# Collision Course


## 3-degrees of warming & humanity's future

BREAKTHROUGH
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COVER IMAGE—Scores killed as floods hit Spain, Sedavi – 30 Oct 2024.

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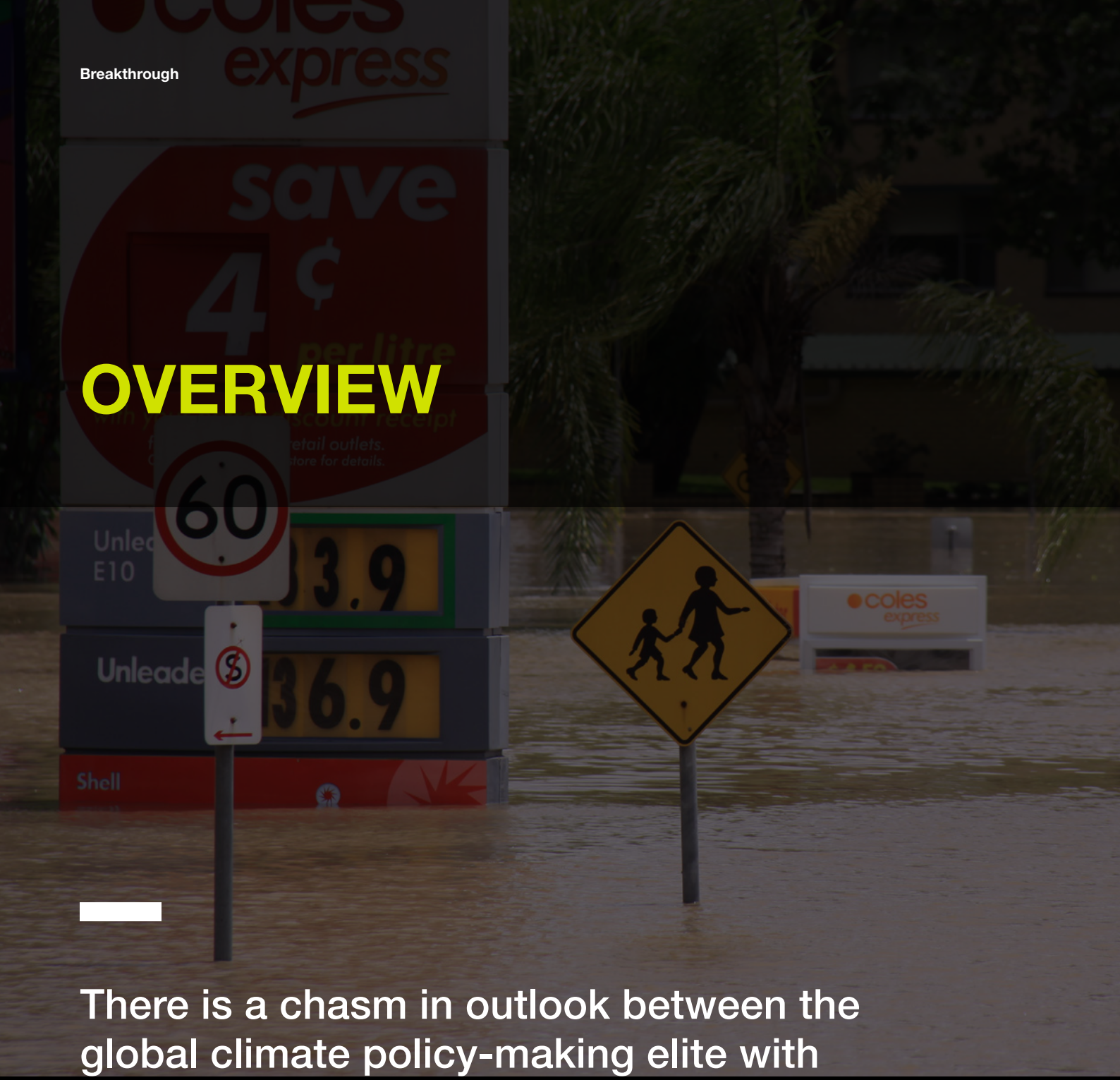



# OVERVIEW

**There is a chasm in outlook between the global climate policy-making elite with their focus on distant goals and slow, non-disruptive change, and activists and key researchers who see the world hurtling towards climate breakdown and social collapse.**

Ian Dunlop, Former Chair of the Australian Coal Association

## What does recent evidence reveal about the conflict between policymakers favoring gradual change and advocates urging urgent action to prevent climate collapse?

- In practical terms, the world has reached 1.5°C of warming and the pace of warming is increasing. An accelerated rate of warming is likely to continue to mid-century given the failure so far to reduce planet-warming greenhouse gas emissions. Many impacts are occurring faster than forecast, and beyond model projections, including the form, severity and frequency of extreme events such as unprecedented heatwaves and floods.
- There is now clear evidence that a number of crucial large-system tipping-point thresholds have been breached or are close to doing so, including polar ice sheets and land-based carbon stores including forests and permafrost, which may further increase the rate of warming. Sustainable planetary boundaries have already been exceeded.
- The physical risks may be abrupt and difficult to predict, and they may also cascade in a domino fashion which is difficult to incorporate into climate models. So methods of understanding climate risks should pay particular attention to the plausible high-end possibilities, because these worst-case scenarios will result in the greatest damage.
- Human emissions of greenhouse gases including carbon dioxide and methane have not yet peaked; hence in absolute terms, decarbonisation has not occurred. Contrary to global policymakers' stated collective intent, petrostates and big oil have signalled their intention to continue to expand production in the coming decades, which would ensure that warming will go far beyond the 2°C threshold.
- The continuing growth in fossil fuel production and emissions increases the likelihood of warming exceeding 3°C, and perhaps substantially because current climate models do not adequately account for the full range of reinforcing feedbacks.
- In a 3°C hotter world, new extremes will occur — of rainfall and unlivable heat, flooding and drought — beyond past human experience. And a committed sea-level rise of tens of metres will be in the process of inundating coastal cities and deltas. Large parts of the tropics will suffer "near-unlivable" extreme heat conditions, and the dry subtropics will dry out and may desertify.
- Together these events will have catastrophic impacts on food and water security, societal stability, and global governance. There is no evidence that, at this level of warming, current human societies can be supported, and there is a significant risk that states and global economic and political networks will crash.
- Reducing emissions, even very fast, is not enough to stop the systemic changes that are under way. Drawing atmospheric carbon dioxide levels back to safe, near pre-industrial levels, is a necessary but slow process; and in the meantime actively cooling the planet must be on the agenda if it can be done safely.
- Global climate-policymaking is embedded in a culture of sustained failure, with an emphasis on incremental, market-driven processes that are structurally incapable of assessing unquantifiable risks, or mitigating them. There is no longer any realistic chance of an orderly transition and large-scale economic disruption, which markets handle poorly, is now inevitable.
- As with other global and existential risks such as war and pandemics, transformative political leadership is now the key element in preventing societal collapse, but this runs contrary to the prevailing neo-liberal ideology that markets and the financial system are most efficient with little government regulation.
- The urgent need is to strengthen and rebuild state institutions in order to redirect production to climate-relevant, socially-necessary goals: to plan and manage the transition and adjustment and to provide a path out of the climate and ecological crises via an emergency mobilisation that consciously makes returning to a safe climate the first priority of economics and politics.

# INTRODUCTION: THE NEW CLIMATE REALITY

Political reality *must be* grounded in physical reality or it's completely useless.

Prof. Hans Joachim Schellnhuber
Director Emeritus Potsdam Institute[1]

**This report assembles some of the recent scientific literature on observations and projections, the systemic risks and the cascading impacts and non-linear features of the climate system. Some data on recent energy trends and projections is included. The final sections document research on the likely physical impacts on human systems, and particularly food production, in a 3°C-warmer future.**

This report will be followed by a second on solutions; why disruption is inevitable and should be embraced; how mainstream policymaking is constructed to fail; and the broader politics of "global boiling", a phrase coined by the UN Secretary-General. Some of these issues are addressed in the conclusion.

The evidence is powerful that, given the current lack of willingness of human society to rapidly reduce greenhouse emissions, we are heading towards 3°C of warming or more. This is increasingly the view of scientists who warn that in this scenario human societies will likely collapse.

The motivation in writing this first report was two-fold.

The first is in response to poorly-informed doomerism. Too much commentary on the likelihood of collapse makes claims not in accord with the credible literature, and thus undermines the basic proposition being put forward. It is not that collapse isn't a real and growing possibility; it is, as the final sections of this report demonstrates. There is plenty of good evidence from respected researchers to make the case, and the argument is more powerful and persuasive when that is done.

The second is in response to pervasive climate brightsiding, the assumption endemic in the professional climate advocacy movement and governments that as long as you tell a positive story and move "in the right direction", it doesn't matter if people understand or agree about the problem. It's all about selling "hope" and avoiding "fear", a deeply misguided understanding about how and why people are motivated to act.

One of the big events in the global climate advocacy calendar each year is Climate Week in New York in September, in partnership with the UN General Assembly. DrilledNews provided this sharp analysis on Climate Week's "toxic positivity" in 2024:

> [There was] an unsettling disconnect between people noshing on passed hors d'oeuvres and sipping craft cocktails while talking about the need to "stay positive!" [and] "give people hope!" and the reality crashing in all around us… Over and over again I heard people emphasise how important it was to tell positive stories; one colleague… described it as "a zombie-like repetition of 'we have to stay positive!'". This insistence that everything is normal and fine when it is so clearly not is something of a hallmark of the climate movement in my experience, particularly amongst those with power and money. People need good news and hope, I know, and amidst cascading crises people are absolutely desperate to feel like things are "normal," but does toxic positivity and censorship of criticism accomplish that? Does this black-or-white insistence [by funders] on how people must feel and talk about climate really move the needle?[2]

The answer is no. In any crisis, facing the world as it really exists is the first step on the road to actions that have the capacity to solve the problem. Public health education campaigns — such as on smoking, AIDS, skin cancer and COVID — have all demonstrated the efficacy of being brutally honest about the problem in order to engage people about the often inconvenient solutions.

Climate is no different.

# 01

# 1.5°C OF WARMING IS HERE & NOW

The era of global warming has ended [and] the era of *global boiling* has arrived.

UN Secretary-General Antonio Guterres, 27 July 2023[3]

**Global warming was 1.5°C in 2023, and 2024 will be hotter. In practical terms, the world has reached the lower end of the Paris target of 1.5-2°C of warming, and an accelerated warming rate is likely to continue to mid-century.**

## 1.5°C of warming in consecutive years

In 2023, global heating was approximately 1.5°C, compared to the late-nineteenth-century, (1880–1910) pre-industrial baseline. [Two of the most significant datasets of global temperatures are Berkeley Earth which put 2023 at 1.54°C above the pre-industrial (1850–1900) level,[4] and Copernicus/ECMWF at 1.48°C.[5]]

El Niño events are associated with warmer temperatures, and contributed to 2023 being a record-breaking year. September 2023 was above 1.8°C and a whopping 0.5°C above the previous September record, and the second half of 2023 was 1.67°C. All sixteen months from July 2023 to October 2024 were over 1.5°C, which has surprised some scientists who anticipated that the end of the El Niño would moderate the record heat.

And although the 2023-24 El Niño had ended by April 2024, record-breaking heat conditions lingered:

- The 12-month running average to the end of August 2024 was 1.58°C;[6]
- The global-average temperature for the boreal (northern hemisphere) summer of June–August 2024 was the highest on record;[7]
- By August 2024, there was a 97% chance of 2024 being hotter than 2023 and the hottest year in at least 100,000 years.[8]

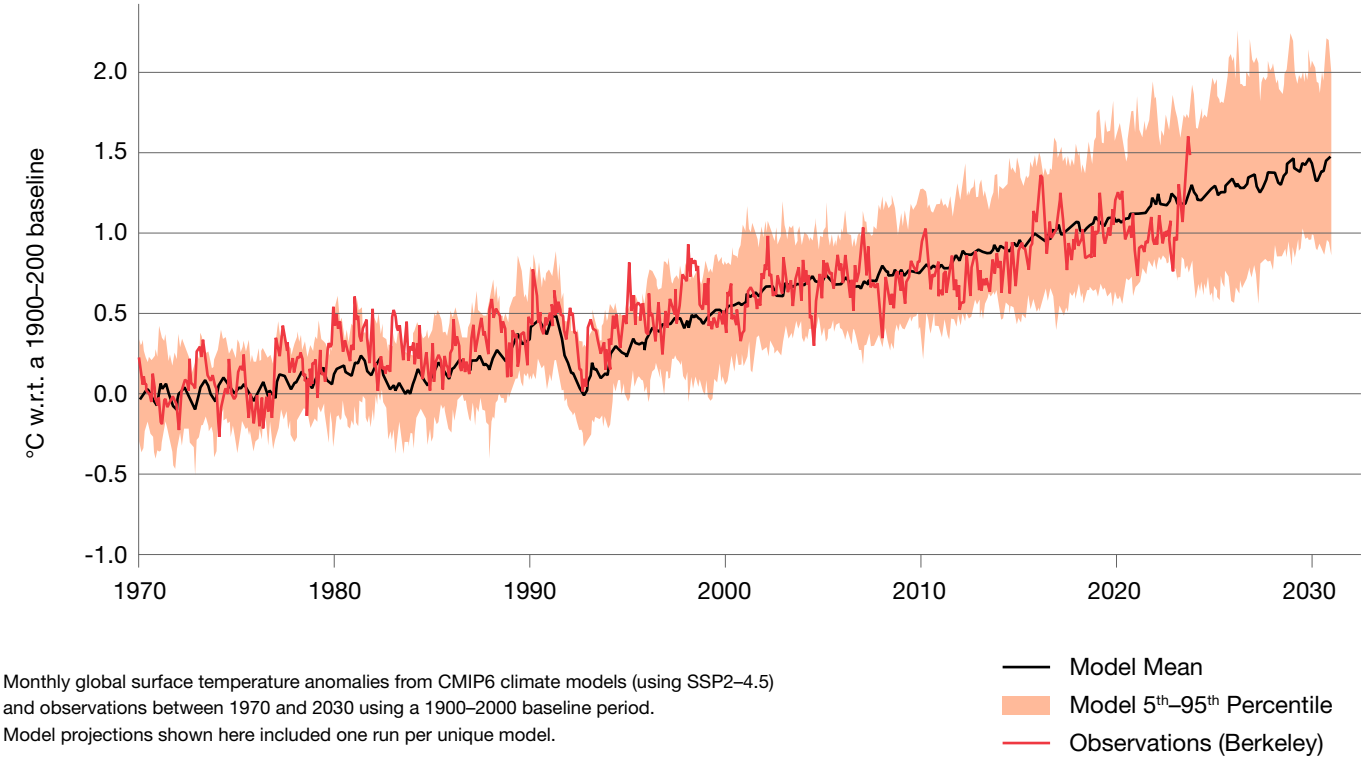
One scientist says that while he had hoped that 2024 would return to a more predictable post-El Niño regime, "it's looking increasingly less likely that last year's elevated temperatures were a mostly transient phenomenon. Rather, some combination of forcings [energy imbalance] or changes in [system] feedbacks may be driving higher global temperatures going forward."[9]

In practical terms, the world has reached 1.5°C. The World Meteorological Organisation says there is a one-in-two chance the current five-year period will be above 1.5°C: "There is a 47% likelihood that the global temperature averaged over the entire five-year 2024-2028 period will exceed 1.5°C above the pre-industrial era."[10]

This is consistent with the most recent generation of climate models (known as CMIP6) which forecast around 1.25°C of warming by the mid-2020s, based on a 1900–2000 baseline. A 1900–2000 baseline is 0.25°C above the 1880–1910 baseline, so this forecast is equivalent to 1.5°C for a pre-industrial baseline.[11] See Figure 1.

