Emergency on Planet Earth

Written by Dr Emily Grossman with the support of the XR Scientists community.
Fact-checked and reviewed by a wide range of experts in relevant fields - both from within the XR Scientists community and external to it.
This guide is also available on the Extinction Rebellion UK website. See here for a selection of key facts from this guide. To save this guide as a PDF, select File -> Download -> PDF Document.
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The science is clear
We are facing an unprecedented global emergency
We must act now

“We are in a planetary emergency.”
Professor James Hansen, Former Director NASA Goddard Institute for Space Studies

“This is an emergency and for emergency situations we need emergency action.”
Ban Ki-Moon, Former UN Secretary-General

"The climate emergency is our third world war. Our lives and civilization as we know it are at stake, just as they were in the Second World War."
Professor Joseph Stiglitz, Economist, recipient of the Nobel Memorial Prize in Economic Sciences

“Based on sober scientific analysis, we are deeply within a climate emergency state but people are not aware of it.”
Professor Hans Schellnhuber, Founding Director of the Potsdam Institute for Climate Impact Research

“There is sufficient evidence to draw the most fundamental of conclusions: now is the time to declare a state of planetary emergency. The point is not to admit defeat, but to match the risk with the necessary action to protect the global commons for our own future.”
Professor Johan Rockstrom, Director of the Potsdam Institute for Climate Impact Research

“Climate change will lead to battles for food.”

Jim Yong Kim, Former President of The World Bank

“Climate change is the greatest security threat of the 21st century,”
Maj Gen Munir Muniruzzaman (Retd.), chairman of the Global Military Advisory Council on Climate Change

“You have to understand, this is also a crisis for the world. The fact is that if the poor are suffering today, then the rich will also suffer tomorrow.”
Dr Sunita Narain, Director General of the Centre for Science and Environment

“Climate change is moving faster than we are - and its speed has provoked a sonic boom SOS across our world. We face a direct existential threat.”
António Guterres, United Nations Secretary-General

"We have all the resources we need to deal with this. There is nothing magical about reducing carbon dioxide in the atmosphere. We just don’t have the political or economic will to do this.”
Professor Stephan Harrison, Professor of Climate and Environmental Change, University of Exeter

“Listen to the cry of the earth and the cry of the poor, who suffer the most. The urgent need for interventions can no longer be postponed.”
Pope Francis

“The future of the human race is now at stake.”
Rowan Williams, Former Archbishop of Canterbury

Introduction

Humanity is facing a crisis unprecedented in its history. A crisis that, unless immediately addressed, threatens to catapult us towards the destruction of all we hold dear, our planet's ecosystems and the future of generations to come. This crisis has been caused by human activities and we have to stop making it worse or we will face catastrophe that we cannot think our way out of, invent our way out of or buy our way out of. In one way or another, it will affect every one of us and everything we love.

The science is clear: the world is heating and the breakdown of our environment has begun. Even now, warmer temperatures are wreaking havoc, causing an increase in extreme weather, floods, storms and droughts - along with rising sea levels, heat stress in our oceans and degradation of our soils. Extreme weather events are having devastating impacts on agriculture and destroying homes, costing taxpayers billions of dollars and leaving millions of people in need of humanitarian aid.

If we keep going as we are, the coming years will bring more wildfires, unpredictable super storms and scorching heatwaves. Rising sea levels and droughts could render vast tracts of land uninhabitable through flooding and desertification, putting food supplies at risk. Receding glaciers threaten to cut off fresh water supplies for millions. Mass migration and famine are likely to take us towards civil unrest and ultimately war, raising the terrifying possibility of societal collapse.

But that's not all. Around the world, biodiversity is being annihilated at a terrifying rate. Population sizes of thousands of species of mammals, birds, fish and reptiles have fallen by 60% since the 1970s. We are losing our crop-pollinating insects and soil-rejuvenating earthworms. Species are going extinct 100 to 1,000 times faster than they would be doing naturally. Many scientists say we are now entering the Earth's Sixth Mass Extinction event, with one million species threatened with extinction - many within decades. Only this time it's our fault. The consequences will be catastrophic if we do not act swiftly.

Millions of our trees are being felled to feed the ever-increasing demands for palm oil, clothes and meat. Our soils are being degraded through deforestation and intensive agriculture. We are running out of raw materials and using up our resources. Our rivers are being poisoned and our seas are acidifying and filling up with plastic. The air is so toxic that it kills millions each year.

As Sir David Attenborough put it: "We are facing a man-made disaster on a global scale."

These climate and ecological crises can no longer be ignored or denied. Yet in spite of promises from governments, greenhouse gas emissions continue to rise steeply and biodiversity loss shows no sign of slowing.

In November 2019, a group of more than 13,000 scientists from 153 countries declared “clearly and unequivocally that the Earth is facing a climate emergency” and that without deep and lasting changes, the world’s people face "untold human suffering".

The time has come to take radical action. The future of our children, and our grandchildren, is at stake.

This horrifying narrative sounds almost too unbelievable to be true. Can it really be as terrifying as all that?

We hear so many conflicting opinions and reports – how do we know for sure what is true? Can we really be sure that the world is warming any more than it has in the past? And even if it is, are we certain that humans are to blame? Are species really going extinct at such high rates? And even if they are, why does this matter to us? Are things really going to get worse? If so, how much worse? And how soon? And what can we do about it?

Over the following sections, we, an expert group of science writers, climate scientists and ecologists, most of whom are members of the Scientists for Extinction Rebellion community, explain simply what’s really going on on our planet today. We present clear and unequivocal evidence - backed up by the latest research - that we are indeed in a state of planetary emergency, that human activities are to blame for this crisis, and that the arguments often used by skeptics or deniers to contest this fact are simply not true and are designed to avoid action.

We also provide clear evidence that our governments are not doing nearly enough to address the crisis. And we explain why, without bold and radical action within the next few years, the impacts of this emergency will be catastrophic and irreversible, leading to incalculable suffering and loss of life.

We show that the time has come to take radical action. That the future of our planet is at stake. And that we cannot afford to wait another second.

Contents

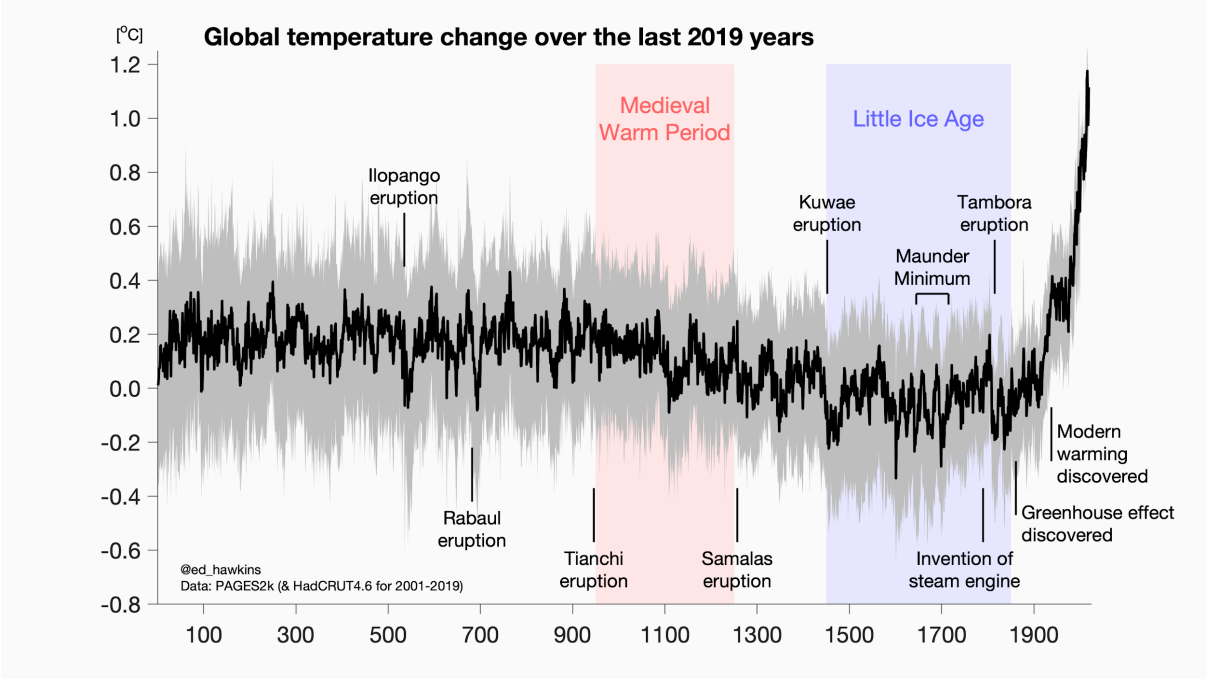
Part 1: Back to the start… How did we get into this climate mess and is it really that bad?

How can we be so sure that the Earth is heating?

"Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen."
Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report

"Join the dots. It's happening. It's happening in your world, it's happening in my world. And let's be very clear about this - it is going to get much worse."
Dr Sunita Narain, Director General of The Centre for Science and Environment

Independent temperature records from multiple official sources confirm that there is absolutely no doubt whatsoever that the Earth is heating.

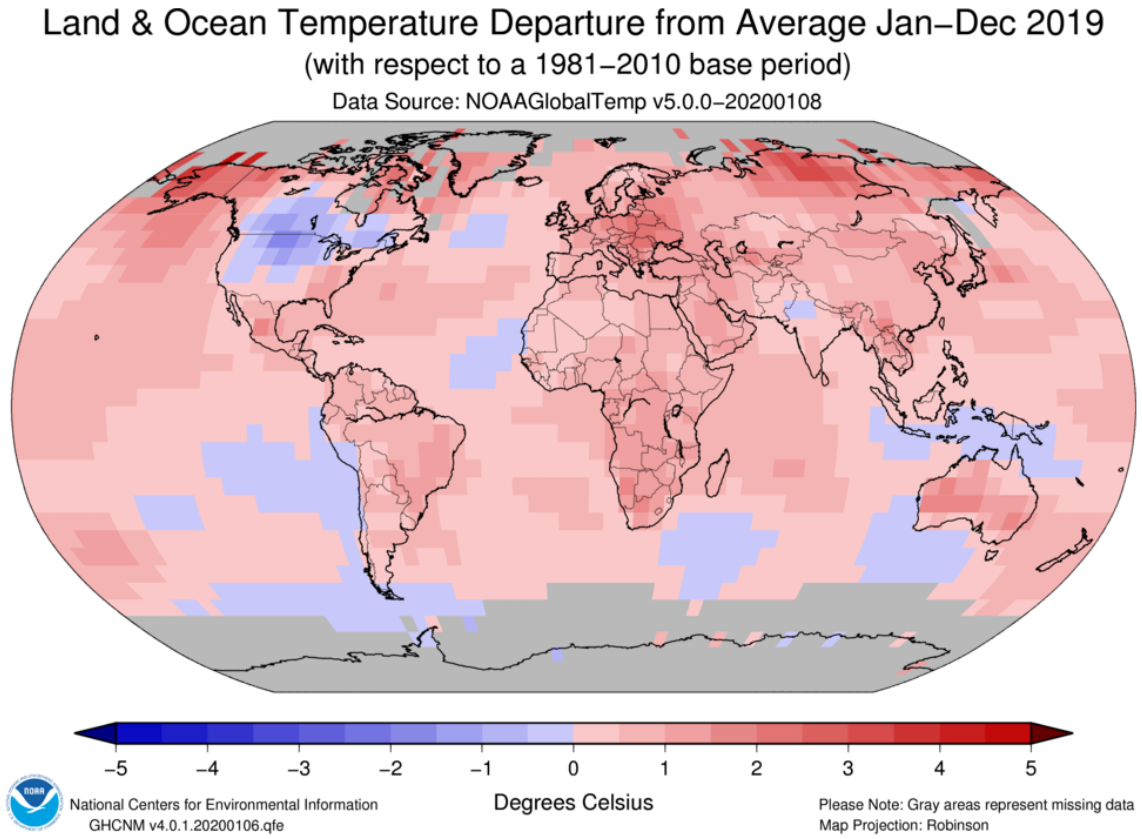


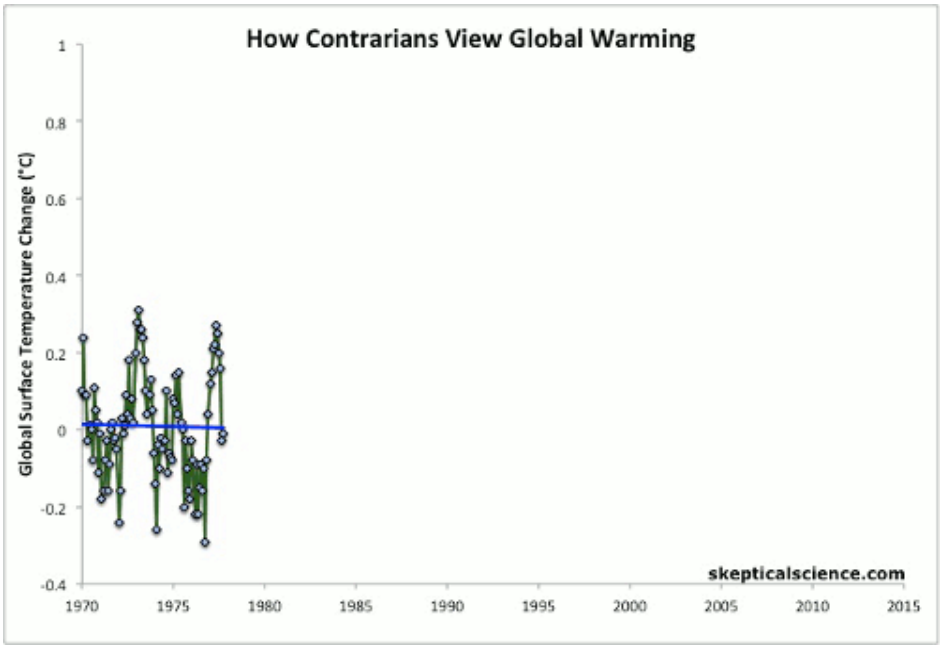
Each of the last three decades has been successively hotter than the one before, 19 of the top 20 hottest years have occurred in the last 19 years, and the past four years have been the hottest on record. 2016 was the hottest year ever recorded, whilst in 2019, nearly 400 temperature records were broken across 29 countries,

June 2019 was the hottest on record, and July 2019 was the hottest month ever recorded. As of July 2020, January 2020 was the warmest January ever recorded in Europe, we saw the hottest May ever and we already have an 85% chance that 2020 will turn out to be the hottest year on record.

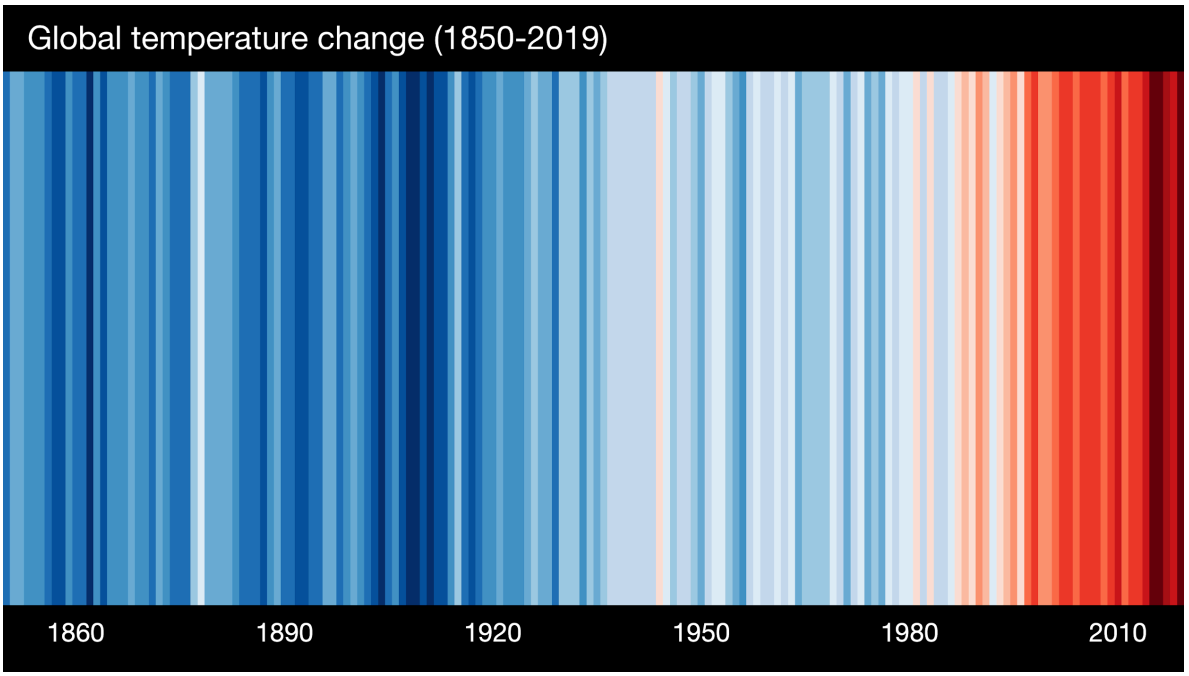
Some people argue that global heating can't be happening because the weather seems to be getting colder where they live. This may indeed be true, but what's important to remember is that when we talk about *global heating* and *climate change*, we are talking about changes in *long-term* average trends in atmospheric conditions - normally measured over decades - whereas when we talk about *the weather* we are referring to *short-term* and *local* variability around that average.

What this means is, whilst we are clearly seeing an overall increase in average global temperatures, there can still be significant *regional* and *yearly* variations in the weather. In any one year there may be some parts of the world that are colder than usual, and there may be entire years that are colder than previous years. Indeed, those wishing to confuse the public that global heating isn't occurring sometimes do so by pointing to misleading graphs that are based on false or misinterpreted data that refers to regional as opposed to global changes, or cherry-pick data that focus on short-term trends rather than looking at the bigger picture.





The key point is that *long-term* and *global* trends show unequivocally that our planet is not only heating up, but that its rate of heating is accelerating. In fact, it has even been proposed that it is climate change itself that is causing some regions to experience more extreme, colder winters due to the disruption to weather patterns.



It's also worth noting that there is variation in how fast the climate is changing in different parts of the world. For example continental regions (where most people live)

heat up much faster than the oceans. An extreme example of this is the Arctic, which is warming at more than twice the rate of the global average due to a phenomenon called Arctic Amplification. In contrast, there are areas of the globe that are warming a bit slower than the average.

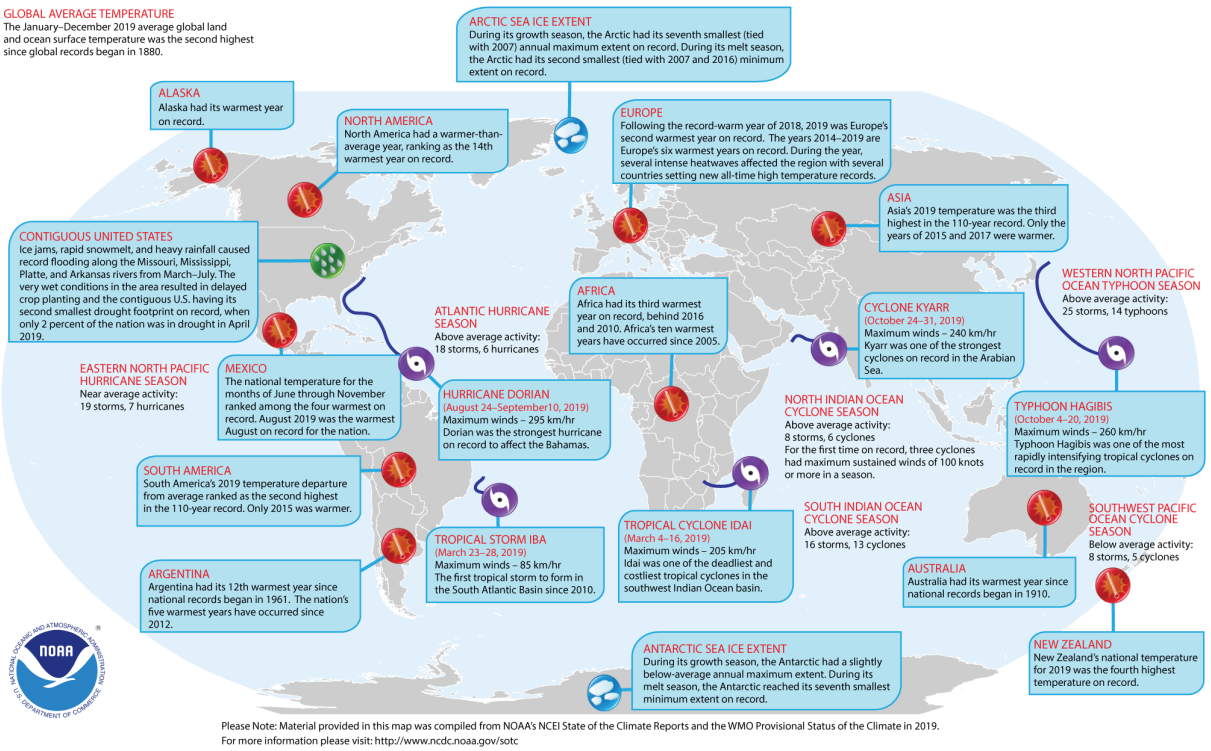
Why should we care about a few degrees of heating?

"It is generally foolish to bet against the judgments of science, and in this case, where the planet is at stake, it is insane."
Professor Steven Weinberg, Nobel-Prize winning Theoretical Physicist, 2018

Over the past 12,000 years the Earth's climate has been remarkably stable. It was this stability that gave the predictability and security that was needed for agriculture and human civilisation to develop, without which we could not have flourished. However, the burning of fossil fuels, large-scale deforestation and intensive farming practices that have been taking place since the start of the Industrial Revolution are causing us to now rapidly leave that period of climate stability behind and head into the unknown. As a result, we risk disrupting our planet's environmental conditions *way beyond* that which we can adapt to. Indeed, we are already beginning to see the consequences - see section on what's already happening to our planet as a result of global heating.

The average surface temperature of our planet has now risen by around 1°C since pre-industrial times. One degree may not sound like much, but the Earth is so massive that it takes a colossal amount of energy to warm it by even a tiny amount. In fact, the current rate of global heating is the equivalent energy of five nuclear bombs going off *every second*. Adding this much energy to the Earth's climate inevitably has huge knock-on effects, causing extreme weather events across the globe, melting ice caps and disrupting life on land and in our oceans, which puts stress on agriculture and endangers fresh water supplies. The rise in global average temperature between the last ice age (over 17,000 years ago) and today is 4.5°C - yet we could see a similar amount of heating by the end of this century, in a fraction of the time.

At just 1°C of global heating, climate change is already here and is having devastating impacts on people and ecosystems across the world. Every fraction of a degree of further warming will not only exacerbate these impacts but also increase the risk of triggering irreversible tipping points. We are on course for things to get an awful lot worse over the coming decades unless we act radically and act NOW. Yet our governments continue to procrastinate and delay meaningful action.

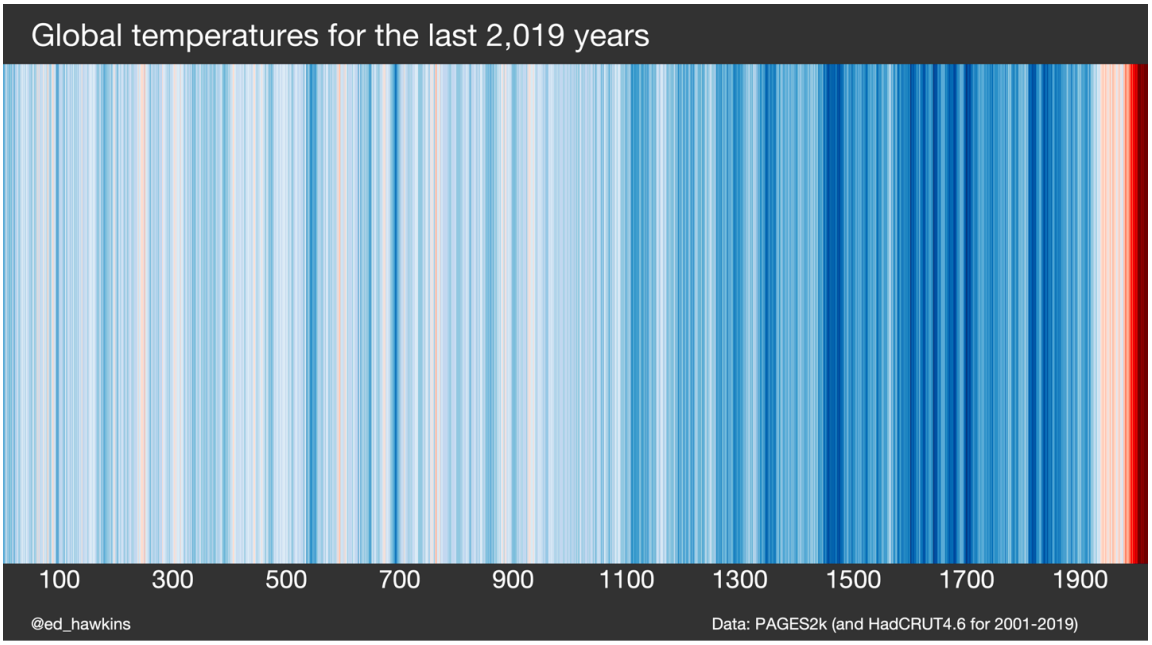


Hasn't the Earth been hotter in the past?

"You'd have to go back to the last interglacial [warm period between ice ages] about 125,000 years ago to find temperatures significantly higher than temperatures of today."

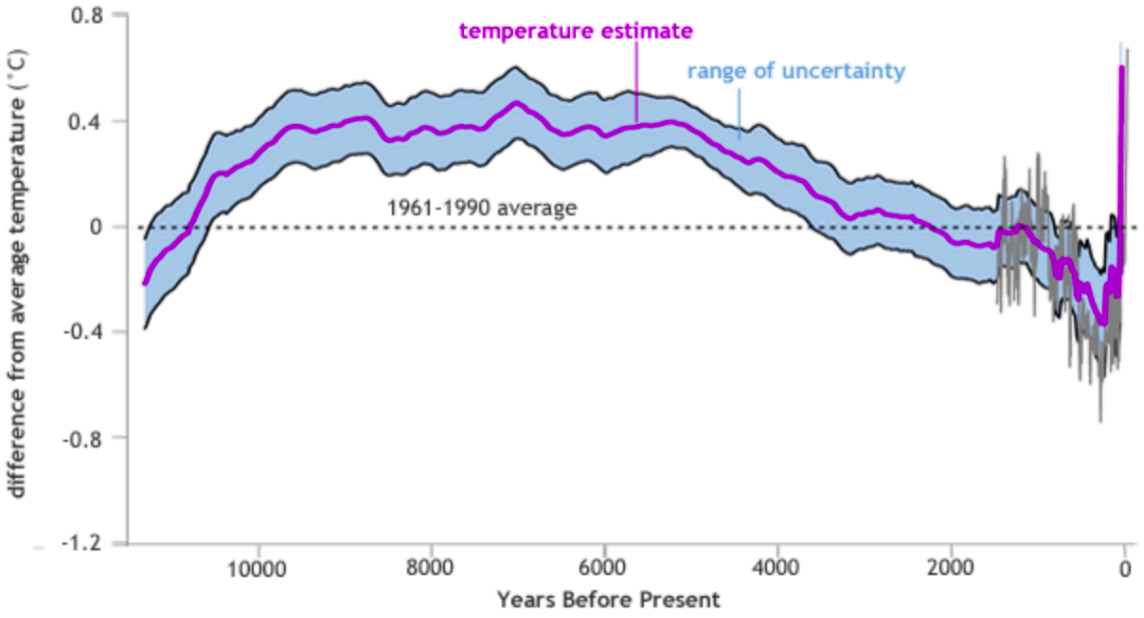
Dr Carrie Morrill, paleoclimatologist at the National Climatic Data Centre

The planet is now very probably hotter than at any point in at least the last 125,000 years, long before human civilisation began, when sea levels reached over 6 m higher than they are today.



But what's even more concerning is how *fast* our temperatures are rising. Over the past 45 years, our planet's temperature has been increasing a whopping 170 times faster than the baseline rate of cooling over the previous 7,000 years. Indeed, our current rate of warming is unprecedented over the last 10,000 years.

Global temperatures over the past 11,300 years compared to the average between 1961 and 1990



Over the rest of this century, future temperature rises are predicted to be taking place not just much faster than it did during our recovery from the last ice age but

hundreds of times faster than any extended period of warming in the last 65 million years. That's when the dinosaurs went extinct. Crucially, when temperatures rise this fast, it is impossible for many living creatures and plants to have time to *adapt* to such changes. Not to mention the fact that many places on Earth that creatures would have previously used to take refuge from increasing temperatures have now been degraded, fragmented or colonised by human activities.

To make matters worse, geological records show that there have been some incidences of *abrupt* climate change in the past, when just a small change in one element of the climate system led to *rapid* changes in the whole system that have taken place over the course of centuries or even decades. This suggests the terrifying possibility that if we push global temperatures over a certain threshold today (which could happen at any time), we could trigger abrupt, unpredictable and potentially irreversible changes over the course of *decades* or even *years* - leading to large-scale impacts and massive disruption.

The bottom line is that the changes in temperatures that we've been seeing on our planet in recent years are truly *unprecedented*. At a time when sunspot activity is decreasing and when, according to the Earth's natural orbital cycles, we ought to be cooling down and heading slowly towards our next ice age (see section on the effects of natural fluctuations in carbon dioxide), instead, greenhouse gases (such as carbon dioxide) from human activities are causing global temperatures to rise at a terrifying rate.

As our carbon dioxide levels reach concentrations not observed for millions of years (see section on what greenhouse gas emissions are like today), we will inevitably soon surpass *any* past climates experienced by humans.

