea-level rise. *Nature Climate Change,* vol. 12, 2022, pp. 808-813. https://doi.org/10.1038/s41558-022-01441-2.

31. Kulp, S. et al. (2019). *New elevation data triple estimates of global vulnerability to sea-level rise and coastal flooding.* Nature Communications. https://www.nature.com/articles/s41467-019-12808-z.pdf.

32. Rahmstorf, S. (2024). *Is the Atlantic Overturning Circulation Approaching a Tipping Point?* Oceanography. https://tos.org/oceanography/article/is-the-atlantic-overturning-circulation-approaching-a-tipping-point.

33. Hoegh-Guldberg, O. et al. (2022). 3. Impacts of 1.5 ºC Global Warming on Natural and Human Systems. *IPCC Special Report on Impacts of Global Warming of 1.5°C above Pre-industrial Levels in Context of Strengthening Response to Climate Change, Sustainable Development, and Efforts to Eradicate Poverty.* Cambridge University Press. doi:10.1017/9781009157940.005.

34. Lenton, T. M. et al. (2023). *Global Tipping Points Report 2023.* University of Exeter. https://report-2023.global-tipping-points.org/.

35. Bykova, A. (2020). *Permafrost Thaw in a Warming World: The Arctic Institute's Permafrost Series Fall-Winter 2020.* The Arctic Institute Centre for Circumpolar Security Studies. https://www.thearcticinstitute.org/permafrost-thaw-warming-world-arctic-institute-permafrost-series-fall-winter-2020/.

36. Schuur, T. (2019). *Permafrost and the Global Carbon Cycle.* NOAA in the Arctic. https://arctic.noaa.gov/report-card/report-card-2019/permafrost-and-the-global-carbon-cycle.

37. Permafrost Pathways. (2022). *Permafrost thaw is threatening Arctic communities and our global climate.* https://permafrost.woodwellclimate.org.

38. Lenton, T. M. et al. (2023). Global Tipping Points Report 2023. University of Exeter. https://report-2023.global-tipping-points.org/. This report (p59) set out the data with high confidence but a wider temperature range than for other tipping points. The Greenland ice sheet has a range of key drivers, including atmospheric circulation changes and positive (amplifying) feedback loops. For example, the melting of the ice sheet causes a dampening of the albedo effect. This means the temperature range for Greenland ice sheet collapse has a range from 0.8 to 3.0 degrees Celsius with high scientific confidence.

39. Lenton, T. M. et al. (2023). *Global Tipping Points Report 2023.* University of Exeter. https://report-2023.global-tipping-points.org/.

40. Kirdyanov, A. (2024). Thawing permafrost can mitigate warming-induced drought stress in boreal forest trees. *Science of The Total Environment,* vol. 912. https://www.sciencedirect.com/science/article/pii/S0048969723074879.

41. Gibson, C. (2018). Wildfire as a major driver of recent permafrost thaw in boreal peatlands. *Nature Communications.* https://www.nature.com/articles/s41467-018-05457-1.

42. Thompson, B. (2021). The 'zombie' fires that keep burning under snow-covered forests. *Nature.* https://www.nature.com/articles/d41586-021-01360-w.

43. Ogden J. (1983). *Coral reefs, seagrass beds and mangroves: their interaction in the coastal zones of the Caribbean.* United Nations Educational, Scientific and Cultural Organization. https://unesdoc.unesco.org/ark:/48223/pf0000057596.

44. Lenton, T. M. et al. (2019). Climate tipping points — too risky to bet against. *Nature*, vol. 575, 2019, pp. 592-595. https://doi.org/10.1038/d41586-019-03595-0.

45. Oreskes, N. et al. (2019). Scientists Have Been Underestimating the Pace of Climate Change. *Scientific American*. https://www.scientificamerican.com/blog/observations/scientists-have-been-underestimating-the-pace-of-climate-change/.

46. Turner, B. (2023). Catastrophic climate 'doom loops' could start in just 15 years, new study warns. *Live Science.* https://www.livescience.com/planet-earth/climate-change/catastrophic-climate-doom-loops-could-start-in-just-15-years-new-study-warns.

