Gemologist

Can we adapt to the new climate normal?

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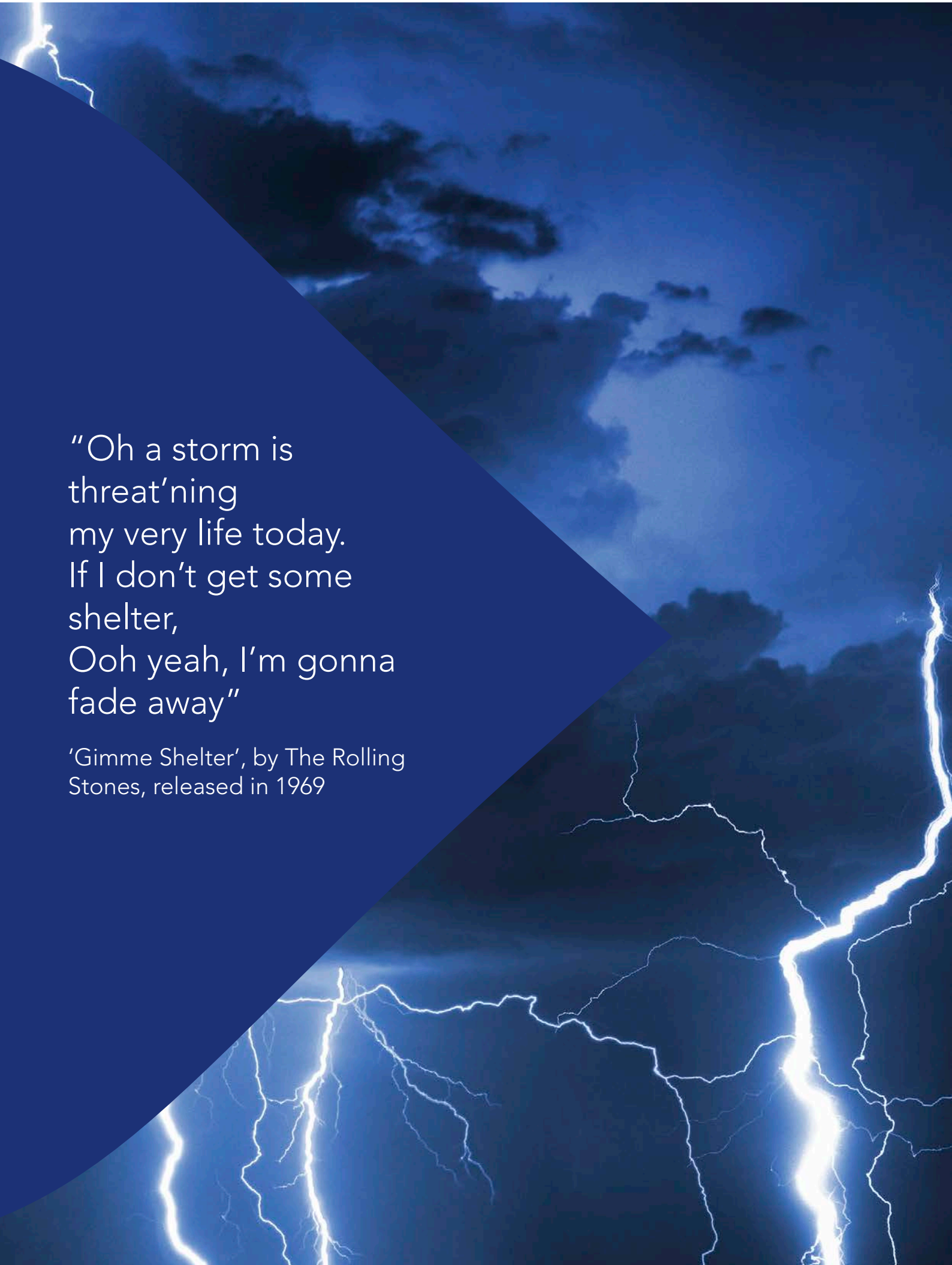


"Oh a storm is
threat'ning
my very life today.
If I don't get some
shelter,
Ooh yeah, I'm gonna
fade away"

'Gimme Shelter', by The Rolling Stones, released in 1969

Released at the rough end of the 1960s, 'Gimme Shelter' painted a picture of society on the edge of chaos: war was just a shot away. Now, more than 50 years since it hit the airwaves, the ominous mood of The Rolling Stones' classic hasn't faded away.

Yet again, a storm has come. People have sheltered, and continue to do so, at home as a virus that emerged rapidly from Wuhan claims lives across the planet and ravages businesses, economies and social norms. At this stage of the crisis, the human, social and financial costs of the coronavirus pandemic remain incalculable. It will have both short- and long-term consequences for individuals, families, business, politics and finance globally. But humanity has weathered severe crises before, and is doing so again.

As a species, we are survivors. We adapt.

However, humanity will have to summon all of its adaptive ingenuity to combat the bigger threat coming our way. A crisis of our own making, climate change, threatens the entire sheltering capacity of the earth itself.

The coronavirus lockdowns have at least had positive environmental side effects. Falling industrial production has cleared the air in even the most polluted regions, helped further by stay-at-home orders that have kept many cars off the road, airplanes grounded and their noxious fumes and carbon dioxide (CO_2) emissions out of the atmosphere. Waterways, rivers and seas in urban centres normally flooded with tourists have become clearer. The canals in Venice, for example, are now reportedly the cleanest in living memory[1].

Efforts by governments, companies and individuals to mitigate climate change are essential to our survival.

These signs of nature's apparently quick recovery during this pause in full-speed modern living offer some encouragement that humans can help rewind the environmental clock given the significant increase in average global temperatures since the mid-20th century (see figure 1). But they should not blind us to the scale of the task of climate-change mitigation (if you're optimistic about our ability to prevent or substantially limit further temperature rises), or adaptation (if you believe we need to brace ourselves for what's coming), nor the short timeframe in which we must achieve either outcome.

In fact, we have been accelerating ever-faster towards this moment since the last ice age ended about 10,000 years ago. This was when humans, many of whom had left Africa eons before, progressed from hunting-and-gathering food to growing crops and managing livestock.

Agriculture could only take root in environments of relatively constant temperatures. Then, in the geological blink of an eye, the human race exploded in size from perhaps 1m to hundreds of millions by the late middle ages. We advanced, our civilisation and exploration of scientific and humanitarian enquiries fueled by self-sustaining food-production techniques. With the early 19th century discovery of vast energy sources in the form of coal and oil, our global population grew exponentially.

Over the past 200 years, we have tamed nature and seemingly secured our survival through fossil-fuel powered industrialisation. Despite the fact that we retain vestigial flight-or-fight reflexes and attendant anxieties, we have subdued virtually all the wild threats that terrified us, apart from bacteria, viruses and, of course, each other.

Especially in the developed world, we live at historically luxurious comfort levels. Millions reside in well-constructed, temperature-controlled homes that are fed by complex plumbing and electrical systems that attest to human mastery of scientific principles. Child mortality has plummeted while average longevity has increased almost everywhere. Before the current pandemic, leisure had become one of the world's biggest industries.

But over time, another human characteristic has become clear: holistic knowledge lags our inventiveness.

For example, replacing the horse with the internal-combustion engine boosted economic productivity and emptied our streets and waterways of manure, but created a new problem. CO_2 levels in the atmosphere have, well, skyrocketed to levels never before evidenced in ice cores dating back to the dawn of humanity and through many cycles of planetary cooling and warming.

Gimme shelter

Before continuing, let me confirm that in this issue of *Gemologist* I do not aim not to recreate the fear in Bill McKibben's *Falter* or trace the ground covered by David Wallace-Wells in *The Uninhabitable Earth*[2]. I have no desire to update Hieronymous Bosch's vision of hell. Like many others, I've had my fill of dystopian fiction, TV, films, commentary and social-media angst.

And yet, the evidence of planetary warming is overwhelming – as seen in the melting of the Arctic and Greenlandic ice sheets or the accelerating erosion of the Thwaites and Pine Island Glaciers in Western Antarctic. Worryingly, the gathering body of climate-change data has not yet been matched by many plausible solutions to counter the implied catastrophic environmental effects.