What exactly are greenhouse gases and what is the greenhouse effect?

"Everything that is expected to result from global climate change driven by greenhouse gases is not only happening, but it's happening faster than anybody expected."
Professor John Holdren, Science and Technology advisor to President Barack Obama, Director of the Woods Hole Research Center

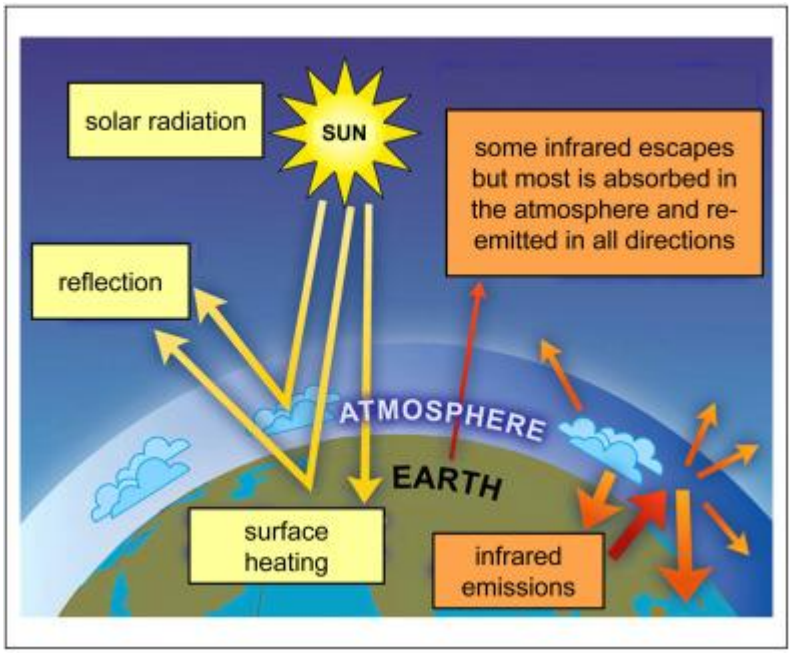
The temperature at the Earth's surface is controlled primarily by the levels of certain gases in the atmosphere, such as water vapour, carbon dioxide and methane. Although these gases only make up a tiny fraction of our atmosphere (current carbon

dioxide levels are around 410 parts per million (ppm), which is just 0.041%), just like how a drop of ink can affect the colour of a huge volume of water, tiny amounts of these gases can have enormous impacts on our atmosphere. Due to their special structure, these molecules can absorb heat emitted from the Earth's surface as a result of it having been warmed by the Sun, preventing some of that heat from escaping back out into Space. In this way, it can be said that the gases provide an insulating 'blanket' around the Earth, which traps heat in our atmosphere keeping us warm.

This heating effect has (somewhat wrongly) been compared to how the glass roof of a greenhouse traps heat energy from the Sun, keeping the inside of the greenhouse warmer than its surroundings. Hence this phenomenon has become known as *the greenhouse effect* and the gases known as *greenhouse gases*. We have known about the greenhouse effect for well over 150 years, and the science behind it is well established.

The greenhouse effect, in its *natural* form, is essential for life here on Earth; without greenhouse gases in our atmosphere, the average temperature at the Earth's surface would be around -18°C, dropping to temperatures at night that would be far too cold for us to survive. However, by burning fossil fuels (as well as by farming cattle, growing rice, burning trees, intensively ploughing soil and using chemical fertilisers) humans have been adding huge quantities of *additional* greenhouse gases into the atmosphere, 'supercharging' the greenhouse effect beyond anything that humans have ever experienced.

How the Greenhouse Effect works



Carbon dioxide is by far the most important greenhouse gas - responsible for approximately 75% of the Earth's human caused heating - because it is emitted in *much larger quantities* than any of the other 'long-lived' greenhouse gases. It also has an extremely long lifetime: any excess can stay in the atmosphere for hundreds or even thousands of years and therefore it accumulates in our atmosphere, increasing its concentration. Concentrations of carbon dioxide have now increased by over 40%, from around 280 ppm in preindustrial times to over 414 ppm in July 2020 and rising.

Other greenhouse gases are important too though. For example, methane is a very potent greenhouse gas, being 86 times better than carbon dioxide at trapping heat over a twenty-year time frame. However, on average, it breaks down in the atmosphere in around 9 years, meaning that it can't accumulate in the atmosphere as much as carbon dioxide over long time periods. Yet even over a 100-year time frame, methane is still approximately 34 times more potent than carbon dioxide. Plus, when methane breaks down it actually turns into carbon dioxide. Methane concentrations in the atmosphere have more than doubled since pre-industrial times, recently exceeding 1.8 ppm.

Per kilogram, nitrous oxide is an even more powerful greenhouse gas than methane, with nearly 300 times the global heating potential of carbon dioxide and a lifetime somewhere between that of carbon dioxide and methane - roughly 120 years. Levels of nitrous oxide have increased by around 22% since the preindustrial period.

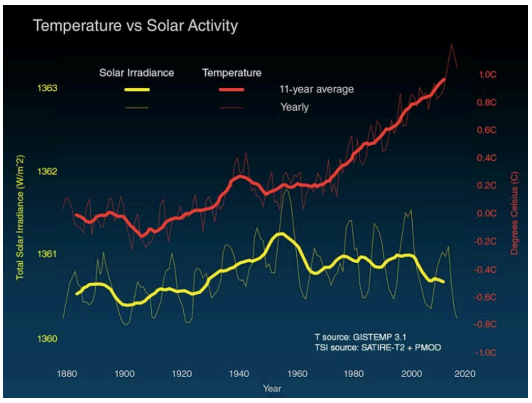
Water vapour is also a greenhouse gas and occurs in our atmosphere in higher concentrations than carbon dioxide. However, the amount of water vapour in the atmosphere is controlled by the temperature of the air (increasing by around 7% with every degree celsius of increase in air temperature), rather than by human-caused emissions. For that reason, the amount of water vapour in the air is seen as an 'amplifying feedback' that increases global heating, rather than the initial *cause* of such heating.

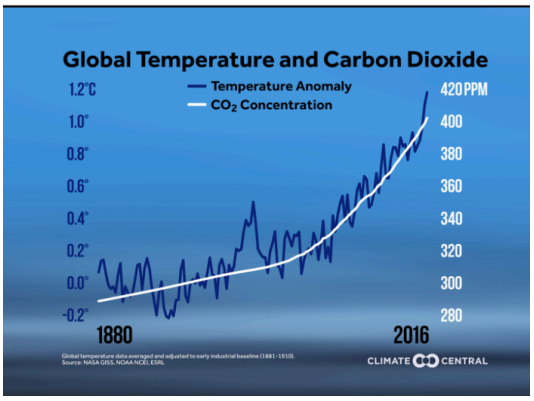
Can we be certain that humans are causing global heating?

"*Human influence on the climate system is clear, and recent anthropogenic emissions of green-house gases are the highest in history.*"
Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report

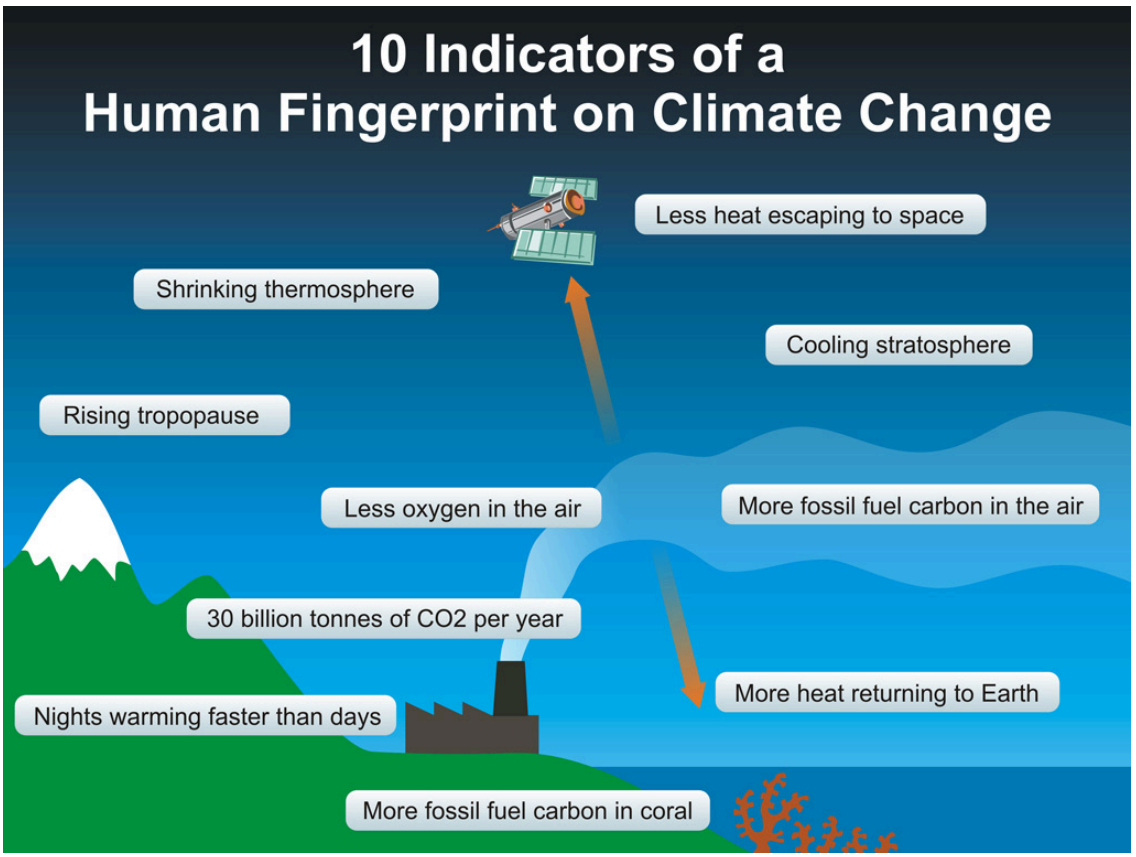
There is now absolutely no doubt that the recent increase in global temperatures is almost entirely due to human factors. A vast body of peer-reviewed scientific evidence confirms that natural cycles, volcanic activity, galactic cosmic rays and changes in solar activity from sunspots have had a negligible effect on our current

temperature rise. Instead, rises in global temperature have followed the trajectory of increased greenhouse gas levels.





Indeed, scientists have been able to find an unmistakable "human fingerprint" on climate change. Firstly, the Earth's atmosphere is reacting exactly as we would expect it to if it were being exposed to an increase in greenhouse gases (as opposed to, for example, if it were experiencing increased solar activity). Secondly, detailed analysis of the carbon atoms in the carbon dioxide accumulating in the atmosphere shows that they must have been released by the burning of fossil fuels. Thirdly, measurements taken by satellites show that increases in greenhouse gases are trapping infra-red radiation from the Earth and causing the atmosphere to heat up.



Such evidence confirms that the direct impact of humans on our global climate is no longer a matter for debate. Indeed, an analysis of 12,000 academic papers on the subject of climate change published from 1991-2011 found that 97% of the papers that expressed a position agreed that humans are responsible for the exceptional levels of global heating that we are seeing today. To be clear, this doesn't mean that the other 3% *disagreed*; it just means that their work didn't meet the threshold to show that they agreed. The consensus has only gotten stronger: more recently, analysis of 11,602 peer-reviewed articles on “climate change” and “global warming” published in 2019 found 100% agreement that it is human activity that is responsible for this.

Whilst climate change deniers sometimes post articles or comments from scientists that seem to refute the overwhelming evidence of human-caused global heating, these articles often rely on inaccurate claims about climate science. The scientists themselves tend not to have expertise in a climate-related field, or they have links to the fossil fuels industry - or both.

The scientific community as a whole are overwhelmingly concerned about what is going on on our planet. In the words of Professor Lonnie Thompson, director of the Byrd Polar Research Centre: “Virtually all of us are now convinced that global warming poses a clear and present danger to civilization.”

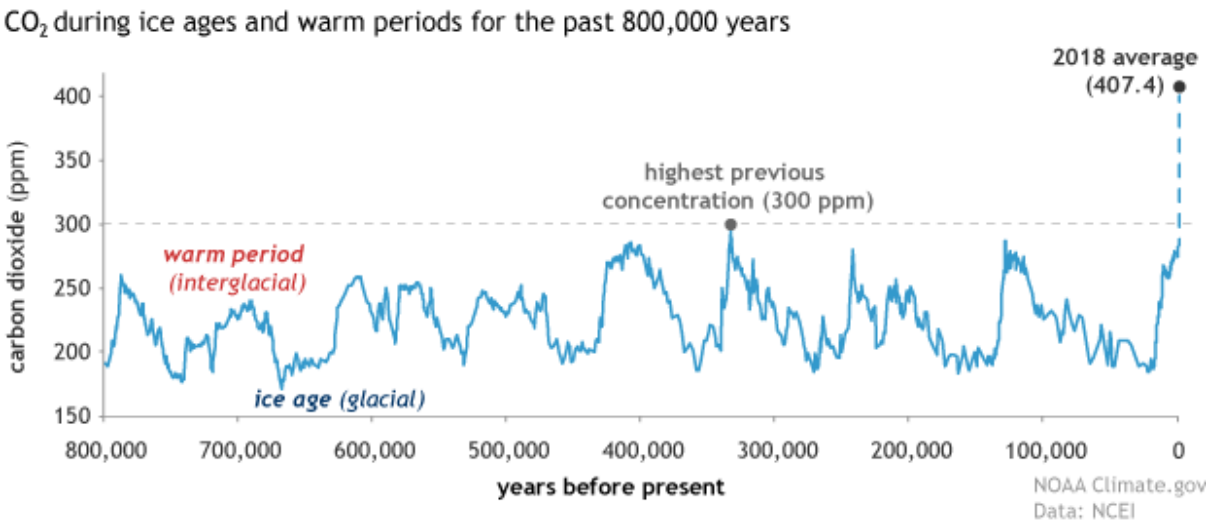
Haven’t natural fluctuations in carbon dioxide affected the Earth’s temperature?

"*At present rates of human emissions, there will be more CO_2 in Earth’s atmosphere by 2025 than at any time in at least the last 3.3 million years.*"
Dr Elwyn De La Vega, University of Southampton

In the absence of human activities, the levels of carbon dioxide in our atmosphere tend to remain fairly stable over time. Carbon dioxide is constantly being absorbed into the oceans, and locked into carbon compounds in trees and plants by a process called *photosynthesis*. Other living creatures feed off these trees and plants, taking the carbon compounds into their own bodies. These carbon compounds are then turned back into carbon dioxide through a process called *respiration*, and the carbon dioxide is released back into the atmosphere. Carbon dioxide is also released when dead matter decays and rots, or is burnt. This process of the constant removal and replacement of carbon dioxide in our atmosphere is known as the *carbon cycle*.

Whilst analysis of air bubbles trapped in Antarctic ice sheets reveals that over the past 800,000 years there also have been periods in the Earth's history where the carbon dioxide levels have naturally risen and fallen, this has taken place *extremely gradually*. These changes are brought about by natural variations in the way in which the Earth travels around the Sun (known as Milankovitch cycles), which lead to changes in the absorption of sunlight on Earth. For example, a small increase in the amount of sunlight being absorbed causes the oceans to warm slightly, which results in some of the carbon dioxide dissolved within them being released back into the atmosphere. The increase in atmospheric carbon dioxide leads to more ocean warming, which causes more carbon dioxide to be released, which causes more warming... and so on and so forth. The changes in temperature caused by this feedback loop, and others like it, drive the transitions into ice ages (glacial periods) and back out of them (interglacial periods). The last time this happened was around 17,000 years ago, when we began to transition out of our most recent ice age.

The key point here is that these *natural* changes in carbon dioxide levels, triggered by cycles in the Earth's orbit and modulated by feedback cycles within the Earth system, take place over *tens of thousands of years*. In contrast, the extremely rapid increases in carbon dioxide levels that we have been seeing over the past 60 years, due to human actions, have been taking place about 100 times faster than any of these previous natural increases.



Carbon dioxide levels today are higher than they have been in more than 3 million years. Back then, global average temperatures were 2-3°C higher than in pre-industrial times and sea levels were a whopping 16 m higher. Studying these past changes has revealed to climate scientists just how *sensitive* the Earth system is to changes in greenhouse gas concentrations. This is one of the key reasons why scientists are so alarmed about the current rapid rise in their concentrations.

What's happened in the past few thousand years?

Around 17,000 years ago the Earth began to come out of its most recent ice age. As carbon dioxide levels naturally rose, the planet warmed. Then, about 12,000 years ago, global temperatures reached a plateau and we entered a period of relative *climatic stability* known as the Holocene. It is this stability that allowed humans to settle and farm. Then, around 5,000 years ago, greenhouse gas levels started to naturally fall again and temperatures began a slow decline, which would eventually have sent us towards our next ice age.

However, a few thousand years ago, human actions began to disrupt the Earth's natural cycles. We started cutting down trees to clear land for farming or to burn them to keep warm - reducing the amount of carbon dioxide that could be removed from the atmosphere by photosynthesis. At the same time, we planted paddy fields to grow rice, releasing methane into the atmosphere from microbes growing in waterlogged soils. For a long period of time the levels of greenhouse gases in our atmosphere rose slowly and steadily. It has been proposed that this increasing greenhouse warming effect counteracted what should have been a period of natural cooling due to the Earth's orbital cycles, leaving our global temperatures to remain pretty constant.

That is, until the last couple of centuries. With the start of the Industrial Revolution came mass burning of fossil fuels, large-scale deforestation and intensive farming. As a result, the levels of greenhouse gases began to shoot up astronomically. And with them, our temperatures.

What's happened in the past 150 years?

> *"In just 100 years, fossil fuel use has more than undone 5000 years of natural cooling. It's hotter now than any time in the history of human civilisation. We are catapulting ourselves out of the Holocene into uncharted territory. Current life on Earth is not adapted to this."*
> *Stefan Rahmstorf, Professor of Physics of the Oceans at Potsdam University*

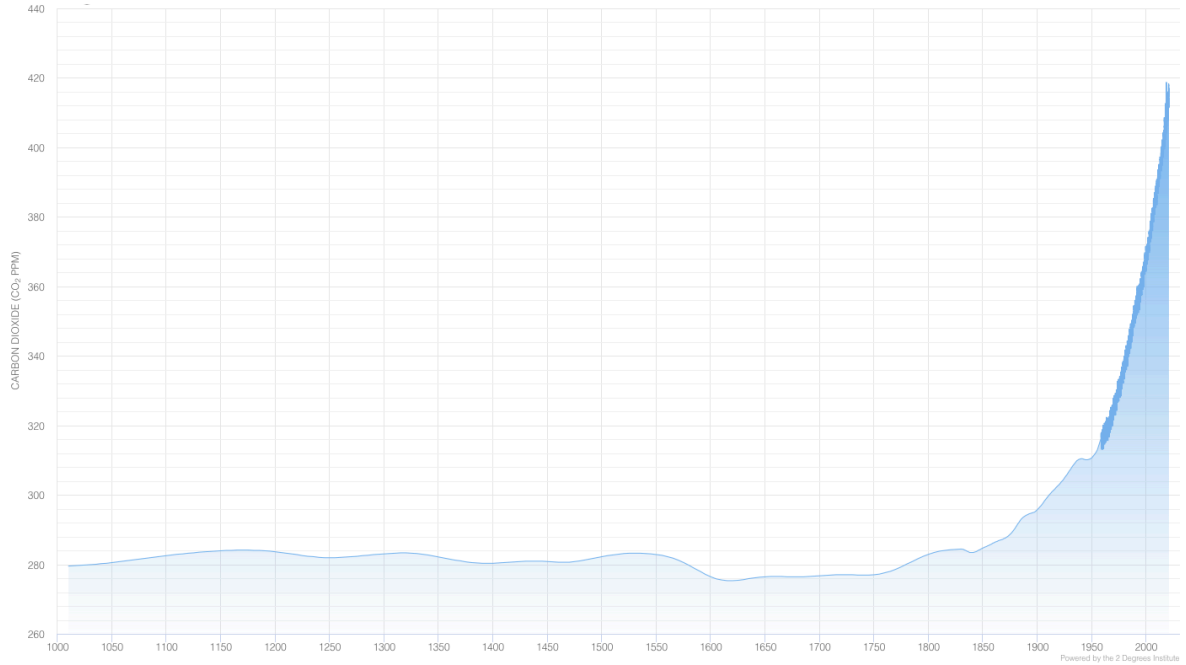
Since the Industrial Revolution, humans have been pumping enormous additional quantities of carbon dioxide into the atmosphere due to the burning of fossil fuels: coal, oil and natural gas. Fossil fuels are naturally occurring substances that were formed millions of years ago from the remains of dead plants and sea-creatures.

When these fuels are burnt, the carbon compounds that have remained trapped underground for millions of years are converted into carbon dioxide and released, adding extra carbon dioxide into the atmosphere that would not naturally be there.

In addition, deforestation on massive scales to clear land for agriculture and livestock has released huge amounts of carbon dioxide back into the atmosphere, and has also meant that there are increasingly fewer trees to absorb excess carbon dioxide from the air (see section on deforestation).

At the same time as humans have been burning fossil fuels and clearing forests, they have also been churning up our planet's soils through intensive farming practices. Healthy soils hold around 70% of the planet's land-based organic carbon. However, when soil is repeatedly ploughed or compacted by heavy machinery or livestock, its ability to store carbon is compromised and vast quantities are released back into the atmosphere in the form of carbon dioxide (see section on soil degradation). The graph below shows just how strikingly carbon dioxide levels have changed over the past 1,000 years.

Carbon dioxide levels in the atmosphere over the past 1,000 years



It's not just carbon dioxide levels that are increasing due to human actions. Methane levels have more than doubled in the last 150 years. Leaks from the oil and gas industry contribute heavily to the amount of methane in our atmosphere, but the waste sector and agriculture are also major sources. There has also been a huge increase in the number of rice-producing paddy fields and in the breeding of cattle for the meat and dairy industries. Microbes in the waterlogged soils of flooded rice fields

release large quantities of methane, as do cows and sheep when they burp and fart due to the presence of similar kinds of microbes in their stomachs that help them to digest grass. In addition, fertilisers and animal waste produce large quantities of nitrous oxide, increasing its levels by around a third in the past 150 years. (See sections on intensive agriculture and livestock farming).

As our greenhouse gas emissions have risen, so too have global temperatures.

What are greenhouse gas emissions like today?

"More than half of all industrial emissions of carbon dioxide since the dawn of the Industrial Revolution will have been released since 1988"
Dr. Peter C. Frumhoff, Director of science and policy at the Union of Concerned Scientists

Due to a deadly combination of burning fossil fuels and changes in land use, we are currently pumping out a whopping great 110 million tonnes of carbon dioxide into the atmosphere every 24 hours. That's over 40 billion tonnes a year! Over the past 60 years, the annual rate of increase in atmospheric carbon dioxide has been about 100 times faster than any previous natural increase in at least the last 800,000 years, such as those that occurred at the end of the last ice age around 12,000 years ago - see graph in section on how natural fluctuations in carbon dioxide have affected the Earth's temperature.

Carbon dioxide concentrations are now over 414 parts per million and rising, an increase of over 45% on pre-industrial levels. That's the highest level seen in at least the last 3 million years.

The scary thing is that because carbon dioxide stays in the atmosphere for such a long time, even if we completely stopped emitting it today we would not reverse the warming that it has caused. It's like filling a bathtub with the plug in it: the water level will keep going up as long as the tap is on, but once you turn the tap off it won't go down unless you *remove* water from the tub. Likewise the level of carbon dioxide and the heating it causes depends on the total amount of carbon dioxide emitted over time, and temperatures will not go back down even once we stop emitting carbon dioxide. If we want to reduce global temperatures, we will have to actively *remove* carbon dioxide from the atmosphere, something which might be impossible to do at the scale required.

This means that the only way we can definitely avoid catastrophic and irreversible damage to our planet is if we reduce carbon dioxide emissions to zero *before* we

reach the level of heating that would cause such changes. This leads to the concept of a “carbon budget” - the maximum amount of carbon dioxide we can emit over the whole century if we want to stay below a certain temperature.

The picture is slightly better for the shorter-lived greenhouse gases, such as methane. Just like how in an *unplugged* bathtub the water level will drop as soon as the tap is turned off, if we stopped emitting methane today, the amount that it heats the atmosphere would drop almost immediately. This makes reducing methane emissions a very effective way to slow the rate of global heating.

However, there is much more carbon dioxide in the air than other greenhouse gases and it stays in the atmosphere for longer, so reducing carbon dioxide emissions is still the most important factor in determining how much the Earth heats up *overall*. So if we want to keep the global temperature rise to below 1.5°C, it is essential that we rapidly reduce global emissions of *both* short- and long-lived greenhouse gases.

Yet despite all the policies and pledges from the government, global greenhouse gas emissions continue to shoot up at an alarming rate. Whilst there has been a recent drop in emissions due to the COVID-19 pandemic, the short term effects on climate will be minimal, and unless concerted effort is taken to stop fossil fuel development in the recovery period it will only be a temporary dip in a long-term upward trend. If this is a hole we need to get out of, we’re still digging.

Indeed, Fatih Birol, executive director of the International Energy Agency and one of the world’s foremost energy experts has warned that we have to act quickly if we want to change the course of the climate crisis and prevent a post-lockdown rebound in greenhouse gas emissions that would overwhelm efforts to stave off climate catastrophe. Birol said: “This year is the last time we have, if we are not to see a carbon rebound.”

We have been warned over and over!

"Future generations are unlikely to condone our lack of prudent concern for the integrity of the natural world that supports all life"
Rachel Carson, SIlent Spring, 1962

The risks of climate change and ecosystem collapse as a result of human action have been known about for many decades. Yet global greenhouse gas emissions have continued to rise steeply.

In 1949, Professor Aldo Leopold, ecologist at the University of Wisconsin, made clear the damage we were doing to our land: "One of the penalties of an ecological education is that one lives alone in a world of wounds. Much of the damage inflicted on land is quite invisible to laymen. An ecologist must either harden his shell and make believe that the consequences of science are none of his business, or he must be the doctor who sees the marks of death in a community that believes itself well and does not want to be told otherwise."

Global warming and its associated risks have been known about for over 40 years. Back in the 1970s, American multinational oil and gas corporation Exxon were aware of the likelihood and risks of human caused climate change.

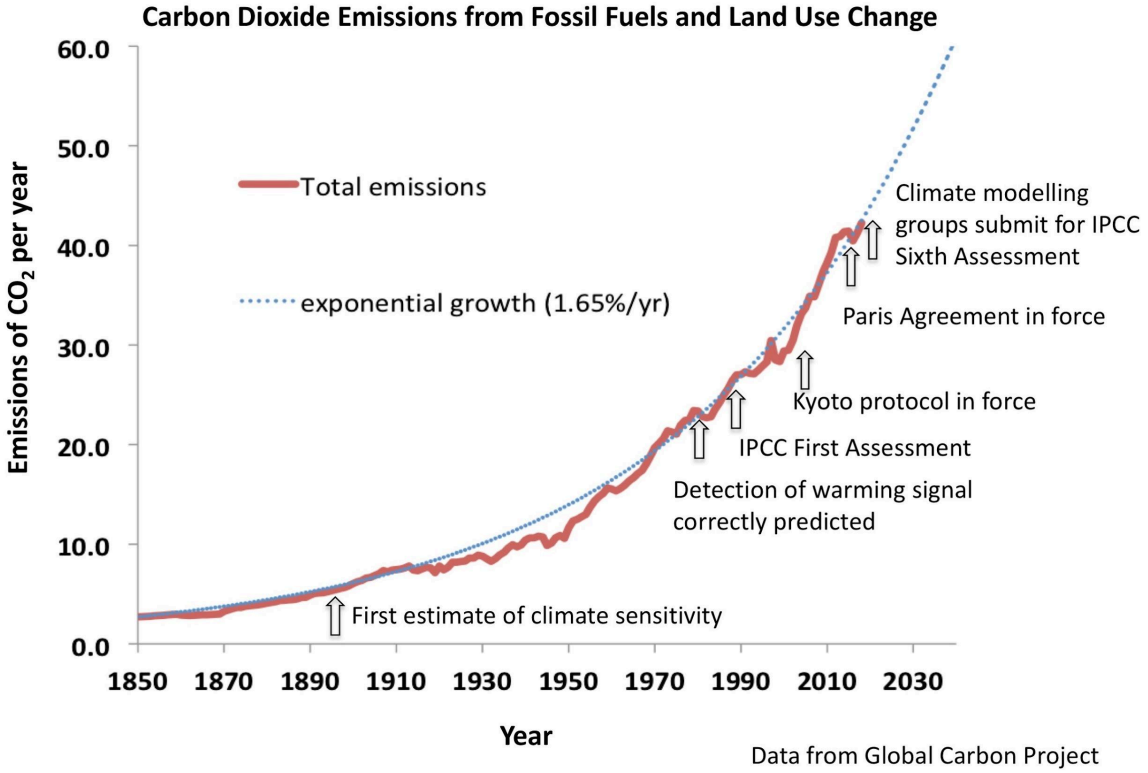
In 1988, climate scientist James Hansen testified before the US congress, provoking the New York Times headline: “Global Warming Has Begun, Expert Tells Senate”. That same year, the Intergovernmental Panel on Climate Change (IPCC) - a massive body of thousands of scientists who volunteer their time to review the science relating to climate change - was founded as part of the United Nations to inform international negotiations. Since then the IPCC has published five massive reports, and many more interim reports, detailing the science of climate change in ever-starker detail.

Yet the warnings were ignored or down-played.