47. Oreskes, N. et al. (2019). Scientists Have Been Underestimating the Pace of Climate Change. *Scientific American.* https://www.scientificamerican.com/blog/observations/scientists-have-been-underestimating-the-pace-of-climate-change/.

48. Dietz, S. et al. (2021). Economic impacts of tipping points in the climate system. *Proceedings of the National Academy of Sciences of the United States of America (PNAS).* https://business.columbia.edu/faculty/research/economic-impacts-tipping-points-climate-system.

49. Hodgson, C. (2023). Financial models on climate risk 'implausible', say actuaries. *Financial Times.* https://www.ft.com/content/a5027391-41a4-4e21-a72d-f8189d6a7b71.

50. Hodgson, C. (2023). Financial models on climate risk 'implausible', say actuaries. *Financial Times.* https://www.ft.com/content/a5027391-41a4-4e21-a72d-f8189d6a7b71.

51. Sun, Y. et al. (2024). Global supply chains amplify economic costs of future extreme heat risk. *Nature*, vol. 627, 2024, pp. 797-804. https://doi.org/10.1038/s41586-024-07147-z.

52. Romanello, M. et al. (2023). The 2023 report of the Lancet Countdown on health and climate change: the imperative for a health-centred response in a world facing irreversible harms. *The Lancet,* vol. 402, no. 10419, 2023, pp. 2346-2394. https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(23)01859-7/abstract.

53. Romanello, M. et al. (2023). The 2023 report of the Lancet Countdown on health and climate change: the imperative for a health-centred response in a world facing irreversible harms. *The Lancet,* vol. 402, no. 10419, 2023, pp. 2346-2394. https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(23)01859-7/abstract.

54. Romanello, M. et al. (2023). The 2023 report of the Lancet Countdown on health and climate change: the imperative for a health-centred response in a world facing irreversible harms. *The Lancet,* vol. 402, no. 10419, 2023, pp. 2346-2394. https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(23)01859-7/abstract.

55. World Economic Forum & Oliver Wyman. (2024). *Quantifying the Impact of Climate Change on Human Health*, pp. 26. https://www3.weforum.org/docs/WEF_Quantifying_the_Impact_of_Climate_Change_on_Human_Health_2024.pdf.

56. Anand, A. (2023). *How agriculture is exacerbating global warming.* S&P Global. https://www.spglobal.com/commodityinsights/en/market-insights/blogs/agriculture/071323-how-agriculture-is-exacerbating-climate-conditions.

57. Chandrasekhar, A. et al. (2022). *UN land report: Five key takeaways for climate change, food systems and nature loss.* Carbon Brief. https://www.carbonbrief.org/un-land-report-five-key-takeaways-for-climate-change-food-systems-and-nature-loss/.

58. Halpern, B. S. et al. (2022). The environmental footprint of global food production. *Nature Sustainability,* vol. 5., 2022, pp. 1027-1039. https://doi.org/10.1038/s41893-022-00965-x.

59. Poore, J. & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. *Science,* vol. 360, no. 6392, 2018, pp. 987-992. https://www.science.org/doi/10.1126/science.aaq0216.

60. World Economic Forum. (2020). *New Nature Economy Report Series: 2. The Future of Nature and Business.* https://www.weforum.org/publications/new-nature-economy-report-series/future-of-nature-and-business/.

61. Allianz. (2023). *Agrifood Industry 2023 Outlook.* https://www.allianz-trade.com/en_SG/resources/reports/agrifood-report-2023.html#:~:text=The%2520global%2520agrifood%2520market%2520has,%252B6%2525%2520over%2520that%2520span.

62. Food and Agriculture Organization of the United Nations (FAO). (2021). *Agriculture on the proving grounds: Damage and loss.* https://www.fao.org/interactive/disasters-in-agriculture/en/.

63. Andarcia, M. V. (2024). *The Panama Canal, exposed to the effects of climate change.* Universidad de Navarra. https://en.unav.edu/web/global-affairs/el-canal-de-panama-expuesto-a-los-efectos-del-cambio-climatico.