Efforts by governments, companies and individuals to mitigate climate change are essential to our survival. Unfortunately, even after accounting for such momentous moves to cut carbon emissions, the accepted paradigm of continuous economic growth appears to be sentencing the world to a much warmer, and scarier, environment in the future.

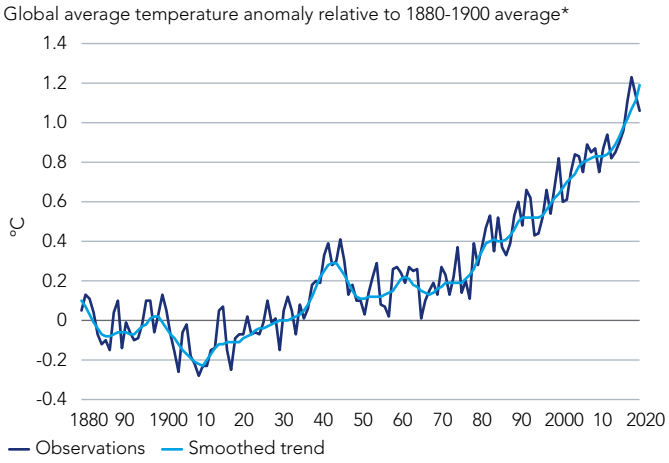
[1] "'The virus brought something… beautiful': clear water flows through Venice amid Coronavirus lockdown," by Shawn Langlois, published by MarketWatch on 18 March 2020.

[2] "Falter," by Bill McKibben, published by Henry Holt & Company in 2019; and "The Uninhabitable Earth," by David Wallace-Wells, published by Penguin Books Ltd in 2019.

Today, long-term bond yields signal that the world probably faces decades of sub-par growth, regardless of the looming economic damage from pandemic-fighting measures. In economies that are already slowing, citizens are unlikely to support the further growth-suppressing measures necessary to drive emissions down to safer levels. There are green industries and policies that will generate activity, to be sure, but they appear far too small to compensate for the volume of output recorded previously.

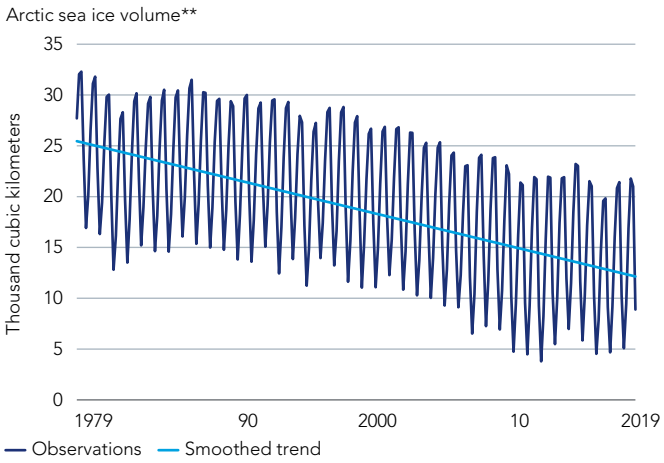
Before the coronavirus locked down populations, CO_2 emission rates were guiding us beyond 1.5°C and 2°C temperature-rise scenarios in the next 12 and 25 years, respectively, according to a study by Ricard Millar[3]. These estimates may even be optimistic given they exclude feedback loops like the melting Arctic permafrost.

Figure 1. The earth has warmed by roughly 1.1°C since the late 1800s



* Temperature anomaly is defined as increase in average global temperature (ie, average of all daily mean temperatures across all locations [both land and sea] for all days in a given year).
Source: McKinsey Global Insistute as at 2020, citing: NASA Goddard Institute for Space Studies, GISTEMP 2019; University of Washington Pan-Arctic Ice Ocean Modeling and Assimilation System, PIOMAS 2019.

Figure 2. The declining volume of Arctic sea ice

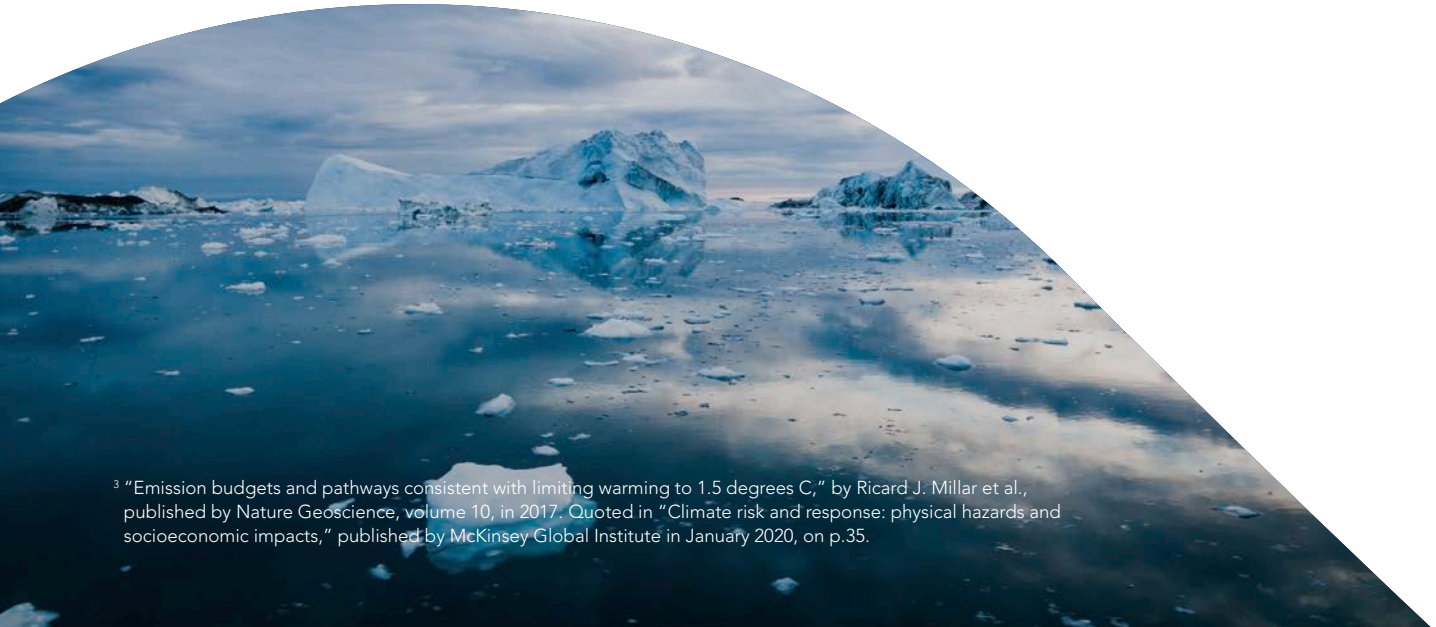


** Periodicity in the data is because sea ice volume follows a periodic cycle with the Earth's seasonal cycle: sea ice traditionally reaches annual low volumes in September and maximum volumes in late Northern Hemisphere spring.
Source: McKinsey Global Insistute as at 2020, citing: NASA Goddard Institute for Space Studies, GISTEMP 2019; University of Washington Pan-Arctic Ice Ocean Modeling and Assimilation System, PIOMAS 2019.