In 1992, the Union of Concerned Scientists, including the world’s leading scientists and the majority of living science Nobel laureates, published the “World Scientists’ Warning to Humanity”, calling on humankind to curtail environmental destruction and warning that “a great change in our stewardship of the Earth and the life on it is required, if vast human misery is to be avoided.” The authors feared that humanity was pushing Earth’s ecosystems beyond their capacities to support the web of life, and described how we are fast approaching many of the limits of what the biosphere can tolerate without substantial and irreversible harm. They implored that we cut greenhouse gas emissions and phase out fossil fuels, reduce deforestation, and reverse the trend of collapsing biodiversity. Indeed, a few years later, in 1995, the UN Environment Programme also warned that the Earth’s biological resources were under serious threat.

The warnings were still not heeded. On the contrary, the rate of greenhouse gas accumulation in the atmosphere between 1987-2019 (since when the dangers were first known) was *four and a half times faster* than it was between 1955-1986. In fact, more than half of our total fossil fuel emissions have been emitted in the last three decades. The graph below shows just how *rapidly* and how *consistently* our

emissions have been rising, even since various climate warnings have been issued and climate treaties negotiated.



In 2017 there followed a second, even more urgently worded letter from the Union of Concerned Scientists: "World Scientists' Warning to Humanity: A Second Notice", which was signed by more than 15,000 scientists. A few years later, the urgency was made crystal clear by more than 13,000 scientists from 156 countries who signed the "World Scientists' Warning of a Climate Emergency". In it they declared that "Scientists have a moral obligation to clearly warn humanity of any great existential threat … Based on this obligation and the data presented below, we herein proclaim ... a clear and unequivocal declaration that a climate emergency exists on planet Earth."

Now, after almost 40 years of warnings and 30 years of international climate negotiations, we have precious little to show for it. On the contrary, carbon emissions from burning fossil fuels have *increased* by over 50% since 1990. If we are to prevent disaster the time for action is now.

As Professor Sherwood Rowland, Nobel Prize Winner in Chemistry for discovering how we were destroying the ozone layer said: "What's the use of having developed a science well enough to make predictions if, in the end, all we're willing to do is stand around and wait for them to come true?"

Part 2: It’s getting hot in here… What’s already happening to our planet as a result of global heating and why?

What is already happening to our weather?

More extreme weather

“World leaders should be listening not just to scientists but also to the people who are being affected by extreme weather events right now. They are seeing it with their own eyes and suffering from it. Humanity just won’t be able to cope with the world we are heading for.”
Professor Peter Stott, the Met Office

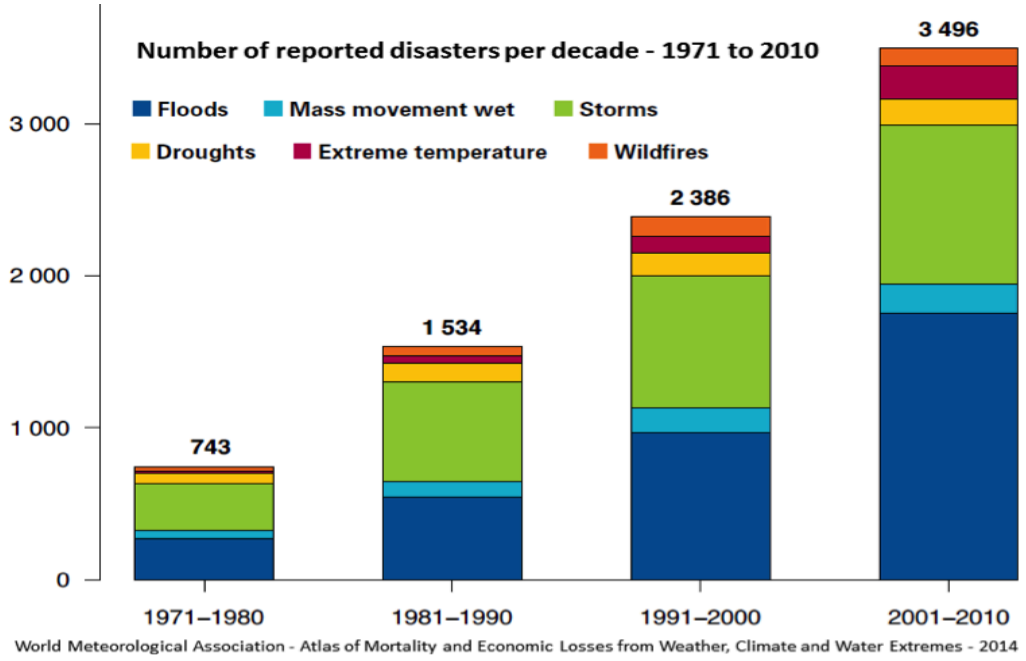
“The analysis clearly shows climate change has already changed our weather patterns and is having adverse effects on people’s lives. It is beholden on all governments to take heed of these warnings and start cutting carbon emissions as quick as possible.”
Professor Mark Maslin, University College London

"We are seeing increases in extreme weather events that go well beyond what has been predicted or projected in the past. We're learning that there are factors we were not previously aware of that may be magnifying the impacts of human-caused climate change... Increasingly, the science suggests that many of the impacts are occurring earlier and with greater amplitude than was predicted"
Professor Michael Mann, Director of the Earth System Science Center at Pennsylvania State University

Global heating is having a huge impact on our natural weather systems. This is because the increased amount of heat energy trapped in the Earth’s atmosphere and oceans (as a result of greenhouse gas emissions) increases the *total amount of energy* in our weather systems. As a result, global heating doesn't just cause an overall rise in global temperatures, it also leads to more frequent and more extreme heatwaves, heavier rainfall, and more intense tropical storms and hurricanes. Generally, wetter areas are getting wetter, increasing the risk of flooding, and dryer areas are getting drier, increasing the risk of droughts and forest fires.

There also is growing concern that global heating might be causing further disruption to our weather by *weakening the jet stream* - an air current that carries air around the globe and contributes to worldwide weather patterns. It is thought that a weakening of this current could lead to a "blocking" of our weather systems, increasing the likelihood of extreme weather events such as storms and floods, and making heatwaves and droughts last for longer periods of time. This could also explain why some areas are having more extreme cold periods despite the world getting hotter overall.

The number of extreme climate-related disasters - including extreme heat, droughts, floods and storms - has doubled since the early 1990s and studies have shown that more than two thirds of all extreme weather events investigated were made more likely, or more severe, by human-caused climate change.



Such extreme weather events are having devastating impacts on agriculture, leaving millions of people in need of humanitarian aid and costing taxpayers billions of dollars. In the first six months of 2019, extreme weather events displaced a record seven million people from their homes.

It should be noted that the total number of people killed by such events is actually decreasing - an argument used by climate skeptics to claim that such events are not getting more frequent. On the contrary, this just shows that we are getting better at *predicting* extreme weather events and getting people out of harm's way in time. Looking only at death rates massively misrepresents the human, agricultural and financial impacts of the ever-increasing numbers of extreme weather events.

Indeed, the economic costs of damage caused by natural disasters are skyrocketing. Whilst its true to say that 'natural disasters' include those not related to climate change, and economic costs can go up simply due to there now being more infrastructure that can be damaged, we know that financial losses due to extreme weather events are rising faster than those due to non-climate related disasters, such as Earthquakes.

Indeed, in 2017 extreme weather disasters caused overall losses of US$340 billion, the second-highest annual loss ever. Less than half of these losses were covered by insurance. According to Morgan Stanley, from 2016-2018 climate-related disasters cost the world $650 billion.

Christiana Figueres, former United Nations' Climate Chief, warned: "We are moving towards a world that the insurance industry calls systemically uninsurable because the degree of destruction will be such that the insurance companies cannot deal with the level of risk that would be brought upon us. The expense of a constant construct, reconstruct, reconstruct, frankly, no country can afford."

The McKinsey Global Institute Climate Risk and Response Report 2020 warned: "Greater awareness of climate risk could make long-duration borrowing more expensive or unavailable, impact insurance cost and availability, and reduce terminal values. This could trigger capital reallocation and asset repricing. This recognition could happen quickly, with the possibility of cascading consequences."

The following sections explain some specific ways in which global warming is *already* affecting our weather. Follow the links to read about how extreme weather is predicted to be impacting our world by 2050 or by the end of the century.

Longer and more intense heatwaves

"These records will be broken in a few years. What we see with European heatwaves is that all the climate models are underestimating the change that we see."
Friederike Otto, Associate Professor Climate Research Programme, University of Oxford

As global temperatures increase, not only does the average day in many locations become hotter, but the chance of extremely hot days is greater too – increasing the frequency and intensity of heatwaves. Indeed, studies have shown that human-induced warming has made scorching heatwaves significantly more likely

and also more intense when they hit. There have now been more than 230 attribution studies around the world and these have found that 95% of heatwaves were made more likely or worse by climate change.

Heatwaves are intensified in areas where the land is already dry, as dry soils can't absorb as much heat. As a result, more heat is radiated back into the atmosphere, leading to even more sustained heating. This worrying feedback loop can trigger 'mega-heatwave' events. See section on drying soils and mega-heatwaves.

The mega-heatwave that struck Europe in 2003 was made at least twice as likely due to climate change and approximately 70,000 more people died than usually die in an average year - the vast majority of these deaths were directly attributable to the extreme temperatures. This record breaking heatwave also had a massive impact on ecosystems across Europe and caused over $15 billion in economic losses. A more recent analysis from 2014 calculated that, due to the warming seen in just the course of a decade, a similarly extreme event is already about ten times more likely than in 2003.

During the Russian mega-heatwave of 2010, made at least three times more likely by man-made climate change, Russia's wheat harvest declined by 40% - contributing to a global wheat shortage as well as a 90% increase in international grain prices - leading to economic losses of more than $15 billion.

In 2017, 157 million more people worldwide were exposed to heatwaves than in 2000, and hotter weather contributed to the loss of 153 billion hours of labour (a 60% increase from 2000) as workers in construction, farming and other industries had to stop work, often reducing the family income. In India, heat caused the number of hours worked to fall by almost 7%, whilst in England and Wales there were 700 more deaths than normal during a 15-day hot spell in June and July.

In 2018, unprecedented heat and wildfires that "could not have occurred without human-induced climate change" swept across the northern hemisphere with at least 224 locations around the world experiencing all-time record-breaking heat. A record 220 million more over 65s were exposed to heatwaves compared with 2000. The sweltering heat that the UK experienced that summer was made 30 times more likely by climate change. The 2018 heatwave in Japan, which led to over 1,000 deaths, was *so severe* that researchers said that it "could not have happened without global warming."

In 2019 nearly 400 temperature records were broken across 29 countries, with July being the hottest month *ever recorded*. Studies show that the searing mega-heatwaves that summer would have been *extremely unlikely* without climate

change. Indeed, climate change made the sort of extreme heat felt in France and the Netherlands that summer up to 100 times more likely to occur whilst the record-breaking temperatures in the UK were around 20 times more likely to have occurred. Following record breaking heat that led to the hottest day ever recorded in Australia, Dr Sophie Lewis, a climate scientist at the University of New South Wales, said "It's not just the frequency that we're breaking them [temperature records], it's the margin... We're now seeing temperatures that are occurring outside what we'd expect from natural variability alone".

As of July 2020, January 2020 was the warmest January ever recorded in Europe, and Siberia faced a record breaking heatwave, made some 600 times more likely due to climate change, which saw temperatures as high as 38°C in the Arctic Circle. We have just seen the hottest May ever recorded and we now have an 85% chance that 2020 will be the hottest year on record.

What is of particular concern is that the heatwaves hitting Europe have been even more frequent and severe than climate models have predicted. Experts say that Europe and the eastern Mediterranean appear more vulnerable to hotter temperatures than Africa and Southeast Asia, largely because so many older people (who are particularly at risk from increasing temperatures) live in cities which trap heat and can therefore be hotter than surrounding areas.

It is not just human health but also infrastructure that suffers under increased heating. Alex Hynes, Managing Director of Scotland's railway, warned "Britain's railways can no longer cope with the effects of the climate crisis."

Follow the links to read about how more intense heatwaves are predicted to be impacting our world by 2050 or by the end of the century.

Longer and harsher droughts

"An estimated 3.6 billion people (nearly half the global population) already live in areas that are potentially water-scarce at least one month per year."
United Nations world water development report, 2018

Warmer air is able to hold more water vapour. This means that in areas where the air is already dry, global heating makes it even less likely that water vapour in the air will condense to form clouds, resulting in reductions in rainfall and increasing the chance of droughts. To make matters worse, drier soils caused by increased temperatures exacerbate the impacts of reduced rainfall, leading to longer and deeper droughts -

with major impacts on global food production and water availability (see sections on impacts on food production and water availability).

It has been proposed that the severe drought experienced by Syria between 2007-2010, made more likely by global heating, was a key factor that contributed to the outbreak of civil war which started in 2011.

The Western US has been crippled by droughts in recent years. The "exceptional" drought in California between 2010-2014 was made much more likely by climate change.

In 2015 a drought in Southern Africa, made up to three times more likely by climate change, reduced agricultural outputs by 15%, whilst in 2017 a drought in East Africa - made up to twice as likely by climate change - displaced around 800,000 people in Somalia. In 2018 an intense drought in Cape Town, made three times more likely by climate change, led to severe water restrictions being put in place and the city came to within days of turning off its water supply: dubbed 'Day Zero'. It has been calculated that climate change made the chance of a drought this severe go from a "once in 300 years" event to a "once in 100 years" event.

In 2019, Australia's Murray-Darling basin saw its most severe drought in 120 years of records and Tasmania had the driest January in 120 years, whilst parts of Zimbabwe had the lowest rainfall since 1981, contributing to making more than 5.5 million people at risk of extreme food insecurity. India experienced a harsh drought followed by a searing heatwave, with Chennai being left nearly out of water as its reservoirs ran dry. Global heating has also been directly linked to the "megadrought" that's currently gripping the South West United States, the worst in over 500 years.

Follow the links to read about how increased droughts and water shortages are predicted to be impacting our world by 2050 or by the end of the century.

More forest fires

"What climate change does is exacerbate the conditions in which the bushfires happen."
Dr Imran Ahmed, climate scientist at the Australian National University

The hot, dry conditions produced as a result of climate change also increase the chance of - and spread of - forest fires. Indeed, hotter years have been shown to have more fires and the 2019 Lancet Countdown report found that human exposure

to wildfires has doubled since 2000. Wildfires can also dramatically increase air pollution - see section on how we are polluting our air.

Wildfires are Earth's greatest natural disturbance affecting an area the size of India every year. Large forest fires in the western United States have become five times more frequent since the 1970s and 80s, scorching over six times as much land, and lasting almost five times as long.

Indeed, recent years have seen record-breaking wildfires take hold across the globe. The UK saw a record breaking number of fires in 2019 leading scientists to conclude that climate change "has already led to increasing wildfire risk". This included the Saddleworth moor fire, which burned during the UK's warmest winter day on record.

In 2016, the Fort McMurray Fire in Canada, estimated to have been made up to six times more likely by climate change, burnt through 1.5 million acres of forest, burned 2,400 homes and buildings and caused 80,000 people to flee their homes - resulting in $10 billion in damage. The devastating recent bushfires in Australia are now estimated to have burnt 20% of Australia's forest cover, destroyed more than 1,500 homes and killed over 1 billion animals. Experts had been warning for years that a hotter, drier climate would contribute to bushfires becoming more frequent and more intense.

Wildfires have also decimated more than 52,000 square miles of Arctic forest in Siberia, with 11,000 square miles destroyed in just 3 months, making it the largest wildfire disaster in the history of Russia. Other huge areas of the Arctic caught fire too, from eastern Siberia to Greenland to Alaska, with more than 4,000 square miles of forest burned in Alaska. Thomas Smith, an Assistant Professor in Environmental Geography at the London School of Economics, told USA Today: "These are some of the biggest fires on the planet, with a few appearing to be larger than 380 square miles."

To make matters worse, these Arctic fires are having huge knock-on effects on global warming. Smith said: "The fires are burning through long-term carbon stores (peat soil) emitting greenhouse gases, which will further exacerbate greenhouse warming, leading to more fires."

More extreme storms and floods

"There's this remarkable building of this body of evidence that we're making these storms more deleterious."

Dr. James Kossin, Atmospheric Research Scientist, National Oceanic and Atmospheric Administration

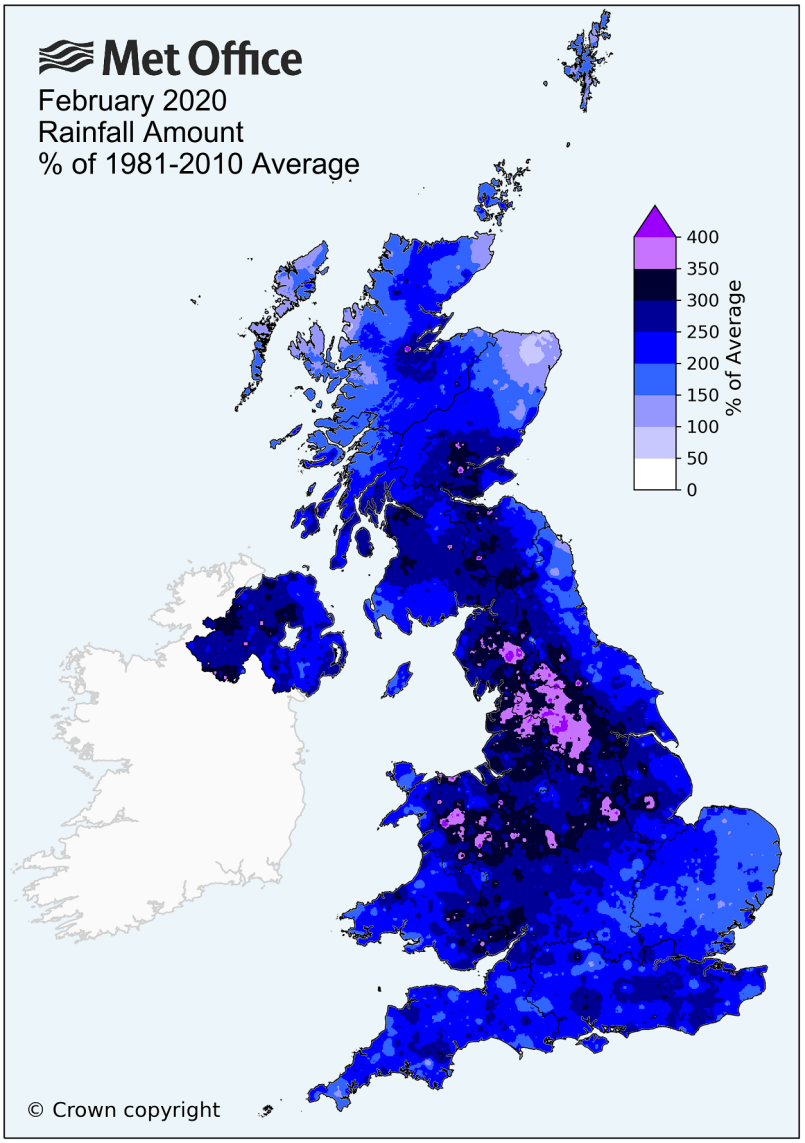
As global temperatures rise, warmer air and warmer seas result in an increase in the amount of water evaporating from the oceans. Warmer air is also able to *hold* more water vapour - its capacity increasing by 7% for each additional 1°C of heating. The resulting excess of water vapour in the air means that when the air eventually cools down enough for clouds to form, not only will there be more frequent rainfall than usual but there's also a greater chance that downpours will be heavier. This results in more extreme rainfall, storms and floods, with major impacts on food production. Indeed, 18% of extreme rainfall events are directly attributable to the heating we have already seen.

For example, extreme rainfall is increasing across the United States - in the North East the number of downpours have increased by a whopping 71% since the 1950s. This increase in rainfall is leading to worse flooding in many areas. Following the wettest 12 consecutive months in US history there were major floods in the Midwest: the Mississippi river saw high water in every sub-basin, with one town seeing over 200 consecutive days of flooding. The flooding massively delayed planting and suppressed yields for soy and corn across the region, prompting a plant biologist from the University of Illinois to state "we are living climate change right now."

In 2020 we have already seen more record breaking flooding around the world. At the beginning of the year 175,000 people were displaced in Jakarta following its most intense rains on record. Japan's Kyushu region also experienced record breaking rainfall, with over 100 mm of rain falling in an hour. Over one million people were evacuated and thousands of properties were destroyed. Parts of China have also seen their worst rainfall since records began, with 40 million people affected as 33 rivers rose to their highest levels in history resulting in major flooding along the Yangtze, inflicting billions of dollars worth of damages.

Studies show that climate change has increased the extent and frequency of flooding in the UK and other parts of northern Europe too - particularly in parts of Northern and Western Britain. Indeed, the UK Met Office reports that climate change is causing heavy rainfall events to be getting more frequent in the UK. Extended periods of extreme winter rainfall in the UK, similar to those seen in winter 2013-14, are now about seven times more likely due to human-induced climate change and the heavy rains associated with Storm Desmond, an extratropical cyclone that hit the UK, Ireland and parts of Northern Europe in 2015, were made about 60% more likely due to human-induced climate change.

The UK saw extreme flooding in February 2020, with the Met Office declaring that it was the wettest February on record. Three storms battered the UK with weeks of heavy rain and gales of up to 70 mph and the Environment Agency was forced to declare a record 594 simultaneous flood warnings across England. Some regions received over 400% of their previously normal rainfall, and in East Yorkshire 78 homes and businesses experienced severe flooding, with some homes left almost completely underwater. In Wales, a month's worth of rain fell in 48 hours and the flooding of the River Wye was over half a metre bigger than anything seen for 110 years. The Environment Agency warned that people in the UK need to brace themselves for "more frequent periods of extreme weather like this" because of climate change.



The record-breakingly wet February had followed a series of record floods across the UK the previous November, when several areas in Yorkshire and Derbyshire were

struck by a month's worth of rain in a single day and the river Don reached record levels, with some villages hit by their third “once-in-a-lifetime” deluge in the past 20 years. More than 500 homes were flooded and more than 1,000 properties were evacuated.

Dr John Marsham, a climate change researcher at the University of Leeds and the National Centre for Atmospheric Science, told the Yorkshire Evening Post that the extreme weather is proof of a climate emergency. He said: "It is exactly what we expect from our climate change research, the UK is getting hotter and you can see that in the Met Office report. We're headed towards catastrophic damage. It's going to get worse and we have to adapt quickly. What we do in the next 10 years is critical to avoid catastrophic climate change."

To make matters worse, nearly half of the world’s coastal wetlands, which usually provide *natural protection* from storm surge flooding (as well as being important stores of carbon), have been lost over the last 100 years – due to sea level rises, global heating, human activity, and extreme weather events. Indeed, areas with more wetland coverage experience significantly less property damage from storms and floods (see section on wetlands).

Aside from the direct impacts on people’s lives, homes and businesses, flooding can also cause hazardous chemicals from old mines, industrial sites and sewage works to be swept up and dumped into rivers and onto farmland, posing a major threat to human health and ecosystems. After floods in the UK in 2012, levels of lead were much higher in rivers and were sufficient to kill farm animals grazing on the land. Following the floods resulting from Hurricane Harvey, there were several incidents of leaks at toxic waste sites around Houston, and a new report found around 2000 similar sites near the coast of the US are in danger of being flooded. This will be a big issue with flooding in the future.

Storms and floods also have huge economic impacts, and some insurance companies are already warning that they will soon stop insuring basements in London, New York and Mumbai.

The UK Environment Agency estimated that the floods in England in 2007 cost £3.2 billion and that the cost of winter floods across the UK in 2015 were around £1.6 billion, with insurance policies of many of those worst hit not covering the full losses. The clean-up bill following the storms in the UK in February 2020 is set to top £360 million, with the average household claiming £36,000 on insurance. The UK National Audit Office estimates that for every £1 spent on protecting communities from flooding, around £9 in property damages and wider impacts can be avoided.

Follow the links to read about how more intense storms, floods and hurricanes are predicted to be impacting our world by 2050 or by the end of the century.

Stronger hurricanes

"Unrestrained climate change means we will see many more [Hurricane] Harveys in the future."
Professor Michael Mann, Director of the Pennsylvania State Earth System Science Centre

Rising temperatures are causing a supercharging of hurricanes, whereby hurricanes become more intense, produce more rainfall and cause higher storm surges - increasing the risk of major damage from such events. Indeed, the proportion of tropical storms that have rapidly strengthened into powerful hurricanes has tripled over the past 30 years. Tropical storms are also being diverted away from their usual tracks, meaning more coastal cities are now in their path.

In recent years we have seen a series of extremely powerful storms, including Hurricane Patricia in 2018 - the strongest storm on record with sustained winds over 200 mph. Indeed, of the seven cyclone regions studied by scientists, since 2013, five have had the strongest storm on record - which would be extremely unlikely just by chance.

One of these storms was Typhoon Haiyan, which struck the Philippines and killed 8,000 and displaced 4 million people due to a massive 20-30 foot storm surge. The ocean temperatures in the Western North Pacific had increased dramatically in recent years, at least in part due to global heating, providing more favourable conditions for the formation of such incredibly powerful storms.

Hurricane Harvey is estimated to have displaced 30,000 people and caused up to $125 billion dollars worth of damages, making it one of the costliest tropical storms to ever strike the United States. Harvey broke records for the most rainfall ever from a single storm in the US, with some parts of Housten receiving over 1.5 m of rainfall. It's been calculated that 20 trillion gallons of water fell over East Texas. Scientists studying the event concluded that climate change made the rainfall about 8-19% more intense, or, to put it another way, three quarters of the economic damages due to the intense rainfall were attributable to human caused climate change.

Just weeks after Harvey struck Texas, Maria, the strongest storm of 2017 (a category 5 hurricane), devastated the caribbean including the islands of Dominica, St Croix and Puerto Rico and killed 2,900 people. It is estimated to be the third costliest storm on record (next to Harvey and Katrina). Scientists who have studied this storm also say that climate change increased the likelihood of the record breaking extreme rainfall of this storm by nearly a factor of five.

In 2019, cyclone Idai struck Mozambique, Zimbabwe and Malawi. Over 600,000 people were displaced. In the city of Beira alone nearly 80% of homes and public infrastructure were destroyed and a cholera outbreak followed in the storm's wake. The huge destruction caused by cyclone Idai makes it the costliest tropical cyclone ever in the South-West Indian Ocean basin. When asked whether Idai was linked to global heating, Dr Friederike Otto of Oxford University, said “There are three factors with storms like this: rainfall, storm surge and wind. Rainfall levels are on the increase because of climate change, and storm surges are more severe because of sea level rises.”

Hurricane damage is exacerbated by losses in wetlands. Indeed, recent wetland losses are estimated to have increased the property damage from Hurricane Irma in 2017 by $430 million.

Follow the links to read about how more intense storms, floods and hurricanes are predicted to be impacting our world by 2050 or by the end of the century.

What is global heating doing to our oceans, coastlines and wildlife?

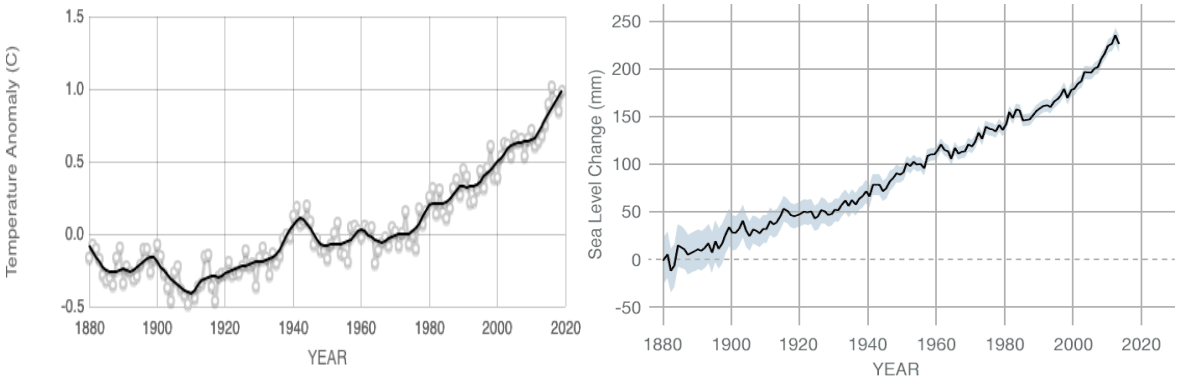
Melting ice and rising seas

“Sea level is rising much faster and Arctic sea ice cover shrinking more rapidly than we previously expected. Unfortunately, the data now show us that we have underestimated the climate crisis in the past.” Stefan Rahmstorf, Professor of Physics of the Oceans, Potsdam University

As atmospheric conditions get hotter, the water in our oceans heats up too. Indeed, over 90% of the increased heat trapped in our atmosphere is being stored in the oceans. In 2019, the heat in the world’s oceans reached a new record level, confirming “irrefutable and accelerating” heating of the planet. It has been calculated that the heat energy being absorbed by the oceans is the equivalent of between 3 to 6 Hiroshima-size atomic bombs every second.

All this this extra heat causes the water to expand and take up more space, resulting in rises in sea levels.

Changes in global temperatures and sea levels since 1880



In addition, hotter water in our oceans, along with hotter air in our atmosphere, leads to the melting of sea ice, ice sheets and mountain glaciers. Fortunately, when sea ice melts it doesn't affect sea levels - just like how an ice cube melting in a glass of water doesn't cause the water level to go up. However, when *land-based* ice sheets and glaciers melt, the water runs off into the sea, causing sea levels to rise - just like what would happen if you added another ice cube to the glass of water and waited for it to melt.

In the Arctic, the area covered by sea ice in the summer has shrunk by 40% since 1979 and is now declining at a rate of 12.8% per decade. Compared to the average sea ice cover between 1981 and 2010, we have now lost about two million square km of ice - that's an area larger than Alaska and California combined. As of July 2020 the sea ice was yet again at a record low for the time of year, and this year may break the record for lowest annual minimum previously set in 2012. Arctic sea ice is what polar bears use to hunt seals on, so they are now being forced to forage on land where they have difficulty in finding prey. Dr Steve Amstrup, chief scientist at conservation organisation Polar Bears International warned: "If we allow the sea ice loss to continue, all the polar bears will soon be gone."