It is also important to understand that estimates of the current trend in global average warming based on the previous period will be an underestimate when temperatures are consistently rising, because it is an average of the past ten or twenty years, which in general were cooler than the present. A better measure would be an average of observations of the most recent ten years combined with projections of the next ten years. This, as Figure 1 indicates, would yield a figure close to 1.5°C.

**Climate Models (CMIP6) and Observations (1970–2030)**




Monthly global surface temperature anomalies from CMIP6 climate models (using SSP2–4.5) and observations between 1970 and 2030 using a 1900–2000 baseline period. Model projections shown here included one run per unique model.

**Figure 1:** CMIP6 model projections based on scenario SSP2-4.5, and observations from 1970 to 2023, on a 1900–2000 baseline. 1.25°C above the 1900–2000 baseline as projected by the model ensemble for the mid-2020s is equivalent to 1.5°C above the traditional 1880–1910 pre-industrial baseline (Climate Brink).

## The rate of warming is accelerating

There is now clear evidence that the rate of climate warming is accelerating, and that most policymakers' expectations of future warming being in the 1.5–2°C range by 2050 are now too conservative.

From 1970–2008, global mean surface temperatures rose by 0.18°C per decade, but from 2010 onwards the rate jumped to 0.3°C per decade.[12] This is consistent with the most recent CMIP6 climate models which have an expected rate of warming 0.3°C per decade from 2015 through 2050, in a current-policy-type scenario, known as SSP2-4.5.[13] The rate may increase further.

There are two key indicators that are consistent with the observed acceleration in warming: the rate of increase in ocean heat content has accelerated over recent decades;[14] and Earth's energy imbalance — the difference between incoming energy from the sun and the amount of heat radiating from Earth back into space — has more than doubled since 2000.[15]

The causes of the acceleration include:

- The still-rising and record-breaking levels of annual greenhouse gas pollution, with atmospheric carbon dioxide ($CO_2$) levels up an unprecedented 4.7 parts per million (ppm) in the last year;[16] and methane levels which, are more than double the pre-industrial level, and whose rate of increase has accelerated over the last decade, is now greater than at any time since global record-keeping began;[17]
- Decreasing levels of sulfate aerosols — due to cleaner air policies in China and for shipping fuels — which have a temporary cooling impact;[18]
- The increased warming of both hot and cold ocean currents shows that horizontal mixing of tropical heat to the poles is accelerating, and that vertical mixing with cold deep water is slowing down, leading to increased ocean stratification with a "hot" layer of water on top. This will cause sea surface temperature to increase more rapidly and $CO_2$ mixing with the deep ocean to decrease.[19]
- The weakening of various carbon sinks, such as in the Arctic and the Amazon, which have both become net emitters of greenhouse gases, and the failure of the land sink in 2023[20] (see Section 3).

LEFT— Scores killed as floods hit Spain, Paiporta – 30 Oct 2024.

# 02

# FASTER THAN FORECASTED, CLIMATE EXTREMES HIT HARD

This is happening at a much *faster rate* than ever documented in the past… If anything, we are much more likely to underestimate the impact of those changes on human society than to overestimate them.

Katharine Hayhoe, chief scientist for The Nature Conservancy, 17 February 2024[21]

**Many impacts are occurring faster than forecast, and beyond model projections, including the severity and frequency of extreme events and system-level tipping points. What has happened in the past is no longer a good guide to what's going to happen in the future.**

A rash of extreme climate rainfall, flood and heatwave events during 2023 and 2024, as well as record-breaking global temperatures, have astounded scientists, who called 2023 "unprecedented", "absolutely gobsmackingly bananas", "scary" and "frightening". Their surprise is unsurprising, because the limitations of climate models mean we will not know exactly how the climate crisis will unfold until it's too late.[22]

Dr Gavin Schmidt, director of NASA's Goddard Institute for Space Studies, says: "It's humbling, and a bit worrying, to admit that no year has confounded climate scientists' predictive capabilities more than 2023 has."[23] Schmidt says that there is a data collection problem in using models to explain what has just happened, and what may be expected: "All of the forecast systems are now using input files that are out of date. And for some of them a lot."[24] For example, CMIP6 models have not been updated with real world greenhouse and aerosols data since 2014.[25]

Prof. Johan Rockström, Director of the Potsdam Institute, says that "the planet is changing faster than expected, hitting harder on people across the world. We must admit we have underestimated risks".[26] And Sarah Perkins-Kirkpatrick of the University of NSW says that "we are hitting record breaking extremes much sooner than I expected".[27]

Associated with the onset of an El Niño, the global sea surface temperature (SST) in 2023 was an astounding 0.3°C above 2022 values for the second half of the year.[28] "We had seen El Niño conditions before," says Rockström, "so we expected higher surface temperatures [last year] because the Pacific ocean releases heat. But what happened in 2023 was nothing close to 2016, the second-warmest year on record. It was beyond anything we expected and no climate models can reproduce what happened. And then 2024 starts, and it gets even warmer. We cannot explain these [trends] yet and it makes scientists that work on Earth resilience like myself very nervous."[29]

The big picture is that important elements of the global climate system, such as polar ice-sheets, are reaching their tipping points decades to centuries faster than was previously projected. Many events in the climate system are beyond climate models' projections; that is, current models are not capturing all the risks.[30] They overlook or downplay the impacts of non-linear and difficult to predict processes such as the loss of ice sheet mass, ocean heat drawdown, rising sea levels, upticks in extreme events, carbon stores losing integrity, and more. Examples include:

- Prof. Jason Box says that for Greenland there is "a more rapid response of the ice than is currently encoded in climate models that project sea-level rise… we cannot yet rely on ice sheets models for credible sea level projections".[31]
- $CO_2$ and methane release from deep permafrost are not routinely included in climate models.[32] Prof. Merritt Turetsky says that: "Permafrost is thawing much more quickly than models have predicted, with unknown consequences for greenhouse-gas release."[33]

- Nor have models accounted well for the slowing of the Atlantic Meridional Overturning Circulation (AMOC).[34]
- Models have been unable to reproduce the frequency and intensity of persistent summer weather extremes of recent years.[35]
- Australia has experienced bushfires of an intensity not projected to happen until the 2090s, forcing a change in the fire intensity rating system. But in 2024 scientists warned again that Australian bushfires could still be more intense and extensive than current predictions.[36]
- And observed changes in temperature extremes in parts of Australia during 2011–2020 tracked much higher than the projected changes for that period, and already are tracking at the changes projected for 2030 (2021–2040) period.
- In 2023, the rapid warming of the North Atlantic was beyond model expectations (greater than four standard deviations), with conditions similar to those scientists expect to be the average at 3°C of warming.[37] By August 2024, the El Niño was fading but the mean Northern mid-latitude SST kept warming. Likewise, in 2023 the rapid retreat of Antarctic sea-ice was astounding and five standard deviations beyond the mean.[38]

Reflecting on the extreme events of 2023, Prof. Katharine Hayhoe told The Guardian that: "We have strongly suspected for a while that our projections are underestimating extremes, a suspicion that recent extremes have proven likely to be true… We are truly in uncharted territory in terms of the history of human civilisation on this planet."[39] In a similar vein, NASA's Gavin Schmidt points to the problem of trying to understand the future based on the recent past when the changes are now rapid and systemic: "The system is changing in a way where what happened in the past is no longer a good guide to what's going to happen in the future."[40]

LEFT— Flooding following storm In the Valencia Town of Paiporta, Spain – Nov 2024.

# 03

# SYSTEM TIPPING POINTS TUMBLE ABRUPTLY

Climate change has arrived, with *severe impacts emerging* at lower temperatures than expected. The distribution has shifted; historic tail risks are now expected. Climate risks are complex, interconnected and could threaten the basis of our society and economy. A systems approach is required.

***Climate Scorpion***, March 2024[41]

**There is now clear evidence that a number of crucial system-level tipping points have been reached, in some cases decades to centuries earlier than had been projected. Seven of nine sustainable planetary boundaries have already been exceeded.**

## Tipping points

A tipping point is a threshold beyond which large change is initiated in a system and becomes self-perpetuating, and the change is often abrupt and irreversible on long timescales.[42] Passing these thresholds may constitute an ecological point of no return, after which it may be practically impossible to return the climate to pre-industrial (Holocene) stability. Tipping points may interact to form tipping cascades that act to further accelerate the rate of warming and climate impacts (see Section 7).

Australian researchers warned in February 2024 that the effects of tipping points on the global climate "are generally not currently accounted for in projections based on climate models. This means that effects of tipping points are also not included in national climate projections and impact assessments for Australia and may represent significant risks on top of the changes that are generally included."[43]

Prof. Johan Rockström says that the following Earth system elements "are likely to cross tipping points already" at 1.5°C of warming:[44] The Greenland Ice Sheet; the West Antarctic Ice Sheet (WAIS); abrupt thawing of permafrost; loss of all tropical coral reef systems; and collapse of the Labrador Current, one element of the Atlantic Meridional Overturning Circulation (AMOC).

This analysis comes from the *Global Tipping Points* report, which in late 2023 warned that five important natural thresholds already risk being crossed, and three more may be reached if the world heats to 1.5°C above pre-industrial temperatures. Such tipping points "can trigger devastating domino effects, including the loss of whole ecosystems and capacity to grow staple crops, with societal impacts including mass displacement, political instability and financial collapse".[45]

They include:

- The **Greenland Ice Sheet** likely reached its tipping point 20 years ago.[46]
- The **West Antarctic** glaciers have passed a tipping point;[47] and the Paris Agreement temperature target of 1.5°C is sufficient to drive the runaway retreat of WAIS.[48] In May 2024, scientists warned that Thwaites Glacier, nicknamed the "Doomsday Glacier", is near collapse.[49]
- Parts of **East Antarctica** might be similarly unstable.[50] Denman Glacier has been identified as susceptible to collapse of its ice shelf and inundation of the glacier itself, which sits on a retrograde base below sea level.[51]
- **Summer Arctic sea-ice**, where three-quarters by volume has already been lost,[52] and is in a death spiral.[53]
- **Arctic permafrost**, which is now a net source of major greenhouse gases.[54]
- **Canada's boreal forests** are one of Earth's largest terrestrial carbon storehouses. Long a reliable "sink" for carbon, the forests since 2001 have become instead an increasing carbon "source", and passed their tipping point. In the 2020s, Canada's forests have raised the country's total emissions by 50%.[55]
- **Tropical forests** are also nearing critical temperature thresholds.[56] The forest systems are oscillating to non-forest ecosystems in eastern, southern and central Amazonia.[57] The Amazon has become a net carbon source during recent climate extremes and the south-eastern Amazon was a net land carbon source over the period 2010–2020.[58] And the South American monsoon is heading towards a "critical destabilisation point" or tipping point likely to cause Amazon dieback.[59]

— **Tropical coral reef systems**. Researchers warn that "warming of 1.5°C relative to pre-industrial levels will be catastrophic for coral reefs" worldwide.[60] The IPCC reported that nearly all tropical reefs will become extinct even if global warming is kept to 1.5°C.

The permafrost and forest changes represent fundamental changes in the carbon cycle, in which systems that have had a major role in absorbing carbon from the atmosphere and storing it, flip to becoming a source of carbon to the atmosphere. If the land-based stores become sinks, that drives up the rate of warming. In October 2024, *The Guardian* reported on preliminary research findings showing the amount of carbon absorbed by the land sinks had temporarily collapsed in 2023: "The final result was that forest, plants and soil – as a net category – absorbed almost no carbon."[61]

And the biggest story of 2024 is the non-trivial and unacceptable risk of Atlantic Meridional Overturning Circulation collapsing by mid-century, which would be "a going-out-of-business scenario for European agriculture".[62] A July 2023 study estimated "a collapse of the AMOC to occur around mid-century under the current scenario of future emissions", with a 95% probability of it occurring between 2025 and 2095.[63] And a paper in publication estimates the probability of an AMOC collapse before the year 2050 to be 59±17%.[64] A full breakdown of AMOC could happen within a few decades, says AMOC specialist Stefan Rahmstorf.[65] AMOC collapse would result in the West Africa and South Asia monsoons becoming unreliable, a one-metre sea level rise on both sides of the North Atlantic, Australia becoming warmer and more prone to flooding, a flip of the wet and dry seasons in the Amazon, and as much as half of the world's viable area for growing corn and wheat could dry out. "In simple terms [it] would be a combined food and water security crisis on a global scale."[66]

## Planetary boundaries

In 2009, a group of eminent researchers identified a framework of "planetary boundaries" that define "a safe operating space for humanity".[67] If we cross these limits, they said, abrupt or irreversible environmental changes can occur with serious consequences for humankind.

The nine planetary boundaries identified are: climate change; change in biosphere integrity (biodiversity loss and species extinction); stratospheric ozone depletion; ocean acidification; biogeochemical flows (phosphorus and nitrogen cycles); land-system change (deforestation); freshwater use; atmospheric aerosol loading (microscopic particles in the atmosphere that affect climate and living organisms); and introduction of novel entities.

The boundary for atmospheric $CO_2$ was said to be no more than 350 ppm, because transgressing this boundary "will increase the risk of irreversible climate change, such as the loss of major ice sheets, accelerated sea-level rise and abrupt shifts in forest and agricultural systems". The current $CO_2$ level is greater than 420 ppm.