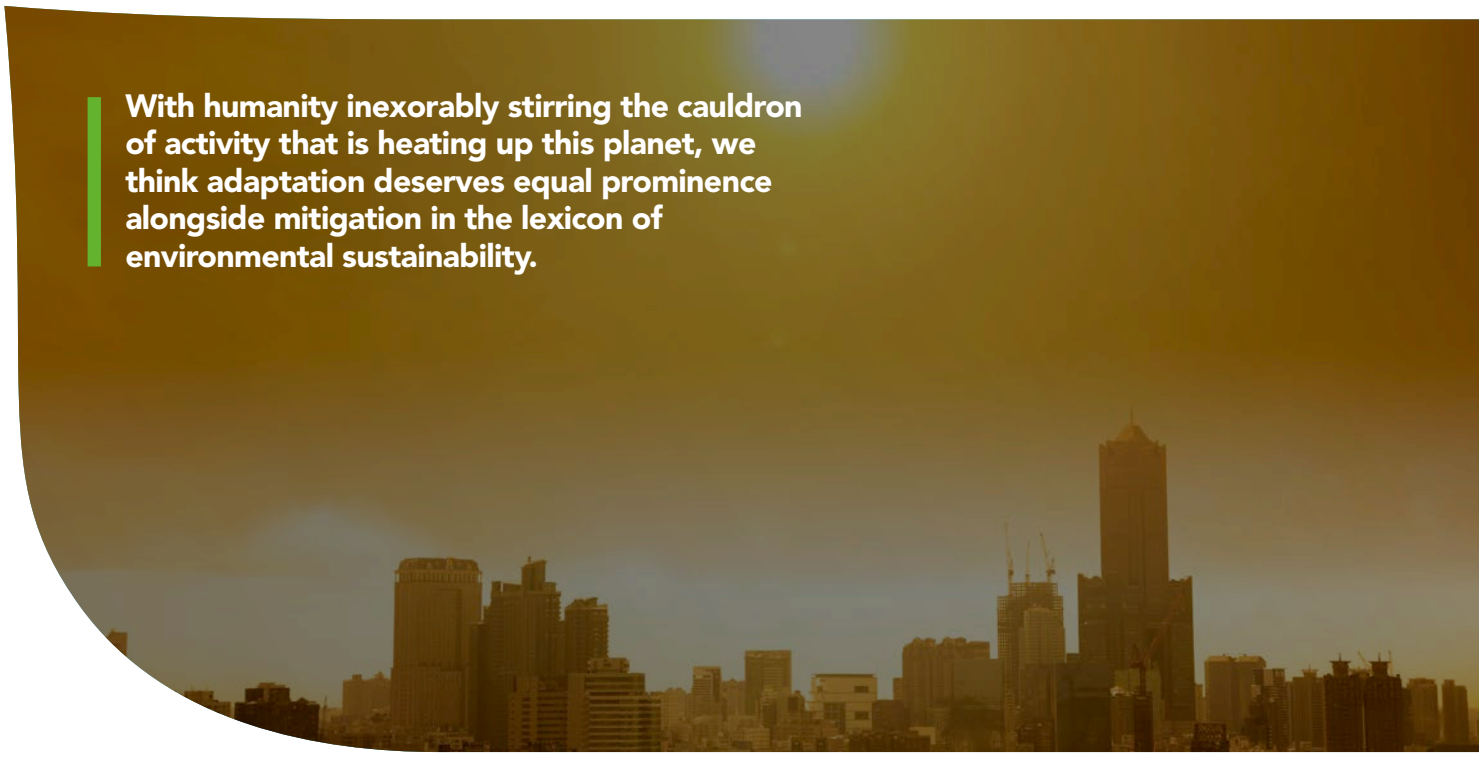
With humanity inexorably stirring the cauldron of activity that is heating up this planet, we think adaptation deserves equal prominence alongside mitigation in the lexicon of environmental sustainability. It is also a topic deserving of in-depth research by investment managers with long-term perspectives. To us, adaptation can be defined as: the measures nations, cities, companies and individuals must take in order to prepare for living in a degraded environment. Adaptation may include large-scale capital projects or even the relocation of essential infrastructure and populations, and we need to consider the implications of these now.

A crisis of our own making, climate change, threatens the entire sheltering capacity of the earth itself.

Here we discuss ways investors can begin to grapple with climate-change adaptation. After all, we need to get some shelter, not fade away.



[3] "Emission budgets and pathways consistent with limiting warming to 1.5 degrees C," by Ricard J. Millar et al., published by Nature Geoscience, volume 10, in 2017. Quoted in "Climate risk and response: physical hazards and socioeconomic impacts," published by McKinsey Global Institute in January 2020, on p.35.



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Climate calibrations

After turning the last page of *The Uninhabitable Earth* eight months ago, I had the first of two recent climate-change revelations.

As the title suggests, David Wallace-Wells' analysis conjures up a bleak future for humanity under global warming. His first sentence sets the tone: "It is worse, much worse, than you think."

How much worse can it be? The evidence marshalled by Wallace-Wells suggests most of the climate change damage will accrue in the developing world – at least for the next decade or so. *Perhaps*, I thought, *global warming won't affect my life here in London?* But of course, even in that unlikely outcome, my career is inextricably linked to emerging markets. *There is no escaping it, then.*

To us, adaptation can be defined as: the measures nations, cities, companies and individuals must take in order to prepare for living in a degraded environment.

My second major climate-change insight came half-way through reading the 2020 McKinsey Global Institute (MGI) report, "Climate risk and response: physical hazards and socioeconomic impacts," which includes a scenario analysis of the world warmed-up by 2°C[4]. *Just 2°C? That's not so much*, I thought. *The temperature changes more than that in a few hours every day, and we all cope.* Then I reflected more deeply on how adversely our bodies react as they warm by even 1°C. And now the evidence from the coronavirus pandemic serves as a grim reminder of our limited capacity in handling rising heat levels.

The body is a sensitive instrument which operates well only if it maintains a core temperature that is very close to 37°C. An increase of core body heat by only 0.2°C can compromise our multi-tasking abilities; a rise of 0.9°C and our neuromuscular coordination falters; at 1.3°C above optimum, simple mental performance sags; heatstroke risk kicks in with a 3°C rise; and death threatens us at 5°C above normal[5].

An increase of core body heat by only

0.2°C

can compromise our multi-tasking abilities

[4] "Falter," by Bill McKibben, published by Henry Holt & Company in 2019; and "The Uninhabitable Earth," by David Wallace-Wells, published by Penguin Books Ltd in 2019.

[5] "Climate risk and response: physical hazards and socioeconomic impacts," published by McKinsey Global Institute in January 2020, p 64.

Core temperature is determined primarily by a combination of activity level and 'wet-bulb' temperature (a measure of air temperature and relative humidity) that regulates how much heat the body can exhaust by evaporating sweat. In environments where air temperature is higher than core body temperature, the body quickly loses its ability to dissipate heat through radiation and convection. At a wet-bulb temperature of 35°C, the core temperatures of healthy, well-hydrated human beings resting in the shade would rise to lethal levels after just four to five hours of exposure.

Heat problems, of course, are not limited to humans. Warmer oceans kill coral and plankton, making life unviable for fish. Farm animals are also heat-sensitive, as is their feedstock. Corn has a physiological threshold at about 20°C, beyond which yields decline dramatically[6].

Clearly, life is fragile and sensitive to changes in temperature. We can't combat an increase of 2°C, as outlined in the MGI report, simply by taking off our jackets. Remember, too, that the 2°C projected increase represents a global average: the Arctic has already heated up by 5°C.

Even for people lucky enough to live in a place that will heat up by only 1°C in the next 20 years, the likely expense of soy and corn livestock feed will make that steak a rare luxury. And since the fish may have starved to death in an oxygen-depleted ocean, those of us not already vegan may be seriously warming up to the idea. (Such lifestyle changes, of course, will be minor impacts relative to other disruptions.)

Modern science and technology could help defray some of the worst impacts of climate change on the planetary food supply, as exhibited by the viability of lab-grown food, enabling us to achieve better living through chemistry. Potentially, we could also turn some of the side-effects of climate change to our advantage, for example, by trapping the locust swarms blackening the sky above Sudan and processing them into burgers.

Regardless of any ingenious technological responses to global warming, humans will have to clear plenty of other hurdles in the Anthropocene era.

Carbon dioxide levels in the atmosphere have skyrocketed to levels never before evidenced in ice cores dating back to the dawn of humanity and through many cycles of planetary cooling and warming.