The Greenland ice sheet, the second largest in the world, is losing ice seven times faster than in the 1990s, whilst the Antarctic ice sheet has lost three trillion tonnes of ice in the past 25 years and is now losing 252 billion tonnes a year - that's six times more than it was 30 years ago.

Overall, over the past 40 years the amount of ice we have lost from our planet averages out to the loss of around 300 double-decker-sized chunks of ice... EVERY SECOND.

What's even more concerning is the fact that the scale and speed of ice sheet loss is *faster* than models have predicted, threatening inundation for hundreds of millions of people. The Antarctic ice sheet is losing mass at an accelerating pace and it is thought that some regions may be reaching a tipping point, potentially leading to rates of sea level rise at least an order of magnitude larger than those observed now.

Dr. Louise Sime, Climate Scientist at the British Antarctic Survey, said: "This finding should be of huge concern for all those who will be affected by sea level rise. If this very high rate of ice loss continues, it is possible that new tipping points may be breached sooner than we previously thought."

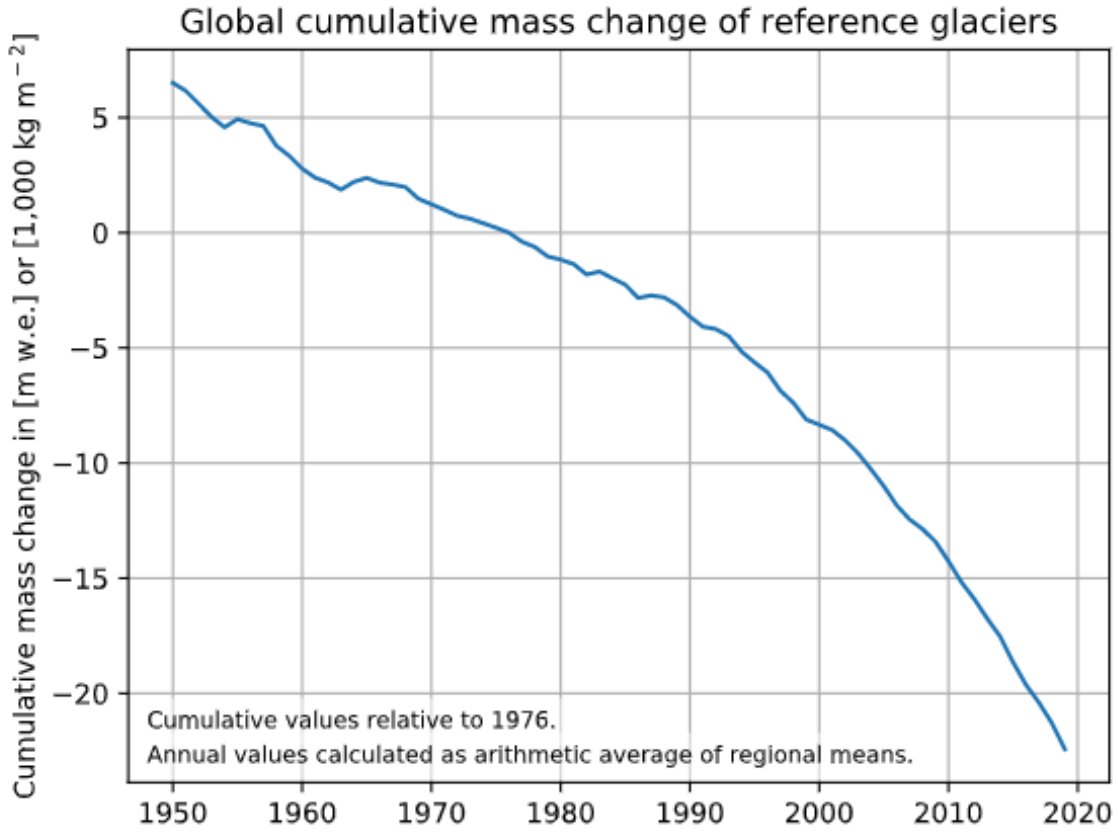
The 'fast melting' part of the ice sheet is already showing signs of an "unstoppable and irreversible" collapse which would lock in around one metre of sea level rise. Indeed, in January 2020, scientists revealed that a massive sheet of ice in the Thwaites Glacier in West Antarctica, known as the "doomsday glacier", is melting far faster than experts had previously thought, with "huge implications" for global sea level rise. David Holland, Professor of Atmosphere and Ocean Science at NYU, said: "That is really, really bad. That's not a sustainable situation for that glacier."

Our glaciers are melting too. Melting glaciers are not only responsible for about a third of our observed sea level rise, but mountain glaciers also store up water and release it in the dry season, making them an important source of water in mountain areas. Indeed, drainage basins from glaciated mountain ranges cover 26% of the global land surface (outside of Greenland and Antarctica), and are lived in by almost one-third of the world's population. There are currently about 1.9 billion people across the globe living downstream of mountain glaciers, depending on water from these glaciers for irrigation, hydropower, domestic consumption and industry and who would be negatively affected by their loss.

In 2018, the World Glacier Monitoring Service reported the *30th consecutive year* that global glaciers had lost mass. The European Alps have lost over a billion tonnes of ice since the year 2000 and are continuing to lose 1.2% of their mass every year. A study of the Himalayas found that glaciers there are now melting twice as fast as they were between 1975 and 2000 and are losing 8 billion tonnes of ice a year - that's the equivalent to 3.2 million Olympic-sized swimming pools.

The Andes are estimated to be losing an even more alarming *23 billion tonnes* of ice each year, with glaciers in the tropical Andes having already shrunk by 30-50% since 1970. For example, the glaciers of Bolivia shrank by 43% between 1986 and 2014. Researchers point out that these dwindling glaciers are estimated to "provide 20% to 28% of water for El Alto and La Paz. Therefore glacier loss will have a considerable

impact, which will be felt particularly during the dry season, when glacial water provides the majority of urban water. The glaciers and mountain water systems also support agriculture, power generation and natural ecosystems throughout the region."



Loss of homes due to rising seas

"The shock for us was that tidal flooding could become the new normal in the next 15 years; we didn't think it would be so soon… If you live on a coast and haven't seen coastal flooding yet, just give it a few years. You will."
Dr. Melanie Fitzpatrick, climate scientist with the Union of Concerned Scientists' Climate Program

"[The impacts of tidal flooding] are happening and will be devastating for coastal communities."
Andrew Shepherd, Professor of Earth Observation at the University of Leeds

Rising seas are already displacing hundreds of thousands of people from vulnerable coastal areas in the South Pacific, Indonesia and Bangladesh, and climate displacement is already well underway in places such as Vietnam. Over the past six

decades, much of the Isle de Jean Charles, Louisiana - once home to 400 people - has disappeared due to subsidence caused by oil and gas extraction and now rising sea levels. In November 2019 it was reported that five whole Pacific Islands - part of the Solomon Islands - have now been entirely lost to rising sea levels, with a further six having large parts of their coastline eroded, destroying entire villages.

As a result of a combination of subsidence and rising sea levels, a storm that hit Venice in 2019 caused the worst floods in 50 years and left Saint Mark's Square submerged under more than one metre of water. Saint Mark's Basilica has only flooded six times in the past in 1,200 years - four of these floods were in the last 20 years, with the last one only one year before.

Many coastal cities in the United States are now seeing 'nuisance flooding' at high tide closing roads, blocking drains and damaging infrastructure. According to the National Oceanic and Atmospheric Organization such flooding has already "increased in the U.S. on average by about 50 percent since 20 years ago and 100 percent since 30 years ago." Experts say that, for those living in coastal areas, tidal flooding could become the new normal in the next 15 years.

Follow the links to read about how rising seas and increased coastal flooding are predicted to be impacting our world by 2050 or by the end of the century.

Impacts of heating on ocean life

"Unless we take evasive action, our future oceans will have fewer fish, fewer whales and frequent dramatic shifts in ecological structure will occur, with concerning implications for humans who depend on the ocean."
Dr Éva Plagányi at the Commonwealth Scientific and Industrial Research Organisation, Australia

Scientists have warned that marine heatwaves are sweeping oceans "like wildfires", with extreme temperatures killing swathes of sea-life and destroying crucial species that provide shelter and food to many others - such as seagrass, kelp and corals. In fact, due to the slow response of the oceans to atmospheric heating, we have already locked in a large future increase in marine heatwaves.

Repeated heat stress has now caused nearly half of the world's corals to bleach and then die. Tropical coral reefs are some of the most important and diverse ecosystems on the planet, which support up to one million other species and provide food, protection from storms and livelihoods for nearly one billion people.

As Michael Mann, Professor of Atmospheric Science at Pennsylvania State University, put it: “Our generation is going to be responsible for the loss of one of the most majestic ecosystems on the face of the Earth. We're literally watching the death of this natural wonder.”

Ocean warming not only damages sea life directly, but also causes the oxygen that is usually dissolved in seawater to become less soluble. This leads to areas of water with depleted levels of oxygen, which can lead to suffocation of the sea creatures living within them. The runoff of nutrients from agriculture and sewage further exacerbates oxygen decline in coastal waters through causing the overgrowth of algae. This ‘algal bloom’ blocks sunlight from reaching submerged plants, which die and are fed off by bacteria that use up the oxygen in the water - a process known as eutrophication.

Indeed, in the last 70 years, low-oxygen ocean zones have grown by more than 4.5 million square km - an area roughly as large as the entire European Union - whilst the number of ocean ‘dead zones’ (areas with exceedingly low oxygen) has increased by a factor of 10.

Follow the links to read about how more devastating loss of wildlife is predicted to be impacting our world by 2050 or by the end of the century.

Impacts of carbon dioxide on ocean life

Another impact of increasing greenhouse gas emissions on our oceans is that excess carbon dioxide in our atmosphere dissolves in seawater, making it more acidic. Indeed, more than one third of the carbon dioxide in our atmosphere is absorbed by seawater. Increases in acidity affect marine life, from shellfish like clams and oysters to whole coral reef communities, by removing minerals that they require in order to grow their shells and skeletons. This has knock-on effects on the survival and abundance of a wide variety of species.

The oceans are now 30% more acidic relative to the beginning of the industrial era, making them more acidic than any time in the last 65 million years. Today, ocean acidification is occurring approximately ten times faster than anything experienced during the last 300 million years - jeopardising the ability of ocean systems to adapt.

Impacts of heating on land-based wildlife

"Personally I find the results alarming. Species attempt to adapt to changing environment, but they cannot do it at a sufficient pace to ensure that populations are viable. Climate change has caused irreversible damage to our biodiversity already, as evidenced by the findings of this study. The fact that species struggle to adapt to the current rate of climate change means we have to take action immediately in order to at least halt or decrease the rate."
Viktoriia Radchuk, Leibniz Institute for Zoo and Wildlife Research in Germany

Land-based creatures are extremely sensitive to changes in climate. This is because, over millions of years, wild species have evolved to have *finely tuned adaptations* that allow them to live in the specific climate of their local environment. For example, many are adapted to live at certain temperatures and with certain amounts of rainfall – and are also very sensitive to changes in the daily and seasonal variation in these factors. In fact, the local climate is the primary factor that controls where species live.

What this means is that when the climate changes at any particular location in the world, it has direct and powerful impacts on the local creatures.

We are already seeing many devastating and direct effects of climate change on wildlife, for example, trees dying through insufficient water and animals losing their ability to forage for food because of heat stress - leading to local extinctions.

We are also seeing impacts due to changes in the timings of the seasons, such as the early springs that we are experiencing in some parts of the world (which have become a feature on The News). The problem is, such changes in seasonality are experienced unequally by different species, which leads to mismatches in the timing of important life events for animals and plants. For example,pollinating insects are coming out of hibernation before flowers emerge, and the migration of birds is out of synchrony with peaks in abundance of their prey, leading to poor reproduction and death.

In addition, as weather extremes increase in intensity and frequency due to climate change, wild plants and animals are suffering from events such as droughts, wildfires, and floods. These events alone are pushing some species towards extinction. The intense Australian bushfires of early 2020 have destroyed the habitats of many species, with at least 50 rare animals and plants having had over four fifths of their habitat areas affected. It has been estimated that over 1 billion animals were also killed, and it is feared that this, in combination with loss of habitats, will lead to local extinctions of species like the koala.

Given that today's climate is changing so fast that there is no time for creatures to *adapt*, often the only option for species is to try to *move*– in order to look for new areas that have a suitable climate for them to live in. This may sound straightforward, but, in a rapidly changing climate, species have to shift their ranges *remarkably fast*. Even amongst land mammals, which are much more mobile than plants or insects, it is estimated that, at best, 30% of species will not be able to shift *fast enough* to keep up with climate change. While some species are indeed starting to shift their ranges, this is generally taking place slower than the climate is changing - and there are many species that are not shifting, or that are only shifting only very slowly.

An additional challenge to creatures being able to shift location is that creatures within an ecosystem need to have the very specific species that they interact living alongside them. For example, plants rely on their pollinators, predators on their prey, and herbivores on the plants they eat. So if different creatures in an ecosystem are not able to shift at the same rate, ecological communities will become unstable.

To make matters worse, even if species were to be able to move, many of the cooler or more sheltered places on Earth (that creatures could use to take refuge from increasing temperatures) have now been degraded, fragmented or colonised by human activities.

Plus, there are those animals that require conditions of *extreme cold* for their survival. As global temperatures rise rapidly, there is nowhere on Earth for them to escape to. For example, polar bears usually stand on floating blocks of sea ice when they're out hunting for seals in the freezing Northern seas. However, due to rising temperatures sea ice is rapidly melting so they are now forced to walk or swim enormous distances to get to any remaining ice, or to forage for food on land where they have difficulty in finding prey. Some bears have resorted to travelling south and scavenging for food in places where humans live. In February 2019, 50 polar bears invaded the remote Russian town of Belushya Guba. Videos posted on social media showed the scrawny starving creatures picking their way through rubbish bins, rummaging through dumps and even roaming around inside buildings. Sea ice and land-based ice sheets are also critical for organisms such as whales, seals, and sea birds.

Land-based wildlife is not only being enormously impacted by climate change, but also by land degradation, deforestation, pollution and over-consumption. For lots more information on the devastating impacts that humans are already having on wildlife, see section on how we are destroying our wildlife.

Follow the links to read about the catastrophic loss of wildlife we are expecting by 2050 and by the end of the century.

Part 3: The lie of the land… What other damage are we doing to our planet?

How are we damaging our land and our waters?

"*Surely we have a responsibility to leave for future generations a planet that is healthy and habitable by all species*"
Sir David Attenborough

Loss of natural resources

75% of the Earth's land has now been severely altered by human actions such as industry and farming. Only 13% of the world's oceans remain as wilderness, free from human influence and exploitation. Today, approximately 60 billion tonnes of renewable and nonrenewable resources are extracted globally each year from our ecosystems, nearly twice the figure from 1980. According to some studies we are producing wastes and using the Earth's resources 70% more quickly than they can be absorbed or replenished, effectively using up our annual ecological budget by August each year.

Deforestation

"It's very important to keep repeating these concerns [about the Amazon]. There are a number of tipping points, which are not far away. We can't see exactly where they are, but we know they are very close. It means we have to do things right away. Unfortunately that is not what is happening. There are people denying we even have a problem."
Philip Fearnside, Professor at Brazil's National Institute of Amazonian Research

Since the onset of agriculture about 12,000 years ago, the number of trees worldwide has dropped by 46% - that's the loss of a staggering 3 trillion trees. Forest cover is now at only 68% of what it was in preindustrial times, and around 15 billion trees are now being cut down each year. In the temperate zone, we retain only 1-2% of the original forest cover. The majority of tropical deforestation is driven by our demand for just four commodities - beef, soy, palm oil, and wood products. Palm oil is found in a myriad of popular products such as soaps, shampoo, chocolate, bread and even crisps.

In the Amazon - home to one in ten known species - a lethal combination of human-caused burning and climate change have now resulted in the destruction of nearly one-fifth of the rainforest: 17% across the entire Amazon basin and approaching 20% in the Brazilian Amazon. Deforestation of the Brazilian Amazon is now occurring faster than three football fields a minute, pushing the world's biggest rainforest closer to a dangerous tipping point beyond which it would not be able to recover. In July 2019 alone, Brazil lost an area of forest bigger than the size of Greater London.

Deforestation is not only severely compromising the Earth's natural ability to protect us from the devastating impacts of climate change; it is actually making global heating worse. Natural processes such as tree growth remove about half of human carbon dioxide emissions from the atmosphere every year. In this way, trees act as what's called a carbon 'sink'. The fewer trees, the less carbon dioxide can be mopped up.

However, new research has found that due to higher temperatures, droughts and deforestation, trees in the tropics are now taking up a third less carbon than they did in the 1990s. Simon Lewis, Professor in the School of Geography at Leeds University, said: "We've found that one of the most worrying impacts of climate change has already begun. This is decades ahead of even the most pessimistic climate models. Humans have been lucky so far, as tropical forests are mopping up lots of our pollution, but they can't keep doing that indefinitely. We need to curb fossil fuel emissions before the global carbon cycle starts working against us. The time for action is now."

To make matters worse, when cleared trees are burnt, enormous quantities of stored carbon are *released* back into the atmosphere. It has been calculated that clearing carbon-rich forests releases the same amount of carbon every year as driving 600 million cars. Indeed, global deforestation is responsible for nearly a fifth of all greenhouse gas emissions.

Worrying new research has revealed that up to one fifth (20%) of the Amazon rainforest is now emitting more carbon dioxide than it absorbs, suggesting that it could be "showing the beginnings of a major tipping point", past which the forest would lose its ability to renew itself. The authors had previously calculated that a tipping point could occur at around 20-25% deforestation (see section on tipping points). They warn that in the next 30 years, more than half of the Amazon could transform from rainforest to savanna. Indeed, another study has revealed that it is possible that the entire Amazon will rapidly decline and to go from a carbon 'sink' to a carbon 'source' within the next few decades.

If forests become *sources* of carbon rather than *absorbers* of it, their role would switch from one of slowing climate change, to one of amplifying it.

Forests and woodlands do more than capture carbon. They are also important across the globe in preventing floods, stopping soil erosion, cleaning air and water, providing habitats for wildlife and food and other resources for local people. Indeed, tropical rainforests are the most biodiverse areas on the planet. Losing these forests would greatly contribute to the loss of other species.

Intensive agriculture

Intensive agriculture is by far the biggest driver of global deforestation and wildlife loss and is severely damaging our soils and waters.

Our soils hold around 70% of the planet's land-based carbon. However, when soil is repeatedly ploughed, the ability of the small creatures and microorganisms within it to store carbon is compromised and vast quantities are released back into the atmosphere in the form of carbon dioxide. Conversely, compacting soil, for example by human traffic or livestock, also diminishes its capacity to hold carbon by creating oxygen-poor zones in the soil. (See action on soil degradation)

Intensive agriculture can also lead to the drying out of peatlands, which store twice as much carbon as all the world's forests. (See section on loss of wetlands, peatlands and other natural ecosystems).

In addition, the nitrates released by chemical fertilisers can destroy wildlife in local rivers and lakes through a process called eutrophication. Plus, agricultural pesticides are strongly implicated in the declines of pollinators. Globally there has been a five-fold increase in pesticide use since 1950, with over 4 million tonnes sprayed annually. Screening in the US revealed that, from 1992-2014, toxicity for insects from pesticides in the environment increased 48-fold.

The IPCC estimates that, if the entire spectrum of food production were factored in - from growing crops to transportation and packaging - up to 37% of all greenhouse gas emissions come from the global food system. Switching over to less intensive farming techniques - requiring less heavy machinery, fewer chemical fertilisers and less international transport - would not only make a huge impact on global greenhouse gas emissions, but would help to restore our soils and our wildlife. Approaches such as organic farming can reduce damage to the natural world and

degradation of soils and beneficial species such as pollinators, but must be combined with changes in diets to offset the lower yields.

Livestock farming

"Nothing really compares to beef, lamb, pork, and dairy – these products are in a league of their own in the level of damage they typically do to the environment, on almost every environmental issue we track"
Dr. Joseph Poore, environmental scientist at the University of Oxford

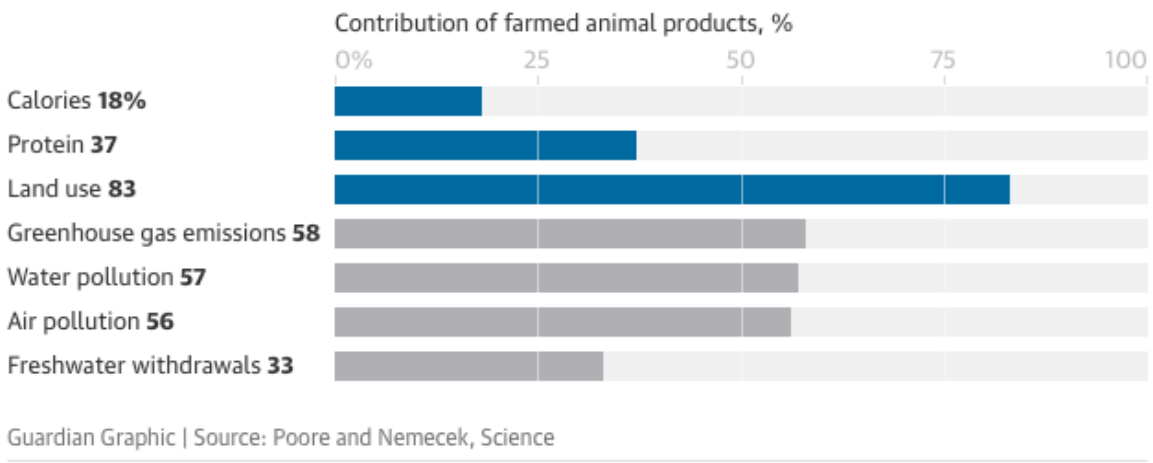
Currently a massive 26% of the planet's ice-free land is used for livestock grazing, with an area the size of Panama (18 million acres) being lost to livestock production each year.

In addition, livestock have a huge impact on global heating. Firstly, the enormous amount of land required for the grazing of animals and the growing of animal-feed is acquired through the clearing of carbon-rich forests, releasing carbon dioxide back into the atmosphere. Secondly, cows and sheep release an enormous amount of methane – a powerful greenhouse gas – in their burps and farts. In a single day, the 1.5 billion cows on our planet produce around 680 billion litres of methane (some calculations make it more like 500-650 litres per cow per day, ie 975 billion litres in total!). Thirdly, livestock are responsible for 65% of all human-related emissions of nitrous oxide due to the use of fertilisers to grow feed and the production of animal waste. Nitrous oxide is an extremely potent greenhouse gas nearly 300 times more powerful than carbon dioxide.

Overall, replacing all animal products with plant-based products (and allowing the land freed up to regrow) would be the equivalent to reducing global greenhouse gas emissions by a staggering 28%. (It is often claimed that it is more like 50%, but that reasoning is scientifically flawed, as explained in this blog.) Indeed, deforestation, cow burps and farts, and fertilisers produce more greenhouse gases than all the world's cars, lorries and planes put together.

In addition, keeping livestock is an extremely inefficient way to use the Earth's land and its limited resources to feed us. More than four fifths of the world's farmland is used for livestock, but livestock provide less than one fifth of the world's calories - and only about one third of our protein. It's not just about the land taken up by animals themselves. One third of the world's croplands are currently being used to grow food for these livestock. It would be far more efficient to feed these crops directly to humans: approximately 90% of energy is lost between each stage in a

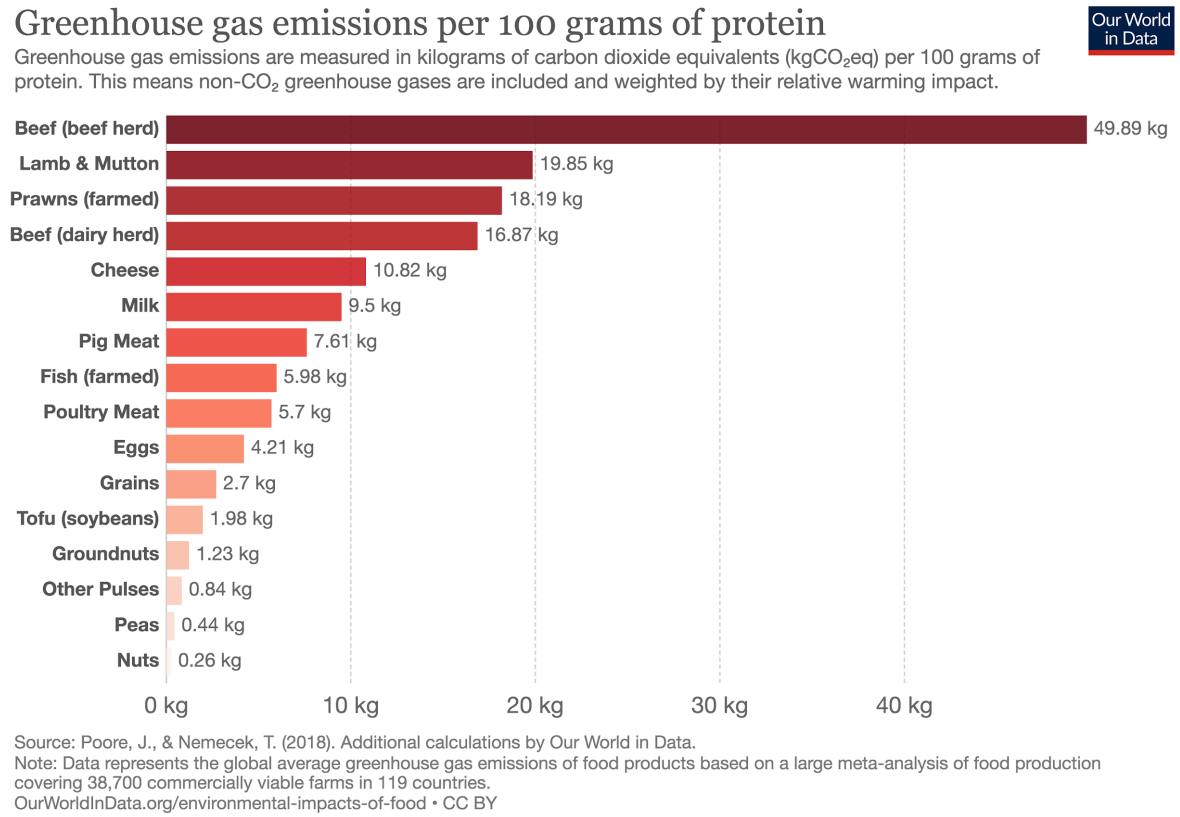
food chain, so we could feed far more humans by eating crops directly rather than feeding them to livestock and then eating the livestock.



Indeed, it has been calculated that cutting out livestock and replacing the calories with plant products would free up 76% of the world's agricultural land for reforestation, habitat restoration and other less intensive forms of agriculture.

Livestock farming also uses up precious water. Producing a kilo of beef requires 50 times more water than for a kilo of tomatoes, cabbages or potatoes, and a kilo of chicken requires 14 times more.

Farming cattle is particularly bad for the planet. Not only do cows take up an enormous amount of land, but for every 100 g of protein, beef produces up to 105 kg of greenhouse gases, while tofu produces less than 3.5 kg and nuts, peas and pulses produce even less. Grass-fed or organically farmed cows don't actually help much: in fact they can actually make things *worse* as letting cows roam freely might be better for the cows but it uses up far more land.



Soil degradation

"Soil is lost rapidly but replaced over millennia and this represents one of the greatest global threats for agriculture"
Duncan Cameron, Professor of Plant and Soil Biology at the University of Sheffield

Increased deforestation, overgrazing and the use of chemicals are also causing severe damage to our soils. This process is exacerbated by increases in extreme weather events, such as extreme rainfall that causes fertile topsoil to be washed away into rivers, or increased erosion due to drought, winds, or high temperatures.

Indeed, erosion carries away 25 to 40 billion tonnes of fertile topsoil every year and a third of our soils are now classified as being moderately or highly degraded. It can take about 500 years to form just 2.5 cm of topsoil, yet we are currently losing soil 10-100 times faster than it can be regenerated. This problem is made worse by the fact that earthworms - creatures that usually play a key role in the restoration of degraded soils - cannot compensate for the loss of healthy soil as they too have been depleted by 80% or more by the chemicals used in intensive farming. The UK has some of the most degraded soils on Earth, with nearly 85% of fertile peat topsoil

in East Anglia having been lost since 1850, and the remainder at risk of being lost over the next 30–60 years.

A whopping 95% of what we eat relies on healthy soils, so degradation of our soils is having a huge impact on global food production - see section on human impacts on global food production.

Loss of topsoil also leads to increased pollution, flooding and desertification.

Soil degradation also has a knock-on effect on global warming. Soils hold around 70% of the planet's land-based carbon, mostly from dead plant or animal matter, which is processed and cycled by small animals and microorganisms, such as earthworms, bacteria and fungi. In fact, just a spoonful of healthy soil contains 6 billion microorganisms. However, when soil is repeatedly ploughed or compacted by heavy machinery or livestock, the ability of the soil's biological communities to store carbon is compromised and vast quantities are released back into the atmosphere in the form of carbon dioxide. (See section on intensive agriculture).

Globally, it is estimated that agricultural soils have now lost up to 75% of the carbon they held before being used for agriculture. Or maybe more.

Loss of grasslands, mangroves, wetlands and peatlands

Humans have caused damage across all of the world's natural ecosystems, including wetlands, grasslands, mountains, tundra, rivers, coastal zones, and oceans.