An update in September 2023 described as "the first scientific health check for the entire planet" found that six out of nine planetary boundaries had been broken because of human-caused pollution and destruction of the natural world.[68] And in September 2024 researchers announced that a seventh boundary — ocean acidification — is on the brink of being breached.[69]

In May 2023, an assessment of "Safe and just Earth System Boundaries" (ESBs) identified eight global and regional ESBs and found that "seven of eight globally quantified safe and just ESBs and at least two regional safe and just ESBs in over half of global land area are already exceeded".[70]

In October 2023, twelve authors, including those who had led the planetary boundaries work, published "The 2023 state of the climate report: Entering uncharted territory", and warned that at 2.6°C warming we face "potential collapse of natural and socioeconomic systems in such a world where we will face unbearable heat, frequent extreme weather events, food and fresh water shortages, rising seas, more emerging diseases, and increased social unrest and geopolitical conflict. Massive suffering due to climate change is already here, and we have now exceeded many safe and just Earth system boundaries, imperilling stability and life-support systems."[71]

# 04
# THE WORLD IS NOT DECARBONISING

It appears the green recovery following COVID-19 that many had hoped for has largely failed to materialize. Instead, carbon emissions have *continued soaring*, and fossil fuels remain dominant.

***The 2023 state of the climate report: Entering uncharted territory***, October 2023[72]

**Annual human-caused greenhouse gas emissions continue to increase. In absolute terms, decarbonisation has not occurred because lower emissions from electricity use are being offset by growth in other areas of energy use, and there is likely to be a slow decline in total emissions up to 2050.**

## Emissions

The world's energy-related $CO_2$ emissions in 2023 increased to a new record high,[73] despite clean energy growth. Whilst wind and solar power climbed by 13% in 2023, that did not match the world's growing consumption of primary energy, which rose 2% for the year.[74] Much of that increased demand came from AI, cloud computing and crypto industries.

In summary, the world has not yet started to decarbonise in absolute terms because lower emissions from electricity use are being offset by growth in other areas of energy use. So, for the time being at least, we are not experiencing an energy transition: what humanity is doing is adding energy from renewable sources to the growing amount of energy it derives from fossil fuels.[75] Australia is a good example, where reductions in the electricity sector are cancelled out by rises in other sectors (see Figure 2).

**Australia**
Annual greenhouse gas emissions

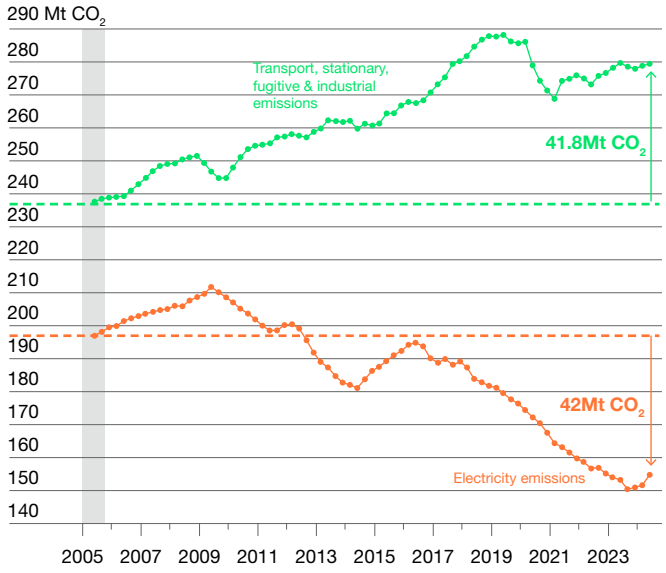



**Figure 2:** Australian emissions: Reductions in the electricity sector are cancelled out by rises in other sectors (Australia Institute).

United States crude oil production officially hit a record 13.4 million barrels per day in August 2024, and since 2008 has skyrocketed 350%. The US is now the world's largest oil producer, exceeding Russia's output by ~35% and Saudi Arabia by ~38%.[76] And the US plans to more than double gas exports.

Replacing coal with gas is no help if that gas is exported as LNG, with a new study finding that exported gas is 33% worse in terms of planet-heating emissions over a 20-year period compared with coal.[77]

And coal use up to 2030 may be higher than previously anticipated. The STEPS scenario in the International Energy Agency's *World Energy Outlook 2024* has electricity demand rising faster than renewables output, resulting in coal demand in 2030 being 300 million tonnes of coal equivalent (Mtce) higher than in their 2023 report.[78]

The share of fossil fuels in global energy consumption over the last 25 years has decreased from 86% in 1997 to 82% in 2022. And the IEA calculates that the $CO_2$ intensity of power fell 6% in the thirty years from 1990 to 2021.[79]

## Projected emissions

At some point, perhaps soon, yearly global emissions will peak, plateau and slowly decrease, depending on the rate of increase in renewable energy construction and innovation, the rate of economic growth, the fate of fossil fuel financial dis/incentives such as subsidies and carbon taxes, and several other factors. When that will happen, and the likely rate of fall, is contentious, as are the projections of future fossil fuel demand by the industry itself, and from the International Energy Agency (IEA).

The UN Environment Program (UNEP) and IEA both project emissions will drop only 10–20% by 2050, with all major oil/gas nations planning to expand production. The UNEP *Production Gap* report finds on current plans emissions may be as high in 2050 as today (Figure 3).[80] The IEA says that stated policies will result in oil and gas production in 2050 as high as 2020, with coal halved.[81]

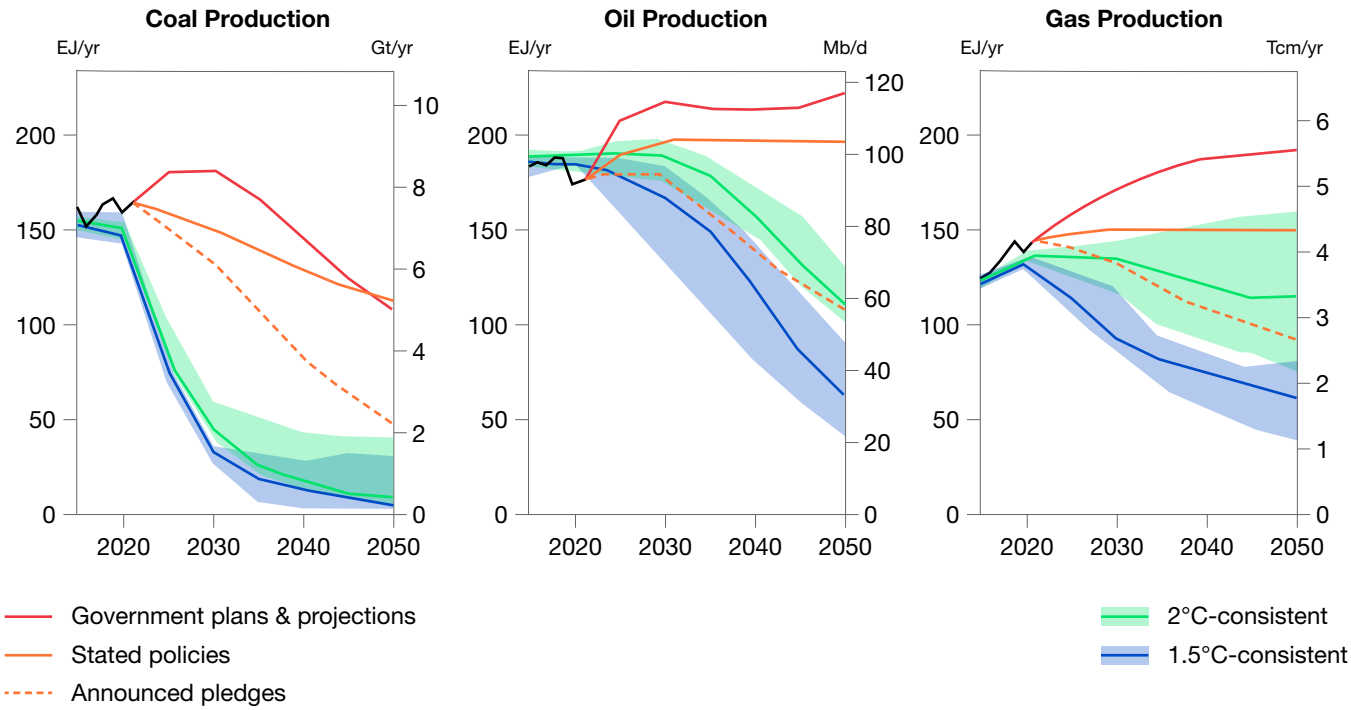



**Figure 3:** Projected coal, oil and gas energy production to 2050 (UNEP *Production Gap* report)

The OECD projects that a world economy more than twice the size of today will need 80% more energy in 2050 and, without new policy action, the global energy mix in 2050 will not differ significantly from today, with the share of fossil energy at about 85%, renewables including biofuels just over 10%, and the balance nuclear.[82]

But others say this is too pessimistic: "While the fossil fuel industry still argues there will be strong market demand for oil and gas in 2050, this ignores all the evidence of past disruptions that superior technologies don't take market share, they take whole markets."[83] And the IEA also says that global oil demand growth is slowing sharply due to surging electric vehicle sales.[84]

# 05

# PETROSTATES & BIG OIL ARE ON THE OFFENSIVE

Unexpected strong demand for oil has stiffened the industry's opposition to government and activist demands to phase out fossil fuel development. Policymakers also have *shifted their focus* to energy supply security and affordability since Russia invaded Ukraine and during the latest conflict in the Middle East.

Marianna Parraga and Arathy Somasekhar, 19 March 2024[85]

## Contrary to global policymakers' stated collective intent, petrostates — including Australia — and big oil have signalled their intention to abandon mitigation commitments and continue to expand production in the coming decades.

The largest fossil-fuel-producing states around the world plan to keep on expanding production, whilst major fossil fuel companies are backtracking on their climate pledges.[86]

A report by Global Energy Monitor has concluded that the world's fossil-fuel producers are on track to nearly quadruple the amount of extracted oil and gas from newly approved projects by the end of this decade, with the US leading the way in a surge of activity.[87] This is just one indication that petrostates and big oil have no intention of reducing production, but the opposite.

This is well illustrated in the UNEP *Production Gap* report from 2023 (see Figure 4). As a result, current government plans worldwide will likely result in emissions in 2050 almost as high as they are today.[88]

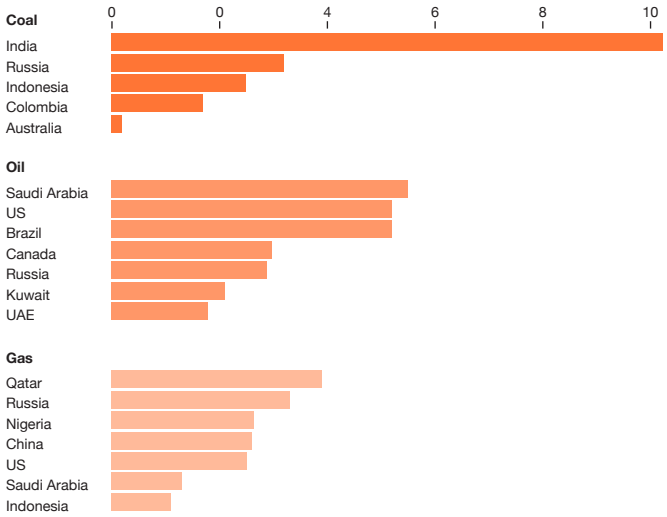



**Figure 4:** Planned increase in fossil fuel production for 2030 relative to 2021, exajoules (UNEP *Production Gap* report/*The Guardian*)

## Petrostates

The intentions of the world's five largest fossil fuel producers are clear — and civilisation-threatening — as reported by the UN:[89]

- In China, oil production is projected to be flat to 2050, but gas will increase more than 60% from 2020 to 2050, while coal use will remain high till 2030 then decline sharply.
- In the United States, oil production will grow and then remain at record levels to 2050, and gas is projected to continuously and significantly increase to 2050; whilst coal will drop by half. LNG export capacity is on track to more than double between 2024 and 2028 if projects currently under construction begin operations as planned.
- Projections for Russia are available only to 2035, with coal and gas production projected to increase significantly, while oil remains flat.
- In Saudi Arabia, oil production is projected to grow by 26-47% by 2050, with gas up 40% between 2019 and 2050. Together they make up almost half of the Saudi economy.
- And in Australia, one of the world's top two liquified natural gas and coal exporters, gas production is projected to stay above the current level for the next 15 years, with coal remaining high over the same period, above 450 million metric tons annually.

The world's largest oil producers are (in order) the United States, Saudi Arabia, Russia, China, Canada, Iraq, Iran, United Arab Emirates, Brazil and Kuwait. And the world's largest gas producers (in order) are the United States, Russia, Iran, China, Canada, Qatar, Australia, Norway, Saudi Arabia, and Algeria. Of those 15 states, seven are theocratic states or one-party dictatorships, where there is no democratic space to challenge state policy; and in the remainder the fossil fuel industry wields enormous political power.

- Those 15 nations include three of the four top arms manufacturers, two of the top three arms exporters and the top three arms importers (India, Saudi Arabia and Qatar). Fossil fuels fund militarisation.
- A petrostate chaired the 2023 UN climate policy-making conference COP28 (UAE); another COP29 (Azerbaijan). Azerbaijan appointed a state oil company veteran as COP29 president.
- It is likely that a number of states would fiscally collapse without fossil fuel income. States where the fossil fuel sector is greater than 20% of GDP are shown in Table 1.

| States with fossil fuels >20% of GDP | Fossil fuels % of GDP | Fossil fuels % of government revenue |
|---|---|---|
| **Russia** | 20% | 45% |
| **Saudi Arabia** | 42% | 87% |
| **Azerbaijan** | 48% | 64% |
| **Iraq** | 42% | 85% |
| **Qatar** | 37% | 81% |
| **Kuwait** | 50% | 85% |
| **Iran** | 23% | 40% |
| **UAE** | 30% | 40% |
| **Norway** | 24% | 32% |
| **Algeria** | 25% | 60% |

**Table 1:** Fossil fuels as a proportion of GDP and government revenue in selected petrostates*

*Figures vary considerably from year to year depending on the price of oil and gas.

## Big oil

From 2016 to 2022, fifty-seven entities including nation-states, state-owned firms and investor-owned companies produced 80% of the world's $CO_2$ emissions from fossil fuels and cement production.[90] The three biggest companies were all state-owned: oil firm Saudi Aramco, Russia's energy giant Gazprom and state-owned producer Coal India.