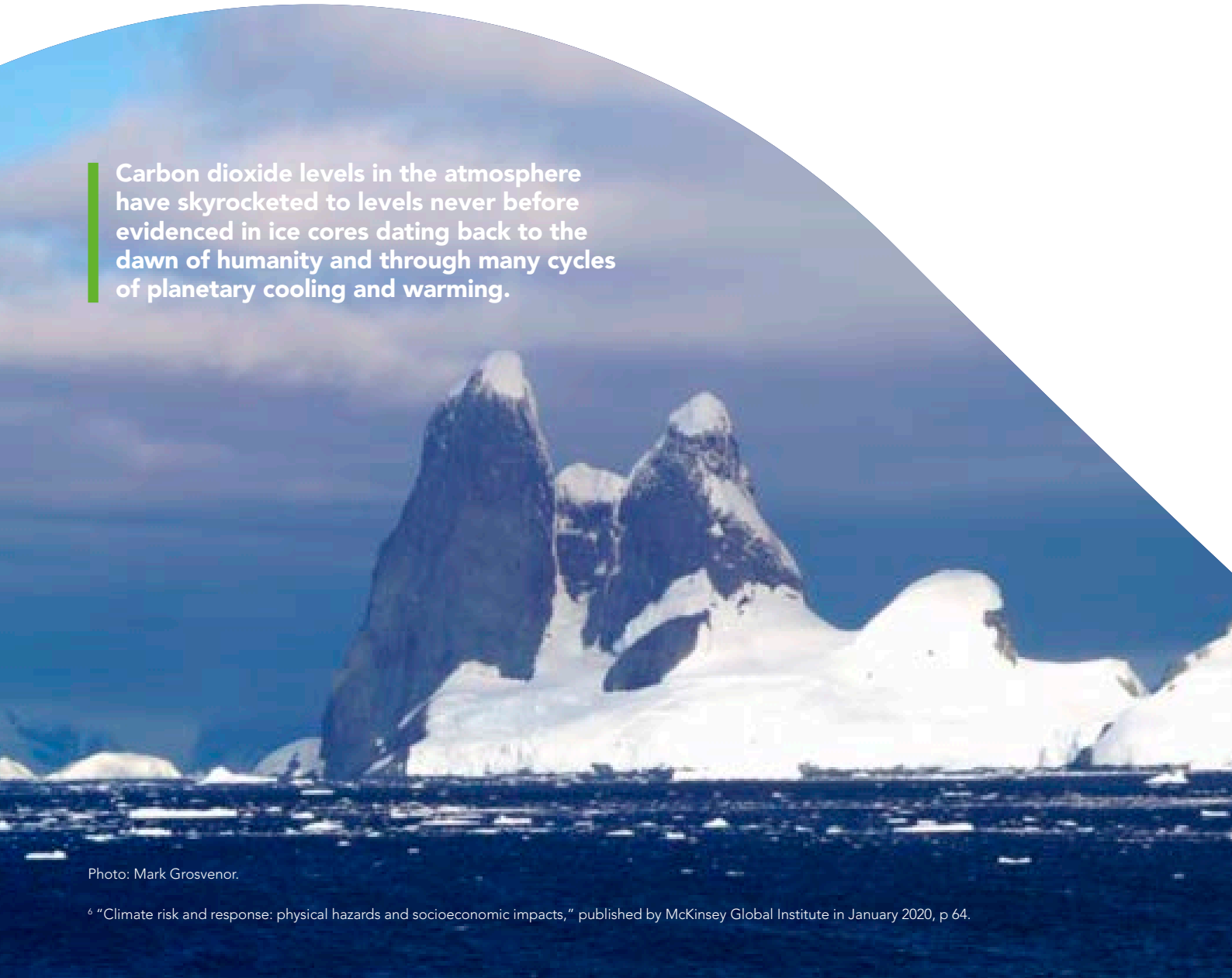


Photo: Mark Grosvenor.

[6] "Climate risk and response: physical hazards and socioeconomic impacts," published by McKinsey Global Institute in January 2020, p 64.

Photo: Mark Grosvenor.

Two degrees of separation

We should not be fooled by the seemingly small numbers cited in the science: 1°C of warming since the 19th century and a 2°C increase by the end of this century. These figures are not trivial. As the effects of tiny variations in our body temperature show, incremental rises can make a big difference.

At a 2°C rise, the already fast-melting ice sheets will collapse. Other projected consequences include:

- Water scarcity threatening 400m more people
- Major cities in the equatorial band of the planet becoming unlivable
- Heat waves killing thousands each summer, even in northern latitudes

In a world of 2°C warming, India, for instance, could see 32-times as many extreme heat waves, each lasting five-times as long and exposing 93-times more people to temperature-related physiological risks.

High levels of CO_2 emitted into the atmosphere now will steadily heat the planet well into future centuries.

If we can't reduce the current level of CO_2 in the atmosphere soon, the global temperature increase could hit 3°C, condemning Southern Europe, Central America, the Caribbean and Northern Africa to permanent drought. Under this warming level, wildfires – such as the late-2019 blazes in Australia – would be more frequent, searing twice the current annual average land area burned in the Mediterranean and six-times the amount in North America.

If we can't reduce the current level of CO_2 in the atmosphere soon, the global temperature increase could hit

3°C

At 4°C, damage from river flooding would grow 20-fold in India, 30-fold in Bangladesh and as much as 60-fold in the UK. Estimates of flood damage costs in this global warming extreme have gone as high as $600tn – or twice the current level of global wealth[7].

[7] "The Uninhabitable Earth," by David Wallace-Wells, published by Penguin Books Ltd in 2019, pp 12-13

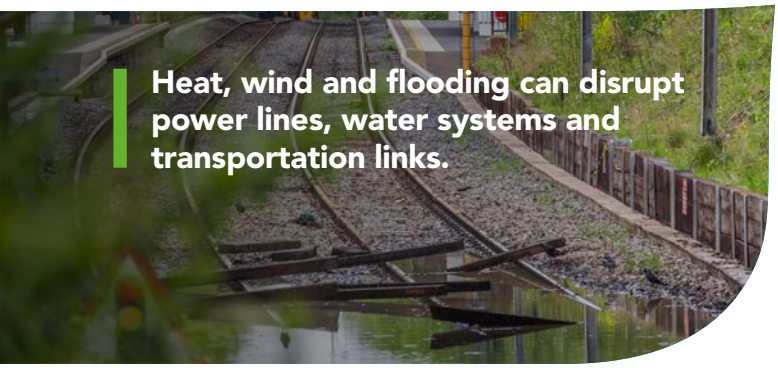
On the optimistic assumption that we succeed in limiting warming this century to 2°C, the atmosphere will still have amassed CO_2 at around 500 parts per million, harking back to a level not seen since the Middle Miocene era 16m years ago, when our ancestors were apes. During this epoch, the earth's average global temperature ranged from 5°C to 8°C above the readings we observe today, resulting in sea levels that were some 40 metres or more higher – not the 0.5-metre increase the 2013 Intergovernmental Panel on Climate Change report forecasted for the end of this century[8].

High levels of CO_2 emitted into the atmosphere now will steadily heat the planet well into future centuries. Some models, including ones by economists Professors Gernot Wagner and Martin Weitzman[9], see an 11% chance we overshoot to 6°C. Wallace-Wells cites data from Nobel laureate William Nordhaus suggesting that better-than-anticipated economic growth increases the odds to one-in-three that emissions exceed the UN's worst-case business-as-usual scenario, causing a temperature rise of 5°C or more.

Wallace-Wells also examines the peak of the UN climate change probability curve, which reaches 8°C of warming. Thankfully, this scenario remains highly unlikely with the resulting environment so horrifying that we will skip over it for now. Few of us are stoic enough to seriously consider living through the Book of Revelation just yet.

How can investors adapt?

Global warming is a universal issue whose enormity seems to increase every year as new records for temperature, storm severity and species extinction are set, before being broken again – and the challenge of containing rising temperatures becomes more daunting.



Heat, wind and flooding can disrupt power lines, water systems and transportation links.

If the big picture is too overwhelming, it can help to dissect the problem into discrete categories. For example, MGI has made an interesting attempt at framing the various theatres of risk arising from global warming, classifying the effects of the climatic disequilibrium into five areas:

Livability and workability

Because the human body naturally limits its efforts to prevent overexertion, heat stress will reduce labour capacity as workers must take breaks to avoid heatstroke. Looking beyond the workplace, about 470m people in rural areas today lack access to safe food and medicines due to inadequate electricity and refrigeration, and an estimated 630m living in urban slums have little or no access to cooling due to inadequate power supplies[10]. Climate change is regressive: those dependent on outdoor work in areas of increasing heat duress are the most exposed – and they are also often the most vulnerable, lacking savings or adequate income. Furthermore, increased temperatures will influence disease vectors, potentially undermining the progress made in combating them in the current climate.