64. Food and Agriculture Organization of the United Nations (FAO). (2021). *Agriculture on the proving grounds: Damage and loss*. https://www.fao.org/interactive/disasters-in-agriculture/en/.

65. Severson, K. (2021). Texas Farmers Tally Up the Damage From a Winter Storm 'Massacre'. *The New York Times.* https://www.nytimes.com/2021/03/04/dining/texas-farms-storm-damage.html.

66. A cold chain, also known as a cool chain, is a temperature-regulated supply chain system used for the storage, transportation and distribution of perishable items such as vaccines, chemicals, seafood, meat and dairy products.

67. Cool Coalition. (2022). *Chilling Prospects 2022: Using data science and innovative business models to strengthen agricultural cold chains in India and Nigeria.* https://coolcoalition.org/chilling-prospects-2022-using-data-science-and-innovative-business-models-to-strengthen-agricultural-cold-chains-in-india-and-nigeria/.

68. Fox, T. et al. (2022). *Sustainable and Resilient Cold Chains: The 2050 Imperative*. Centre for Sustainable Cooling. https://www.sustainablecooling.org/wp-content/uploads/2023/08/The-Local-to-Global-Summit-Report.pdf.

69. United Nations Environment Programme (UNEP) & Food and Agriculture Organization of the United Nations (FAO). (2022). *Sustainable Food Cold Chains.* https://openknowledge.fao.org/server/api/core/bitstreams/cf42e3c6-157e-4ea9-8873-8b3cc9242b96/content.

70. Food and Agriculture Organization of the United Nations (FAO). (2023). *The Impact of Disasters on Agriculture and Food Security: Avoiding and reducing losses through investment in resilience,* p.12. https://www.fao.org/publications/home/fao-flagship-publications/the-impact-of-disasters-on-agriculture-and-food-security/en.

71. Peng, S. et al. (2004). Rice yields decline with higher night temperature from global warming. *Proceedings of the National Academy of Sciences of the United States of America (PNAS),* vol. 101, no. 27, 2004. https://www.pnas.org/doi/full/10.1073/pnas.0403720101.

72. Mirzabaev, A. et al. (2023). Severe climate change risks to food security and nutrition. *Climate Risk Management,* vol. 39, no. 100473, 2023. https://www.sciencedirect.com/science/article/pii/S2212096322000808.

73. Food and Agriculture Organization of the United Nations (FAO). (2023). *The Impact of Disasters on Agriculture and Food Security: Avoiding and reducing losses through investment in resilience,* p.12. https://www.fao.org/publications/home/fao-flagship-publications/the-impact-of-disasters-on-agriculture-and-food-security/en.

74. Accenture analysis.

75. World Bank Group. (2023). *Urban Development.* https://www.worldbank.org/en/topic/urbandevelopment/overview.

76. United Nations Environment Programme (UNEP). (2024). *Cities and climate change.* https://www.unep.org/explore-topics/resource-efficiency/what-we-do/cities-and-climate-change.

77. Rose, M.E. (2022). *A guide to decarbonizing the built environment.* World Economic Forum. https://www.weforum.org/agenda/2022/01/decarbonizing-the-built-environment/.

78. World Business Council for Sustainable Development. (2024). *Roadmap to Nature Positive: Foundations for the built environment system,* pp. 9. https://www.wbcsd.org/wp-content/uploads/2024/06/Roadmaps-to-Nature-Positive-Foundations-for-the-built-environment-system.pdf.

79. World Business Council for Sustainable Development. (2024). *Roadmap to Nature Positive: Foundations for the built environment system,* pp. 9. https://www.wbcsd.org/wp-content/uploads/2024/06/Roadmaps-to-Nature-Positive-Foundations-for-the-built-environment-system.pdf.

80. Hagan, R. (2024). Europe weather chaos - live: Italy braces for Storm Boris flooding as Portugal wildfires blaze and deaths rise. *The Independent.* https://www.independent.co.uk/news/world/europe/storm-boris-europe-flooding-portugal-wildfires-italy-poland-news-b2614310.html.