Natural and semi-natural species-rich grasslands are one of the most damaged ecosystems on Earth, with over 80% having been lost in northern Europe and North America alone in the last century. These grasslands host a unique range of wildlife, and can support low intensity livestock production as well as provide clean water and resources for poor rural communities globally.

An area of coastal ecosystems larger than New York City - nearly 1 million hectares - is destroyed every year, removing an important buffer from extreme weather for coastal communities and releasing carbon dioxide into the atmosphere.

In addition, more than 85% of the wetlands that were present in the 1700s have now been lost, due to a combination of natural factors (magnified by climate change) and human activities such as agriculture and rural development, with 50% of wetlands

being lost in the last 100 years and 35% since 1970. Wetlands are extremely important to our planet as they provide natural protection from flooding, storms and hurricanes, as well as being stores of carbon. Wetland types found in coastal areas include salt marshes, bottomland hardwood swamps, fresh marshes, and mangrove swamps.

In the United States alone, coastal wetlands cover about 160,000 square km (40 million acres), and each square kilometre of wetlands along the Atlantic and Gulf Coasts is estimated to provide an average of $1.8 million worth of property protection. That's an estimated $288 billion worth of storm protection provided to the United States by wetlands every year. Yet between 2004 and 2009, in the coastal areas of the Atlantic, Pacific, the Gulf of Mexico and the Great Lakes, wetlands were lost at an average rate of about 320 square km (80,000 acres) per year. Recent wetland losses are estimated to have increased the property damage from Hurricane Irma in 2017 by $430 million.

A whopping 35% of the world's mangrove forests may have been lost between 1980 and 2000 and they are now at risk of extinction. Mangroves are amongst the most productive ecosystems on Earth, providing a unique habitat for many species and many benefits for human beings, such as coastal protection and fisheries. They are also a crucial carbon sink. Whilst just 0.7% of the world's forests are coastal mangroves, they store up to 4 times as much carbon as tropical forests and provide approximately $2.7 trillion in benefits to humans every year. Since 2000, nearly one third of the world's remaining mangroves have been lost, with their stored carbon being released back into the atmosphere.

Damaged peatlands - a type of wetland that occurs in almost every country on the globe, making up nearly half the world's wetlands - account for about 10% of greenhouse gas emissions globally. Although peatlands cover only 3% of the world's land, they are the largest natural organic carbon store on land, storing twice as much carbon as all the world's forests. When peatlands dry out, due to global heating or drainage for agriculture, large amounts of carbon dioxide is released.

How are we polluting our waters?

We are also severely polluting our waters. Since 1980, there has been a ten-fold increase in plastic pollution, with now an estimated 300 kg of plastic entering the ocean every second. This adds up to a staggering 4.8-12.7 million metric tonnes of consumer plastics ending up in the world's oceans each year. Plastic pollution has resulted in the presence of more than 100 million particles of macroplastics in only

12 regional seas worldwide, and 51 trillion particles of microplastic floating on the ocean surface globally. A recent study found that off the coast of Oregon, USA, there's an average of 11 tiny pieces of plastic to every oyster. Nearly all of these microplastic pieces came from clothing fibres or abandoned fishing gear.

Unfortunately, recycling isn't necessarily the answer to this problem. Shockingly, a huge proportion of 'recycled' plastic actually ends up in the ocean, buried in landfill or even being burned. Due to ocean currents, there are now areas in the ocean where enormous amounts of plastic collects in one place, resulting in huge 'garbage dumps of the sea'. The Great Pacific Garbage Patch for example, which is halfway between Hawaii and California, contains more than 1.8 trillion pieces of plastic, weighs more than 43,000 cars and is three times the size of France.

Plastics are not the only pollutant in our seas and freshwaters. Pesticides, herbicides, detergents, industrial chemicals, oil and sewage also make their way into our waters, as well as soil eroded from the land by human activities. More than 80% of wastewater resulting from human activities is discharged into rivers or sea without any pollution removal. Nitrates from the use of agricultural fertilisers are now the most common chemical contaminant in our groundwater. Indeed, human activity now produces as much nitrogen on an annual basis as all the world's natural processes combined. These nitrates can find their way into lakes and coastal waters, and along with phosphates, cause algal blooms which poison waters and dramatically reduce the growth of plants and fish through a process called eutrophication. In addition, 300-400 million tonnes of poisonous heavy metals, solvents, toxic sludge, and other wastes from industrial facilities are dumped annually into the world's waters.

Flooding can exacerbate this problem, as it can cause chemicals from old mines to be swept up and dumped into rivers and onto farmland. For example, after floods in the UK in 2012, levels of lead were much higher in rivers and were sufficient to kill farm animals grazing on the land.

How are we polluting our air?

"There is an air pollution pandemic"
Professor Thomas Munzel, Specialist in Interventional Cardiology, Risk Factors and Prevention, University Medical Centre of Mainz

According to the World Health Organisation, a staggering 9 out of 10 people on our planet breathe polluted air (that's air containing high levels of pollutants), with most air pollutants that we are exposed to coming from the burning of fossil fuels. Indeed,

air pollution is the world's largest environmental cause of disease and premature death across the globe, being responsible for an estimated 7 million premature deaths each year, with 4.8 million dying from outdoor pollution, and the remainder from household pollution. Overall, air pollution kills more people each year than smoking.

The sources of air pollution vary across the world. In many places traffic emissions are now the major source of air pollution but other important sources include industry, coal-fired power plants, agriculture and households. People are also exposed to air pollution in their own homes through indoor burning of fossil fuels and biomass-based fuels such as wood for cooking, lighting and heating. Wildfires also dramatically worsen air pollution in broad areas.

Across Europe, toxic air results in nearly 800,000 early deaths each year. In the UK, air pollution results in 28,000 to 36,000 premature deaths a year and over 60% of people in England are living in areas which exceed the World Health Organisation's legal limits for air pollution - with more than 40 towns and cities in the UK being at, or exceeding, these limits.

In London alone, two million people are living with illegal toxic air - of which more than 400,000 are children - and 32 out of 33 boroughs exceed legal air quality limits. Air pollution in London has been estimated to cause the deaths of 24 people every single day. The UK's Environment Audit Committee found that the cost of the health impacts of air pollution was likely to exceed estimates of £8 to 20 billion.

For more information, see section on health threats from air pollution.

How are we destroying our wildlife?

Why should we care about the loss of our wildlife?

Not only do our fellow species have as much a right to exist as we do, nature also supports human life here on Earth in a multitude of ways. Insects pollinate our crops, and a range of animals eat the pests that would otherwise destroy the crops on which we rely. Animals, microbes and fungi decompose and recycle dead matter, enriching our soils and recycling nutrients. Robust wild plant communities can prevent floods, stabilise soil and provide clean water and air. Coastal salt marshes and mangroves buffer us against storm surges and flooding from the sea (see section on loss of grasslands, mangroves, wetlands and peatlands).

Most human communities depend wholly or partly on wild food from the sea and a whopping 3 billion people across the globe rely on wild-caught and farmed seafood as a primary source of protein. In many parts of the world, people obtain wild food, medicines and fuel from natural ecosystems. And, as described earlier, trees and other plants are critical in capturing carbon and storing it in their bodies or in our soils.

Forest elephants, like other large fruit eaters, play an important role in protecting us from climate change due to their role as 'forest gardeners'. By feeding off smaller shrubs, they 'thin' the forest, helping larger slow-growing plant species to survive. These large trees trap and store huge quantities of carbon dioxide from the atmosphere. Forest elephants have been shown to represent a carbon storage service of $43 billion.

Decimation of plant and animal populations - and loss of species - is greatly compromising these and other benefits that we get from nature.

Loss of species

"Nature is declining globally at rates unprecedented in human history - and the rate of species extinction is accelerating, with grave impacts on people around the world now likely." IPBES Report 2019

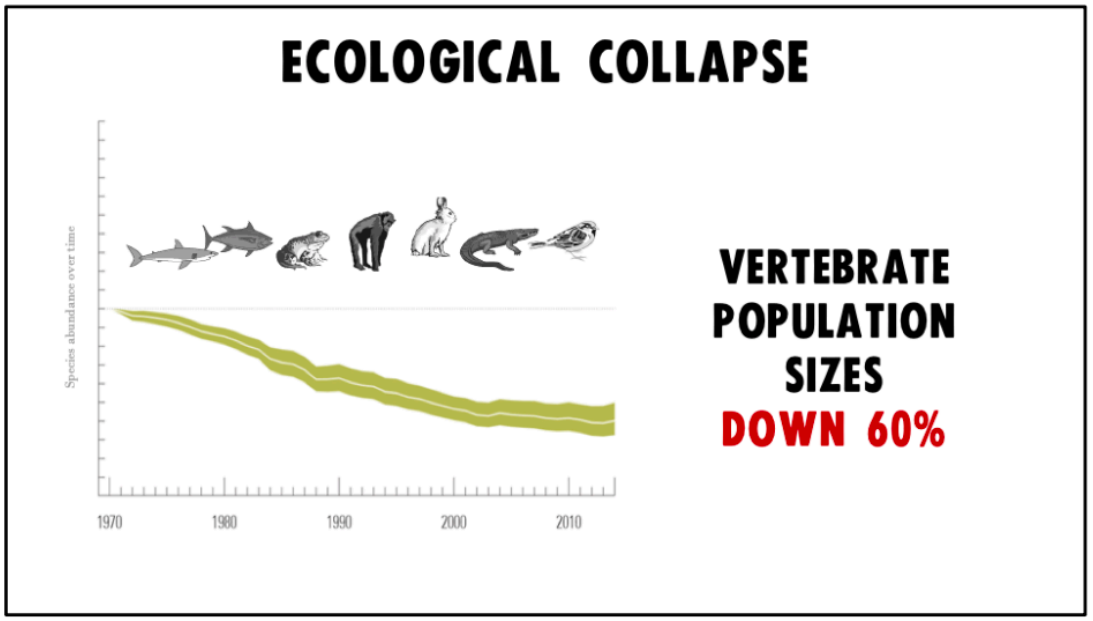
Habitat destruction, climate change, overconsumption and pollution, are having a huge impact on the animals, plants and other species that we share our planet with. In fact, the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) warned that the current biodiversity crisis is on a par with the threat to humanity posed by climate change.

According to Sir Robert Watson, Chair of the IPBES: "The health of ecosystems on which we and all other species depend is deteriorating more rapidly than ever. We are eroding the very foundations of our economies, livelihoods, food security, health and quality of life worldwide."

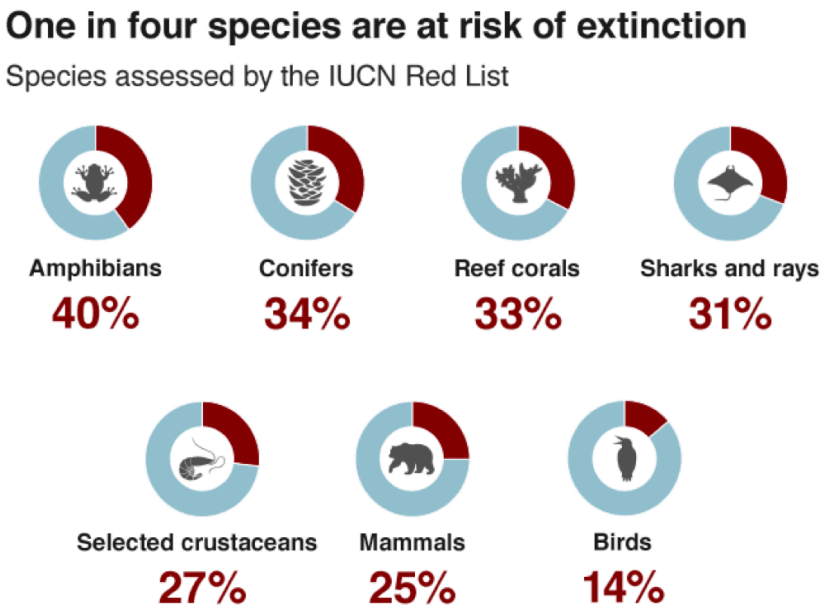
Indeed, a report warns that a "biological annihilation" of wildlife is eroding the foundations of economies, livelihoods, food security, health and quality of life worldwide. The authors of a review of the findings of the largest assessment of the state of nature, write: "Human actions are causing the fabric of life to unravel, posing serious risks for the quality of life of people. Only immediate transformation of global

business-as-usual economies and operations will sustain nature as we know it, and us, into the future."

The latest Living Planet Index estimates an average decline of 60% in the population size of thousands of vertebrate species around the world. (To be clear, this is not quite the same as saying that the *total number* of vertebrates has fallen by 60%.)



Over the last century, 400 vertebrate species went extinct. The International Union for Conservation of Nature (IUCN) found that, of approximately 116,000 species assessed, more than a quarter were *threatened* with extinction, including 25% of mammals. The latest research shows that there are now 515 land vertebrate species on the *brink* of extinction - meaning that there are now fewer than 1,000 individuals left in the world - including the Sumatran rhino, the Espanola Giant Tortoise and several species of Harlequin frog.



In 2019, the IPBES Global Assessment used the information the IUCN had gathered on the proportions of known species found to be at risk, along with information on the number of species on Earth, to estimate that a staggering one million animal and plant species are now threatened with extinction due to human action, many within the next few decades.

The study gave the main direct causes of biodiversity loss as habitat change, direct exploitation (e.g. fishing, hunting and logging), invasive alien species, pollution, and climate change. Some skeptics and commentators have attempted to discredit this "one million" figure. In response, Dr Andy Purvis, lead author of the Global Assessment and Life Sciences Research Leader at The Natural History Museum London, has written an article explaining exactly how it was calculated.

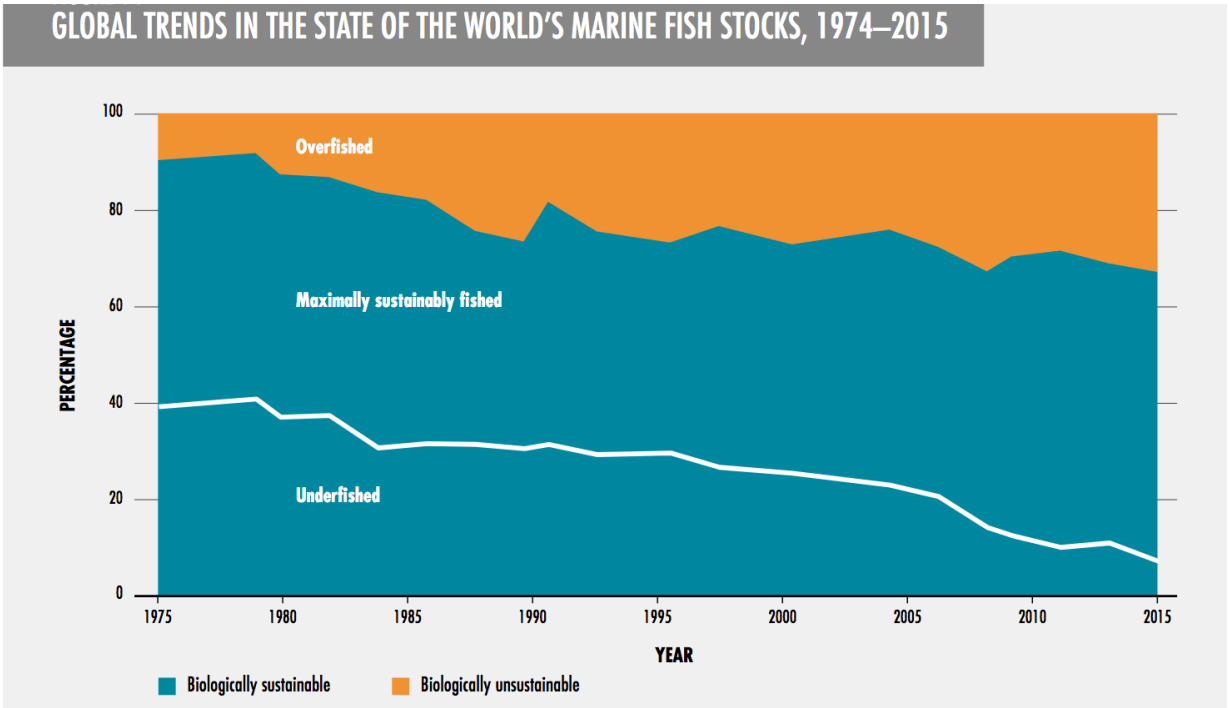
For lots more information on the direct impacts of specifically climate change on our wildlife, see sections on impacts of heating on land-based animals and impacts of heating on ocean life.

Follow the links to read about the catastrophic loss of wildlife we are expecting by 2050 and by the end of the century.

Loss of fish, whales and dolphins

Across Europe, North Africa and Asia, since 1970 populations of great freshwater species, from catfish to stingrays, have plunged by a staggering 94%, mainly driven by alterations of the ecosystems in which they live. According to the UN Food and

Agriculture Organization, a third of commercial fish stocks are being harvested at biologically unsustainable levels and 90% are fully exploited. The population of Pacific bluefin tuna, one of the ocean's most ecologically and economically valuable predators, has also plunged by 94% from historic levels due to rampant overfishing. Fishing doesn't just harm fish. In 2008 it was estimated that a minimum of 300,000 whales and dolphins were killed each year as a result of fisheries bycatch, a number which has likely doubled in the past 10 years, especially when deaths from shipping and habitat loss are also considered. Indeed, a new study has revealed that the fishing industry has seen a decline in the dolphin population in the Indian Ocean of almost 90%, related to the use of illegal 'gillnets' that are widely used by fishing companies across the world.



Loss of insects

"Insect decline should be of huge concern to all of us, for insects are at the heart of every food web, they pollinate the large majority of plant species, keep the soil healthy, recycle nutrients, control pests, and much more. Love them or loathe them, we humans cannot survive without insects."
Dave Goulson, Professor of Biology at The University of Sussex

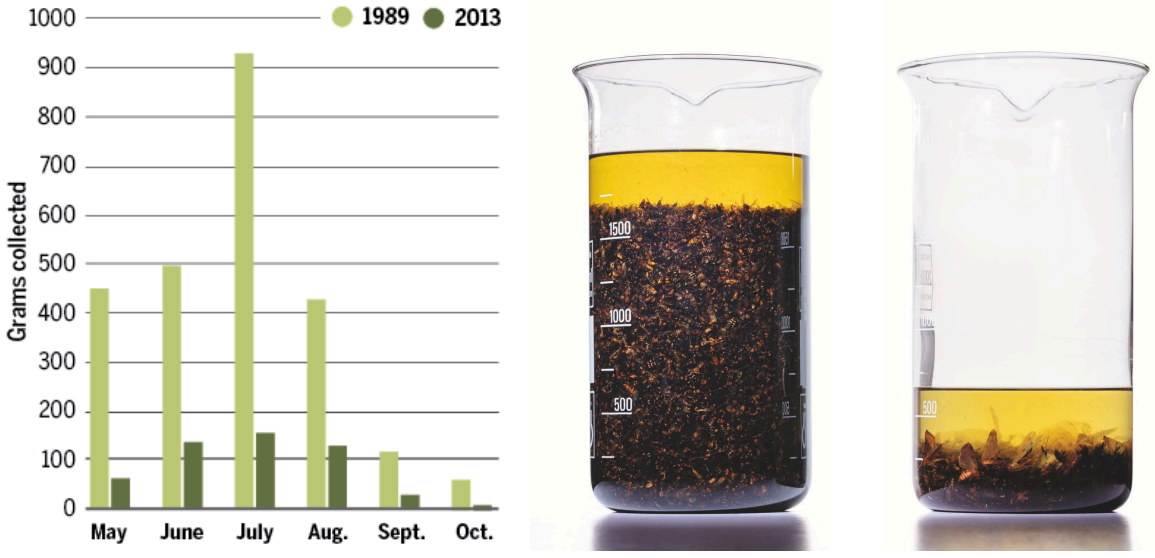
"If we were to wipe out insects alone - just that group alone - on this planet - which we are trying hard to do - the rest of life and humanity with it would mostly disappear from the land and from within a few months"
E.O. Wilson, Entomologist, Harvard University Research Professor Emeritus

Insects pollinate many of our crops, help fertilise the soil they grow in and help control outbreaks of crop pests and other organisms that cause disease in people and livestock. Insects and other small invertebrates are also important in decomposing and recycling dead organic matter - including biological waste - and are critical parts of food webs in all ecosystems.

Indeed, nearly 90% of the world's flowering plants and at least 75% of global food crop types depend, at least to some extent, on pollinators. In fact, 70 of the 100 most important human food crops are pollinated by insects. While there are many important pollinating insects, such as bumblebees, beetles, hoverflies and butterflies, honeybees alone carry out a whopping 80% of crop pollination.

However, several studies have suggested that the numbers of insects are declining dramatically. A 27-year long monitoring study across Germany revealed a dramatic 76% decline in flying insect biomass between 1989 and 2013 (as shown in the figure below). Worryingly, the study took place inside nature reserves, which should be the best protected places.

Left: Comparison of the mass of insects collected by monitoring traps in the Orbroicher Bruch nature reserve in northwest Germany in 1989 and 2013. Right: Samples of flying insects collected from identical traps at a site in Krefeld, Germany over a period of two weeks in August 1994 and August 2016



Another study revealed "frightening" declines of insects and spiders in German grasslands and forests. Dutch scientists have found that butterfly numbers have fallen by an average of over 80% in the last 130 years. Hotter and more frequent extremes in temperatures having led to a "drastic decline" in numbers of bumblebees

across Europe and North America.

Whilst some of these studies were somewhat restricted in terms of the species and locations they considered, casting some doubt on how broadly their conclusions could be applied, a *global analysis* shed more light on insect declines. This analysis suggested a more moderate, but still alarming decline in insect abundance on land by 9% per decade since the 1960s - amounting to around a 43% decline since then (but more in some places, less in others). This same study showed *freshwater* insects are increasing in abundance by about 11% per decade, probably as a result of attempts to clean up waters over the last few years.

Insect numbers are decreasing so much that as many as 10% of insect species may now be threatened with extinction (not 40% as has often been wrongly quoted) due to a wide range of pressures including habitat loss, agro-chemical pollutants and climate change.

Of the more than 800 species of wild bee across Europe (bumblebees, solitary bees and others), 7 are classified as critically endangered, a further 46 are endangered, 24 are vulnerable and 101 are near threatened. Losing wild bee species would have an enormous impact on pollination around the world, wiping out plant species, some of which we rely on for our food.

Ecosystems are like a giant game of Jenga: take a few pieces out from the bottom and the whole lot could come tumbling down. So it is essential that we now safeguard bees along with other insect pollinators.

As American Entomologist Professor E.O. Wilson said, it is "the little things that compose the foundations of our ecosystems, the little things that I like to say, run the world."

Loss of wildlife in the UK

The State of Nature report found that the UK was “amongst the most nature-depleted countries in the world", with 1 in 4 British mammals now at risk of extinction. It found that the average number of mammals has fallen by 26%, whilst 15% of species are under threat of extinction and 2% are already gone for good.The most recent report by the British Trust for Ornithology found that more than a quarter of British bird species are threatened, including the puffin, the nightingale, and curlew. Indeed, we are already seeing a catastrophic decline and impending local extinction of other much-loved residents of the English countryside such as cuckoos and sparrows.

According to the Joint Nature Conservation Committee, a government advisory body, the UK is set to miss 14 out of 19 of its biodiversity targets for 2020.

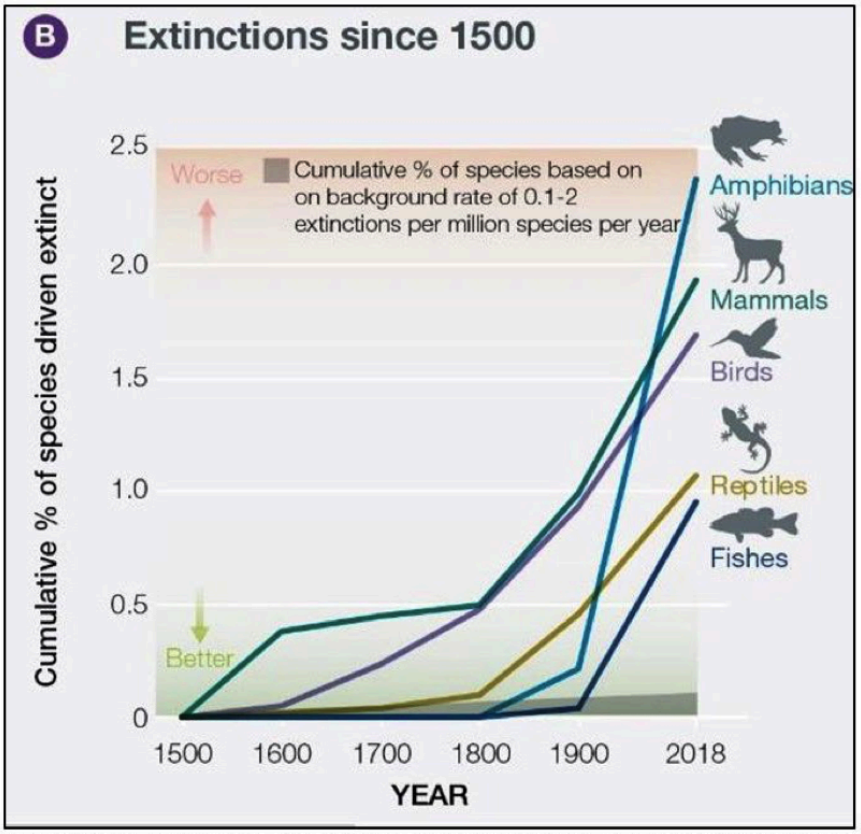
In Europe, the average population size of farmland bird species has fallen by 55% in just the past three decades.

The Sixth Mass Extinction

"This isn't just about losing wonders of nature. With the loss of even the smallest organisms, we destabilise and ultimately risk collapsing the world's ecosystems - the networks that support the whole of life on Earth."
Sir David Attenborough

It's not just how *many* species we are losing; it's how *fast* we are losing them. Globally, species are going extinct at rates 100-1,000 times faster than the 'background rates' typical of Earth's past. The 400 vertebrate species that went extinct in the last century should have taken about 800 to 10,000 years to disappear naturally. Amphibians are now disappearing at a rate between 1,000 to 45,000 thousand times faster than natural background rates.

Several studies have suggested that things are so bad that we are now entering the Earth's Sixth Mass Extinction event. Mass extinctions are defined as times when the Earth loses more than three-quarters of its species in a geologically short interval, as has happened only five times in the past 540 million years or so.


B
Extinctions since 1500
Cumulative % of species driven extinct
2.5
2.0
1.5
1.0
0.5
0
Worse
Better
Cumulative % of species based on
on background rate of 0.1-2
extinctions per million species per year
Amphibians
Mammals
Birds
Reptiles
Fishes
1500
1600
1700
1800
1900
2018
YEAR

Part 4: Sick, thirsty, hungry and homeless… What knock-on effects are we already seeing?

Impacts on human health

"Climate change is a medical emergency, it thus demands an emergency response."
Professor Hugh Montgomery, director of the University College London Institute for Human Health and Performance

In a 2018 report from one of the world's leading medical journals, The Lancet, doctors, academics and policy experts from 27 organizations around the world, warned that "a rapidly changing climate has dire implications for every aspect of human life, exposing vulnerable populations to extremes of weather, altering patterns of infectious disease and compromising food security, safe drinking water and clean air." It stated that the rising heat and wilder weather linked to global warming make climate change the biggest global health threat of the 21st century, with hundreds of millions more people already suffering over the last two decades. Indeed, 800 million people (11% percent of the world's population) are currently vulnerable to climate change impacts such as droughts, floods, heat waves, extreme weather events and sea-level rise. The authors of The Lancet's report called for fast action to curb climate change and prepare global health systems for growing challenges.

It has been estimated that if all countries met the Paris Agreement to stay below 2°C heating, we could avoid 138,000 premature deaths a year across the entire European region of the World Health Organisation. Mental health threats are also on the rise, from children worried about their future in an overheating world to families stressed by disaster losses.

It is estimated that the direct damage costs of climate change to health will be between USD 2-4 billion per year by 2030.

Health threats from extreme weather

The authors of the Lancet Countdown Report said that climate change impacts - from heatwaves to worsening storms, floods and fires - were surging and threatened to overwhelm health systems.

Heatwaves can cause heat stress and lead to premature deaths - see section on heatwaves for some facts and figures about the health impacts we are already seeing. In addition, extreme weather, such as storms and floods, not only cause injuries and loss of life directly but can also shut down hospitals, spur disease outbreaks and produce lingering mental health problems as people lose their homes and livelihoods. Wildfires also dramatically worsen air pollution in some areas (see section on health threats from air pollution).

Extreme weather, along with soil degradation, is also impacting food production and water availability, leading to increased risks of health impacts through starvation, dehydration and malnutrition - for some facts and figures see sections on impacts on global food production and impacts on water availability. Indeed, global heating is not only already reducing crop yields, but is also shrinking the amount of nutrients in cereal crops, increasing the risk of malnutrition even for those who do manage to get enough to eat.

Increased spread of diseases

"Climate change is disrupting natural ecosystems in a way that is making life better for infectious diseases."
Andrew Dobson, department of Ecology and Evolutionary Biology, Princeton University

Higher temperatures help the bacteria that cause deadly diarrhoea (and wound infections) to thrive, leading to increased spread of infectious diseases such as cholera. Since 1950, the Baltic region has seen a 24% increase in coastal areas suitable for cholera outbreaks. Indeed, the second most suitable year on record for the spread of the cholera bacteria was in 2018.

In addition, hotter temperatures increase the frequency with which mosquitoes feed off humans, whilst increased rainfall creates more stagnant water sources for these deadly insects to breed in. Mosquitoes are considered to be one of the most dangerous species on the planet, due to their ability to spread many deadly diseases such as Zika virus, West Nile virus, chikungunya virus infections, dengue fever and malaria. Indeed, almost 700 million people contract a mosquito-borne illness every year resulting in more than one million deaths. A growing number of scientists are concerned that global warming could lead to an explosive growth of the

mosquito-borne diseases worldwide - a problem that will be exacerbated by the fact that mosquitoes are becoming increasingly resistant to insecticides.