Big oil says it should expand or maintain oil and gas production, and has largely abandoned any net-zero-2050 commitments that may have been made:

- Saudi Aramco CEO Amin Nasser said in March 2024 that the world should give up on the idea of phasing out oil and gas: "We should abandon the fantasy of phasing out oil and gas, and instead invest in them adequately."[91]
- Meg O'Neill, CEO of Woodside Energy, rejected what she called simplistic views that the transition to cleaner fuels can "happen at an unrealistic pace".[92]
- Exxon Mobil forecasts global oil demand in 2050 will be the same — or even slightly higher — than current levels, driven by growth in industrial uses such as plastic production and heavy-duty transportation. Exxon's forecasts are similar to other recent projections, including by OPEC and Enbridge.[93]
- In March 2024, Shell — the world's second-largest oil and gas company and largest LNG producer — announced it was watering down its climate targets, with chief executive Wael Sawan saying it was "perilous" for Shell to set 2035 emission reduction targets because "there is too much uncertainty at the moment in the energy transition trajectory".[94]

## Big money

Likewise, for big business CEOs, giving priority to sustainability and climate has declined sharply over the last year,[95] and they are more concerned about inflation, artificial intelligence and geopolitics.

Big finance is backing away from taking a "white knight" role in leading the energy transition, now saying that the first priority is delivering profits to shareholders: "Expecting banks collectively to rapidly reallocate their portfolios may not be compatible with maintaining a profitable, diversified business model."[96]

Writing for *Foreign Affairs,* Meghan L. O'Sullivan and Jason Bordof describe how: "BlackRock CEO Larry Fink championed 'energy pragmatism' in his most recent annual letter, and a few weeks later, a JPMorgan Chase report called for a 'reality check' about the transition away from fossil fuels. In April, Haitham al-Ghais, the secretary-general of OPEC, wrote that the energy transition would require 'realistic policies' that acknowledge rising demand for oil and gas."[97]

## Australia

Australia received one of the lowest scores for "climate action" – ranking fourth-last out of the 168 countries — that were scored in the 2024 Sustainable Development Report published by the Sustainable Development Solutions Network (SDSN). Australia was only ahead of Qatar, Brunei and the United Arab Emirates for climate action.[98]

In Australia since the 2022 election, the federal government has approved seven new coal projects, approved the drilling of 116 new coal seam gas wells, defended in court the right of the coal industry not to consider the climate impact of opening new fossil fuel projects, and passed legislation designed to expedite the expansion of the gas industry, according to the Australia Institute.[99]

The federal government has approved new gas exploration permits in waters off South Australia, Victoria and Tasmania, along with carbon export permits to encourage CCS, a technology not proven at scale.[100]

And government subsidies to fossil fuel producers jumped by 31% to $14.5 billion over the last year.[101]


# 06

# WARMING IS ACCELERATING TOWARDS 3°C OR MORE

We are potentially headed towards 3°C of *global warming* by 2100 if we carry on with the policies we have at the moment.

Prof. Jim Skea, IPCC Chair, 6 October 2024[102]

**The failure to reduce emissions fast and the intention of petrostates and big oil to continue expanding production puts Earth on a path to 3°C of warming or more, given the political inertia and the inertia of the energy system.**

## Factors influencing future warming

Climate-warming greenhouse gas emissions have not yet peaked, but will likely do so soon as the economic advantages of renewable power generation become even more obvious, and ageing coal-fired generators in the electricity sector reach their use-by date. However, as discussed in sections 4 and 5 above, oil and gas production are likely to remain strong — and may increase — until mid-century. On present indications, the emissions decline over the next three decades will be slow.

This pattern is completely at odds with policy-makers' stated intention of holding warming to 1.5–2°C. In 2017, a "carbon law" was articulated by a group of leading scientists who demonstrated that for a two-in-three chance of holding warming to 2°C, emissions would need to be halved every decade from 2020 to 2050; $CO_2$ emissions from land use reduced to zero by 2050; and carbon drawdown capacity of five gigatonnes of $CO_2$ per year be established by 2050.[103] Clearly, given the current state of climate policymaking, we are not within cooee of holding warming to 2°C, with annual emissions likely rising between 2020 and 2030, rather than halving.

Future emissions are a primary determinant of the warming path over the medium to longer term; but so are other factors including accelerated sea-ice loss decreasing Earth's reflectivity, and accelerating emissions from carbon stores (boreal and tropical forest fires, reduced ocean efficiency, and permafrost feedbacks, for example), though these are not systematically incorporated into model projections of future warming.

Another factor is the Earth's Energy Imbalance (EEI), which has grown consistently over the last two decades: a positive EEI "confirms the lag of the climate system in responding to forcing and implies that additional global warming will take place even without further forcing change".[104] One of the drivers of increasing EEI has been a reduction in sulfate aerosol emissions, which are a by-product of burning fossil fuels, and have a strong cooling impact of 0.5–1°C, but are short-lived in the atmosphere. Aerosols have been "masking" some of the warming so far.[105]

Declining coal use and clean air policies reduce the aerosol impact. This is our "Faustian bargain":[106] as fossil fuel use declines, so will aerosol emissions which have been offsetting some warming, so that for the next two decades lower emissions will have little impact on the warming trend.[107] One example: A 5% annual reduction in emissions of a single greenhouse gas, from 2020 and based on a middle-roademissions path, has no statistically significant effect on warming for more than two decades, as compared to a no-mitigation pathway.[108]

## Warming projections

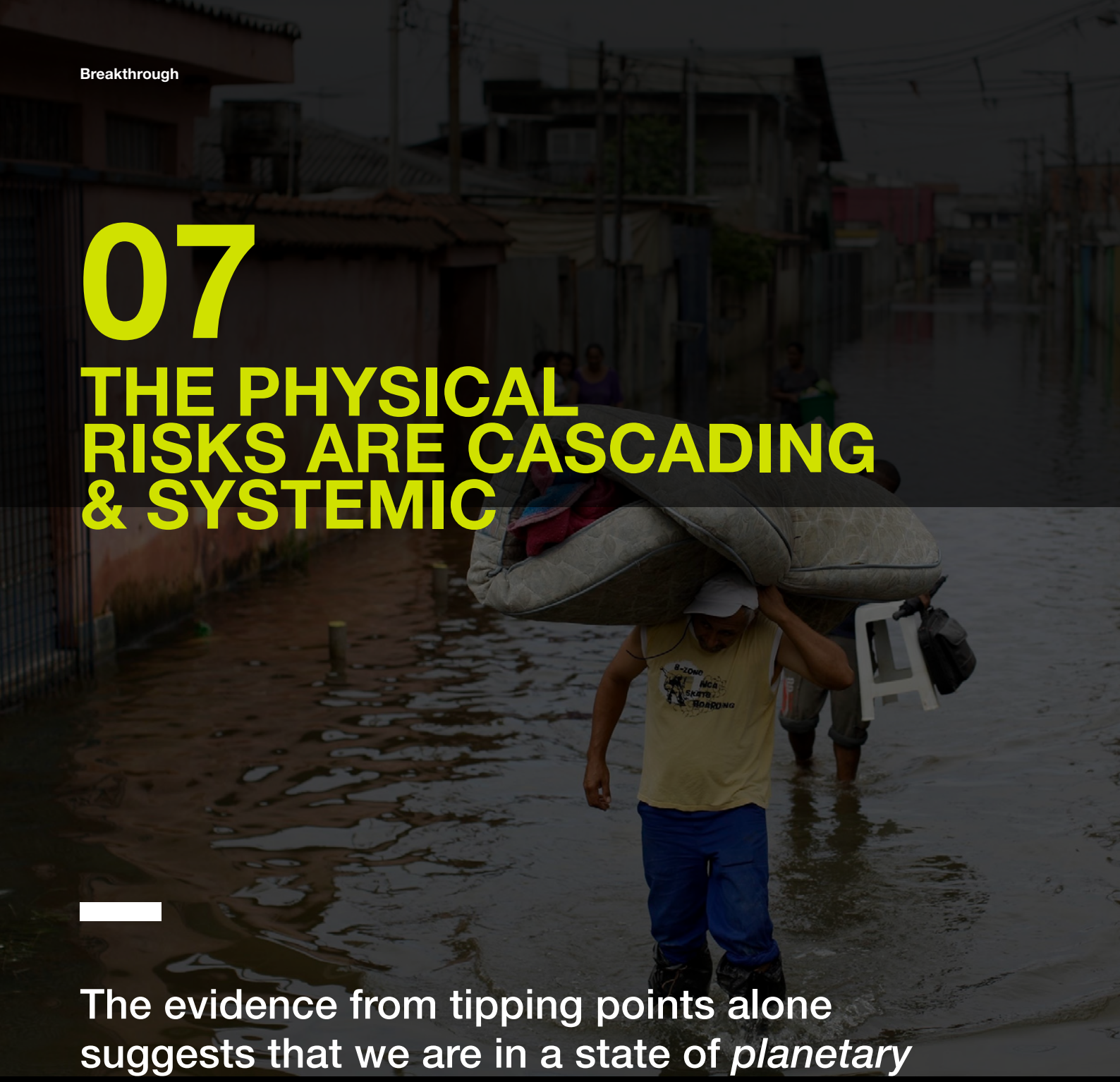
A clear majority of scientists expect warming of more than 3°C, and 82% expect to see catastrophic impacts of climate change in their lifetime, according to a 2021 survey by the journal *Nature*.[109] And a survey of 380 IPCC scientists by *The Guardian* in 2024 found 80% foreseeing at least 2.5°C of global heating, and half 3°C or more.[110] Many of the scientists envisage a "semi-dystopian" future, with famines, conflicts and mass migration, driven by heatwaves, wildfires, floods and storms of an intensity and frequency far beyond those that have already struck.

The Climate Scoreboard shows the progress that the national plans submitted to the UN climate negotiations will make in mitigating climate change. Their analysis (at September 2024) shows that the national contributions to date, with no further progress post-pledge period, result in expected warming in 2100 of 3.2°C (with a range of uncertainty of 1.9 – 4.4°C).[111] Of course, nations may make further commitments, but on the other hand many are not on the path to achieving those commitments they have already made. Similarly, the 2023 IPCC *Synthesis Report* said that implemented policies result in projected emissions that lead to warming of 3.2°C, with a range of 2.2°C to 3.5°C".[112]

A 2021 climate risk assessment by the pre-eminent UK international affairs think-tank Chatham House focussed on a RCP4.5 scenario (which may be too conservative on the future emissions path) and the impacts that are likely to be locked in for the period 2040–50 unless emissions drastically decline before 2030 (which they are not!). The scenario had a mean temperature rise of 2.7°C and a "plausible worst-case scenario" (10% chance) of 3.5°C or more. The report added that could be an underestimate if tipping points are reached sooner than the orthodox science suggests.[113]

Emphasising this point, a rating system to evaluate the plausibility of climate model simulations in the IPCC's latest report shows that models that lead to potentially catastrophic warming "are plausible and should be taken seriously".[114]

There are big questions about the size of the aerosol forcing, and the related issue of how sensitive the climate is to changes in greenhouse gases, which remain an issue of scientific contention. New climate history research published in December 2023, based on a study of the last 66 million years, concluded that global temperature may be more sensitive to $CO_2$ levels than current models estimate.[115] It showed that the last time $CO_2$ levels were as high as today was around 14 million year ago, which is longer than previous estimates, and that climate sensitivity — the amount of warming resulting from a doubling of atmospheric $CO_2$ — may be between 5°C and 8°C, compared to the IPCC orthodoxy of 1.5–4.5°C.



# 07

# THE PHYSICAL RISKS ARE CASCADING & SYSTEMIC

The evidence from tipping points alone suggests that we are in a state of *planetary emergency*: both the risk and urgency of the situation are acute [...] If damaging tipping cascades can occur and a global tipping point cannot be ruled out, then this is an existential threat to civilisation.

Prof. Tim Lenton and colleagues, “Climate tipping points — too risky to bet against”[116]

## The physical risks are non-linear, cascading, systemic and largely irreversible on human time frames. Climate models do not adequately represent all processes and are likely to underestimate the risks.

Many elements of the climate system exhibit **tipping points** or **thresholds** at which a small change causes a larger, more critical change to be initiated, taking that system from one state to a discretely different state far less conducive to human survival and prosperity (see section 3 above). For example, a polar ice sheet may reach a temperature threshold beyond which continuing and accelerated ice mass loss occurs, even without any additional rise in temperature, and such a change may take decades to centuries to be fully realized before a new (ice-free) system stability occurs.

Such threshold changes may be **abrupt and irreversible** on relevant time frames. And once the threshold is passed, returning conditions to pre-threshold conditions may not restore the system. This is known as **hysteresis**, or bifurcation of a system, where it may be more difficult, or impossible, for a system to return to its previous state. Put more simply: the path from A to B is not the same as the path from from B to A. Ice sheets are a good example.

A chilling 2015 report on *Thresholds and closing windows: Risks of irreversible cryosphere climate change* warned that the Paris commitments will not prevent the Earth "crossing into the zone of irreversible thresholds" in polar and mountain glacier regions, and that crossing these boundaries may "result in processes that cannot be halted unless *temperatures return to levels below pre-industrial*" (emphasis added).[117] For example, the tipping point for the most vulnerable West Antarctic glaciers is probably between 0.5°C and 1°C, but cooling the planet back to that range would *not* create the conditions for their re-establishment.