81. Deryugina, T. et al. (2014). *The economic impact of hurricane Katrina on its victims: Evidence from individual tax returns.* National Bureau of Economic Research. https://www.nber.org/system/files/working_papers/w20713/w20713.pdf.

82. Fluvial flooding occurs when a river, stream or lake overflows its banks due to heavy rain or snowmelt. Fluvial flooding can also happen along coasts during high tides or stormy conditions. Pluvial flooding occurs when heavy rainfall creates a flash flood that's independent of an overflowing body of water. Pluvial flooding can happen in any location, including urban or rural areas, and even in areas without nearby bodies of water.

83. Gozzi, L. et al. (2024). *Polish city urged to evacuate as floods batter central Europe.* BBC News. https://www.bbc.com/news/articles/c5yjjqyv84eo.

84. Accenture analysis.

85. Creel, L. (2003). *Ripple Effects: Population and Coastal Regions.* Population Reference Bureau (PRB). https://www.prb.org/resources/ripple-effects-population-and-coastal-regions/.

86. Berdin, V. et al. (2018). *How climate change affects… coastal regions.* United Nations Development Programme (UNDP). https://climate-box.com/textbooks/environmental-chemistry-chemicals/2-6-how-climate-change-affects-coastal-regions/.

87. Whitt, J. & Gordon, S. (2023). *This is the economic cost of extreme weather.* World Economic Forum. https://www.weforum.org/agenda/2023/01/extreme-weather-economic-cost-wef23/.

88. Khatri, A. & Gomez Garcia-Reyes, C. (2023). *Trees for Life: Making our cities greener can cut early deaths by a third.* World Economic Forum. https://www.weforum.org/agenda/2023/02/urban-trees-reduce-heat-deaths/.

89. World Economic Forum. (2021). *How can we adapt our cities to combat worsening heat waves?* https://www.weforum.org/agenda/2021/07/will-cities-become-too-hot-to-live-in/.

90. World Economic Forum. (2021). *How can we adapt our cities to combat worsening heat waves?* https://www.weforum.org/agenda/2021/07/will-cities-become-too-hot-to-live-in/.

91. Cybersecurity & Infrastructure Security Agency (CISA), United States Government. (2024). *Extreme Heat.* https://www.cisa.gov/topics/critical-infrastructure-security-and-resilience/extreme-weather-and-climate-change/extreme-heat.

92. Ham, S. P. (2024). *Stuck bridges, buckling roads – extreme heat is wreaking havoc on America's aging infrastructure.* The Conversation. https://theconversation.com/stuck-bridges-buckling-roads-extreme-heat-is-wreaking-havoc-on-americas-aging-infrastructure-235851.

93. Ham, S. P. (2024). *Stuck bridges, buckling roads – extreme heat is wreaking havoc on America's aging infrastructure.* The Conversation. https://theconversation.com/stuck-bridges-buckling-roads-extreme-heat-is-wreaking-havoc-on-americas-aging-infrastructure-235851.

94. Network for Greening the Financial System. (2020). *Overview of Environmental Risk Analysis by Financial Institutions.* https://www.ngfs.net/sites/default/files/medias/documents/overview_of_environmental_risk_analysis_by_financial_institutions.pdf.

95. Murphy, D. (2023). *How wildfire risk and extreme heat is changing the insurance industry.* World Economic Forum. https://www.weforum.org/agenda/2023/07/wildfire-risk-extreme-heat-changing-insurance-industry/.

96. Insurance deserts are the regions where insurers significantly reduce their presence or cease offering coverage.

97. Murphy, D. (2023). *How wildfire risk and extreme heat is changing the insurance industry.* World Economic Forum. https://www.weforum.org/agenda/2023/07/wildfire-risk-extreme-heat-changing-insurance-industry/.

98. Richter, F. (2023). Charted: *There are more mobile phones than people in the world.* World Economic Forum. https://www.weforum.org/agenda/2023/04/charted-there-are-more-phones-than-people-in-the-world/.

99. Datareportal. (2024). *Digital around the world.* https://datareportal.com/global-digital-overview#:~:text=A%20total%20of%205.52%20billion,using%20the%20internet%20as%20not.