The countries with the most to lose can be classified as 'significantly hotter and more humid countries', including India, Bangladesh, Nigeria, Pakistan, Thailand and Vietnam.

Food systems

Floods, drought conditions and extreme temperatures impact land and crops. It is difficult to grow corn at 35°C, given the plant's physiological threshold of about 20°C[11]. There are five major grain-growing areas in the world: the US Midwest and Canadian Prairies, north-west Europe, southern Russia and the Ukraine, northern India and eastern China. In the case of breadbasket failures, a yield collapse in one or more key production regions for rice, wheat, corn or soy could cause prices to spike by 100% or more in the short term.

[8] "What happened the last time it was as warm as its going to get by the end of this century?" by Howard Lee, published by Ars Technica on 18 June 2018.
[9] "Climate shock: the economic consequences of a hotter planet," by Gernot Wagner and Martin Weitzman. Published by Princeton University Press in 2015.
[10] EIU p22.
[11] "Climate risk and response: physical hazards and socioeconomic impacts," published by McKinsey Global Institute in January 2020, p.64 and p.15.

Climate change is regressive: those dependent on outdoor work in areas of increasing heat duress are the most exposed – and they are also often the most vulnerable, lacking savings or adequate income.

Physical assets

Homes, buildings and entire networks of real-estate assets and infrastructure in central business districts are at risk of being damaged or destroyed by tidal or riverine flooding, extreme precipitation and forest fires.

Infrastructure services

Heat, wind and flooding can disrupt power lines, water systems and transportation links. Power generation can become less productive under very hot conditions, and roads can buckle[12]. This can obviously disrupt other sectors relying on this infrastructure. For instance, in 2018 Hurricane Maria generated winds of up to 280 km/hr, felling more than 90% of mobile phone towers in Puerto Rico. Up to 185,000 airline passengers each year could be grounded by 2050 due to flight cancellations caused by extreme heat.

Natural capital

Glaciers, forests and ocean ecosystems are being disrupted or destroyed, endangering food chains, human habitats and economic activity.

For our purposes as emerging market investors, MGI's five categories represent key threats to economic prosperity. The countries with the most to lose can be classified as 'significantly hotter and more humid countries', including India, Bangladesh, Nigeria, Pakistan, Thailand and Vietnam.

Next, the 'hotter and more humid countries' include Indonesia, The Philippines, Saudi Arabia and Japan. While the latter is not part of the emerging markets benchmark, it remains economically important to the Asian region. China, Brazil, Chile and the US are classified as 'diverse climate countries' with various levels of risk. Some are severe but due to the diversity of their geographies (or economies), they may cope better with climate change.

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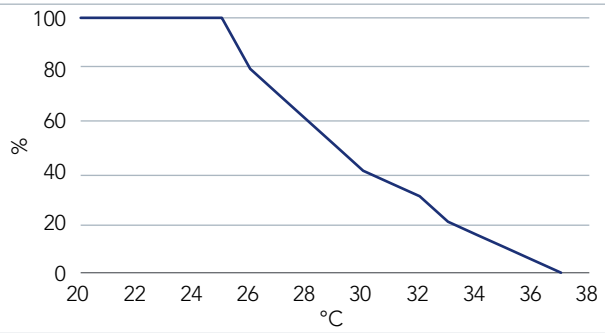
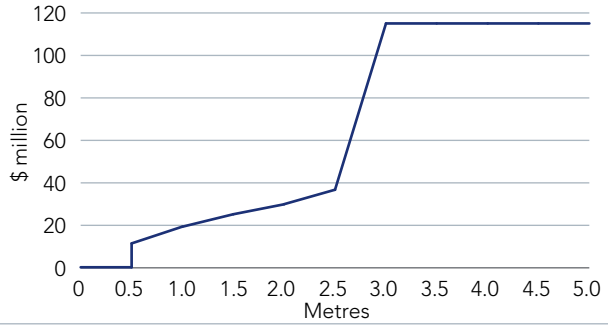
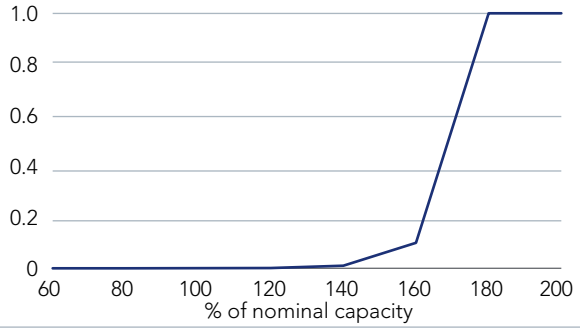
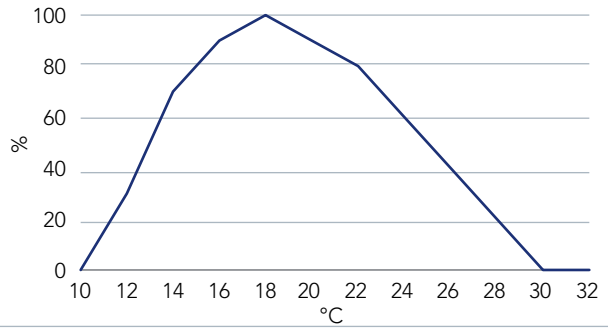
[12] "Climate risk and response: physical hazards and socioeconomic impacts," published by McKinsey Global Institute in January 2020, p.64 and p.15.

Figure 3. The direct impacts of climate change can become nonlinear when thresholds are crossed

System	Example	Nonlinear behavior		
Human	Impact of heat and humidity on outdoor labour	Share of labour capacity in a given hour*		Wet-bulb globe temperature**
Physical	Floodwater impacts on an exemplary UK train station	Asset impact***		Flood depth
	Effects of line over-loading (eg, sagging due to heat) in an electrical grid****	Probability of line tripping		Line loading
Natural	Temperature impact on crop yield	Corn reproductive growth rate		Air temperature

* Immediate effect; longer exposure will cause rapidly worsening health impacts. Humans can survive exposure to 35C wet-bulb temperatures for between four to five hours. During this period, it is possible for a small amount of work to be performed, which is why the working hours curve does not approach zero at 35C WBGT (which, in the shade, is approximately equivalent to 35C wet-bulb).

** Based on in-shade wet-bulb globe temperature (WBGT). WBGT is defined as a type of apparent temperature which usually takes into account the effect of temperature, humidity, wind speed, and visible and infrared radiation on humans.

*** Average cost of a new build train station globally used for asset impact/cost on UK train station; salvageable value is assumed zero once asset passes destruction threshold.

**** Both acute events (for example, flooding, fires, storms) and chronic changes in climatic conditions (such as heat) can affect the grid and may lead to outages.

Source: McKinsey Global Institute as at January 2020, citing Dunne et al., 2013, adjusted according to Foster et al., 2018; Henneaux, 2015; Korres et al., 2016; CATDAT global database on historic flooding events; McKinsey infrastructure benchmark costs; EU Commission Joint Research Centre damage functions database; historical insurance data and expert engineer interviews on failure thresholds; McKinsey Global Institute analysis.

Another perspective on global-warming vulnerability focuses on 'increased water stress countries'. This sub-group includes Mexico, Turkey, Egypt, Iran, South Africa and all of Southern Europe. Russia and Poland as well as most of Northern and Central Europe are classed as lower risk countries in this respect.

Global-warming risk varies from country to country but for those in the 'significantly hotter and more humid countries', the most significant danger centres on the ability to work and even live in extreme heat. India is a case in point: in 2017, heat-exposed work produced about 50% of the nation's economic output, drove about 30% of its GDP growth and employed about 75% of the labour force, or 380m people[13].

Globally, the number of people living in areas with an annual likelihood of experiencing lethal heat waves – defined as three-day surges in temperatures that exceed the threshold of survivability for a healthy human being in the shade – is projected to rise from near zero today to 250m-360m by the end of this decade. This figure could triple over the ensuing 20 years if current fossil-fuel use and emission levels persist, a scenario known as RCP 8.5[14]. Greater air-conditioning usage, estimated at 10% penetration in India and 60% across China today, will probably lower these future estimates, although at what could be a sizable cost to the atmosphere and, since warming affects the sea level, storm severity and food chains[15].