And in 2024, researchers again warned of "overconfidence in climate overshoot", that is, exceeding a temperature target for decades, on the assumption that negative emissions technology will be able to later reduce the heating and restore conditions as if there had been no overshoot. Extinctions caused by overshoot are one example. They show that "global and regional climate change and associated risks after an overshoot are different from a world that avoids it… the possibility that global warming could be reversed many decades into the future might be of limited relevance for adaptation planning today [because] temperature reversal could be undercut by strong Earth-system feedbacks resulting in high near-term and continuous long-term warming… Only rapid near-term emission reductions are effective in reducing climate risks."[118]

Changes in one element of the climate system may also trigger an unforeseen chain or **cascade of events** in which one event in a system has a negative effect on other related components. For example, the mutual interaction of individual climate tipping points and/or abrupt, non-linear changes, may lead to more profound changes to the system as a whole, and interactions between these climate systems could lower the critical temperature thresholds at which each tipping point is passed.[119]

Together, tipping point thresholds, non-linear change and cascading events represent **systemic risks**, that is, the risk of a breakdown of an entire system rather than simply the failure of individual parts:

> More frequent and intense extreme weather and climate-related events, as well as changes in average climate conditions, are expected to continue to damage infrastructure, ecosystems, and social systems that provide essential benefits to communities… Extreme weather and climate-related impacts on one system can result in increased risks or failures in other critical systems, including water resources, food production and distribution, energy and transportation, public health, international trade, and national security. The full extent of climate change risks to interconnected systems, many of which span regional and national boundaries, is often greater than the sum of risks to individual sectors.[120]

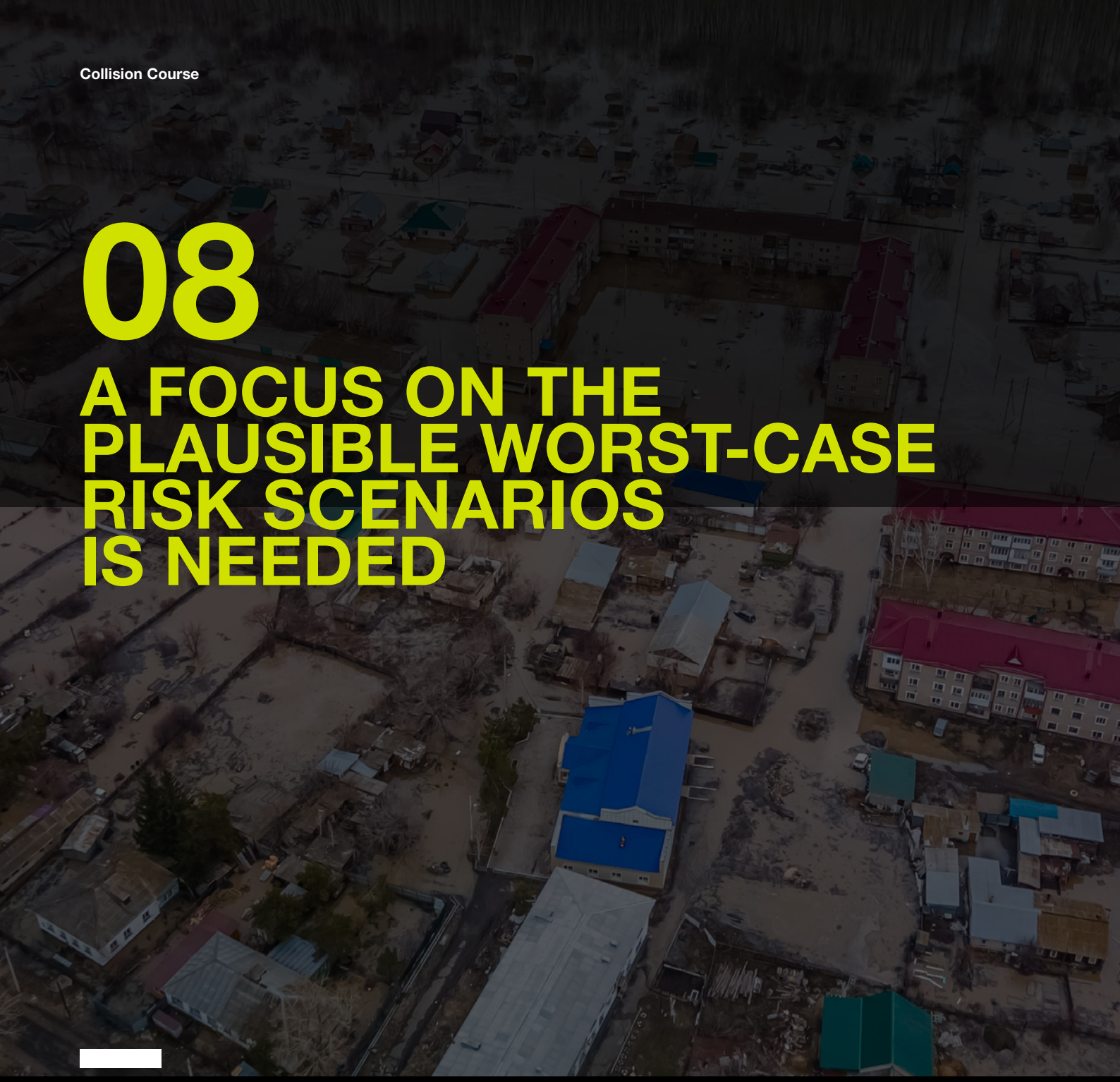
Systemic change means climate elements can tip from one state to an entirely different one with a sudden shock that may permanently alter the way the planet works.[121] In the physical interactions among the Greenland and West Antarctic ice sheets, the Atlantic Meridional Overturning Circulation and the Amazon rainforest, the polar sheets are often the initiators of cascade events,[122] with Greenland and West Antarctica at risk of passing their tipping points within the 1.5°C–2°C Paris range (and there is evidence they have already done so).

Such changes are not adequately incorporated into climate models: "Change can come about abruptly and even catastrophically… Predictive models are the lifeblood of climate science, and the foundation upon which political responses to the climate and ecological crisis are often based. But their ability to predict such large-scale disruptive events is severely limited… The IPCC's estimates of how much $CO_2$ we can still emit to be on the safe side explicitly leave out many known large-scale disruptions or tipping points because of insufficient understanding or because models cannot capture them."[123]

Researchers have also investigated how changes in forest degradation and monsoon circulation are interlinked: "It turns out that forest loss caused by direct deforestation, droughts, and fires might vastly contribute to a changing climate in South America and could drive the coupled Amazon rainforest/South American monsoon circulation system past a tipping point [and] suggest an upcoming regime shift of the Amazon ecosystem."[124]

If cascades coalesce, there is the possibility of "Hothouse Earth". In 2018, a group of eminent scientists explored the potential for self-reinforcing positive feedbacks in major elements of the climate system feedbacks and their mutual interaction to drive the Earth System climate to a point of no return, whereby further warming would become self-sustaining (that is, without further human perturbations), and prevent temperature stabilisation, driving the system to what they termed a "Hothouse Earth".[125] In plain terms, humans would lose control and lack the capacity to stop cascading warming and the researchers warned that "we are in a climate emergency… this is an existential threat to civilisation".[126] This planetary threshold could exist at a temperature rise as low as 2°C, possibly even in the 1.5°C–2°C range.[127] In other words, we may have already arrived at this point, but conclusive evidence of this moment requires hindsight.

LEFT— LEFT— A person stricken by the severe heatwave fights for survival in the 'heat stroke emergency ward' of a Karachi hospital amid life-threatening temperatures on June 27, 2024.



# 08

# A FOCUS ON THE PLAUSIBLE WORST-CASE RISK SCENARIOS IS NEEDED

Facing a future of accelerating climate change while blind to ***worst-case scenarios*** is naive risk management at best and fatally foolish at worst.

Dr Luke Kemp and colleagues, 1 August 2022[128]

**Climate risks are existential and emerging faster than forecast. Their non-linear and cascading nature make them difficult to predict, so particular attention must be paid to the plausible worst-case scenarios, because that is where the greatest possible damage lies.**

A 2018 Australian Senate Inquiry found climate change is "a current and existential national security risk".[129] It recognised that Australia and its neighbours are in the region most exposed to climate impacts, and that climate change is threatening the health of Australians, their communities, businesses and the economy; heightening the severity of natural hazards; increasing the spread of infectious diseases; and creating growing water insecurity threats to agriculture.

All members of the Pacific Islands Forum, including Australia, supported the 2018 Boe Declaration at which all Forum leaders "reaffirm that climate change remains the single greatest threat to the livelihoods, security and wellbeing of the peoples of the Pacific and our commitment to progress the implementation of the Paris Agreement".[130]

American researchers say that climate change and its impacts "are emerging faster than scientists previously thought, and are consistent with observations that we and other colleagues have made identifying a pattern in assessments of climate research of underestimation of certain key climate indicators, and therefore underestimation of the threat of climate disruption".[131]

How we analyse risk, or the threat, of climate disruption depends on the nature of the risk. Nick Spencer, former chair of the UK Institute and Faculty of Actuaries, explains: "Systemic risks, including climate change, are multiplying and intensifying, with their tipping points posing the threat of irreversible harm. Traditional risk management approaches simply don't recognise these characteristics. There is a need to embrace complex risk analysis to help us navigate systemic failure and the disruption from these connected crises."

## The risk of ruin

In risk management, there are potential events so destructive that they are termed catastrophic because of their capacity for human death or suffering on a massive scale, such that societies may never fully recover. This may also be called existential risk or, in actuarial terms, the "risk of ruin", which colloquially in financial and gambling circles, is the risk of "losing everything".

Catastrophic events include nuclear war, climate change, biosecurity including pandemics, and disruptive technologies such as AI. The seventh annual report of the Global Challenges Foundation on such risks added "ecological collapse" to the list,[132] whilst the World Economic Forum's 2024 *Global Risk Report* found that more than half of those surveyed believed that the risk of global catastrophe was high or extreme over the next decade, with climate-related risks again given top ranking.[133]

In the mapping of potential threats, the greatest risk lies at the high-end (or "fat tail") of the range of outcomes, which should be given particular attention. A fat-tail risk is the probability of events with higher impacts occurring than might be expected under a normal probability distribution. Focusing on the most likely outcomes creates a false sense of security.

An emergency exists if the world is approaching a global cascade of tipping points that leads to a "hothouse" climate state: "Cascading effects might be common… examples are starting to be observed."[134] Thus climate change is an existential risk to human civilisation (contemporary society).

## Assessing the risks: Summary

- Climate risks are **existential** in threatening the basis of our society and economy and the sovereign existence of communities and states alike, posing large, irreversible harm if not rapidly addressed.
- Any assessment of climate risks should be carried out in line with **risk management best practices**, taking into account the full range of outcomes, including tipping points and the risk of ruin. This must not be based only on historic experience, which may well be irrelevant to the future state, and must incorporate methods to understand unprecedented climate impacts.
- Climate risk analysis must give particular attention to the **high-end *possibilities*** because that is where the greatest damage and disruption lies. Calculating *probabilities* makes little sense in the most critical instances when the issue is the survival of civilization. Hence a fundamental rule of risk assessment is to focus on the "fat-tail" risks and the plausible worst case scenarios, because when the risks are existential, there is no "second chance" to learn from one's mistakes.
- Benchmarks established for assessing risks and solution efficacy should have a **low probability of failure**. Policies requiring low risks of failure applied to the banking and insurance sector, and in safety management, should also be applied to the far greater risks from climate heating.
- These requirements and the systemic nature of the risks means governments must fundamentally rethink the approach to climate risk assessment and response, **embracing complex risk analysis**. Physical and economic climate models have fundamental limitations so expert elicitation and scenario planning are crucial components in risk analysis.
- A **systems approach** requires an integrated method of analysis of the complex relationships within and between human and physical climate systems in creating cascading and compounding risks — one that avoids silos, cherry-picking potential risks and partial "bottom up" approaches.
- The **urgency of required action** should explicitly be considered and articulated, with policy and project systems structured to respond at the speed required.
- The lack of certainty in risk assessment should not be taken as an excuse for inaction if risks are potentially catastrophic or existential in nature. **Precautionary action** is essential.

# 09

# IN 40 YEARS, A WORLD BEYOND ANYTHING HUMANS HAVE KNOWN

Even moderate climate warming has incredibly *serious consequences* for humanity, and those consequences grow exponentially as the temperature rises. The committed sea-level rise from Antarctica even at 2°C represents an existential threat to entire nation states. We're looking at removing nations from a map of the world because they no longer exist.

Prof. Jonathan Bamber, 23 September 2020[135]

**In a 3°C hotter world, new extremes — of rainfall and unlivable heat, flooding and drought — beyond past human experience will occur. And a committed sea-level rise of several metres will be in the process of inundating coastal cities and deltas. Large parts of the tropics will suffer "near-unlivable" extreme heat conditions, and the dry subtropics will dry out and desertify, together having catastrophic impacts on food and water security.**

The world on its current trajectory is likely heading towards 3°C of warming and perhaps a good deal more, because current climate model projections do not adequately account for all the system-level reinforcing feedbacks. And the risk of ruin demands that attention be given to the plausible high-end possibilities, which are 3.5°C or even higher.

In a 3°C hotter world, large parts of the tropics will suffer "near-unlivable" extreme heat conditions, there will be less rainfall over significant parts of the dry subtropics, and this, combined with increased evaporation rates, will lead to the drying out and desertification across the dry subtropics. New extremes — of rainfall and heat, flooding and drought — beyond human experience and beyond model expectations will occur. And a committed sea-level rise of several metres will be in the process of inundating coastal cities and deltas.

## Extreme heat

As Earth heats, scientists have described those parts of the world that will exhibit levels of heat beyond that ever experienced in human history, defined as those with a mean annual temperature (MAT) of greater than 29°C, where MAT i s the average of daily minimum and maximum over a year. This results in "near-unlivable conditions", currently found on only 0.8% of the planet's surface, mostly in the Sahara.[136] This heat zone at 2.7°C global average warming is illustrated in Figure 5.[137] This could occur as soon as 40 years hence, in the period 2060–2070, if the current trend of accelerated warming is maintained.

RIGHT— Residents clear flood and storm debris from a Brisbane beach following extreme weather, highlighting the increasing frequency of such climate-related events.

Located in the tropical zone, this area of near-unlivability includes Amazonia and parts of Central America; West, sub-Saharan and East Africa; around the Red Sea and the Persian Gulf; parts of Central Asia; South Asia including Pakistan, India and Bangladesh; a significant portion of South-east Asia — including Indonesia, Malaysia. Philippines, Cambodia, Thailand and Myanmar; and areas of northern Australia and the near Pacific. It encompasses more than two-and-a-half billion people.

In this zone, living and working outdoors, including agricultural production, without active cooling such as air conditioning would not be feasible in the hottest periods. Large-scale de-population of the zones illustrated in Figure 5 would be likely.

Cities, which currently hold more than half the world's population, and will add another 2.5 billion people by 2050, will be exposed to double the level of heat stress compared to rural surroundings.[138] At 3°C of warming, 197 cities around the world will experience 150 days or more above 35°C, as illustrated in Figure 6.[139]

New work published in September 2024 showed that large parts of the tropics and subtropics, encompassing 70% of current global population, are expected to experience strong joint rates of change (greater than two standard deviations) in temperature and precipitation extremes combined over the next 20 years. As well, the rapid clean-up of sulfate aerosol emissions, mostly over Asia, leads to accelerated co-located increases in warm extremes and influences the Asian summer monsoons.[140]

## Intensifying extremes

In 2021, the World Meteorological Organization warned about both "too much and too little" water: as global warming intensifies the water cycle, floods and droughts are both increasing, and many countries are unprepared.[141]

Climate extremes will be of a greater magnitude than the increase in average temperature. For example, Prof. Andy Pitman notes that global mean warming is badly understood: as a general rule of thumb, global average warming of 4°C (covering land and ocean) is consistent with 6°C over land, and 8°C in the average warming over mid-latitude land. That risks 10°C in the summer average, or perhaps 12°C in heatwaves. Western Sydney has already reached 48°C. If you add 12°C to the 48°C you get summer heatwaves of 60°C.[142] This is why agriculture in the Murray-Darling Basin (MDB) may become non-viable later this century.