100. Open AI. (2018). *AI and compute.* https://openai.com/index/ai-and-compute/.

101. Garimella, S. & Hughes, M. T. (2023). *Machines can't always take the heat – two engineers explain the physics behind how heat waves threaten everything from cars to computers.* The Conversation. https://theconversation.com/machines-cant-always-take-the-heat-two-engineers-explain-the-physics-behind-how-heat-waves-threaten-everything-from-cars-to-computers-210591.

102. Accenture analysis; see methodology in Annex 2.

103. PwC. (2024). *Protecting people and prosperity: Climate risks to nine key commodities.* https://www.pwc.com/gx/en/issues/esg/how-does-climate-change-affect-natural-resources.html.

104. Yang, S. (2021). The Chip Shortage Is Bad. *Taiwan's Drought Threatens to Make It Worse.* The Wall Street Journal. https://www.wsj.com/articles/the-chip-shortage-is-bad-taiwans-drought-threatens-to-make-it-worse-11618565400.

105. Lakshman, S. (2024). *More Critical Minerals Mining Could Strain Water Supplies in Stressed Regions.* World Resources Institute. https://www.wri.org/insights/critical-minerals-mining-water-impacts.

106. Graham, S. et al. (2024). *AI Datacenter Capacity, Energy Consumption, and Carbon Emission Projections.* IDC Corporate. https://www.idc.com/getdoc.jsp?containerId=US52131624&_gl=1*1smru1*_up*MQ..*_ga*MTM5NjA3OTAyOC4xNzI5MTU1MjUz*_ga_Y7CNRMFF6J*MTcyOTE1NTI1Mi4xLjEuMTcyOTE1NTM2NC4wLjAuMA..*_ga_541ENG1F9X*MTcyOTE1NTI1My4xLjEuMTcyOTE1NTM2NC4wLjAuMA.

107. Siddik, A. B. et al. (2021). The environmental footprint of data centers in the United States. *Environmental Research Letters,* vol. 16, no. 064017, 2021. https://iopscience.iop.org/article/10.1088/1748-9326/abfba1/pdf.

108. Morgan, A. (2023). *The Meta data center in Talavera will consume 600 million liters of drinking water per year in a drought zone.* Gearrice. https://www.gearrice.com/update/the-meta-data-center-in-talavera-will-consume-600-million-liters-of-drinking-water-per-year-in-a-drought-zone/.

109. World Health Organization (WHO). (2023). *WHO calls on governments for urgent action to invest in Universal Health Coverage.* https://www.who.int/news/item/11-12-2023-who-calls-on-governments-for-urgent-action-to-invest-in-universal-health-coverage.

110. Institute for Health Metrics and Evaluation. (2020). *The Lancet: Latest global disease estimates reveal perfect storm of rising chronic diseases and public health failures fuelling COVID-19 pandemic.* https://www.healthdata.org/news-events/newsroom/news-releases/lancet-latest-global-disease-estimates-reveal-perfect-storm.

111. Neergheen-Bhujun, V. et al. (2017). Biodiversity, drug discovery, and the future of global health: Introducing the biodiversity to biomedicine consortium, a call to action. *Journal of Global Health,* vol. 7, no. 2, 2017. https://jogh.org/documents/issue201702/jogh-07-020304.pdf.

112. World Economic Forum & Oliver Wyman. (2024). *Quantifying the Impact of Climate Change on Human Health,* pp. 4. https://www3.weforum.org/docs/WEF_Quantifying_the_Impact_of_Climate_Change_on_Human_Health_2024.pdf.

113. World Bank Group. (2024). *Health and Climate Change.* https://www.worldbank.org/en/topic/health/brief/health-and-climate-change.

114. World Economic Forum & Oliver Wyman. (2024). *Quantifying the Impact of Climate Change on Human Health*, pp. 4. https://www3.weforum.org/docs/WEF_Quantifying_the_Impact_of_Climate_Change_on_Human_Health_2024.pdf.

115. Cross Dependency Initiative (XDI). (2023). 2023 *XDI Global Hospital Infrastructure Physical Climate Risk Report,* pp. 12-13. https://77af07411.flowpaper.com/XDIGlobalHospitalInfrastructurePhysicalClimateRiskReport2023Spdf/#page=1.