Indeed, in recent years the rate of infection spread of malaria has increased dramatically and in sub-Saharan Africa's highlands, zones where malaria-carrying mosquitoes can survive have expanded by 27%. The global incidence of the dengue fever has grown dramatically in recent decades, and it is now the most rapidly expanding infection around the world, with about half of the world's population now at risk. Nine of the ten most suitable years for the ability of mosquitoes to transmit this deadly disease have happened since 2000, with 2017 having the second highest level recorded since 1950.

Rising temperatures are also creating conditions for tropical diseases - which already have devastating health impacts to people who live in the tropics - to spread to other parts of the world where they are not usually seen (see section on future impacts of global heating on human health). There is potential spread of the Asian tiger mosquito - carrier of dengue fever, chikungunya fever, Zika, encephalitis and canine heartworm - which has already been found at isolated spots in Southern England and threatens to become established. Cases of the Zika virus, which causes horrific birth defects, have recently occurred via local transmission in France - enabled by increased temperatures - and there are fears it could spread to the UK soon. A few years ago Italy had a number of cases of malaria in people who had not travelled abroad, whilst in recent years there have been a number of cases of mosquito-transmitted dengue fever in France and Spain.

According to Professor James Logan, head of the department of disease control at London School of Hygiene and Tropical Medicine: "We are seeing mosquito populations move and change and that is likely to bring more malaria. There is evidence that this has already started to happen. It's not just malaria but other vector-borne diseases, such as dengue, which is now in Europe and we are also seeing in the UK. Some places in the UK are warm enough in summer to sustain a potential malaria outbreak."

Hotter conditions may also be giving some disease-causing microbes greater resistance to antibiotics.

The threat of new diseases

It's not just *known* diseases that might spread to new areas with increasing temperatures. Some scientists think that the Spanish flu virus or other unknown

pathogens might be buried in permafrost and as the climate changes they may be released.

In addition, the number of animal diseases newly appearing in humans is increasing. Currently about 60% of human infectious diseases have an animal origin yet this number is going up, with 75% of new human diseases having jumped from animals to humans.

The UN reported that the rising number of new diseases from wildlife is driven in part by degradation of natural habitats, exploitation of wildlife and climate change. For example, deforestation in Malaysia and Singapore caused fruit bats carrying Nipah virus to move from the forest to fruit plantations, where they came into close contact with pigs. Pigs then got the virus from the bats, and then passed it on to humans. Exploitation of wildlife brings humans into closer contact with animal diseases they may not have been exposed to before, whilst climate change increases the chance of transmission of animal diseases to humans because the microbes causing such diseases will thrive in a warmer, wetter, more disaster-prone world. Whilst the exact origins of COVID-19 are not yet certain, it has certainly spread from animals to humans.

Speaking about COVID-19 in March 2020, former United Nations' Climate Chief Christiana Figueres said we should expect more disease outbreaks "if we continue to deny, delude and delay on climate change".

Health threats from air pollution

Air pollutants are produced through the uncontrolled burning of fossil fuels. Air pollution is already the world's largest environmental cause of disease and premature death, being responsible for an estimated 7 million premature deaths each year with 4.8 million dying from outdoor pollution, and the remainder from household pollution. Overall, air pollution kills more people each year than smoking.

Air pollution is further exacerbated by increased numbers of forest fires. California's wildfires in 2018, spurred by drought, not only cost more than 80 lives but also polluted air as far east as Massachusetts.

Exposure to air pollutants has been linked to a huge range of diseases, from lung cancer and respiratory infections to stroke, dementia and even diabetes. Indeed, pollution is the world's largest environmental cause of human disease and premature death, either directly or increasing the risks of dying from a variety of diseases.

About half of the early deaths from air pollution are related to heart disease and stroke. The next most common causes are lung cancer and pneumonia. For more information on the increasing numbers of deaths from air pollution, see section on air pollution.

In the 15 countries that emit the most greenhouse gas emissions, the health impacts of air pollution are estimated to cost more than 4% of their GDP.

Health threats from intensive agriculture

Intensive agriculture is also a source of human diseases due humans coming into close contact with large numbers of highly-bred animals. Indeed, since the 1940s, intensive agriculture, such as factory farming, has been associated with the emergence of 25% of new human diseases.

Certain pesticides used in intensive farming are also thought to cause harm to humans, for example, organophosphates have been linked to cardiovascular diseases and damage to the nervous system. In addition, the risk of the meat we eat containing bacteria that cause food poisoning (such as Campylobacter) is increased by intensive farming, as stressed animals become more susceptible to infection - a matter made worse by the fact that antibiotics given to livestock have led to antibiotic resistance in the bacteria. Such overuse of antibiotics in the farming industry - leading to resistance - is also severely limiting our ability to be able to use antibiotics to treat human diseases.

Children and the elderly are especially vulnerable

Children and the elderly are particularly vulnerable to the health impacts of climate change. Nick Watts, executive director of the 2019 Lancet Countdown Report, warned: “Children’s bodies and immune systems are still developing, leaving them more susceptible to disease and environmental pollutants. The damage done in early childhood lasts a lifetime. Without immediate action from all countries climate change will come to define the health of an entire generation.” As Stella Hartinger at The Lancet put it: “The path that the world chooses today will irreversibly mark our children’s futures. We must listen to the millions of young people who have led the wave of school strikes for urgent action.”

Follow the links to read about how we are expecting to see more devastating impacts on human health by 2050 or by the end of the century.

Impacts on global food production

"It really becomes difficult to see at such levels of warming how we're going to maintain our agriculture such that the population of the world can actually feed itself."
Dr Peter Stott, Head of the Met Office Climate Monitoring and Attribution Team

Soil degradation, rising temperatures, the spread of new pests and diseases, and increases in extreme weather events - such as heat waves, floods and droughts - are already having a huge impact on food production across the globe. Indeed, over 124 million people across 51 countries and territories are already facing crisis levels of acute food insecurity or worse, requiring immediate emergency action.

More than 95% of what we eat is dependent on the presence of healthy soil, yet a third of our soils are now classified as being moderately or highly degraded and we are currently losing soil 10-100 times faster than it can be regenerated (see section on soil degradation). Indeed, The Lancet reported that rising temperatures over the past 30 years have already led to a decline in the capability of many global cereal crops to deliver full yields. In fact, the crop-yield potential of *all* major crops tracked, in all regions of the world, have fallen as temperatures have risen. Over the past 30 years, there have been declines in average global yield potential of maize (-4%), winter wheat (-6%), soybean (-3%) and rice (-4%). Many natural versions of our favourite foods such as chocolate, coffee and avocados are already threatened to the point of extinction.

Rising temperatures are also shrinking nutrient levels in cereal crops, increasing the chances of malnutrition. In addition, the combination of hotter temperatures and increasingly globalised trade enables crop pests and diseases to spread to new parts of the world. For example, the Xylella bacterium, considered to be one of the most dangerous plant diseases worldwide, kills olive, almond, and citrus trees - as well as grapevines. Xylella was once restricted to the Americas, but it has now spread to Europe, the Middle East and Asia. Many of our staple foods, such as wheat, sorghum, potatoes and rice, are also under threat from emerging crop diseases. For example, a fungus called 'wheat blast' has recently emerged and spread in Brazil and the USA, and climate change is making places like Bangladesh more susceptible to this disease. Ocean warming has caused up to a 35% decline in North Atlantic fish yields.

We live in a globally interconnected society, so a reduction in crop yields on one side of the globe is likely to have impacts on food prices on the other. When harvests fail,

countries often ban their food exports, leading to a ‘domino effect’ that can cause price raises across the globe.

Massive price hikes can lead to families struggling to put food on the table, which is what happened in Egypt and other Middle Eastern countries in 2010-2011 during the Arab Spring uprisings. These Middle Eastern countries were the world’s top grain importers and were therefore the most severely affected by a spike in grain prices related to a major drought in China, and also an export embargo in Russia following a record heatwave which destroyed 40% of the grain harvest there. This 2010 Russian heatwave was made considerably more likely by climate change and contributed to a global wheat shortage, as well as a 90% increase in international grain prices.

The climate change-linked heatwave that struck Europe in 2003 resulted in the worst crop decline in 100 years with plants growing 30% less in the heat. Livestock farmers were particularly affected in France - fodder was reduced by 60% and almost 4 million broilers died due to the heat. In Spain the poultry flock was reduced by between 15% and 20%. The exceptional drought in California at the beginning of the last decade (the worst on record, its severity connected to global heating) led to billions of dollars in losses in the agricultural sector. The drought forced farmers to leave over one million acres of farmland fallow and many lakes and reservoirs hit historic lows forcing farmers to pay engineers to drill ever deeper wells and deplete aquifers, however this then leads to increasing soil salinity which further degrades the farmland adding to further future losses.

In a more recent example, the Murray-Darling Basin, known as the breadbasket of Australia, has just experienced its worst two year drought on record, prompting Credit Suisse to warn investors that “whole swathes of what has been the food bowl of Australia is at risk”. Rice outputs slumped by 90% and grain harvests in New South Wales were 60% below their ten year average. Many dairy farms went out of business entirely with a third closing in just 6 years. Abstraction of water from rivers for irrigation exacerbated the low water levels and led to over one million fish dying in mass kills. According to a report by the Interim Inspector General of the Murray-Darling Basin Water Resource: “The past two decades or so have seen a marked change in the volume of water available in the system. Analysis shows that the median annual inflow over the past 20 years is approximately half that of the preceding century. More significantly, the frequency of drier years is also much greater”. Another report by the Australian Bureau for agriculture found that this change in climate has led cropping farmers to see their annual farm profits fall by 35%.

Another dramatic impact of climate change on food availability is demonstrated by

the recent plagues of locusts that wreaked havoc across the Horn of Africa and the Middle East and into East Asia, destroying hundreds of kilometers of crops. The UN warned that "25 million people in the East Africa region will face acute food insecurity in the latter half of the year." It was the largest such outbreak in at least 70 years, and it followed a prolonged period of exceptional rainfall: from October to mid November 2019, the region saw 300% of its average rainfall. This is connected to the Indian Dipole being in a 'positive phase', which, according to a new paper, is becoming more frequent as the climate warms. This led researchers at the Food and Agriculture Organisation of the United Nations (FAO) to warn that "if this trend of increased frequency of cyclones in [the] Indian Ocean continues, then certainly, that's going to translate to an increase in locust swarms in the Horn of Africa".

Even in the UK heavy rainfall and floods in the north of England in 2019 caused widespread damage to winter vegetables such as potatoes, cauliflowers and cabbages. Some wholesalers have said that the supply of some domestically grown vegetables, such as Savoy cabbage, are already tightening, whilst the price for potatoes in the UK was already about 8% higher in the first week of November 2019 than in the previous month, and conditions for growers remained difficult in the early part of 2020. In August 2020, the National Farmers' Union announced that the UK was facing the worst wheat harvest since the 1980s due to consecutive seasons of extreme weather - with yields likely to be down by up to 40%. As a result, some millers have already increased the price of flour by 10%.

Follow the links to read about how we are expecting to see further reductions in food supplies by 2050 or by the end of the century.

Impacts on water availability

"Global freshwater security - and therefore global food security - is at far greater risk than we ever imagined."
Professor Jay Famiglietti, senior water scientist at NASA's jet propulsion laboratory

According to the United Nations World Water Development Report in 2018, an estimated 3.6 billion people (nearly half the global population) already live in areas that are potentially water-scarce at least one month per year. This situation is being exacerbated by hotter, drier conditions and more frequent and more extreme droughts.

In 2017 a drought in East Africa, made up to twice as likely by climate change, displaced around 800,000 people in Somalia. In 2018 an intense drought in Cape Town, made three times more likely by climate change, led to severe water restrictions being put in place and the city came to within days of turning off its water supply, a day that is known as Day Zero (the day when a city's taps dry out and people have to stand in line to collect a daily quota of water). Climate scientists have calculated that climate change has already made a drought this severe go from a 'once every 300 years' event to being a 'once every 100 years' event. At 2°C of heating, a drought of this severity will happen roughly 'once every 33 years'. In 2019, after a harsh drought followed by a searing heatwave, Chennai in India was left nearly out of water as its reservoirs ran dry. For some more examples of how extreme weather events linked to climate change have already impacted fresh water supplies see section on impacts on global food production.

Water availability is also impacted by the melting of mountain glaciers. Today, around 1.9 billion people live in catchment areas downstream of glaciated mountain ranges and depend on glaciers for clean water. Yet these glaciers are rapidly melting. See section on melting ice and rising seas.

Pollution also has large impacts on availability of clean water. In fact, poor water quality due to poor sanitation and poor nutrient management is one of the most widespread problems affecting water supplies. In the United States alone, the annual cost of damage caused by contamination of water by nutrients is approximately US$2.2 billion.

Follow the links to read about how increased water shortages are predicted to be impacting our world by 2050 or by the end of the century.

Mass displacement and threats to safety, human rights and our global economy

"Climate crisis is the greatest ever threat to human rights. The economies of all nations, the institutional, political, social and cultural fabric of every state, and the rights of all your people, and future generations, will be impacted."
Michelle Bachelet, United Nations Rights Chief

In the first six months of 2019, extreme weather events displaced a record seven million people from their homes.

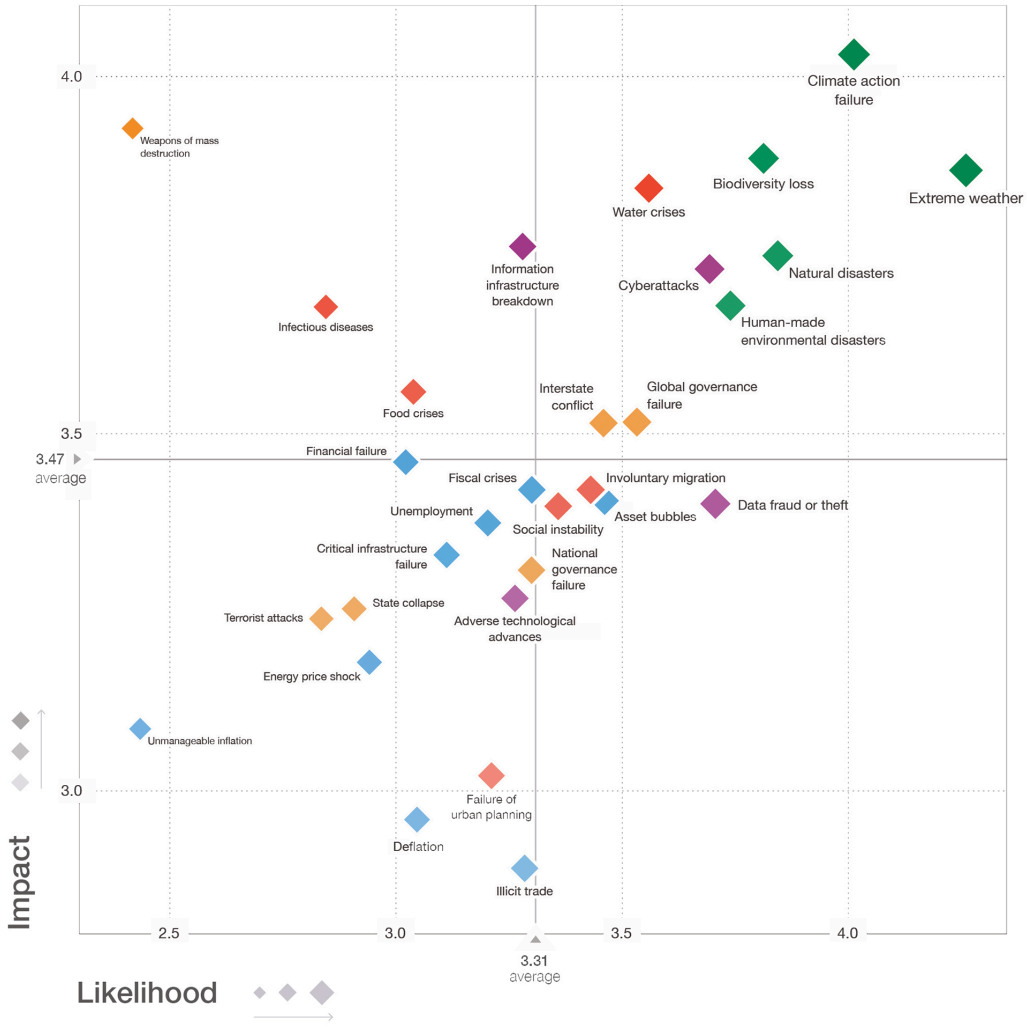
The latest Ministry of Defence Global Strategic Trends report identified climate change and resource use as among the highest risks to global defence and security - with a potential impact (and certainty of occuring) far higher than weapons of mass destruction.

It has been argued climate change has already led to a rise in global inequality.

Extreme weather events (made more likely by climate change) already cause huge financial losses and threaten to make our world “systemically uninsurable” - for more information see section on extreme weather.

According to the World Economic Forum’s (WEF) 2020 Global Risk Report, climate action failure, biodiversity loss and extreme weather were considered the biggest threats to the global economy. The report also stated: "Climate related issues dominated all of the top-five long-term risks in terms of likelihood”. A separate study found that when over 200 global change scientists were asked about their perception of the same risks they assessed likelihood of the risks as even greater then the WEF report.

Average survey responses from experts on the likelihood and impact of particular global risks, on a scale from 1 to 5. Environmental risks are shown in green



The McKinsey Global Institute Climate Risk and Response Report 2020 warned: “Greater awareness of climate risk could make long-duration borrowing more expensive or unavailable, impact insurance cost and availability, and reduce terminal values. This could trigger capital reallocation and asset repricing. This recognition could happen quickly, with the possibility of cascading consequences.”

On Channel 4 News in July 2019, Mark Carney, Former Governor of the Bank of England, said that efforts to reverse global warming will lead to “major changes” in the UK economy. Companies that fail to respond to climate change “will go bankrupt without question.” Carney has also warned that “Once climate change becomes a defining issue for financial stability, it may already be too late.”

Follow the links to read about how mass displacement, poverty and financial instability and social instability and conflict are expected to be impacting our world by 2050 or by the end of the century.

Part 5: Too hot to handle… Where are we heading?

"*We basically have three choices: mitigation, adaptation and suffering. We're going to do some of each. The question is what the mix is going to be. The more mitigation [(reduction of emissions)] we do, the less adaptation will be required and the less suffering there will be*."
Professor John Holdren, former President of the American Association for the Advancement of Science

How hot is too hot? The promises of the Paris Agreement

In an attempt to limit the dangers of climate change, in 2016 the United Nations Framework Convention on Climate Change drew up the Paris Agreement. It came after 25 long years of fractured climate negotiations and was based on the very latest scientific research that showed that the previous target - to limit global heating to 2°C above pre-industrial levels - was not "safe". The purpose of the Paris Agreement was therefore to commit the signing countries to "holding the increase in the global average temperature to *well below 2°C* above pre-industrial levels and pursuing *efforts to limit the temperature increase to 1.5°C* above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change". To date, a total of 189 countries have given their formal consent to the agreement, as well as the European Union.

Whilst committing to keeping heating "well below 2°C" was certainly a monumental step forwards, it is important to realise that we should be aiming much much lower than that. Indeed, we are already seeing enormous impacts of climate change at just 1°C of heating (see section on what's already happening to our planet as a result of warming and why). The risks increase with *every fraction of a degree*. Even if we manage to limit heating to 1.5°C this still comes with huge risks. In particular, this amount of heating will be *absolutely devastating* to some parts of the global south. However, given the appalling lack of adequate action to date, limiting global heating to 1.5°C is really the very most we can hope for right now.

Yet it is now 2020 and in the five years since the Paris Agreement was signed we have seen precious little action at the scale required to keep to the 2°C limit, let alone the 1.5°C one. And we do not have long left to act.

How hot is it likely to get and when?

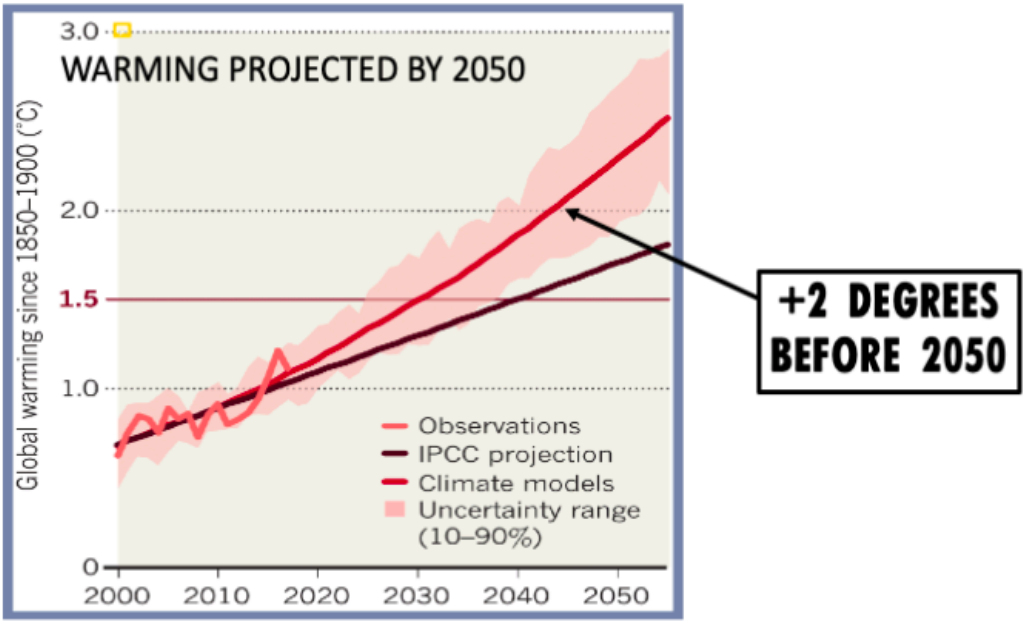
"Should we continue as a planet to increase greenhouse gases as we have done for the past two years and as we have done for the past 150 years, we would way exceed the 2°C maximum temperature rise and certainly the 1.5°C. What that means is that future generations will have to live in a world that is so unstable that it will be very difficult for them to have any predictability about their life whatsoever."
Christiana Figueres, former United Nations' Climate Chief, February 2019

One of the ways that scientists predict how much the Earth will heat up in the future is by using climate models. Climate models are massive computer programs which take the best physical understanding and observations of the real world and use them to simulate how the world's atmosphere, oceans and ice sheets will change in response to different levels of greenhouse gases in the atmosphere. One of the key roles of the Intergovernmental Panel on Climate Change (IPCC) is to combine the results from all the different climate models and then use them to make estimates of how the Earth's temperature and climate will change in the future.

At our current rate of warming, even with all the government policies and pledges in place, the IPCC warns that we will pass 1.5°C of heating some time between 2030 and 2052, probably around 2040. This means that we'll be sailing past 2°C of heating - the amount of heating the 189 countries who signed the Paris Agreement committed to staying "well below" - by around 2060.

However, it is likely that global heating will actually occur *even faster* than this. In a recent piece in Nature, it was argued that our current emissions pathway makes it most probable that we will hit 1.5°C heating by 2030 and 2°C heating by 2045.

In the absolute worst case scenario, if emissions keep increasing and it turns out that the Earth's climate is even more sensitive to changes in greenhouse gas levels that was previously thought, we could be heading over 2°C heating even sooner, perhaps even as early as 2035.



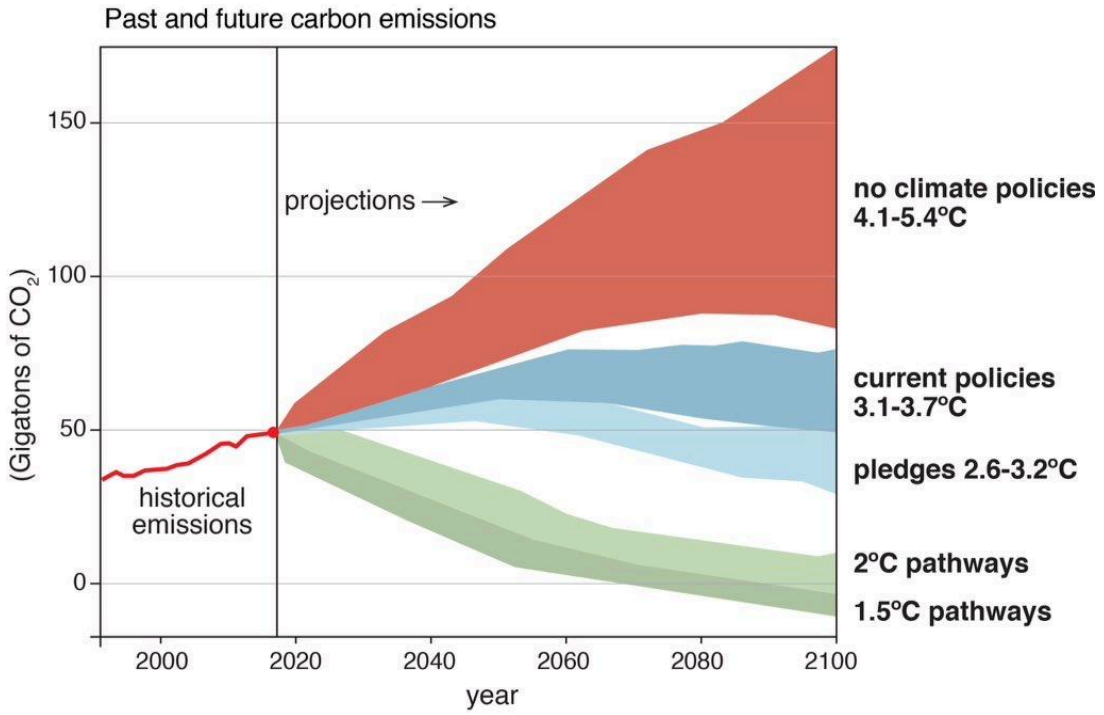
The impacts of a 2°C world would be devastating - see section on what our world will look like by 2050 if we don't take radical action now. But, if we keep emitting greenhouse gases, heating won't stop there. It will only cease when we succeed in *stopping all carbon emissions*.

Even taking into account all climate policies that were already in place in December 2019, by the end of the century we are likely to be heading towards an average global heating of 3°C. Given that we can't predict the climate perfectly and that countries might backtrack on their promises, there remains a significant chance of us going over 4°C heating. A 3°C hotter world would be an absolutely catastrophic outcome. A 4°C hotter world would be even more so. (See section on what our world will look like by the end of the century.)

But what about all the *promises* that governments have made? The thing is, even if governments don't just stick to their *current* policies, but also honour all the *additional pledges and targets* they have made (a situation that has proven time and again not to happen), we are still heading towards around 2.6°C of heating by the end of the century - with a one in three chance of going over 3°C. That's far higher than the promise made under the Paris Agreement to keep heating to "well below 2°C".

The bottom line is that the Paris Agreement will only be met if countries across the world rapidly reduce greenhouse gas emissions to zero, starting NOW. Yet this is NOT what is happening. See section on what global governments are 'supposed' to be doing to address the crisis.

The diagram below shows the future possible scenarios of global carbon dioxide emissions, along with what temperature the world will heat to by the end of the century if we follow each of these 'emissions pathways'. However, it is important to be aware that the range of possible heating is actually wider than shown here. Crucially, this means that even with all the government's *current pledges* in place we could be seeing over 4°C of heating by the end of the century. The diagram clearly shows that if we want to limit heating to 1.5°C we need to rapidly reduce emissions NOW.



Recently, the results of some new climate models caused great alarm because they indicated that we could be headed for *even higher* temperatures than earlier models had predicted. However, further studies showed that almost all of the additional heating predicted by the new models was due to cloud feedback loops, and such feedback loops are notoriously difficult to model (see section on cloud feedback loops). Indeed, whilst the new climate models did appear to be better than previous models at simulating cloud feedback loops in some respects, they were worse in others. Thankfully, more recent work has now shown that the hottest, worst-case scenario predictions of these new models are, in fact, unrealistic and that the models overestimate recent warming trends. Sadly though, the cooler, best case scenario predictions of these new models have now been ruled out too.

What remains clear is that we are most certainly headed for very dangerous levels of warming unless we urgently stop greenhouse gas emissions NOW.

The additional risks of feedback loops

Our Earth's climate system is a complex web of interconnected systems that are not yet fully understood. As the atmosphere and oceans heat up, these different systems interact with each other, risking setting off "feedback loops".

There are two types of feedback loops. Negative feedback loops occur when the Earth responds to warmer temperatures in ways that *suppress* the initial warming, bringing temperatures back down - thus *stabilising* the climate. In contrast, positive feedback loops occur when the Earth responds to warmer temperatures in ways that *amplify* the initial warming. In other words, warming leads to more warming, which leads to *even more* warming. Crucially, these kinds of feedback loops *destabilise* the climate and are therefore a major cause for concern. However, it should be noted that, in most cases, positive feedback loops do not lead to a "runaway" scenario - where the climate just keeps on heating up more and more - because on each cycle of the loop the feedback process causes less warming.

Throughout most of Earth's history, negative feedback loops have tended to dominate, ensuring that the climate stays within a range of temperatures suitable for life. However, in our prehistoric past there have been times when positive feedback loops have taken over, amplifying large changes in the world's climate such as the transitions from warm periods into ice ages.

Today we are playing a dangerous experiment with the climate, adding greenhouse gases into the atmosphere at unprecedented rates. As the atmosphere and oceans heat up, positive feedback loops could kick in *at any time*, sending warming shooting up even faster than it already is.

Today's improved climate models incorporate many such feedback loops. It is therefore not correct to say that climate models do not take into account feedback loops. However, no climate model is perfect and there is always the risk of missing something important - which is why climate scientists also take detailed measurements of the planet and study past climates to provide real-world checks.