The MDB accounts for approximately half of Australia's irrigated agricultural production. Prof. Ross Garnaut warned of the Basin's likely fate more than a decade ago: on a high-emissions trajectory, he said, irrigated agriculture output in the Basin would halve by 2050. And it would end by 2100, accompanied by a 40% drop in pasture productivity in south-eastern Australia.[143] In fact, the reality is worse than Garnaut's projections. CSIRO data shows that annual Basin water inflows have almost halved over the last 20 years.[144]

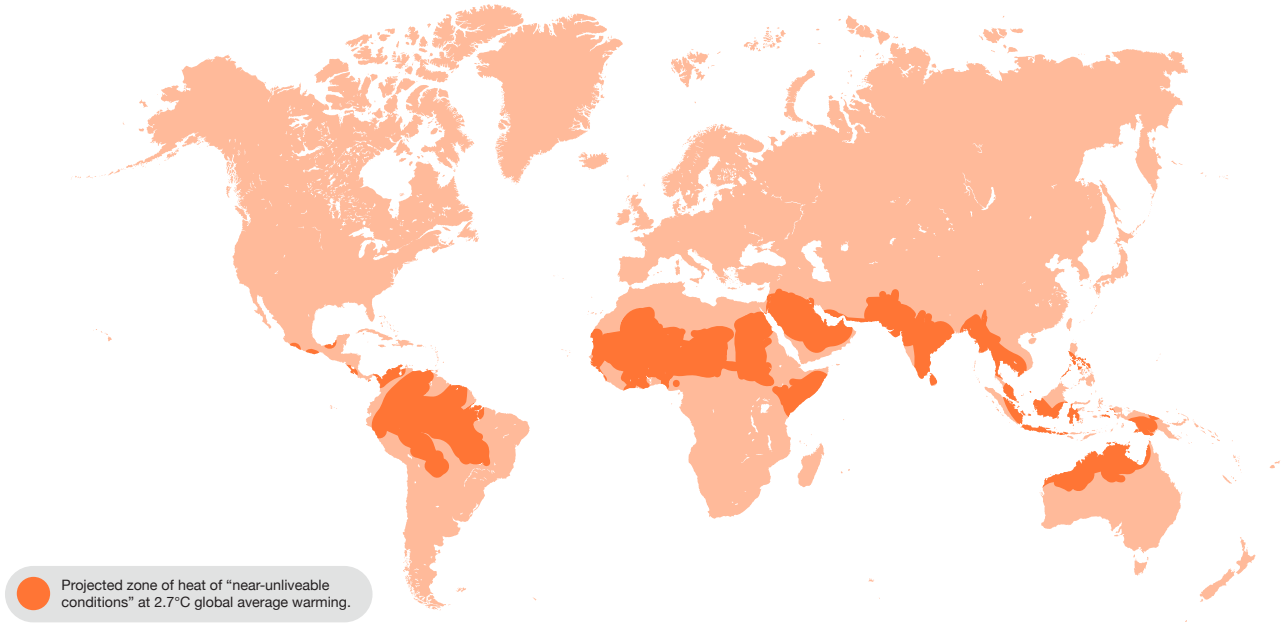



**Figure 5:** Projected zone of "near unlivable" heat at 2.7°C of warming (*Nature*)

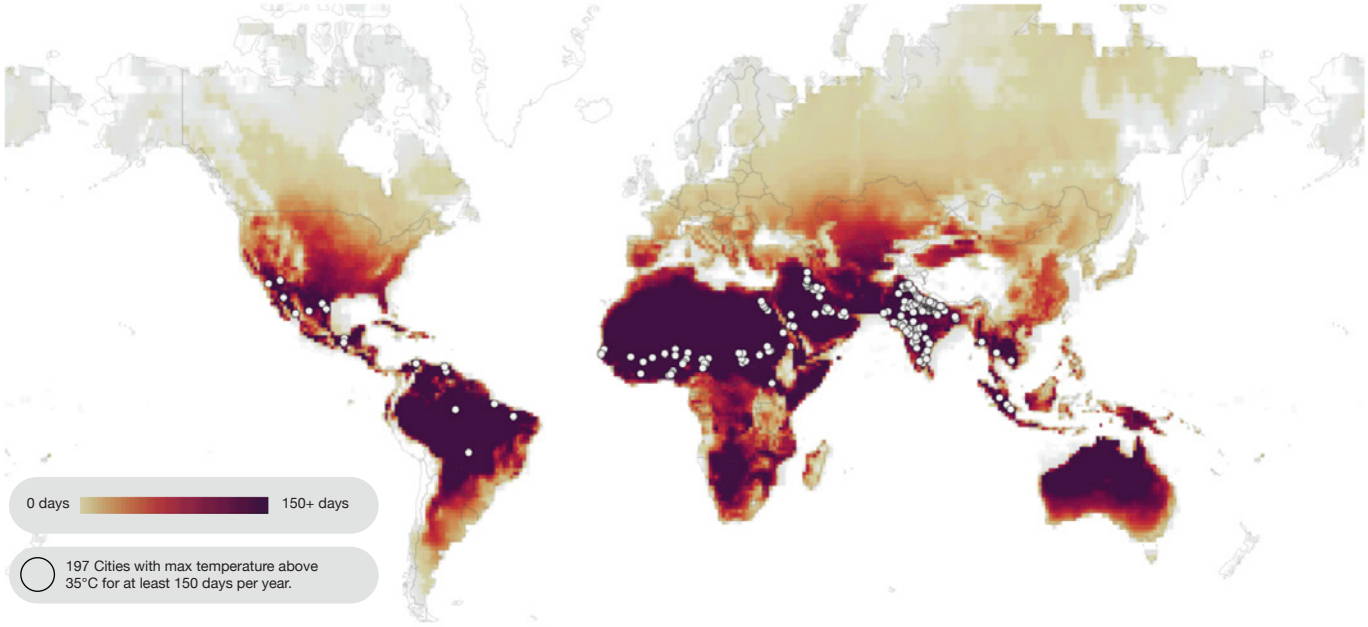



**Figure 6:** Days per year maximum temperature exceeds 35°C at 3°C global average warming (World Resources Institute)

Climate change and the severe loss of summertime Arctic sea ice are leading to amplified Arctic warming — at four times the global average — and the slowing of the Northern Hemisphere Jet Stream, which increasingly exhibits a meandering pattern of intensifying Arctic air mass invasions toward middle latitudes.[145] These events include cold air outbreaks in Central Europe and North America in winter, and the increasing frequency of atmospheric blocking events like the one that steered Hurricane Sandy west into the densely populated New York City area. It is also promoting record-breaking heat intrusions into the Arctic.

The destabilisation of the Jet Stream will also increasingly contribute to lingering heat domes — a persistent high-pressure system over a large area — producing prolonged heat waves and dry conditions with blazing summers, stagnating and lethal heatwaves and more intense wildfires and droughts.[146] As one example, the 2003 European heat wave which led to about 70,000 premature mortalities is likely to be a regular occurrence by the 2040s.[147]

The destabilisation of the Jet Stream has very significantly affected the intensity and geographical distribution of the Asian and West African monsoons and "several studies have concluded that 3 to 5°C global warming is likely to be the threshold for tipping points such as the… collapse of the West African monsoon".[148]

Climate models indicate that dry extremes will be exacerbated in many regions of the world. However, new research pinpoints global regions where current climate model projections of drought increases may be underestimated, and finds that the increase in the longest annual dry spell will be 42–44% greater on average than current models indicate.[149]

Prof. Michael Mann says there is plenty of research showing that climate models fail to resolve some of the processes that are involved in summer season extremes, including floods, heat waves and droughts: "We argue that the models are underestimating the impact that climate change is already having on these extreme events."[150]

## Drying and desertification

The atmosphere carries 7% more water vapour for each one degree rise in temperature, driving more extreme rainfall and flooding events. Whilst rainfall will increase in the tropical zone —in many cases where it will be too hot to live or for crops to survive — and in the high latitudes, there generally will be less rainfall across much of the sub-tropical zone. The Middle East, North Africa and the Mediterranean regions have already experienced a drying trend over the last few decades.

Scientists project that much of the subtropical zone will experience a 5–10% reduction in precipitation for each degree Celsius of global warming. At 3°C of warming, water availability will decrease sharply in the dry tropics and subtropics, affecting about two billion people worldwide, and agriculture may become non-viable in those areas.

As much as 44% of the planet's land areas will be exposed to drying. This will lead to severe drought conditions throughout southern Europe, North America (mainly the eastern and southwestern United States and Mexico), much of southeast Asia, and most of the Amazon—affecting about 1.4 billion people. In the latitude bands between 30 degrees N and 30 degrees S the probability of multi-decadal drought will rise to 80%.[151]

Aridification will emerge over more than 30% of the world's land surface. By mid-century, desertification is likely to be severe in southern Africa[152], the southern Mediterranean[153], west Asia, the Middle East, inland Australia and across the south-western United States.[154] The Sahara will jump the Mediterranean.

A 3°C scenario by US analysts in 2007 described a world in which: "Agriculture becomes nonviable in the dry subtropics, where irrigation becomes exceptionally difficult because of low water availability and increased soil salinization resulting from more rapid evaporation of water from irrigated fields. Arid regions at low latitudes expand, taking previously marginally productive croplands out of production."[155]

## Water stress

The agricultural sector is currently responsible for around 70% of global freshwater consumption. Patterns of land use, population growth, rapid urbanisation, economic development and changing dietary patterns can be expected to have significant effects on demand, in some cases creating or exacerbating competition for supplies.[156]

Between 1970 and the mid-1990s, the amount of economically available water per person globally dropped by more than 35%, according to the United Nations.[157] In 2010, almost 2.4 billion people were living in watersheds with less than 1000 cubic metres per capita per year (defined as chronic water shortage); and approximately 800 million people were living in watersheds with less than 500 cubic metres per capita per year (extreme water shortage).[158] It is estimated there will be a gap of 40% between global water requirements and accessible, reliable water supply by 2030.[159]

A new report from the Global Commission on the Economics of Water finds land and water mismanagement and climate warming together have put "unprecedented stress" on the global water cycle. The water crisis threatens more than half of global food production, with losses to GDP of up to 15% projected in low-income countries.[160]

US intelligence analysis finds that by 2035 "more than 30 countries — nearly half of them in the Middle East — will experience extremely high water stress, increasing economic, social, and political tensions".[161] Countries already experiencing water stress or far worse include Egypt, Jordan, Turkey, Iraq, Israel/Palestine, Syria, Yemen, India, China, and parts of the United States.

Case studies include:

- India's national water supply is forecast to fall 50% below demand as early as 2030.[162]
- A World Bank report on China's water situation foresees "catastrophic consequences for future generations,[163] unless water use and supply can quickly be brought back into balance.
- Pakistan will face severe water scarcity by 2025 and is "one of the most water-stressed countries in the world".[164]
- In the Middle East and North Africa, drought is leading to instability and water weaponization.[165]
- By mid-century, glacial loss may reach 70% in the Andes,[166] with rainfall in Mexico and central America falling by half.
- By mid-century, water flows into the great rivers of Asia will be reduced by the loss of more than one-half, and perhaps much more, of the Himalayan ice sheet. The glaciers may have lost as much as a quarter of their mass over the last four decades and the rate is accelerating. If the rate of loss continues to rise, more than half the ice sheet will be lost by 2050, and up to two-thirds of glaciers.[167] Summer monthly water inputs in an average year would be down by 38% in the upper Indus basin, and by up to 58% in drought conditions.[168]

By 2050, the number of people facing acute water scarcity will have risen to five billion, warns UNESCO, and 1.8 billion people will be living in regions whose groundwater has run out, likely resulting in the large-scale displacement of people.[169] The most recent IPCC report projects that up to three billion people are projected to experience chronic water scarcity due to droughts at 2°C warming, and up to 4 billion at 4°C warming, mostly across the subtropics to mid-latitudes.[170]

## Sea levels

On average, sea-levels rise 10–20 metres for each 1°C of climate warming. For example, the last time there were no polar ice caps, 36–40 million years ago, the temperature was around 3–4°C warmer than pre-industrial levels and sea levels were 70 metres higher than at present.[171] The polar ice sheets have great thermal inertia, so this takes place over many centuries. In past climates, with atmospheric $CO_2$ levels similar to today, sea levels were around 25 metres higher than at present,[172] and rates of change up to five metres per century have been identified in past climates.

Our current coastlines are home to more than 130 cities larger than a million inhabitants, plus other infrastructure such as ports, airports, and some 200 nuclear power plants with seawater cooling. Even a one-metre sea-level rise would be a disaster.[173] But US government agencies, for planning purposes, use sea-level rise scenarios of up to 2.1 metres to 2100.[174]

A one-metre sea level rise would flood 20% of the area of Bangladesh and displace 30 million people, according to Maj. Gen. Munir Muniruzzaman, former military adviser to the president of Bangladesh and chairman of the Global Military Advisory Council on Climate Change.[175]

The lower reaches of the agriculturally-important river deltas such as the Mekong, Ganges and Nile will be inundated, and significant sectors of some of the world's most populous cities — including Kolkata, Mumbai, Jakarta, Guangzhou, Tianjin, Hong Kong, Ho Chi Minh City, Shanghai, Lagos, Bangkok and Miami — inundated and/or abandoned.[176]

Even for 2°C of warming, more than a billion people may need to be relocated due to sea-level rise, and in high-end scenarios "the scale of destruction is beyond our capacity to model, with a high likelihood of human civilisation coming to an end".[177]

## AMOC collapse

There is an unacceptable risk that by mid-century the Atlantic Meridional Overturning Circulation will collapse (see Section 3). Modelling shows that AMOC slowdown would cool London by an average of 10°C and Bergen, Norway by 15°C.[178] Ditlevsen and his co-authors conclude that a collapse of the AMOC heat-transporting circulation would be a going-out-of-business scenario for European agriculture: "You cannot adapt to this."[179]

An Open Letter to the Nordic Council of Ministers by 44 experts from 15 countries issued a stark warning serious about major ocean circulation change in the Atlantic. A string of scientific studies in the past few years that "would have devastating and irreversible impacts especially for Nordic", lead to unprecedented extreme weather, "potentially threaten the viability of agriculture in northwestern Europe", with the effects "likely to be felt globally, including a shift in tropical rainfall belts, reduced oceanic carbon dioxide uptake (and thus faster atmospheric increase) as well as major additional sea-level rise particularly along the American Atlantic coast, and an upheaval of marine ecosystems and fisheries."[180]

In addition, writes Prof. Tim Lenton, the monsoons that typically deliver rain to West Africa and South Asia would become unreliable, and huge swaths of Europe and Russia would be devastated by drought. As much as half of the world's viable area for growing corn and wheat could dry out: "In simple terms [it] would be a combined food and water security crisis on a global scale."[181]

## Declining crop yields

Compounding and cascading impacts of climate change will undermine food security on an increasing scale. These include the loss of corals and fish stocks in the Coral Triangle, coastal and delta inundation and more extreme floods, changed precipitation patterns, droughts and aridification, and fires. Even without accounting for all these simultaneous hazards, scientists say that 2°C of warming around 2040 in South-east Asia will reduce per capita crop production by one-third.[182]

In addition, "Climate impacts occurring outside of the region will further diminish the options available to countries to offset the domestic effects, such as by importing additional food, as Indonesia did on an unprecedented scale during its severe drought in 1998. Amplifying the food insecurity risks is the region's reliance on fisheries. Indonesia obtains more than half of its animal-source protein from fish, while in the Philippines the figure is about 40%. Fish species are already moving out of the region to escape warming waters, and the region's coral reefs, the 'nursery' for roughly 10% of the world's fish supply, are degrading rapidly; globally, over 90% of reefs will have collapsed at 1.5°C of warming."[183]

For every degree of additional warming, average agricultural yields are likely to decline by up to 10%; as well, higher concentrations of $CO_2$ in the atmosphere are already having a serious effect on the nutritional quality of most of the world's major crops – grains, soya, corn and rice.[184] And unless emissions drastically decline this decade, there may be a decline in crop yields of 30% by 2050, whilst food demand will be 50% higher.