116. Cross Dependency Initiative (XDI). (2023). *2023 XDI Global Hospital Infrastructure Physical Climate Risk Report*, pp. 12-13. https://77af07411.flowpaper.com/XDIGlobalHospitalInfrastructurePhysicalClimateRiskReport2023Spdf/#page=1.

117. Cross Dependency Initiative (XDI). (2023). 2023 XDI *Global Hospital Infrastructure Physical Climate Risk Report,* pp. 12-13. https://77af07411.flowpaper.com/XDIGlobalHospitalInfrastructurePhysicalClimateRiskReport2023Spdf/#page=1.

118. Cross Dependency Initiative (XDI). (2023). 2023 XDI *Global Hospital Infrastructure Physical Climate Risk Report,* pp. 10-11. https://77af07411.flowpaper.com/XDIGlobalHospitalInfrastructurePhysicalClimateRiskReport2023Spdf/#page=1.

119. World Bank Group. (2024). *Health and Climate Change.* https://www.worldbank.org/en/topic/health/brief/health-and-climate-change.

120. World Economic Forum & Oliver Wyman. (2024). *Quantifying the Impact of Climate Change on Human Health,* pp. 4. https://www3.weforum.org/docs/WEF_Quantifying_the_Impact_of_Climate_Change_on_Human_Health_2024.pdf.

121. McKie, R. (2024). Arctic zombie viruses in Siberia could spark terrifying new pandemic, scientists warn. *The Guardian.* https://www.theguardian.com/society/2024/jan/21/arctic-zombie-viruses-in-siberia-could-spark-terrifying-new-pandemic-scientists-warn.

122. World Economic Forum & Oliver Wyman. (2024). *Quantifying the Impact of Climate Change on Human Health,* pp. 9. https://www3.weforum.org/docs/WEF_Quantifying_the_Impact_of_Climate_Change_on_Human_Health_2024.pdf.

123. Pharmaphorum. (2022). *Pharma's climate change vulnerability and opportunity.* https://pharmaphorum.com/views-and-analysis/pharmas-climate-change-vulnerability-and-opportunity.

124. United Nations Childrens' Fund (UNICEF). (2023). *What is a cold chain?* https://www.unicef.org/supply/what-cold-chain.

125. PATH. (2020). *Vaccine cold chain Q&A.* https://www.path.org/our-impact/articles/vaccine-cold-chain-q/.

126. Jadeja, N. et al. (2023). Climate and health strategies must take vaccination into account. *Nature Microbiology,* vol. 8, 2023, pp. 2215-2216. https://doi.org/10.1038/s41564-023-01537-1.

127. Erassa, T.E. et al. (2023). Vaccine Cold Chain Management and Associated Factors in Public Health Facilities and District Health Offices of Wolaita Zone, Ethiopia. *Journal of Multidisciplinary Healthcare,* vol. 16, 2023, pp. 75-84. https://doi.org/10.2147%2FJMDH.S385466.

128. Accenture analysis.

129. CDP. (2021). *Finance sector's funded emissions over 700 times greater than its own.* https://www.cdp.net/en/articles/media/finance-sectors-funded-emissions-over-700-times-greater-than-its-own.

130. Raddant, M. & Kenett, D. Y. (2021). Interconnectedness in the global financial market. *Journal of International Money and Finance,* vol. 110, no. 102280, 2021. https://doi.org/10.1016/j.jimonfin.2020.102280.

131. Coelho, R. & Restoy, F. (2023). FSI Briefs No. 18: *Macroprudential policies for addressing climate-related financial risks: challenges and trade-offs.* Financial Stability Institute. https://www.bis.org/fsi/fsibriefs18.pdf.

132. Stranded assets are assets that have suffered from unanticipated or premature write-downs, devaluations or conversion to liabilities.

133. Raddant, M. & Kenett, D. Y. (2021). Interconnectedness in the global financial market. *Journal of International Money and Finance,* vol. 110, no. 102280, 2021. https://doi.org/10.1016/j.jimonfin.2020.102280.