What this means is that it is virtually impossible to predict exactly how much heating we will see in response to different future carbon dioxide 'emissions pathways' (see graph in section on how hot it is likely to get and when). This leaves us with a big risk that, even if we do manage to reduce carbon dioxide emissions enough to - in theory - prevent really dangerous warming, the Earth's atmosphere could end up heating up *far more* than most models predicted, due to feedback loops being more powerful

than expected. This is why, if we want the best possible chance of keeping to the Paris Agreement and preventing catastrophic damage to our planet, it is *even more crucial* that we reduce carbon dioxide emissions *as fast as possible*.

Below are a few examples of feedback loops:

Water vapour and clouds

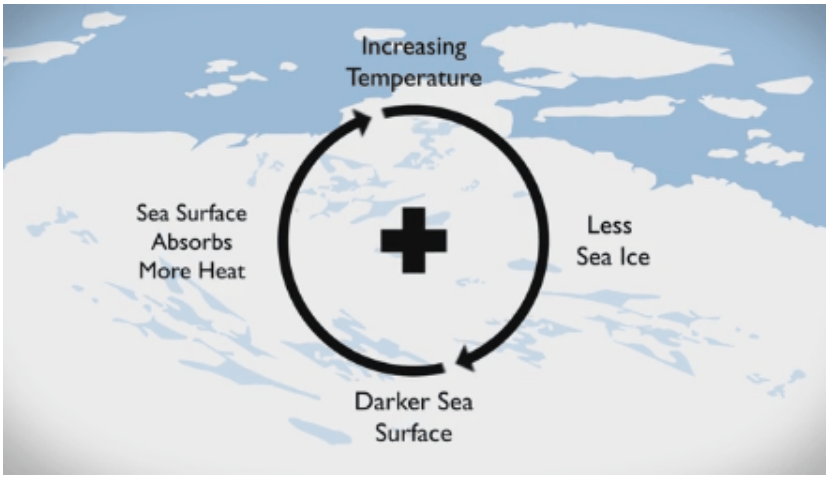
As temperatures go up, more water evaporates into the air. Water vapour is itself a greenhouse gas, meaning as more water evaporates the greenhouse effect gets stronger, causing more warming - a classic example of a *positive feedback loop*. The 'water vapour feedback loop' is one of the most powerful feedback loops, almost doubling the heating effect of increased carbon dioxide levels by themselves.

In addition, as the atmosphere gets more moist we also get more clouds. Not only does this increase the amount of rainfall, leading to bigger storms and dangerous flooding, clouds themselves also feedback on the climate. They do this in two opposing ways: clouds can cool the Earth by reflecting sunlight away from it, and they can warm it by trapping heat and stopping it from escaping out to space. This is why a cloudy day is cooler than a sunny day (more sunlight is reflected away), but an overcast night is warmer than a clear night (more heat is trapped). Hence clouds can result in both positive and negative feedback loops, at the same time. Which of these processes dominates depends not only on the *total amount* of cloud cover, but also on the *types* of cloud present and *where and when* they form. This makes cloud feedbacks notoriously difficult to model.

The ice-albedo effect

Due to its bright white colour (or high albedo), sea ice in the Arctic *reflects* most of the light and heat from the Sun back out to space. However, as the atmosphere warms, sea ice melts. If enough ice melts, the light-coloured reflective surface of the ice eventually disappears, exposing the darker surface of the ocean. This darker surface then *absorbs* the Sun's rays rather than reflecting them, which makes the ocean heat up - a bit like how wearing a black shirt on a hot day makes you feel warmer than wearing a white one. As a result of increasing ocean temperatures, more sea ice melts, which in turn leads to the exposure of more dark water surface, which absorbs more heat, which melts more ice, and so on and so on.

The ice-albedo positive feedback loop



This ice-albedo positive feedback loop is a key reason why the Arctic is warming faster than anywhere else (known as Arctic amplification). Indeed, Arctic amplification has been linked to the drastic reduction in Arctic sea ice. To make matters worse, some climate scientists are now concerned that the amplification of warming in the Arctic is disrupting the Northern Hemisphere jet-stream, causing more extreme weather in the mid-latitudes - areas such as northern Germany, Poland, southern parts of the United Kingdom and the mid United States.

Melting permafrost

Permafrost is a type of soil that has been permanently frozen for many thousands of years. Globally it covers a whopping 15 million square kilometers, about a quarter of the Northern Hemisphere, mostly in Canada, Russia and Alaska. Permafrost is a huge store of carbon. Frozen Arctic soil, for example, holds an estimated 1,460 to 1,600 billion tons of trapped carbon - that's almost twice as much carbon as is currently in the atmosphere. As permafrost melts, bacteria in the soil release vast quantities of this carbon back into the atmosphere in the form of methane or carbon dioxide. Methane is a powerful greenhouse gas with a warming effect many times that of carbon dioxide over short time scales. This causes more warming, which melts more permafrost, and so on.

Although the latest studies suggest that there is as yet "no evidence to date for increasing methane release from the Arctic" and only 5-15% of the trapped carbon is expected to be released this century - much less than could be emitted from fossil fuels - unprecedented heating in the Arctic is causing soils that have been permanently frozen for thousands of years to melt at faster and faster rates. If the permafrost melt rate keeps accelerating, the methane released would have terrible impacts on the climate. Even at slower rates of melting, the longer-term impact of the carbon dioxide released from melting permafrost is a serious cause for concern. If

we can limit global heating to 1.5°C (as opposed to 2°C) we would prevent the thawing of approximately 2 million square kilometers of permafrost.

Wetland methane production

When plants at the bottom of rivers and lakes die, bacteria break them down, releasing methane. Warmer temperatures lead to the growth of more aquatic plants, leading to more methane production. This in turn causes more warming, leading to more plant growth, and so on. This effect is exacerbated by the loss of trees surrounding the lakes as a result of warming temperatures, as the debris from these trees would usually reduce methane production in the lake.

Wetlands are responsible for about half of all natural methane emissions - this is more than the methane emissions from oil and gas, almost as much as the methane emissions from cow burps and many times more than the emissions from melting permafrosts.

Methane levels in the atmosphere stopped rising in the early 2000s for the first time in hundreds of years, but then started increasing again after 2007 and then began accelerating rapidly in 2014. It is still a matter of debate exactly what is the cause of this recent rise, but an increase in methane emissions from tropical wetlands is one of the strongest contenders.

Drying soils and mega-heatwaves

Soils contain huge amounts of stored carbon. Warmer temperatures cause soils to dry out and release their carbon back into the air. This results in more warming, leading to even more soil drying and more carbon being released, and so on. Soils in the tropics store one third of all the carbon on land, and recent experiments show they are more vulnerable to heating than previously thought.

In addition, dry soils can't absorb as much heat as moist soils. So as the atmosphere warms and soils dry out, more heat is radiated back into the atmosphere, leading to more drying resulting in even more heating. It is this kind of positive feedback loop that can trigger ‘mega-heatwave’ events.

Carbon cycle feedbacks

Trees and other plants absorb carbon from the air through photosynthesis and store it in wood and in the soil. Carbon dioxide is also removed from the air by the oceans. Collectively, these *stabilising* "carbon cycle feedbacks" absorb around 50% of the total human-caused carbon emissions, shielding us from the full effect our emissions would otherwise have had. However, it is possible that in the future something could happen to disrupt these processes, in which case we may find that our emissions start to cause even more warming than had previously been thought.

For example, warmer temperatures can lead to dryer forests and dryer soils, and this leads to more wildfires. These wildfires release carbon dioxide back into the atmosphere, which leads to more heating - which in turn causes more drying and more fires.

In addition, whilst plants tend to grow faster at higher levels of carbon dioxide (due to faster rates of photosynthesis), above certain temperatures further increases in photosynthesis can become impossible due to increasing *heat stress*. As a result, in hotter conditions some plants can simply stop growing - a phenomenon that can be easily observed in a vegetable garden, when, during the hottest period of summer, plant growth temporarily stops. And of course, when plants stop growing, they stop absorbing carbon dioxide. Recent research shows that some tropical forests could have already peaked in their absorption of carbon in the 1990s.

The bottom line is that if there is a reduction in the amount of carbon dioxide our trees, plants and soils absorb on a global scale, our carbon emissions budgets shrink accordingly, meaning that we would have to reduce emissions *even faster* than we currently need to, if we want to stay below 1.5°C heating.

How tipping points might make things even worse…

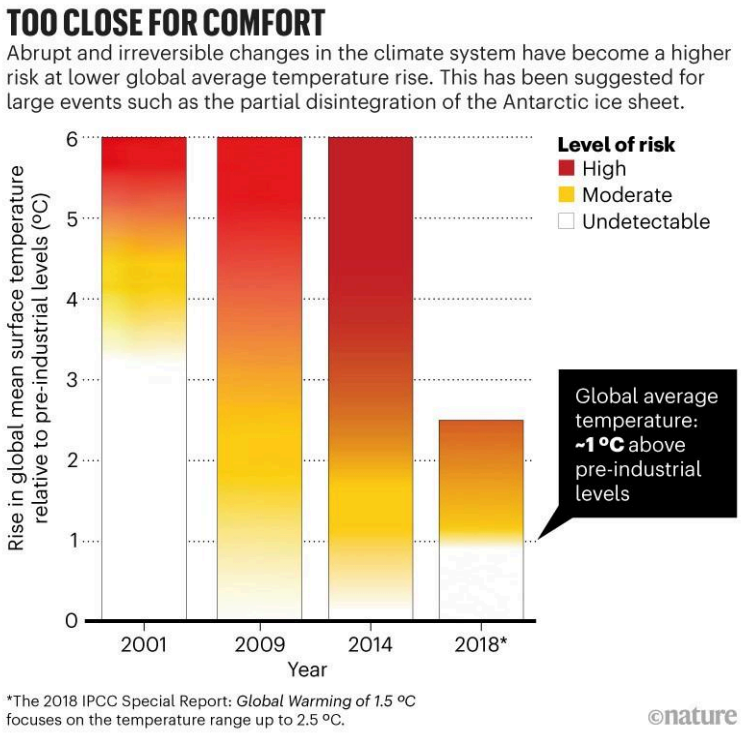
> "*Tipping points are so dangerous because if you pass them, the climate is out of humanity's control: if an ice sheet disintegrates and starts to slide into the ocean there's nothing we can do about that."*
> *Professor James Hansen, former Director of the NASA Goddard Institute for Space Studies*

To make matters even worse, some feedback loops involve 'tipping points'. A tipping point is a threshold above which a small change in temperature will cause the feedback loop to become *self reinforcing*. This would then push that part of the Earth's system into an abrupt or irreversible change, resulting in a completely new state. It may take hundreds or even thousands of years for the change to play out

fully once the threshold is crossed, but the worrying thing is that it would be practically impossible to reverse: the transition to the new state will then continue regardless of whether emissions subsequently go down. It's like passing the point of no return as you approach a waterfall in your boat.

We don't know with any certainty when these tipping points could occur, but the risk gets bigger with every fraction of a degree of heating. In other words, the higher our temperatures go, the greater the risk of passing a point of no return. Scientists have become increasingly concerned by the risk posed by tipping points at even relatively small increases in temperature. Indeed, recent research suggests that some tipping points are vulnerable to being passed even at (or indeed below) 2°C of heating.

Not all tipping points would cause further warming. Some might result in the collapse of an ecosystem (in response to the imminent wiping out of tropical coral reefs), or might result in more sea level rise (in response to the collapse of parts of the West Antarctic Ice Sheet. However, the point is that all tipping points all have the potential to cause *catastrophic damage* that is *irreversible* in our lifetimes. Indeed, the authors of a recent Nature paper warn that the danger posed by tipping points alone suggests we are in a state of planetary emergency: both the risk and urgency of the situation are acute.



There are a number of tipping points that we know about and should be extremely concerned about, and possibly more that we do not. Below, we describe a few of the

key ones. To find out more, see this video where a group of us from the Extinction Rebellion Scientists community discuss tipping points with some of the leading scientists in the field.

Permafrost collapse

One important tipping point relates to the thawing of the Siberian permafrost. This will release both carbon dioxide and the more potent, but less long-lived, greenhouse gas methane. This increases heating, leading to more permafrost thaw, and so on (see section on the additional risks of feedback loops). Beyond a certain level of heating, probably around 3°C or more, we could see a wide scale collapse of the Arctic permafrosts. It is feared that the Arctic may have already crossed a key threshold.

Methane release from melting permafrost is often associated with the fear that warming oceans and melting of ice could release large amounts of methane now contained within ocean sediments. Thankfully, current research indicates that most of this methane will reach the atmosphere as the much less potent greenhouse gas carbon dioxide, which would mean we can breathe a sigh of relief. However, even if only small amounts of methane reach the atmosphere, or they reach it as carbon dioxide, the process remains a possible positive climate feedback or tipping point, and much more research and observations are needed to fully understand the level of risk.

To make matters worse, a worrying recent study has revealed that a process called “abrupt thaw” - involving rapid warming of small patches of frozen ground containing large veins of ice - will lead to the release of far more emissions from permafrost than once thought. Although less than 20% of northern permafrost is susceptible to this kind of rapid thawing, the researchers warn that this process is likely to double the overall contribution of permafrost to the warming of the planet.

As Merritt Turetsky, director of the Institute of Arctic and Alpine Research (INSTAAR) at CU Boulder, explained: "Forests can become lakes in the course of a month, landslides occur with no warning, and invisible methane-seep holes can swallow snowmobiles whole."

Ice sheet slippage

“This finding should be of huge concern for all those who will be affected by sea level rise. If this very high rate of ice loss continues, it is possible that new tipping points may be breached sooner than we previously thought.”
Dr. Louise Sime, Climate Scientist at the British Antarctic Survey

"*Nobody expected the ice sheet to lose so much mass so quickly, things are happening a lot faster than we expected*."
Isabella Velicogna of the University of California, Irvine

Ice sheets on land, such as glaciers and the continent-size ice sheets in Greenland and Antarctica, may give rise to another feedback loop. As the ice melts, water percolates into the ground below it, making the rock slippery, which could make it easier for layers of ice to slide over the bedrock they sit on, accelerating the collapse of glaciers into the surrounding sea.

In addition, warming ocean waters make *ice shelves* vulnerable to melting. Ice shelves protect ice sheets and stop them from slipping down the bedrock and into the sea. Once ice shelves start melting, an irreversible process can be set in motion which leads to the disintegration of entire ice sheets. The problem is, because ice sheets sit on land, when they collapse they lead directly to sea level rise.

Worryingly, the last time carbon dioxide levels were as high as they are today - during periods of the Pliocene era around 3 million years ago, when global temperatures were around 2-3°C higher - sea levels were a whopping 20 m higher than today. Most of this sea level rise was due to the melting of ice sheets ‘grounded’ below sea level and therefore extremely vulnerable to warming seas. These included most of the current West Antarctic Ice Sheet and parts of the East Antarctic Ice Sheet.

Indeed, during the warm period that preceded the last ice age around 125,000 years ago, warming seas were the major driver for the collapse of all or parts of the West Antarctic Ice Sheet. This collapse has been linked to a rapid and irreversible recession of the grounding line - the boundary between the grounded glacier and where it becomes a floating ice shelf.

Given that our current temperatures are similar to those of the last interglacial warm period, and our carbon dioxide levels considerably higher, this leaves us with the terrifying possibility that even current levels of heating are enough to tip over the West Antarctic Ice Sheet, which could lead to increased sea level rises for *centuries to come*, even if we stop emitting greenhouse gases. Worryingly, recent observations suggest this process could already be underway, although it is not clear quite how much this sea level rise this would cause this century. What’s equally concerning is

that unexpected melting is underway in the East Antarctic, an area that is usually seen as being pretty stable.

Thermohaline circulation

Another important tipping point relates to ocean circulation, which plays a crucial role in maintaining regional climates. As Arctic sea ice and the Greenland ice sheet melt, it is feared that changes in ocean circulation in the Atlantic may divert the Gulf Stream. The Atlantic Meridional Overturning Circulation (AMOC), a large system of ocean currents that carry warm water from the tropics northwards into the North Atlantic, has already weakened by about 15% since the middle of the 20th century. If there is continued decline, it would significantly change regional weather patterns and could lead to a significant cooling in Western Europe, even as the rest of the world as a whole heats up, causing massive disruption.

Forest dieback

Trees usually absorb water from the soil and release it back into the atmosphere as evaporation from their leaves. Large forests, such as the Amazon, are self-sustaining in this way, evaporating the water they need in order to survive. Fewer trees means less water can be released from leaves therefore the atmosphere becomes even dryer. Once a certain amount of forest is lost, this can trigger a phenomenon known as *dieback*, in which the forest dries out entirely and transitions to a completely different ecosystem. To make matters worse, lack of water also weakens trees so that a bark beetle or other predator outbreak is more damaging. Once there are entry wounds in a tree, fungal spores (which are everywhere) can get in and rot the tree.

It is thought that most forests are not at risk of dieback until temperatures get above 3°C of heating. However, it could happen sooner than this due to increased deforestation. Indeed, scientists have warned that the Amazon may already be dangerously close to a tipping point and further deforestation could tip it over the edge, leading parts of the rainforest to dieback and transition to a savannah, releasing billions of tonnes of carbon in the process. (See section on deforestation).

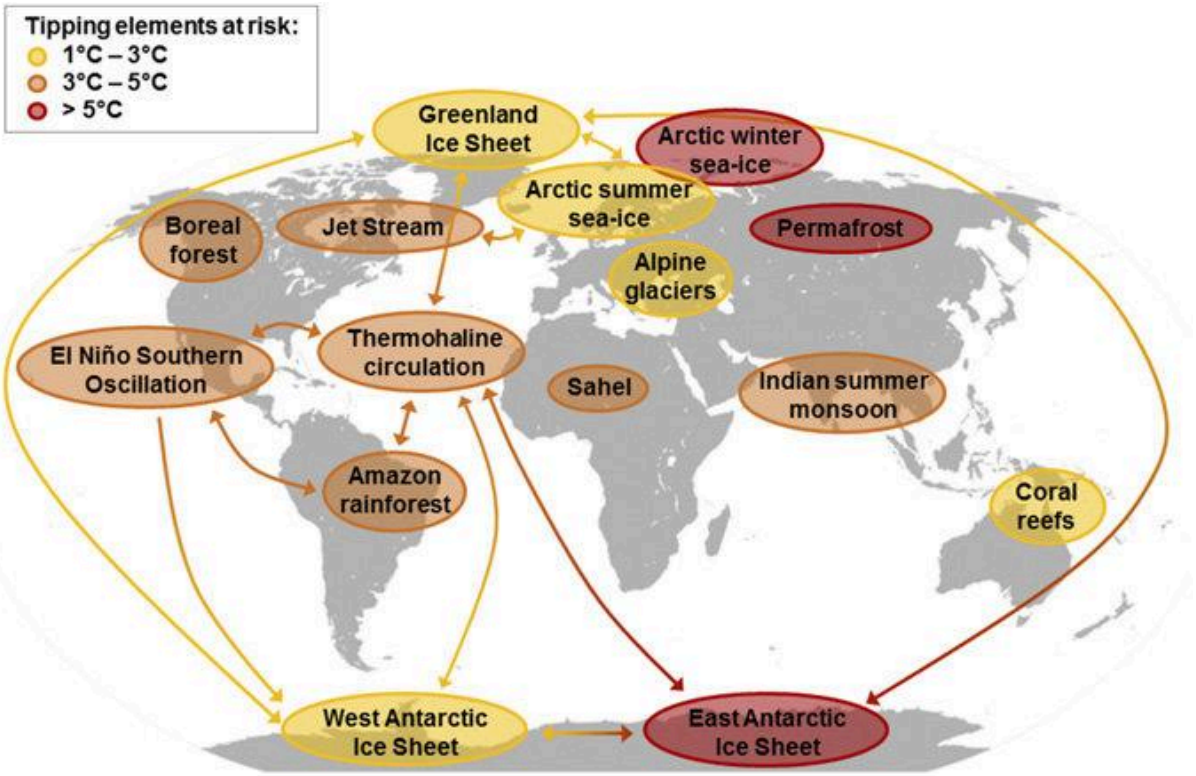
The compound risk of multiple tipping points

Evidence is mounting that not only could the chance of crossing tipping points be higher than was previously thought, but that tipping points could also be

interconnected across different biophysical systems. Indeed, it is feared that once a single climate process passes its tipping point, this could push other processes beyond their own tipping points, triggering other tipping points - and so on. This gives rise to the possibility of a *tipping cascade*, and with it, multiple disasters.

This article gives a more detailed explanation of nine key tipping points that could be triggered by climate change. They are represented more simply in the diagram below, which also shows at what temperature each tipping point is at risk of being breached and how they are all connected with each other:

Global map of potential tipping cascades. The individual tipping elements are colour-coded according to the estimated thresholds in global average surface temperature that could trigger them to become tipping points. Arrows show potential interactions between tipping elements, based on expert knowledge, that could generate tipping cascades



While it is unlikely that interacting feedback loops will cause “runaway” global heating, the longer we emit greenhouse gases and the hotter it gets, the more likely that multiple interacting tipping points could push the Earth into a much hotter state, known as a “Hothouse Earth”, from which it would be impossible to return for thousands of years. In other words, there could come a point where devastating changes to our world get *locked in* by processes that have escaped our control.

There has been a lot of misinformation spread about the “Hothouse Earth” hypothesis. It is important to be aware that it has not yet been proven for certain and, even if it is true, it may take hundreds or even thousands of years to play out.

However, even though the most extreme impacts of tipping points may take a long time to come to pass, the existential risk posed by the possibility of crossing multiple tipping points if we go above certain - unknown - temperature thresholds is very real. Indeed, the idea that human activity can completely transform the planet for thousands of years to come is profound. This really hammers home the need to reduce emissions to zero NOW, and to limit heating to less than 1.5°C.

It’s also worth being aware that even if a tipping cascade *does* get underway, it would still be worthwhile reducing emissions as quickly as possible, as this would slow the rate of change, buying societies and ecosystems some time to adapt and giving us a chance to limit damage and reduce suffering.

What will our world look like in 2050 if we don’t take radical action now?

"The climate emergency is our third world war. Our lives and civilization as we know it are at stake, just as they were in the second world war."
Professor Joseph Stiglitz, Economist

With our governments not doing nearly enough to keep to the Paris Agreement (see section on what global governments are ‘supposed’ to be doing to address the climate crisis), and with the risks of triggering more feedback loops and breaching tipping points getting ever greater by the day, it certainly looks like it’s going to get a lot hotter. But just what will the future bring? How will it affect our lives? And do we really need to be worried about just a few more degrees of heating? In a word, yes.

On our current pathway, even with all the fully implemented government policies in place, we are likely to hit 1.5°C of heating by around 2030 and 2°C by 2050, or perhaps even sooner (see section on how hot it is likely to get and when).

If we allow this to happen, by 2050 our world will be utterly transformed from the one we grew up in, as we shall see in the sections below. However, it’s important to be aware that these temperature ‘milestones’ are not hard limits. Even 1.5°C of warming carries enormous risks, it's just that this is the best we can hope for given what we have already emitted. Similarly, we won’t be catapulted into catastrophe as soon as

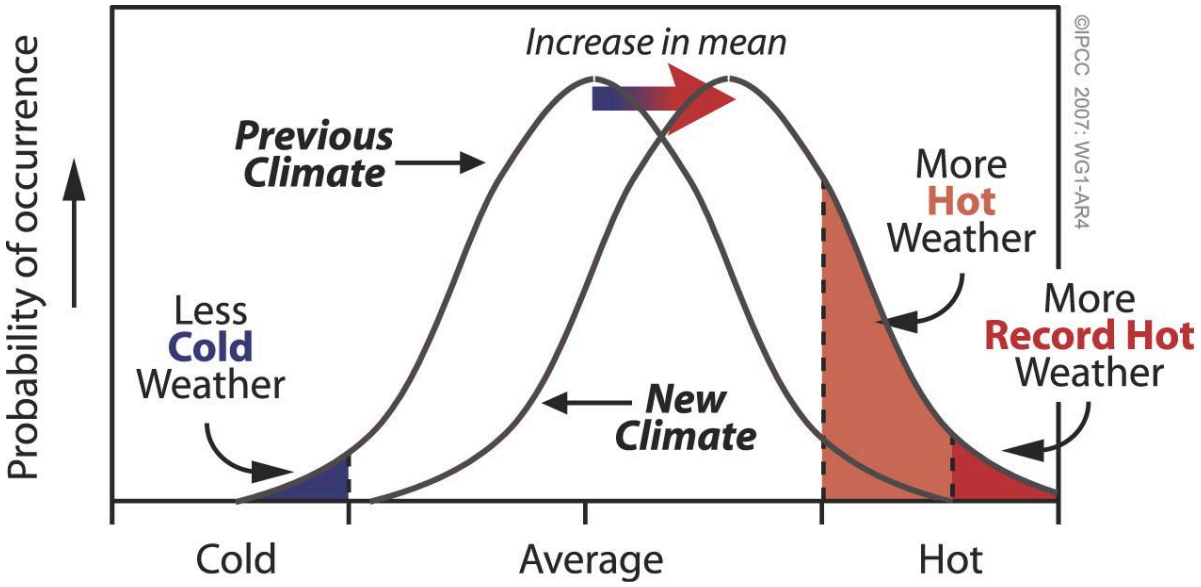
we pass 2°C of heating. The changes our planet faces are on a sliding scale, with increasingly greater risks of more disastrous impacts with each fraction of a degree.

2050: More intense heatwaves and forest fires

"We will start to see the extreme end of the fire behaviour scale occur more frequently because of the increase of temperatures."
Dr Richard Thornton chief executive of the Bushfires & Natural Hazards Cooperative Research Centre

By 2050 we expect to see around 2°C of average global heating, but some regions will heat up by a lot more than that. This means that the chances of there being extreme hot weather events across the globe will increase massively.

Graph showing how increases in the mean (average) temperature affect the probability of extreme hot weather events occurring



Even by 2040, it is predicted that extreme heat waves - such as the one in 2003, when approximately 70,000 more people died than in a usual year, that led to over $15 billion in economic losses - will become an average European summer. In fact, by 2060, almost all summers will be hotter than that.

The IPCC warns that at a global average of 2°C heating we will be experiencing extreme heat waves of the kind seen in 2019 *every summer*. The deadly heatwaves that India and Pakistan saw in 2015, which killed over 3,400 people, may also occur annually. Compared to a heating of 1.5°C, an additional 350 million people across the globe will be at risk of heat stress, an additional 420 million people will frequently be exposed to extreme heatwaves, and an additional 65 million people will be

exposed to *exceptional* heatwaves. Under even a relatively optimistic carbon emissions scenario, it is predicted that 22% of major cities will be heated to the point that their climate is unlike any currently existing city.

Extreme heat will cause misery for those who are unable to afford air conditioning, with workplaces becoming unbearably hot - leading to loss of economic productivity and exacerbating existing inequality. In addition, many countries are simply not equipped to deal with such periods of intense and prolonged heat and critical infrastructure (such as transport systems) will not be able to cope.

The UK Met Office warns that British summers are going to keep getting hotter, on average 3°C warmer and 18% drier. By 2050, the UK is predicted to see a trebling of heat-related deaths - with 7,000 dying due to excess heat each year - and the climate of Leeds is predicted to become more similar to that of Melbourne, with scorching summer heat waves like in 2018 *every other year*. These are conditions that no UK infrastructure is designed to withstand, nor that any of the wildlife and ecosystems of Northern England are adapted to.

2050: More intense storms, floods and hurricanes

Over the coming years, the likelihood of extreme rainfall events is expected to grow more than fourfold in some regions, with much of the world, including Europe and the UK, very likely to feel the *catastrophic* impacts of more frequent severe storms, stronger hurricanes, and more devastating floods. The UK Met Office warns that British winters will get wetter, with extreme flooding events becoming increasingly common. The intensity of rainfall during British summers is expected to increase too, suggesting that, whilst summers may tend to become drier overall, when it *does* rain it will fall in heavier bursts, with major implications for flash flooding.

The IPCC predicts that by 2050 the combination of rising seas and more intense storms will mean that, in many low-lying megacities and small islands, the sort of extreme flooding events previously occurring only once a century could be happening *every year*.

By 2050 we can also expect to see an increase in the amount of rainfall accompanying tropical cyclones, with an increase in tropical cyclone intensity and an increase in the number of very intense (category 4 and 5) tropical cyclones. It is predicted that tropical cyclones are more likely to be hitting Western Europe.

2050: Increased droughts and water shortages

"We know that with increased storms, increased floods, droughts and heat waves, production of food will be more problematic. Ensuring people have access to clean, safe drinking water will become much more difficult."
Professor Mark Maslin, Professor of Climatology at University College London

"On the present projections, many parts of our country will face significant water deficits by 2050, particularly in the southeast, where much of the UK population lives."
Sir James Bevan, chief executive of England's Environment Agency

An estimated 3.6 billion people (nearly half the global population) already live in areas that are potentially water-scarce at least one month per year. The UN warns that, by 2050, between 4.8 billion and 5.7 billion people will be living in areas that are water-scarce for at least one month each year. Indeed, according to UN-endorsed projections, by 2030, due a combination of climate change, human action and population growth, global demand for fresh water will exceed supply by a staggering 40%.

By around 2050 the IPCC warns that 410 million people living in urban areas will be regularly exposed to severe drought, 50% more people may see increased climate-induced water stress, and 184-270 million more people will be exposed to increases in water scarcity.

It's not just droughts and population rises that can cause water scarcity. 78 of the world's mountain 'water towers' (reservoirs of freshwater locked away in high altitude snow, glaciers and mountain lakes) are incredibly vulnerable to the effects of global warming and climate change. Indeed, melting mountain glaciers threaten to put the 1.9 billion people living downstream of them at risk of serious water shortages for drinking water and crop irrigation. That's more than one fifth of the world's population.