Research on future yields in the USA concluded that under current production systems and practices, aggregate crop yields could decrease during the end of the century (2050–2100) by 8%–19% under the mildest scenario (RCP 2.6), and by 20%–48% under the most severe scenario (RCP 8.5)."[185]

The problem is not just the impact of average levels of warming, but of heat extremes at crucial times. Temperatures exceeding critical thresholds, especially during sensitive periods, may cause drastic drops of yield for wheat, maize and rice. Temperatures equal to or higher than 30–34°C at the time of flowering may inhibit pollen production and grain setting, giving unstable yields from year-to-year; lethal limits beyond which the plant dies are in the range of 45–47°C. The probability of crossing such thresholds in a given year — for example maize in the Midwestern US and rice in southern China — becomes increasingly significant with global temperature rise of more than 2°C, and in the worst cases reach somewhere in the region of 25% (maize) and 75% (rice) respectively with global temperature rise of around 4–5°C.[186]

Another major risk is simultaneous crop failure across major producing countries, which would have devastating impacts on both supply and price, triggering social consequences reminiscent of the events of the Arab Spring. By the 2040s, the probability of a 10% or greater yield loss in any one year within the top four maize producing countries — the US, China, Brazil and Argentina which currently account for 87% of the world's maize exports — rises to between 40 and 70%. The probability of a synchronous, greater-than-10% crop failure across all four countries during the 2040s is just less than 50%, or almost one year in every two.[187]

There are also impacts other than heat. New analysis by the World Resources Institute shows that one-quarter of the world's crops are grown in areas where the water supply is highly stressed, highly unreliable or both.[188]

As well, the disruption of the AMOC will have severe consequences for marine ecosystem productivity and fisheries. Global fisheries are affected by widespread coral bleaching, ocean acidification, substantial loss of coastal nursery wetlands, and warming and drying of tributaries that serve as breeding grounds for anadromous fish. If the world's coral systems are lost, coastal ecosystems will only be able to provide 20–50% of the fish protein that they do today for half a billion people.

And 3°C would be "catastrophic" for the livelihoods of the world's poorest three billion people, comprising mostly subsistence farmers, whose livelihood will be severely impacted, if not destroyed, with a one- to five-year megadrought, heat waves, or heavy floods.[189]

# 10
# ON THE ROAD TO CLIMATE RUIN

On our current path, civilisation as we know it will disappear. If we meet current commitments only – net zero by 2050 – perhaps some form of humanity will survive, managing the challenges of continued *extreme weather events*, ice loss, and sea-level and temperature rises.

Sir David King, former UK Chief Scientist and founder Climate Crisis Advisory Group, 27 May 2024[190]

**We are facing the potential collapse of natural and socioeconomic systems in a world of unbearable heat, frequent extreme weather events, food and fresh water shortages, rising seas, more emerging diseases, and increased social unrest and geopolitical conflict.**

Understanding how the physical impacts of climate heating impact human society is a complex and daunting task. The *Age of Consequences* analysis explained that:

> Climate change is a manifestation of phenomena that are complex in the technical sense of that word. Complex phenomena are nonlinear and unstable, 'Nonlinear' means that incremental change in the level of inputs to a system can result in major, and even discontinuous changes in the system's output, 'Unstable' means that it is not possible to create a single, normative model for the system's behaviour: instead, modelling must assume the possibility of surprise. It is readily seen that even incremental levels of climate change will have political consequences, but a less obvious, and major, premise of this chapter is that *nonlinear climate change will produce nonlinear political events*… If the environment deteriorates beyond some critical point, natural systems that are adapted to it will break down. This applies also to social organization. Beyond a certain level climate change becomes a profound challenge to the foundations of the global industrial civilization that is the mark of our species.[191]

## Food insecurity

At 3°C of warming, food production would be inadequate to feed the population due to an average one-fifth or more decline in crop yields, a decline in the nutritional content of crops, catastrophic decline in insect populations, desertification, monsoon failure and chronic water shortages, and conditions too hot for human summer habitation in significant food-growing regions.

In 2021, Chatham House warned that the world "is dangerously off track to meet the Paris Agreement goals", the risks are compounding, and "without immediate action the impacts will be devastating in the coming decades", especially for food security.[192] The think tank's report, *Climate change risk assessment* 2021, concluded that:

- Impacts likely to be locked in for the period 2040–50, unless emissions rapidly decline, include a global average 30% drop in crop yields by 2050;
- The average proportion of global cropland affected by severe drought will likely rise to 32% a year (where severe drought is defined as greater than 50% yield reductions);
- By 2040, almost 700 million people a year are likely to be exposed to droughts of at least six months' duration, nearly double the global historic annual average;
- Cascading climate impacts will "drive political instability and greater national insecurity, fuelling regional and international conflict".

The evidence is clear as to how climate change is driving up food prices around the world.[193] This may be an emerging pattern of foodflation in which climate heating will unrelentingly drive prices up and up.

The Chatham House assessment explored the systemic cascading risks leading to food insecurity (Figure 7). The most important drivers were changes in rainfall levels and patterns, and heatwaves, leading to drought and crop failure. These result in food shortages, food price spikes, malnutrition and hunger, starvation and increasing poverty. Together they become drivers of migration and ensuing conflict; and social unrest and protests which led to governance and state failure. This is a pattern exhibited during the Arab Spring driven by price spikes after concurrent wheat harvest failures in major exporting nations; and across sub-Saharan Africa.[194]

Lloyds of London warns that a systemic shock to global food crop production "could have widespread economic, political and social impacts, including food price rises, food riots and changes in stock market values". Food system shock could trigger significant claims across multiple classes of insurance, compounded by the potential for the shock and its consequences to span multiple years.[195]

At 3°C climate disruption to food security, energy and water infrastructure could lead to business defaults on a scale that the insurance industry would be unable to cope with, and to significant falls in consumer spending: "Equity markets would also see abrupt shifts as a result of destruction of infrastructure and crops, leading to a sell-off of assets, declining equity prices, and shortfalls in pension funds, and ultimately undermining the financial markets, all of which would then spill over into the real economy."[196]

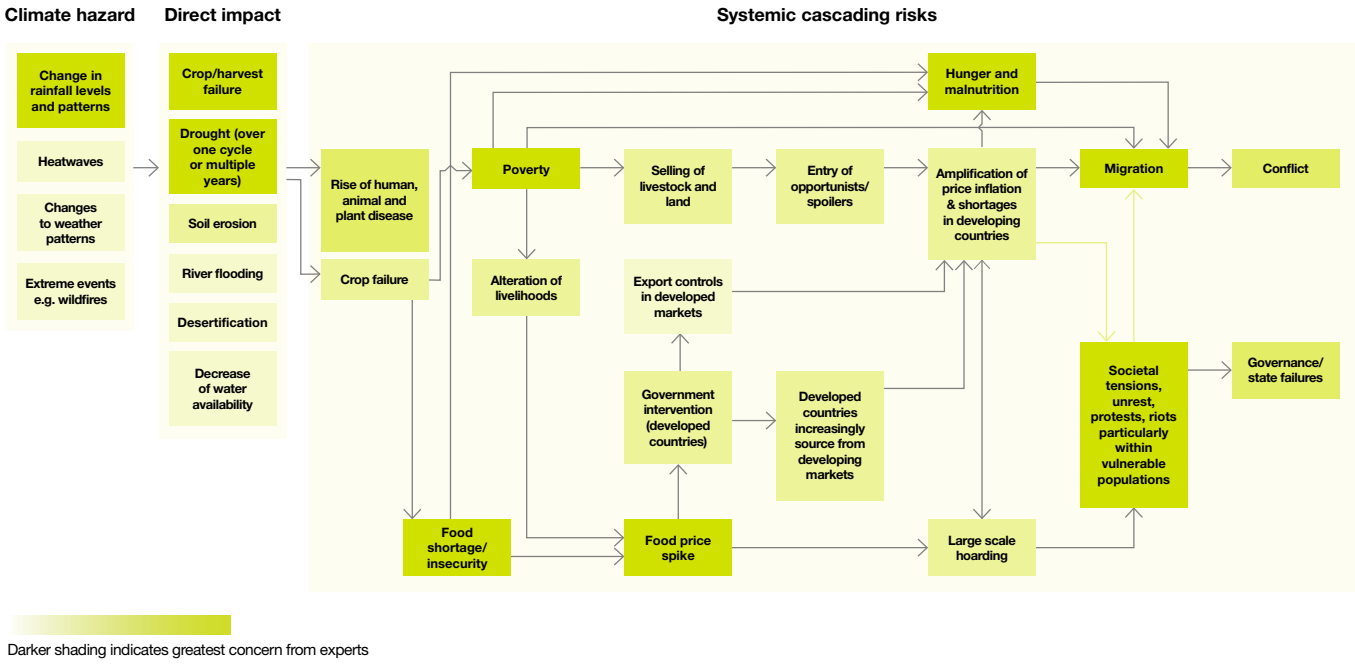



**Figure 7:** Expert assessment of systemic cascading risks that are likely to lead to food insecurity (Chatham House)

## Forced migration/displacement

How many people could be displaced internally and externally at 3°C? Nobody knows. Research has established that disasters like droughts, floods or storms make violent internal political conflict more likely, particularly in countries with pre-existing risk factors.[197]

The Syrian war, in part driven by climate factors — an epochal drought and a climate-driven spike in wheat prices caused by simultaneous crop failures in Russia, Australia and China which triggered the Arab Spring — led to the internal and external displacement of 13.5 million Syrians, more than half of the population. 6.8 million Syrians are refugees and asylum-seekers, and another 6.7 million people are displaced within Syria. The external displacement became a political crisis in Europe, and a driver of Brexit and growing ultra-nationalist politics across Europe.

A Rand report for the UK government concludes that: "Rising sea levels in coastal regions and severe droughts in the Sub-Saharan region are likely to trigger population displacement. Other drivers of displacement could include natural resource shortages and competition as drinking water becomes scarcer and crop yields lower, or as crops are destroyed by extreme weather as in China where several studies indicate that crop yields for rice, wheat and maize will decrease."[198]

A 2021 report from the World Meteorological Organisation and the African Union Commission concluded that high water stress caused by global warming will displace up to 700 million Africans by 2030, and aggravate conflicts on the continent. An analysis by Washington DC-based Brookings Institution said that seven out of the 10 most climate vulnerable nations in the world are located in Africa.[199]

In 2007 senior US national security analysts concluded that: "Perhaps the most worrisome problems associated with rising temperatures and sea levels are from large-scale migrations of people — both inside nations and across existing national borders… potentially involving hundreds of millions of people. The more severe scenarios suggest the prospect of perhaps billions of people over the medium or longer term being forced to relocate. The possibility… poses an enormous challenge even if played out over the course of decades."[200]

A 2020 study on extreme heat found that "over the coming 50 years, one to three billion people are projected to be left outside the climate conditions that have served humanity well over the past 6000 years", and that at 3°C of warming "near unlivable" extremes are projected to "envelop 1.2 billion people in India, 485 million in Nigeria and more than 100 million in each of Pakistan, Indonesia and Sudan".[201] Another study from 2020 reached a similar conclusion: warming of 2°C could provide more than 500 million people additional incentive to emigrate, whilst warming of 3°C could provide additional incentive-to-emigrate to well over a billion people.[202]

The idea that a billion people may be displaced may seem fanciful, but the UN also agrees with this figure: "Unless we change the way we manage our land, in the next 30 years we may leave a billion or more vulnerable poor people with little choice but to fight or flee."[203]

Or worse: in 2017, researchers wrote of "the likelihood of approximately half of the population exposed to deadly heat by 2050", which "could pose existential risks to humans and mammals alike unless adaptation measures are implemented, such as providing air conditioning to the entire population or a massive relocation of most (sic!) of the population to safer climates".[204]

## The big picture at 3°C

Climate heating is just one of the drivers of the global polycrisis[205] driving humanity towards social collapse. Almost all human systems and the natural systems on which they rely are in crisis or beyond their sustainable boundaries: from ecosystems to regimes of state power.

In the *2023 State of the Climate Report: Entering uncharted territory*, 12 researchers warned of "potential collapse of natural and socioeconomic systems in such a world [of 2.6°C warming] where we will face unbearable heat, frequent extreme weather events, food and fresh water shortages, rising seas, more emerging diseases, and increased social unrest and geopolitical conflict".[206]

A year later, in *2024 State of the Climate*, 14 researchers — including William Ripple, Johan Rockström, Michael E Mann, Naomi Oreskes, Tim Lenton and Stefan Rahmstorf — warned that:

> We are on the brink of an irreversible climate disaster. This is a global emergency beyond any doubt. Much of the very fabric of life on Earth is imperiled. We are stepping into a critical and unpredictable new phase of the climate crisis… We are witnessing the grim reality of the forecasts as climate impacts escalate, bringing forth scenes of unprecedented disasters around the world and human and nonhuman suffering. We find ourselves amid an abrupt climate upheaval, a dire situation never before encountered in the annals of human existence. We have now brought the planet into climatic conditions never witnessed by us or our prehistoric relatives within our genus, *Homo.*[207]

Whatever the words, the understanding is widely shared that contemporary nations and societies, and likely the global social system, are heading towards collapse. "If we carry on the way we are going now, I can't see this civilisation lasting to the end of this century," says Professor Tim Lenton.