134. Coelho, R. & Restoy, F. (2023). FSI Briefs No. 18: *Macroprudential policies for addressing climate-related financial risks: challenges and trade-offs.* Financial Stability Institute. https://www.bis.org/fsi/fsibriefs18.pdf.

135. Financial Stability Board. (2024). *Climate-related Risks.* https://www.fsb.org/work-of-the-fsb/financial-innovation-and-structural-change/climate-related-risks/.

136. World Bank Group. (2019). *Action Plan on Climate Change Adaptation and Resilience: Managing risks for a more resilient future.* https://documents1.worldbank.org/curated/en/519821547481031999/The-World-Bank-Groups-Action-Plan-on-Climate-Change-Adaptation-and-Resilience-Managing-Risks-for-a-More-Resilient-Future.pdf.

137. Gourevitch, J. D. et al. (2023). Unpriced climate risk and the potential consequences of overvaluation in US housing markets. *Nature Climate Change,* vol. 13, 2023, pp. 250-257. https://doi.org/10.1038/s41558-023-01594-8.

138. ClimateCheck. (2023). *Mortgage Loan Lenders and Climate Risk.* https://climatecheck.com/risks/governance/mortgage-loan-lenders-and-climate-risk.

139. ClimateCheck. (2023). *Mortgage Loan Lenders and Climate Risk.* https://climatecheck.com/risks/governance/mortgage-loan-lenders-and-climate-risk.

140. Vikas, N. (2024). *Navigating climate risks: 3 strategies for building resilient financial institutions.* World Economic Forum. https://www.weforum.org/agenda/2024/07/navigating-climate-risks-key-strategies-for-resilient-financial-institutions/.

141. Emambakhsh, T. et al. (2022). *Climate-related risk to financial stability.* European Central Bank. https://www.ecb.europa.eu/press/financial-stability-publications/fsr/special/html/ecb.fsrart202205_01~9d4ae00a92.en.html.

142. Accenture analysis.

143. United Nations University – Institute for Environment and Human Security (UNU EHS). (2023). *Uninsurable future.* https://interconnectedrisks.org/tipping-points/uninsurable-future.

144. Swiss Re Group. (2024). *How big is the protection gap from natural catastrophes where you are?* https://www.swissre.com/risk-knowledge/mitigating-climate-risk/natcat-protection-gap-infographic.html#/.

145. The protection gap refers to the difference between insured and uninsured losses.

146. Guy Carpenter. (2023). *Insured Versus Uninsured Loss.* https://www.guycarp.com/insights/2016/03/insured-versus-uninsured-loss.html.

147. Murphy, D. (2023). *How wildfire risk and extreme heat is changing the insurance industry.* World Economic Forum. https://www.weforum.org/agenda/2023/07/wildfire-risk-extreme-heat-changing-insurance-industry/.

148. Baker, S. & Burger, M. (2024). *Top 5 climate-related liability issues that your board should consider.* World Economic Forum. https://www.weforum.org/agenda/2024/09/top-5-climate-change-related-liability-issues/.

149. Sugrue, D. P. et al. (2023). *Global Reinsurers Grapple with Climate Change Risks.* S&P Global. https://www.spglobal.com/ratings/en/research/articles/210923-global-reinsurers-grapple-with-climate-change-risks-12116706.

150. Baldwin, S. & Coon, D. (2022). *The Impact of Climate Change on the Reinsurance and ILS Market.* Risk Management Society (RIMS). https://www.rmmagazine.com/articles/article/2022/07/14/the-impact-of-climate-change-on-the-reinsurance-and-ils-market.

151. Bassett, D. et al. (2023). *Climate Risk Modeling Solutions,* 2023: *Market and Vendor Landscape.* Market Quadrants & Chartis. https://climate.moodys.com/sites/default/files/content/rms-files/pdf-files/Chartis_Climate-Risk-Modeling-Solutions-2023.pdf.

152. S&P Global Sustainable1 (2023). *Physical Risk Scores and Financial Impact Data – Methodology.* https://portal.s1.spglobal.com/survey/documents/SPG_S1_Physical_Risk_Methodology.pdf.

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