Global-warming risk varies from country to country but for those in the 'significantly hotter and more humid countries', the most significant danger centres on the ability to work and even live in extreme heat.

The bottom line is that by 2050, there is an estimated 80% cumulative average likelihood that a person living in an at-risk area will experience a lethal heat wave at least once over a 10-year period[16]. This projection indicates that dissecting the threats caused by climate change into discrete problems does not produce less-scary statistics!

However, this granular analysis offers a much clearer guide to emerging-market investors who want to factor likely scenarios into their long-term analysis. (Later in this piece, we will comment on our efforts to do so.)

India: in the line of fire

Emerging markets face greater climate change risks than developed countries. Among them, the hottest and poorest are most under threat.

Countries with large populations whose jobs are outdoors, like India – where 42% of the workforce are employed the agricultural sector[17] and 3.8% in construction[18] – stand to lose the most as the number of days with insufferable heat spikes. Among labourers, the effective number of outdoor daylight work hours lost in an average year would increase by 15% in 2030[19], leading to a 2.5-4.5% drag on GDP.

By 2050, the number of Indian people expected to fall into the lethal-heat-wave danger zone is forecast to range between

310m and **480m**

About 10% of Indians, or 120m people, already live in areas with a non-zero annual probability of lethal heat waves – defined as three-day surges in temperatures that exceed the threshold of survivability for a healthy human being in the shade – and this proportion is expected to increase by 5%-10% by 2050[20]. By 2030, between 160m-200m of the Indian population will be exposed to this danger, and among them an estimated 80m-120m don't have air-conditioned homes. The number of people expected to fall into the lethal-heat-wave danger zone is forecast to range between 310m and 480m by 2050 – although most of the population is expected to live in air-conditioned accommodation by then (which, absent technological innovations, will contribute to further heating up the environment outside their homes). Looking farther out, in the last 20 years of this century India is projected to experience 181 days a year with temperatures in excess of 35°C[21]. For context, the country's average annual temperature in 2018 was 25.9°C[22]. This would not only be hazardous to the health of the people and natural environment of India but render plenty of outside work, as it is currently done, obsolete.

[13,14,15] "Climate risk and response: physical hazards and socioeconomic impacts," published by McKinsey Global Institute in January 2020, p.64-67, p. 93. The Representative Concentration Pathway (RCP) scenarios are used by the Intergovernmental Panel on Climate Change. RCP 8.5 is the most aggressive, in which emissions continue to rise throughout the century.

[16] "Climate risk and response: physical hazards and socioeconomic impacts," published by McKinsey Global Institute in January 2020, p. 93.

[17] "World Bank Open Data," accessed at data.worldbank.org in April 2020.

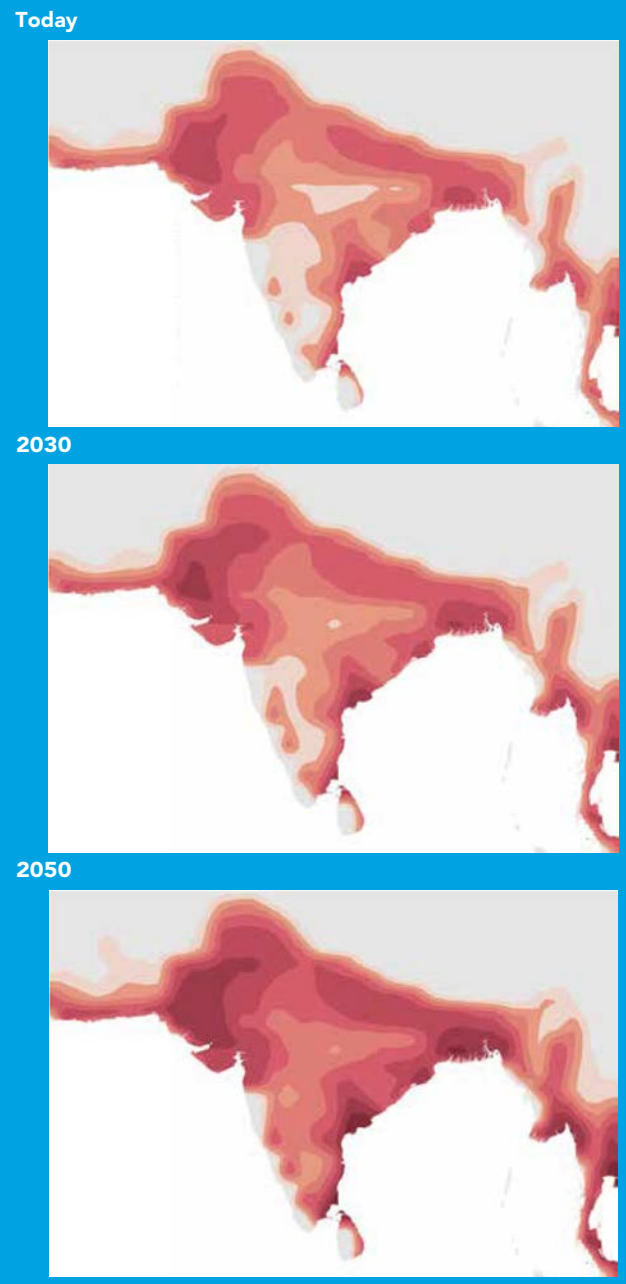
[18] "Construction," published by investindia.gov.in in 2020.

[19,20] "Climate risk and response: physical hazards and socioeconomic impacts," published by McKinsey Global Institute in January 2020, pp. 64-67, p.69, p.93.

[21] The Climate Impact Lab, quoted in "The cooling imperative," published by the Economist Intelligence Unit in 2019, on p 12.

[22] "Annual average temperature across India, 2012-2018," by Madhumitha Jaganmohan, published by Statista on 23 September 2019.

Figure 4. The projected number of working hours lost due to greater heat and humidity in India and South Asia



*Lost working hours include loss in worker productivity as well as breaks, based on an average year that is an ensemble average of climate models.
Note: See the Technical Appendix for why we chose RCP 8.5. All projections based on RCP 8.5, CMIP 5 multi model ensemble. Heat data bias corrected. Following standard practice, we define current and future (2030, 2050) states as the average climatic behavior over multidecade periods. Climate state today is defined as average conditions between 1998 and 2017, in 2030 as average between 2021 and 2040, and in 2050 as average between 2041 and 2060.

Note: See the Technical Appendix for why we chose RCP 8.5. All projections based on RCP 8.5, CMIP 5 multi model ensemble. Heat data bias corrected. Following standard practice, we define current and future (2030, 2050) states as the average climatic behavior over multidecade periods. Climate state today is defined as average conditions between 1998 and 2017, in 2030 as average between 2021 and 2040, and in 2050 as average between 2041 and 2060.
Source: McKinsey Global Institute as at 2020, based on data from the Woods Hole Research Center.

Urbanisation, a great driver of productivity gains historically, may mitigate the loss of outdoor employment to some extent, but comes with its own problems. Cities raise temperatures by trapping heat and preventing its dissipation into the lower atmosphere, and paving over undeveloped land and erecting buildings obstructs the natural processes of ventilation and heat dispersion known as evaporative cooling. The resulting microclimates, known as urban heat islands, can make cities 1°C-3°C warmer than in surrounding areas. This phenomenon has been measured in London, New York, Paris and Las Vegas. A 2007-2010 study showed that urban heat-island effects increased winter temperatures in Delhi by up to 4°C-7°C[23].

Heat also presents challenges to logistics businesses. India has a dearth of integrated cold storage and transport. Estimates suggest that the country has less than 15% of the refrigerated trucks that it needs and less than 1% of the pack-houses, where produce is sorted and processed and field heat is removed, that it requires. As a result, just 4% of India's food is moved through cold-chain logistics to ensure that it is exposed to consistent temperatures – compared with 70% in the UK and 10% worldwide – while 40% of certain harvested crops are dumped before reaching consumers[24]. Indeed, up to 40% of post-harvest losses can occur by the first mile of transit[25]. Meanwhile, long-distance truck drivers face a higher risk of road accidents or health problems if they don't have air-conditioned cabs. In India, drivers routinely become dehydrated because they do not stop regularly enough for refreshments[26].