Opening the Innovation Zero Congress in London in May 2023, Prof. Johan Rockström described the path we are on: "2.5°C global mean surface temperature rise is a disaster. It's something that humanity has absolutely no evidence that we can cope with… [There] would be a 10-metre sea-level rise. There would be a collapse of all the big biomes on planet Earth – the rainforest, many of the temperate forests – abrupt thawing of permafrost, we will have the complete collapse of marine biology… Over one-third of the planet around the equatorial regions will be uninhabitable because you will pass the threshold of health, which is around 30°C. It's only in some parts of the Sahara Desert today that has that kind of average temperature."[208]

Chatham House's *Climate Risk Assessment 2021* concluded that by 2050 global food demand would be 50% higher, but crop yields may drop by 30%. As desertification spreads across the dry sub-tropics, and one-third of the planet experiences unprecedented heat, it is not difficult to see why it concluded that cascading climate impacts will "drive political instability and greater national insecurity, and fuel regional and international conflict".

The *Age of Consequences* "Severe" 3°C scenario[209] developed by a group of senior US national-security figures in 2007 describes a 3°C scenario:

- Massive nonlinear events in the global environment give rise to *massive nonlinear societal events*. In this scenario, nations around the world will be *overwhelmed by the scale of change* and pernicious challenges, such as pandemic disease. The internal cohesion of nations will be under great stress, including in the United States, both as a result of a dramatic rise in migration and changes in agricultural patterns and water availability. The flooding of coastal communities around the world, especially in the Netherlands, the United States, South Asia, and China, has the potential to *challenge regional and even national identities*. Armed conflict between nations over resources, such as the Nile and its tributaries, is likely and nuclear war is possible. The social consequences range from increased religious fervour to *outright chaos*. In this scenario, climate change provokes *a permanent shift in the relationship of humankind to nature*' (emphasis added).

Finally it must be acknowledged that scientists have warned that warming of 4°C is incompatible with an organised global community, is devastating to the majority of ecosystems, and has a high probability of not being stable.[210] The World Bank says it may be "beyond adaptation".[211]

## What scientists say about potential social collapse

### Prof. Will Steffen and colleagues

Could anthropogenic climate change result in worldwide societal collapse or even eventual human extinction? At present, this is a dangerously underexplored topic… yet there are ample reasons to suspect that climate change could result in a global catastrophe.[212]

### Dr Joelle Gergis

It's extraordinary to realise that we are witnessing the great unravelling; the beginning of the end of things. I honestly never thought I'd live to see the start of what sometimes feels like the apocalypse. The Earth is really struggling to maintain its equilibrium. It's possible that we are now seeing a cascade of tipping points lurching into action as the momentum of instability takes hold and things start to come apart.[213]

### Prof. Kevin Anderson

The trend line tells us that we are heading towards 3 to 4°C of warming across this century – an absolute climate catastrophe, and it's a catastrophe for all species, including our own… We are locking in very high levels of sea level rise, maybe 7-8 metres. We are changing weather and rainfall patterns as well as insect pollination of our crops. All of this plays out one disaster after another. We're talking about societal collapse here.[214]

### Prof. Will Steffen

Given the momentum in both the Earth and human systems, and the growing difference between the 'reaction time' needed to steer humanity towards a more sustainable future, and the 'intervention time' left to avert a range of catastrophes in both the physical climate system (e.g. melting of Arctic sea ice) and the biosphere (e.g. loss of the Great Barrier Reef), we are already deep into the trajectory towards collapse.[215]

### Prof. Hans Joachim Schellnhuber

If we continue down the present path "there is a very big risk that we will just end our civilisation. The human species will survive somehow but we will destroy almost everything we have built up over the last two thousand years."[216]

### Prof. Johan Rockström

Let me just make one point very clear: 2.7°C is without any doubt a disaster. It's a point we haven't seen for the past 5 million years. There's no evidence that we can support humanity as we know it on a 2.7°C planet.[217]

# CONCLUSION

The *problem is that the status quo* is a suicide. Those (Paris) commitments, even if fully met, would lead to an increase in temperature […] above 3 degrees which would mean a catastrophic situation.

UN Secretary-General Antonio Guterres, May 2019[218]

In 2005, James Hansen, sometimes dubbed the "godfather" of modern climate research, warned that humanity was "on the precipice of climate system tipping points beyond which there is no redemption".[219] Nineteen years later, we are heading for eye-watering social and ecological disruption, and civilisational collapse. Cities and regions and nations will drown and desertify. There will be an unrelenting global food crisis. Billions will be displaced and the global economic and governance systems of contemporary society will not work.

In practical terms, the world has reached 1.5°C of global heating, the rate of warming is accelerating and will likely continue on that path for several decades, especially given the failure so far to bend the emissions curve down fast. That means 2°C by 2040, or shortly after, and the emergence of vast zones of unlivable heat two decades after that on the present course of grossly inadequate action. Tipping points have been passed or are close at hand for some of the biggest elements of the climate system, including polar ice sheets and vast forest and permafrost carbon stores; and system inertia and hysteresis make preserving and restoring those systems very challenging. Scientists are increasingly alarmed that we may be heading towards AMOC collapse by mid-century.

Any rational response would be an emergency "All hands on deck" rallying cry. Reducing emissions, even very fast, is not enough to stop the systemic changes that are under way. Drawing atmospheric carbon dioxide levels back to safe, near pre-industrial levels, is a necessary, but slow process; and, in the meantime actively cooling the planet must be on the agenda if it can be done safely. This is what the Climate Crisis Advisory Group has termed a "Reduction, Removal and Repair" strategy.[220] This approach is also discussed in our briefing paper *Accelerating climate disruption and the strategy to reduce, remove and repair*.

Avoiding civilisational collapse means governments and nations making climate the first priority of economics and politics, especially for the world's largest and high-polluting economies. It would mean making human security, not national security, the focus of geopolitics. It would mean the rich providing the capacity for developing nations to make a fast transition. It would recognise that disruption is inevitable, dislocation is necessary and this is not a period for business and politics-as-usual.

But instead of honestly facing this truly existential threat, nations are all-in on a process of sustained collective denial via the United Nations Framework on Climate Change, and its annual hi-viz global meetings known as the Conference of the Parties (COP), where thousands of the global policy-making elite — both government and corporate — have gathered every year for three decades. The process has failed, as it is designed to do. Every country, including the petrostates, has a veto over every outcome, and it shows. The original goal of "preventing dangerous anthropogenic interference with Earth's climate system" has been left by the wayside.

The COP climate policy-making paradigm, the "official future", is crafted to fit the desires of global capital and the fossil fuel industry. Change paths must be incremental and non-disruptive, and certainly should not strand large amounts of capital. Action is delayed with long-term, non-enforceable goals such as "net zero by 2050", which remains common currency despite the evidence that such procrastination is facilitating a path towards collapse, not preventing it. The "net" in practical terms means "not" zero. The primary emphasis is on carbon-price or emission-cap market mechanisms which have devolved into rorted offset schemes[221] and the like. Cheating occurs by systematically underestimating national emissions, and sectoral ones such as gas industry methane emissions.[222] Plus the technological cargo cults, such as carbon capture and storage[223] which is, says Prof. Kevin Anderson."a rhetorical device for maintaining business-as-usual and delaying real-world emission cuts".[224]

Behind the scenes, rhetoric rarely matches reality. The *New Republic* reported that: "An October 2020 email exchange between Shell executives — unearthed as part of an investigation by the US House Committee on Oversight and Reform — noted that the company's net-zero talking points had 'nothing to do' with the group's business plans."[225]

Then there is the quasi-scientific excuse for continuing with high emissions: that of "overshooting" the goal and later getting back to cooler conditions, except the path back may not be possible in the way imagined by policymakers.[226] And the economic models — Integrated Assessment Models — used to justify this procrastination, which are barely credible and make leaps of faith and assumptions at odds with real-world conditions.

This "official future" is one of confusion, delay, fake solutions and fake news carefully manicured by the fossil fuel industry over many decades. Many governments — in Australia, the UK and the USA, for example — remain captured by fossil fuel interests. In Australia, recent egregious examples include the Northern Territory Chief minister telling anti-gas protestors that "you are wasting your time";[227] South Australia's energy and mining minister telling an oil and gas industry conference that his state government is "at your disposal";[228] Western Australia's environment watchdog stripped of power to assess big polluting projects;[229] and the Australian Government's strategy that "new sources of gas supply are needed".[230]

The "official future" which is performed each year at the COPs, and every week of the year in parliaments and markets, is a fig leaf for a state and corporate failure of imagination and the need to think the unthinkable. The most unthinkable proposition is that large-scale disruption is now inevitable because markets have failed on climate risks. When all is said and done, the choice is social collapse and economic disruption due to the failure to act fast enough, or economic disruption as a necessary consequence of emergency-level fast change, no matter how politically unpalatable that may appear to be. There is no third way.

This is a structural problem, because the physical changes in the climate system are often non-linear and hence difficult to project, but markets crave stability and fear disruption. Climate damages are radically uncertain[231] (basically, unquantifiable) so that cost-benefit analysis — a basic tool of private-sector risk management — breaks down. The risk cannot be priced. In circumstances where the climate risks are global and existential, markets are unable to fully assess the risks and mitigate them. Just as they can't for other large-scale and unquantifiable risks, such as war, pandemics, and the threat posed by AI.

In 2011, Paul Gilding's *The Great Disruption* concluded that it was an illusion to think the contradictions can be resolved within the current economic frame and that disruption and chaos was now inevitable as system failure occurs. It laid out the reasons to "address the emergency with the commitment of our response to WWII and begin a real transformation to a sustainable economy".[232]

Five years earlier, Nicholas Stern had said that "paths requiring very rapid emissions cuts are unlikely to be economically viable" and disruptive because "it is difficult to secure emission cuts faster than about one per cent per year except in instances of recession."[233] Analyst Alex Steffen concludes that:

> It is no longer possible to achieve [an] orderly transition, to combine action at the scale and speed we need with a smooth transition and a minimum of disruption [...] We are not now capable of designing a future that works in continuity with our existing systems and practices while producing emissions reductions and sustainability gains fast enough to avoid truly dire ecological harm. This is an option that no longer exists.[234]

And the risk intelligence company Verisk Maplecroft assesses that "there is 'no longer any realistic chance' for an orderly transition for global financial markets because political leaders will be forced to rely on 'handbrake' policy interventions to cut emissions."[235]

Even though Sir Nicholas Stern named global warming as the "greatest market failure" in history, governments have been ideologically reluctant to act sufficiently to correct this greatest distortion of the market. Our political leaders, who should be honestly assessing the risks, and initiating or joining their populations in a difficult but necessary conversation about why climate heating is driving us towards unimaginable levels of social breakdown, are instead looking the other way. The public conversations about looming social collapse are avoided at all cost, so a discussion about necessary disruption never happens.

In Australia's case, the current government has locked away the nation's first climate and security risk assessment because its public release would make a mockery of their dance of death with the fossil fuel industry to expand coal and gas production.

Twentieth century history teaches us that economic crises leading to sustained stagnation is fertile terrain for authoritarian politics; a lesson reflected in events this century too, where authoritarian leaders including Donald Trump have downplayed or denied the climate crisis. China is the notable exception. And there is evidence that global heating disruption creates fertile ground for political strongmen to come to power.[236] As a deepening climate crisis leads to a deepening economic crisis, what is the path to avoiding the rise of authoritarian political leaders and their climate denial in a feedback loop that will only quicken collapse?

In such circumstances, the primary responsibility and leadership role in any nation must be shouldered by government. Only the state apparatus has the whole-of-nation, whole-of-system powers and capacity to respond with the interests of the people as a whole at heart. But the biggest polluters and sources of fossil fuels are either petrostates or governments captured by the fossil fuel industry.

Instead of state leadership, writes George Tsakraklides, we have reached a point where "the full-time job of government, corporates and the media is now to simply keep everyone convinced that this self-annihilating civilisation is somehow supposed to make sense. Well, it doesn't, as we are all finding out... as we enter a bumpy, bruising, bloody descent towards an economic, cognitive and spiritual abyss."[237]

Boris Frankel, in his *Fictions of Sustainability*, has pointed out that in the present economic circumstances — low growth, stagflation, disruption — the material needs of decarbonisation cannot be absorbed by growth, but only by reallocation of financial and physical resources.[238] He says that if there are no major technological breakthroughs in the next decade (especially regarding decoupling), then climate disruption and resource depletion will force governments to take emergency action and scale back production in the face of systemic breakdown.

Climate disruption and resource overuse will also destabilise markets, resulting in continuing low growth and growing inequality. Markets have and will likely continue to fail to respond to the twin crises, and instead creeping financialisation — credit-fuelled consumption, speculation in everything from shares and real estate to NFTs and crypto currencies, and an increasing burden of debt and debt servicing — will continue to be the hallmark of neoliberalism's pernicious hold.

If resources are to be redirected to economic transition and equity needs, there is a crying need to curb the power of financial capital and rechannel current economic behaviour away from speculation to socially-useful ends: a liveable and biodiverse planet. Against this possibility, business has strongly opposed state intervention as a guiding principle of its behaviour, and succeeded in blocking state leadership of the climate emergency.

Australian financial commentator Alan Kohler once quipped that that politics is a sideshow, as central banks run the global economy and Silicon Valley governs society.[239] The 2024 victory by Donald Trump and his Silicon Valley-annointed Vice President JD Vance fits the bill. Their agenda absolves governments of climate responsibility, and is a direct assault on global efforts to prevent and mitigate the crisis.

In this time of great political volatility in America the challenge to mobilise the world in time to avoid the collision is set to be severely hindered, leaving our future hanging in the balance.

The urgent need is to take back and rebuild state institutions destroyed by neoliberalism in order to redirect production to socially-necessary goals — decarbonisation and cooling, and basic public needs including secure food and water, and health, education and transport — to plan and manage the transition and adjustment, and to curb the destructive path of financialisation. This would be a massive politically-directed reallocation of resources not only in the OECD, but in China, India, Nigeria and more. In the first instance this is a question of what needs to be, and can be, produced within resource sustainability and safe-climate boundaries.

There is a battle for the role of the state, with democratic community movements worldwide — including citizens, students, the labour movement, grassroots organisations, and a myriad of other diverse constituencies — demanding that the state act to overturn deregulation's hegemony. And just as proposals focussed on Green New Deals and market-driven growth have failed to deal with systematic market failure on climate risks and resource depletion, so also enhanced social expenditure will also fail if state leadership does not provide a path out of the climate and ecological crises via an emergency mobilisation.

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