Government action

Government and civil authorities, at many levels, are aware of the problem. One project in the Punjab and Bangalore found that introducing better cold-chain logistics – which enable wider and coordinated access to cooling facilities for producers – reduced citrus food waste by 75% and raised farm-gate profits tenfold. Preserving produce can also provide farmers with additional benefits: they can sell produce further afield or wait to sell it at better prices, particularly during a supply glut. For fishermen, cold storage and transport can dramatically improve profits: fresh fish last only a few hours in the heat but can last for up to 10 days if stored at 0°C.[27]

At the national level, the India Cooling Action Plan (ICAP), finalised in 2019, targets the following reductions by 2038[28]:

- 20-25% in overall cooling demand
- 25-40% in cooling energy requirements
- 25-30% in refrigerant demand by 2038

[23] "A study of urban heat island and its association with particulate matter during the winter months over Delhi," by Puneeta Pandey et al, published in *Science of the Total Environment*, vol 414, on 1 January 2012.

[24,25,26] "The cooling imperative," published by the Economist Intelligence Unit in 2019, p.23, p.42 and p.24.

[27] Irish Seas Fisheries Board, quoted in "The cooling imperative," published by the Economist Intelligence Unit in 2019, on p. 23.

[28] "India Cooling Action Plan (ICAP)", published by Drishti IAS on 13 April 2019 at drishtiias.com.

The ICAP aims to achieve these goals through a wide variety of measures:

- The use of emerging technologies that don't require cooling gases
- The introduction of variable-speed air conditioning
- Re-using cold energy, as in Japan, and waste heat
- 'Cooling as a service', where third parties own the cooling infrastructure and charge user fees for access
- Green roofs and white-painted roofs
- Shaded-street infrastructure, including positioning buildings so they shade each other
- Restoring green spaces
- Passive cooling: optimising building design to capture natural wind flows, use airtight doors, triple-glazed windows and insulated concrete panels.

The ICAP also aims to train and certify 100,000 technicians while investing more in cooling research.

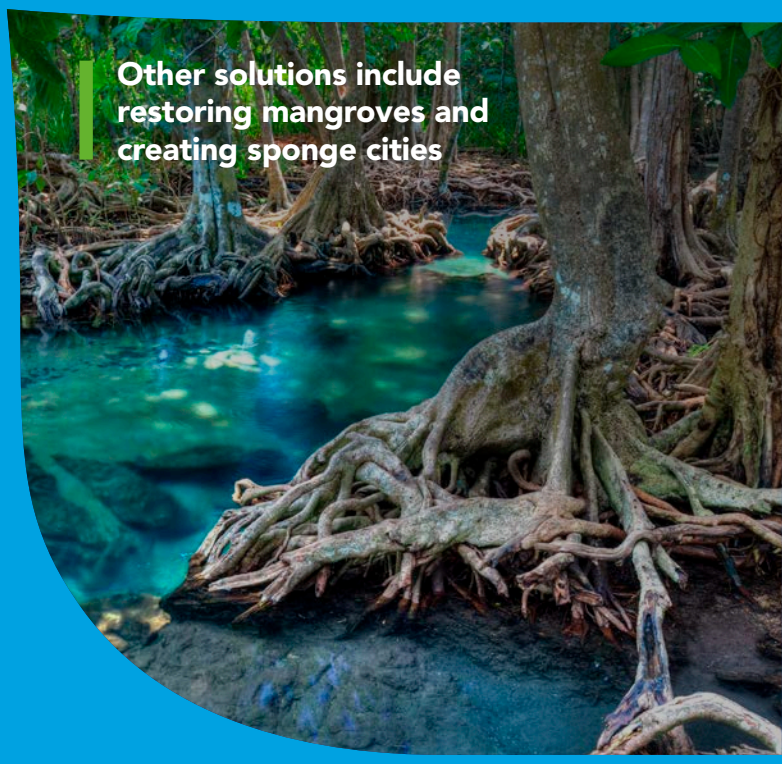
By 2050, large sections of Mumbai and Kolkata will be prone to coastal flooding

Action is being taken at the local-government level as well. Ahmedabad, the state capital of Gujarat in India's north, has implemented a Heat Action Plan to address expected average July temperatures of 33°C (and the extremes concealed by averages). It includes establishing early-warning systems and cooling shelters to protect those without air conditioning. The city government has also reduced employees' working hours during the hottest parts of the day.

Other solutions include restoring mangroves and creating 'sponge cities' – a term coined in Hyderabad, when the city authorities started collecting storm water to lessen the impacts of seasonal floods on vulnerable urban areas. Sponge cities may replace concrete pavement with wetlands, create green rooftops and rain gardens, allowing storm water to be absorbed back to the land. Rain can also be collected for use in irrigation or the home[29].

Rising sea levels also pose a planning challenge. Satellite images show that stretches of Mumbai's coastline have eroded by as much as 18 meters since 2000, which is partly due to slum dwellers and developers paving over mangroves in addition to global warming. By 2050, large sections of Mumbai and Kolkata will be prone to coastal flooding, according to a new study that corrects land height estimates from previous research[30].

Just 4% of India's food is moved through cold-chain logistics to ensure that it is exposed to consistent temperatures – compared with 70% in the UK.



Ahmedabad has implemented a Heat Action Plan to address expected average July temperatures of **33°C**

At the corporate level, examples are currently scarce. Among them is Mahindra & Mahindra – a large car manufacturer and parent of our Mahindra Logistics' portfolio holding – which is experimenting with techniques such as tri-generation, a heat recovery system, and radiant cooling, where cool surfaces are used to absorb heat. Ecozen, a start-up based in Pune, has developed a portable cold-storage box which runs on solar power and has a maximum capacity of 15ft x 10ft x 10ft. The boxes can be rented to other farmers when not being used by their owners.

Sponge cities may replace concrete pavement with wetlands, create green rooftops and rain gardens, allowing storm water to be absorbed back to the land.

Ultimately, a hotter environment with concomitant droughts, storm surges and supercharged cyclones could force Indian authorities to implement more extreme measures to help the population adapt. They might have to relocate people and climate-sensitive industries from high-risk areas, incurring much expense and enormous disruption.

[29] "In 2014, China launched its own sponge-city initiative, covering more than 30 cities including Shanghai, with another 600 cities expected to join in the coming decade.

[30] "New elevation data triple estimates of global vulnerability to sea-level rise and coastal flooding," by Scott Kulp and Benjamin Strauss. Published in *Nature Communications* on 29 October 2019.

Adaptation within our portfolio

Recently, we surveyed the companies in our global emerging market portfolios to assess their levels of preparedness for a 2°C change in average global temperature and their **readiness to adapt** to the perils of a hotter planet. This complements our efforts to engage with companies on **mitigating climate change** in their operations, as well as boosting the quality and extent of their disclosures and actions towards environmental, social and governance (ESG) matters.

However, given the increasing frequency of severe storms, heat waves, droughts, and riverine flooding – not to mention the longer-term threat of rising seas – we are increasingly concerned that the management teams of our portfolio companies could be underestimating climate-change risks that could threaten the viability of their businesses.

Granted, while we are in the midst of a pandemic, ongoing trade tensions and technological disruption, company management teams already have a lot to deal with. Moreover, newly greened investment analysts sending long questionnaires about dozens of (other) ESG issues have created an enormous demand for sustainability data for many companies. Efforts to satisfy this, let alone take action, might even be untenable.

To date, our survey results have in general been disappointing. To summarise:

- While the majority of the companies we surveyed are aware of the climate-change risks we sought to examine in the survey, only half were able to address the questions in a detailed way.
- Among the more advanced, Mexican retailer Walmex, Indian two-wheel vehicle maker Hero MotoCorp and Brazilian furniture and civil-construction supplier Duratex had all launched concrete initiatives to safeguard their long-term futures against global-warming risks.
- Only one company in the portfolio, Indian property and casualty insurer ICICI Lombard, met our full expectations for preparedness – which is not surprising given that its business is focused on pricing risk.
- Others, including China Mengniu Dairy, manufacturer Bharat Forge and power-tool firm Techtronics have begun to study the issue.

For the rest, given the many other challenges they face, perhaps highlighting the importance of climate-change mitigation and long-term adaptation, and encouraging them to start making plans, is the most we can expect at this point in time[31].

Mitigation at the policy level

Globally, at the national and municipal levels, awareness is growing quickly, sparking numerous initiatives ranging from sponge cities to innovative insurance programs like the UK's Flood Re – a joint public-industry funded mechanism to provide flood cover at a reasonable cost to owners of homes that were built before 2009 and are located in flood zones. The authorities governing Singapore, Shanghai and Rotterdam have advanced projects to defend against rising seas and other climatic threats. Others in Denmark, New York and Boston are in various stages of study and planning.

Wilder ideas are also gaining currency as the reality of global warming dawns, including a proposed dam between Orkney, part of an archipelago off the north coast of Scotland, and Bergen in Norway to provide a bulwark for Denmark against an incursion by the North Sea. Another dam has been proposed from a point on the south coast of England to the west coast of France; together, these would protect coastlines along the entire English Channel and Baltic Sea from rising waters. Airborne climate-change solutions, like spraying sulfur into the atmosphere (call this 'Bosch's rain') and other, even more extreme, suggestions are doing the rounds.

[31] The conversations spurred by our survey are taking place in the context of engagements on corporate-governance and social issues, in addition to other environmental concerns. We also discuss the strategic, operational and financial dimensions of their businesses in the course of corporate engagements.

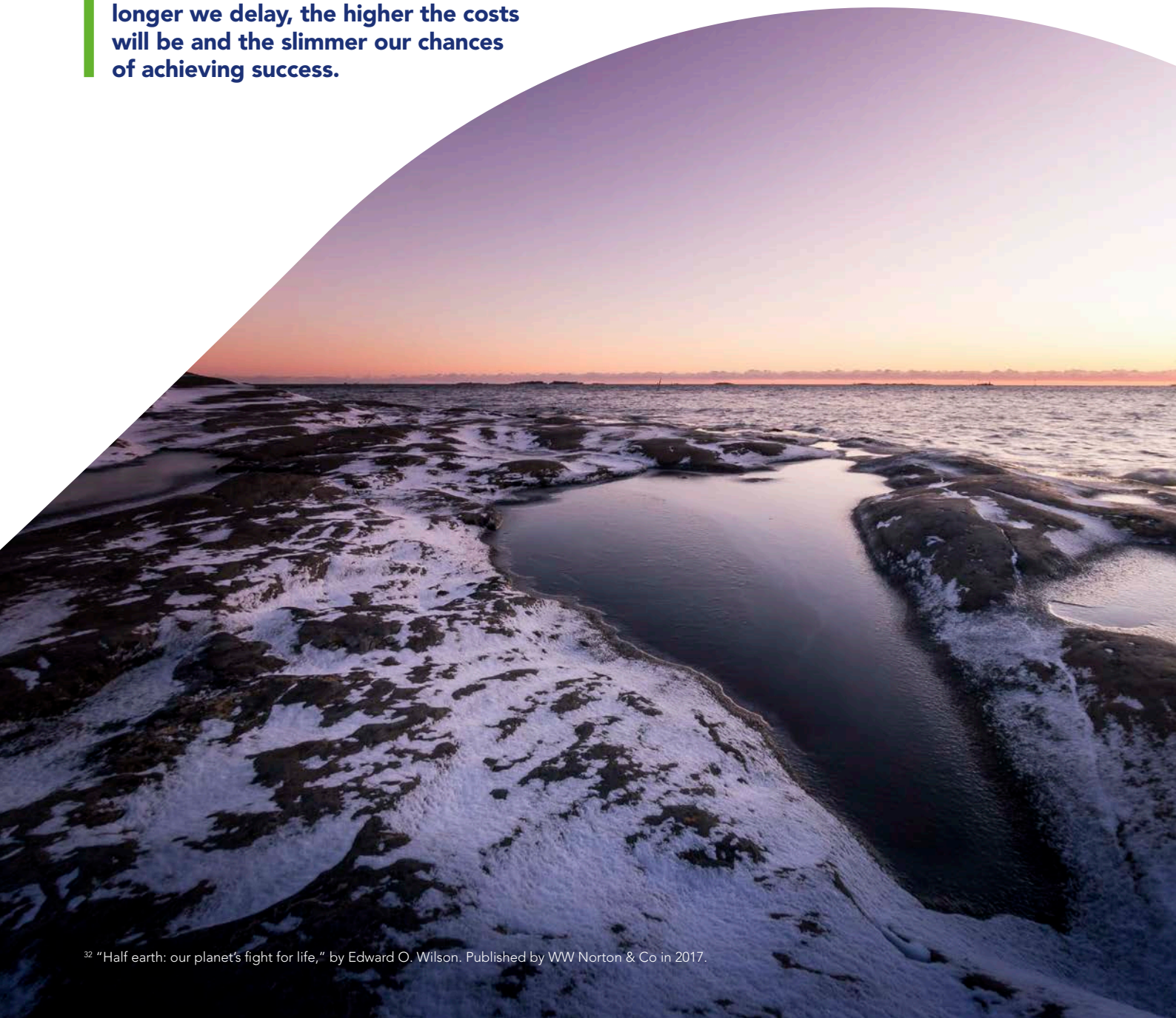
Then there is the 'Half Earth' idea put forward by Pulitzer Prize winner E.O. Wilson. The biologist's plan involves letting nature run its rehabilitative course on half the planet, sequestering humanity in the remaining, habitable hemisphere[32]. Finally, energy giants Chevron, Equinor, Total and ADNOC have built or are in the planning stages of constructing carbon capture and storage facilities. This expensive technology is typically trotted out by fossil-fuel proponents to justify continuing business as usual, but with massive subsidies for a number of years it could possibly, at some stage, become economic.

Eventually, all companies must become aware of the economic and political threats approaching their business operations, and responsible management teams will respond to the climate-change storm. The rapid, if globally disjointed, response to the coronavirus outbreak proves that the world can summon immense resources to counteract existential challenges.

There is still time to act, but the longer we delay, the higher the costs will be and the slimmer our chances of achieving success.

We encourage all investors to make climate change a core theme of their interactions with businesses: all companies, not only those we invest in, must begin to focus on adapting for the rougher weather ahead.

Sadly, despite our knowledge and better instincts, the slow onset of climate change, the high cost of combating or mitigating it, and its less immediately tangible impacts have made deferring action the default human response. There is still time to act, but the longer we delay, the higher the costs will be and the slimmer our chances of achieving success.



[32] "Half earth: our planet's fight for life," by Edward O. Wilson. Published by WW Norton & Co in 2017.

Anthropogenic adaptation: can we survive our success?

Humanity in its current form emerged up to 300 millennia ago. In the eons since, our species has reached spectacular scientific, cultural and philosophic heights that have arguably been matched by our capacity for destruction – of each other, animals and the natural environment. Sometimes this damage has been inflicted intentionally, sometimes not.

To our credit, we have adapted to withstand a wide range of threats – war, disease, famine, natural disasters, economic depression and terrorism – and have often used the experience and knowledge gained in order to improve the lives of future generations. Through bitter experience, humans have learnt some valuable lessons in crisis management and even prevention.

As long-term investors, it's our duty to emphasise the biggest long-term risk of our time and support companies' efforts to adapt.

But the anthropogenic phenomenon of climate change will test our ability to avoid mortal danger more than ever before. Humanity's ability to adapt, something we have excelled at, must again come to the fore.

Science, technology and behavioural changes (regulated or not) can help take the edge off global warming. As investors, we know that mitigation is one vital aspect of addressing the problem. Perhaps more importantly, we can help businesses prepare for the inevitable, albeit, in some cases, longer term environmental changes coming their way. Our engagements show that few companies we know first-hand take the glaring risk of global warming into account. As long-term investors, it's our duty to emphasise the biggest long-term risk of our time and support their efforts to adapt.

Some months before the coronavirus crisis hit, we initiated discussions on climate-change adaptation with about half of the companies in our portfolio. These conversations will now include the rest of our holdings and continue throughout the pandemic. We encourage all investors to make climate change a core theme of their interactions with businesses: all companies, not only those we invest in, must begin to focus on adapting for the rougher weather ahead.

We all need to get some shelter, so we don't fade away.

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