In the Andes and the Himalayas alone, the melting of glaciers threatens the water supplies of hundreds of millions of people, leading to a potential reduction in water supply for more than 240 million people. The Indus river basin (stretching from the Himalayan mountains in the north to the plains of Pakistan in the south and finally flowing out into the Arabian Sea) is globally the most important such water tower and it is highly vulnerable to climate change. This water tower currently supports 206 million people. However water supplies are set to decrease in line with warming air

temperatures while the population is set to increase. Glaciers are also important for hydropower and irrigation, so glacier melting will also put electricity and food supplies at risk.

In Europe, the loss of these frozen water towers will have a devastating impact on mountain regions important for providing water to France, Germany, Spain, such as the Rhone in France and the Rhine in Germany, as well as the Bulgarian Black Sea Coast and the Caspian Sea Coast. The Rhine region relies on water for power and industry too.

According to Dr Bethan Davies, from the Department of Geography at Royal Holloway University: “Limiting global warming to 1.5°C relative to pre-industrial temperatures will retain around 75% of all mountain glaciers, which provide a critical buffering service in the world’s mountains.”

It’s not just mountainous regions that will be at risk of water shortages. London is listed in the top 10 most likely cities in the world to hit Day Zero – the name given to the day when a city completely runs out of fresh water. According to the Greater London Authority, the city is likely to have supply problems by 2025 and "serious shortages" by 2040. In March 2019, Sir James Bevan, chief executive of the Environment Agency, warned: “On the present projections, many parts of our country will face significant water deficits by 2050, particularly in the southeast, where much of the UK population lives.” He explained that in about 20-25 years, demand for water could close in on supply, in what he described as “the jaws of death - the point at which, unless we take action to change things, we will not have enough water to supply our needs.”

2050: Rising seas and increased coastal flooding

“The future for low-lying coastal communities looks extremely bleak… But the consequences will be felt by all of us. There is plenty to be concerned about for the future of humanity and social order”
Prof Jonathan Bamber at Bristol University

As global temperatures continue to rise, we risk triggering the collapse of more sectors of the West Antarctic ice-sheets. Indeed, global heating of 1.5-2°C may well lead to collapse of the major Antarctic ice shelves, locking in a long-term and unstoppable sea level rise of several metres over the next few centuries - possibly sooner if temperatures continue to increase. Even if we are able to limit global

heating to 1.5°C, sea levels still are predicted to continue to rise for hundreds of years - every 5 years we delay action locks in another 0.2 m.

Unless we drastically reduce emissions now, the IPCC predicts that, by 2050, the combination of rising seas and more intense storms will mean that, in many low-lying megacities and small islands, the sort of extreme flooding events previously occurring only once a century could be happening *every year*. Indeed, new studies show that if we don't adapt and build sea defences, land currently inhabited by more than 300 million people is likely to flood at least once a year - that's three times more than was previously thought. Rising sea levels are predicted to overwhelm the ability to build adequate coastal defences, forcing many millions of people to have to leave their homes.

See here for an interactive map showing which areas of the globe are predicted to be below annual flood level by 2050. Large parts of Vietnam, the world's third largest rice exporter, could practically disappear, with almost 25% of the Vietnamese population - that's more than 20 million people - living on land that is likely to be underwater at least once a year. 10% of people in Thailand also live in areas like this. Basra, Iraq's second-largest city, could practically disappear too, triggering local conflicts. Other cities most at risk from sea level rise include Kolkata, Mumbai, Ho Chi Minh City, Shanghai, Bangkok and Miami. Without major investment, flooding in cities across the globe is forecast to cost over US$1 trillion per year.

Colette Pichon Battle, Executive Director of the Gulf Coast Centre for Law and Policy, warned: "The impact on families [of rising sea levels] is going to be something that I don't think we could ever prepare for."

The UK will be one of the worst hit, with large parts of the English coastline and areas around its rivers, such as Sussex, Kent, Cambridgeshire and Central London, predicted to regularly fall below sea level by 2050. Although it's worth being aware that experts in Cambridgeshire have responded to these flooding projections with promises of an "ongoing commitment from all organisations to maintaining and improving flood defences already present in Cambridge and the Fens". Even so, the Environment Agency estimates that 800 coastal homes in the UK will be lost in the next 15 years and that rising seas are likely to eventually force many people to have to relocate.

The residents of sea-threatened Fairbourne in Wales could be the first entire UK community in which rising sea levels and eroding coastlines will force people to have to relocate. Sea defences in this area will stop being maintained in the 2050s, but the local council says it may begin "decommissioning" the village before then and start moving residents out, potentially creating hundreds of British climate refugees.

2050: More devastating loss of wildlife on land and in the oceans

“Climate change is the biggest threat wildlife will face this century”
National Wildlife Federation

“The climate crisis has arrived and is accelerating faster than most scientists expected. It is more severe than anticipated, threatening natural ecosystems and the fate of humanity.”
World Scientists’ Warning of a Climate Emergency

Over the next decades, without radical intervention, wildlife will continue to decline with an estimated one million species facing extinction due to human action.

We have already locked in a large future increase in marine heatwaves due to the fact that our oceans respond very slowly to atmospheric heating. Indeed, the IPCC warns that marine heatwaves are projected to further increase in frequency, duration, spatial extent and intensity. This will have devastating impacts on ocean life.

The latest studies suggest that the Arctic could be ice-free in summer as soon as 2035, with devastating impacts on polar bear populations and other Arctic ecosystems. By 2050, more than 99% of our tropical coral reefs will have been lost: that is near total destruction of some of the most important and diverse ecosystems on the planet, which support up to one million other species and provide food, protection from storms and livelihoods for nearly one billion people.

Losing the diversity of our ecosystems, combined with climate breakdown, will place huge strains upon our social systems. It is feared that this could ultimately result in the collapse of our globally interconnected network of civilizations, resulting in great suffering and the deaths of many hundreds of millions, and perhaps even billions, of people.

2050: Further reductions in food production

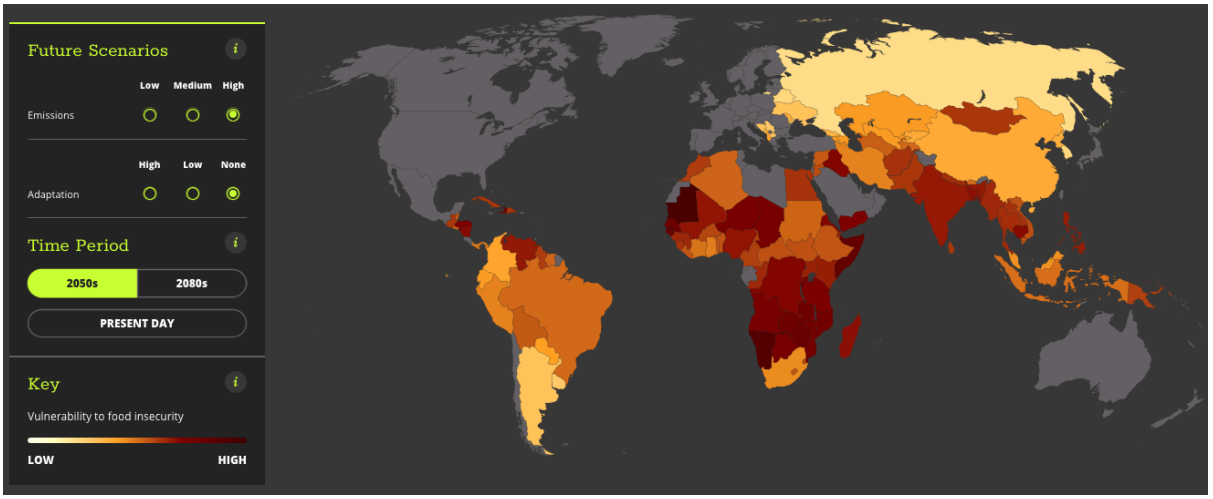
“Climate change will lead to battles for food.”
Jim Yong Kim, Former President of The World Bank

At even 1.5°C of heating, predicted to happen around 2030, in West Africa and the Sahel reduced maize and sorghum production is likely, with the size of areas suitable

for maize production reduced by as much as 40%, leading to increased risks of undernutrition.

At 2°C of heating, expected by around 2050 unless we make radical changes, the risk of extreme weather hitting several major food producing regions of the world at the same time could more than triple. Land degradation and climate change together are predicted to reduce crop yields by an average of 10% globally and up to 50% in certain regions. U.S. maize production could decrease by about 18%, and there is predicted to be a roughly 7% risk of the world's top four maize exporters suffering simultaneous crop failures of 10% or more. Rice and wheat will become less nutritious, and there will be a higher risk of malnutrition. Continued loss of pollinating insects would affect more than 75% of global food crop types, reducing yields and risking US$235-577 billion of global crop output annually.

Infographic showing the vulnerability of non-OECD countries to the threat of food insecurity due to climate change by 2050 if we fail to reduce emissions or adapt to changes



Overall, by 2050, up to 1.5 billion MORE people (that would be five billion people in total) particularly in Africa and South Asia, are likely to face shortages of food and clean water.

In the absence of good governance, food insecurity in some parts of the world, resulting in a domino effect of price hikes across the globe, could lead to a dramatic increase in the incidence of food riots.

The UK, for example, is dependent on a complex global industrial consumer economy. Around 50% of UK food comes from foreign imports, including about 70-80% of fruit and vegetables. Some reports even suggest that, if we include the imported ingredients in products that are processed in the UK, up to 80% of all our food relies on foreign imports. Imports are mainly from mainland Europe, where

crops are already susceptible to damaging heatwaves. The UK Climate Change Risk Assessment highlighted food security issues from both domestic and international supply chains as a key risk in need of urgent action.

To make matters worse, a new study has shown that, when compared against the real world impacts of the 2003 European heatwave, even 'state of the art' models of the impacts of climate breakdown still underestimate the scale of the impacts of heatwaves on important sectors such as agriculture. The authors state that this "means that societal risks from future extreme events may be greater than previously thought".

2050: More devastating impacts on human health

"Climate change poses the biggest global health threat of the 21st century"
The Lancet Commision on Climate Change

Warmer temperatures will continue to increase the spread of infectious diseases such as malaria and dengue fever, with risks of them appearing in new parts of the world.

According to the World Health Organisation (WHO), between 2030 and 2050, climate change is expected to cause approximately 250,000 additional deaths per year, from malnutrition, malaria, diarrhoea and heat stress alone.

The WHO has identified malaria as one of the most climate-sensitive diseases and predicts at least another 60,000 deaths from it by 2050. Countries that have eradicated the disease could see a deadly return - including parts of Europe. Increasing numbers of new diseases and viruses may also appear by 2050. Allergies are predicted to be much worse by 2040 too - with about 2.5 times as many grains of pollen per cubic metre of air as there is today. See section on more intense heatwaves for information on how heat-stress - and the numbers of heat-related deaths - is predicted to increase by 2050.

According to a new report from the Organisation for Economic Co-operation and Development (OECD), by 2060, unless action is taken, outdoor air pollution alone could cause 6 to 9 million premature deaths a year and cost 1% of global GDP - around USD 2.6 trillion annually - as a result of sick days, medical bills and reduced agricultural output.

2050: Mass displacement

"Climate change is the result of the greatest market failure the world has seen. We risk damages on a scale larger than the two world wars of the last century. What we are talking about is extended world war. People would move on a massive scale. Hundreds of millions, probably billions of people would have to move."
Lord Nicholas Stern, Professor of Economics and Government

New studies show that by 2050, sea-level rise will result in annual flooding of land currently home to 300 million people (three times more than was previously thought), overwhelming the ability to build adequate coastal defences and forcing many millions of people to have to leave their homes. This will particularly affect parts of Asia, with cities in China, Bangladesh and India having the greatest numbers of people at risk.

The World Bank has estimated that by 2050 there could be 140 million people in Sub-Saharan Africa, Latin America and South Asia who will be forced to move within their countries due to climate change - as a result of high temperatures, crop failures and flooding. These refugees will be moving out of harm's way as migration is essentially a form of adaptation to a more hostile world. According to a study carried out by the Institute for Environment and Human Security of the United Nations University, by 2050 there could be up to 200 million environmental migrants globally, with most displacement occurring within nations or to bordering countries.

2050: Poverty and financial instability

"Once climate change becomes a defining issue for financial stability, it may already be too late."
Mark Carney, former Governor of the Bank of England

Compared to an average global heating of 1.5°C, at 2°C heating the IPCC warns that an additional several hundred million people will be left susceptible to the risks of climate-related poverty. Between 3-16 million people could be forced into *extreme* poverty because of rising food prices and crop failures.

In terms of the global economy, climate change is set to have a myriad of negative impacts, and indeed there may be many financial benefits from measures undertaken to tackle climate change, as summarised in this article. The IPCC predicts that, in the United States alone, each degree of warming will lead to a loss

of 2.3% of GDP. On our current trajectories, by 2050 this will amount to financial losses in the US of more than $446 billion. However, the economic models the IPCC use to make these predictions have come under criticism by many economists and climate scientists, and actual losses are likely to be much higher.

2050: Social instability and conflict

"*The political and economic map of the world simply cannot cope with these stresses, without real change in the way nations plan, govern and commit resources. Disaster relief will likely be inadequate, insurance funds will probably fail, and vast dislocations of supplies and services are to be expected. Having a capable army and rescue services will not be enough. The threat of mass casualties, political upheaval, and conflict within and between states will certainly increase*"
General Wesley K Clark (Ret.), Former NATO supreme allied commander for Europe

There are concerns that mass migration caused by rising seas or agricultural failure could trigger or exacerbate regional conflicts - especially in some countries such as Iraq, whose second largest city Basra is predicted to be almost totally submerged by 2050 - driving political instability and increasing the chances of armed conflict and terrorism. General Castellaw, a member of the advisory board of the Centre for Climate and Security, told the New York Times: "So [rising sea levels] is far more than an environmental problem. It's a humanitarian, security and possibly military problem too."

What will our world look like by the end of the century?

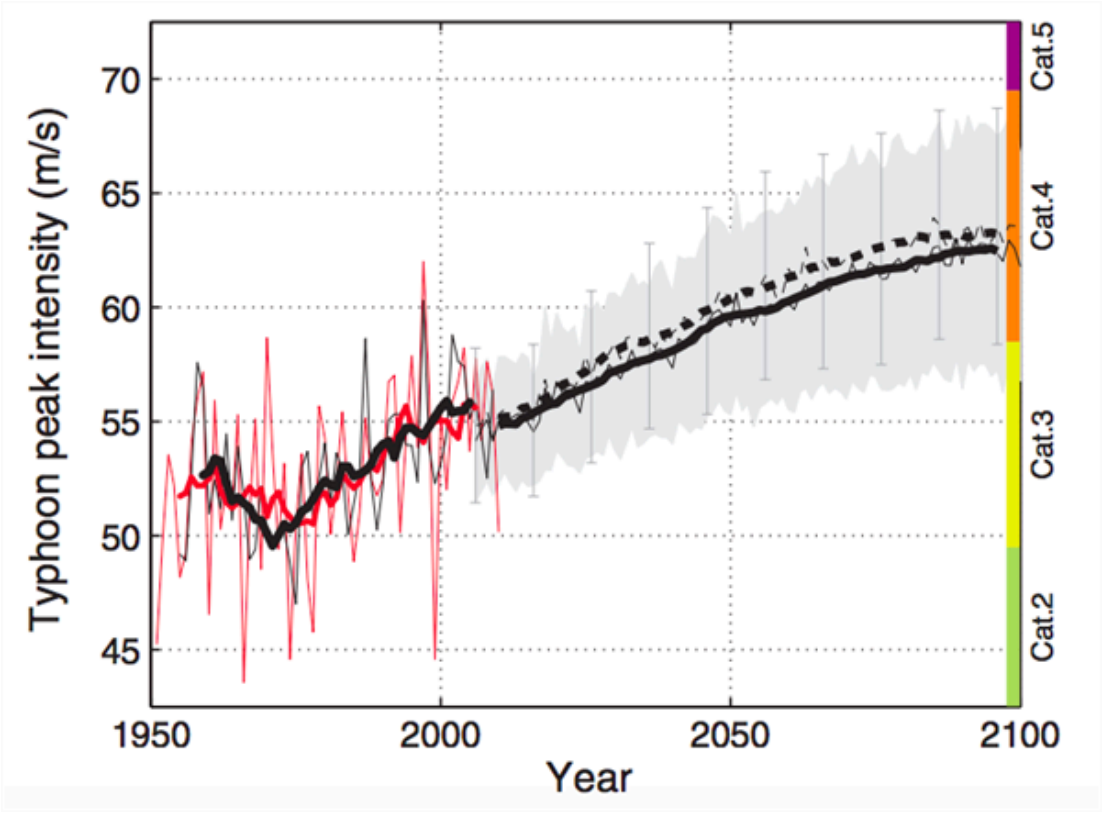
"The next 20 years will be worse than the last 20 years - all indications point to that - and things will be completely nuts by the end of the century if we keep doing what we're doing now."
Dr Angeline Pendergrass, National Center for Atmospheric Research (NCAR) in Boulder, Colorado.

Taking into account climate policies that were in place in December 2019 we are heading towards an average global temperature rise of 3°C by the end of the century, with a significant chance that we could be hitting 4°C heating or more.

2100: Extreme weather

At 3°C of heating, where we are currently most likely to be headed for by the end of the century, the increase in extreme weather events will be devastating. Drastic increases in heatwave duration and frequency will lead to substantial impacts on human health, mortality and the global economy. There will be large reductions in rainfall and water availability resulting in large increases in extreme drought and very high risks of water deficit. Scientists predict that by 2100 the intensity of tropical storms in the Western North Pacific could increase substantially.

Changes in average typhoon intensity in the Western North Pacific from 1950 to present day and predicted increases in typhoon intensity up to 2100



2100: Flooding and mass migration

The IPCC predicts that by 2100, the combination of rising seas and more intense storms will mean that, in most areas, the sort of extreme flooding events previously occurring only once a century could be happening *every year*. Huge areas of land across the globe could become uninhabitable and we are likely to see a huge increase in mass displacement and climate refugees.

2100: Wildlife loss

Without urgent action, over the next century the combination of rapid changes in the climate and human-caused damage to our land will lead land-based ecosystems to be faced with an environment that will be unlike anything seen in our recent evolutionary history. It is predicted that 640,000 more species will be at risk of extinction - in addition to the one million species already threatened with extinction over the coming decades due to human action (see section on how we are destroying our wildlife).

The changes in our environment will not only be of a similar magnitude to the very largest changes that have taken place in the last 65 million years, but they will also be happening *many times faster*. To make matters worse, while in the past creatures could have migrated to cooler areas to seek refuge from rising temperatures, many such areas have now been severely degraded, fragmented or colonised by human activities. In addition, the speed of the changes that will be taking place means that many plants and animals will not be able to migrate *fast enough* to keep up with climate change, even if there were to be the habitats to move to.

It is very likely that by the end of the century, unless we make radical changes now, we will see drastic warming at the poles, with the Arctic very likely to be ice-free each summer - leading to critical habitat losses for organisms such as polar bears, whales, seals, and sea birds. A collapse in permafrost may occur. Alpine habitats are also likely to suffer critical losses and we are likely to see increases in the frequency of marine heatwaves of around 50 times, relative to pre-industrial times, with devastating impacts on ocean life.

2100: Impacts on human health, food and water

By the end of the century human health will be drastically impacted by extreme weather events and heat stress. In addition, increasing temperatures will lead to a large increase in the spread of infectious diseases. For example, by 2061-80, an additional half a billion people could be at risk from diseases carried by the Aedes aegypti mosquito.

By 2100 there will be substantial reductions in agriculture and crop yield, resulting in major regional food insecurities and very high risks of under nutrition, especially in communities dependent on dryland agriculture and livestock. It is predicted that there

will be a 10-30% decrease in overall crop production. Major droughts and crop losses in one part of the world will affect food prices on the other side of the world. More than 10 million tonnes of fish will be at risk every year, worth tens of billions of dollars.

In addition, IPCC projections state that most glaciers - the world's largest supplies of mountainous freshwater - will be gone by 2100. Globally, about 1.9 billion people live downstream of glacierised mountain ranges and depend on the water from these glaciers for drinking water, irrigation and industry. In places like the Himalayas, glacier recession will lead to very severe water shortages.

Whilst 3°C warming would be terrible, there is a significant chance that we could reach a catastrophic 4°C warming by the end of the century...

What will our world look like by the end of the century if we reach 4°C of heating?

"There is a growing sense of panic in those who really understand what a 4°C world might be like."
Professor Will Steffan, Director of the Australian National University Climate Change Institute

On our current emissions pathways there is a significant chance that temperatures could sail past 3°C of heating, reaching a terrifying 4°C (or more) of heating by the end of the century, made all the more likely if governments renege on their promises to cut emissions or if positive feedback loops kick in and tipping points are breached. In fact, if feedback loops are much stronger than we expect, 4°C of heating could be reached as early as the 2060s - under an extreme worst case scenario.

Professor Richard Betts, Chair of Climate Impacts at the University of Exeter and Head of Climate Impacts at the Met Office Hadley Centre, warns: "Global warming of 4˚C this century is quite possible and would bring massive risks to life and society - heatwaves, coastal and river flooding, droughts and more... We don't know how society would respond to the massive risks of 4˚C global warming. Transformational change would be needed."

Even if emissions slow down, until they reach net zero the world will keep heating up and we'll reach 4˚C heating sooner or later - a situation we simply cannot allow to happen.

Professor Kevin Anderson, deputy director of the Tyndall Centre for Climate Change Research, warns: “There is a widespread view that a 4°C future is incompatible with any reasonable characterisation of an organised, equitable and civilised global community.”

Professor Johan Rockström, director of The Potsdam Institute for Climate Impact Research, has said that in a 4°C-warmer world: “It’s difficult to see how we could accommodate 8 billion people or even half of that. There will be a rich minority of people who survive with modern lifestyles, no doubt, but it will be a turbulent, conflict-ridden world.” By 2100, in the absence of the catastrophic impacts of global heating, it is predicted that we would be heading for a population of around 11.2 billion.

According to a World Bank report in 2012: “…there is also no certainty that adaptation to a 4°C world is possible. A 4°C world is likely to be one in which communities, cities and countries would experience severe disruptions, damage, and dislocation, with many of these risks spread unequally. It is likely that the poor will suffer most and the global community could become more fractured, and unequal than today. The projected 4°C warming simply must not be allowed to occur.”

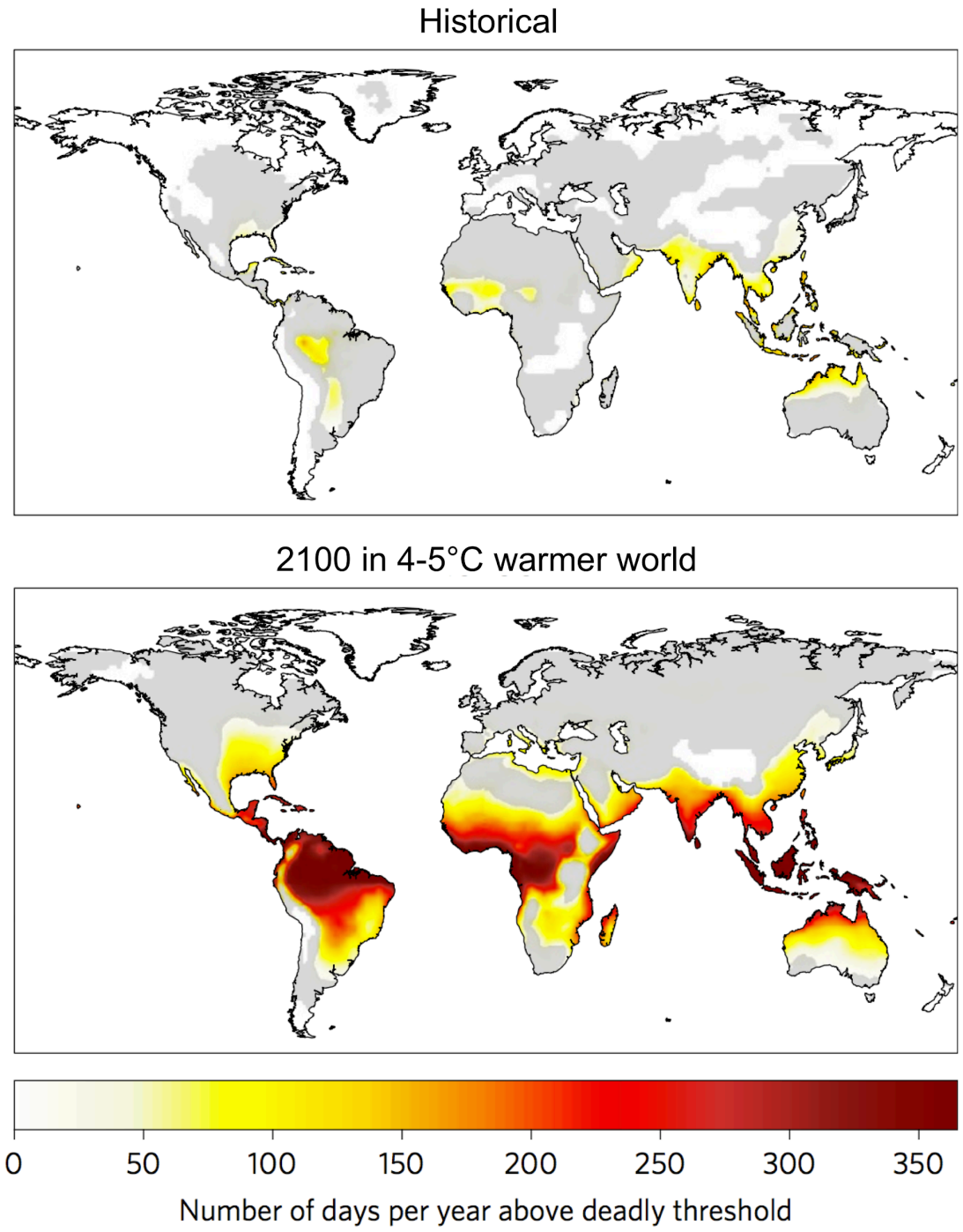
Here are a few more specific predictions about what a 4°C hotter world would look like:

4°C of heating: Extreme heat

At 4°C of heating, research shows up to three quarters of the world’s population could be at risk from deadly heat extremes, with billions facing a ‘deadly threshold’, as shown in the figure below adapted from the study.

Number of days per year exceeding the threshold of temperature and humidity beyond which climatic conditions become deadly. Top: average between

1995-2005 (historical); bottom: average between 2090-2100 in a world 4-5°C hotter than in preindustrial times



The combined increase in temperature and humidity could become so high in the densely populated agricultural regions of South Asia that towards the end of the century there could be days when humans will not be able to tolerate being outdoors for more than a few hours at a time. In North China, deadly heat waves may limit habitability of one of the world's most populous regions in the world, leading to heat extremes that exceed "the threshold defining what Chinese farmers may tolerate

while working outdoors." Huge areas of the world will become uninhabitable. Even somewhere cool like the UK will have temperatures above 40°C every few years, much hotter than the current hottest day on record.

4°C of heating: Rising seas, flooding and mass displacement

At 4°C of heating, we would expect to see a sea level rise of up to one metre (with much more locked in over the coming centuries), but, if emissions are high and there is a large contribution from melting ice sheets, there is more than a 10% chance of it exceeding two metres - quite possibly a lot more if parts of the West Antarctic Ice Sheet have collapsed by then. Land currently inhabited by 230 million people is predicted to be below the waterline at high tide - potentially resulting in *daily* flooding - with some island nations "likely to become uninhabitable".

Given that the West Antarctic Ice Sheet is responding to climate change even more quickly than scientists first thought, it is possible that we could even be headed towards a rise of two metres by the end of the century - although other studies suggest it may not be as much as this. Sea level rise won't stop in 2100 either. If warming is sustained we will be committed to around a 5m sea level rise over the coming centuries if the West Antarctic Ice Sheet collapses, and up to another 7 m if the Greenland ice sheet melts.

At 4°C of heating the Alps could become almost completely deglaciated. In Europe alone, an additional 250,000 to 400,000 people would be exposed to river flooding each year - and up to 5.5 million per year to coastal flooding - and annual coastal flood damages are projected to increase 100 to 1,000 times.

In the UK, The Environment Agency estimates that 7,000 properties around England and Wales, worth more than £1 billion, will be lost to rising seas over the next century as coastlines erode. They say that the cost of protecting these properties is considered to be too high. The Committee on Climate Change had previously warned that 1.2 million homes in England will be at significant risk from coastal flooding by 2080, though this number is likely to now be far higher.

Overall, global sea level rise is expected to displace hundreds of millions of people by 2100, and eventually rising seas are predicted to displace the 680 million people living in low-lying coastal zones, along with the 65 million citizens of small island states.

4°C of heating: Wildlife loss

As the climate becomes radically different to what species have experienced previously or are able to adapt to, it is predicted that at 4°C heating about 1.3 million more species will be at risk of extinction (about 16% of all species) and 15% of species communities will suffer abrupt and disruptive changes**.** However, these numbers are likely to be too conservative as they are based on *average* changes in temperature and rainfall, and it is difficult to predict how many extra species will be driven extinct by additional processes such as extreme weather events, and local changes such as the melting of sea ice. It's important to realise that these numbers are *in addition* to one million species currently at threat from due to over-exploitation of the land and sea by humans (see section on how we are destroying our wildlife).

At 4°C of heating, the additional carbon dioxide in the atmosphere is predicted to cause the acidity of the world's oceans to rise by 150%. It is thought that, in our prehistoric past, extreme changes in ocean acidity like this played a large role in mass extinction events.

4°C of heating: Reductions in food production

At 4°C of heating the production of maize in the US, much of which is used to feed livestock and make biofuel, could be cut in half. The risk of the world's top four maize exporters suffering simultaneous crop failures of 10% or more shoots up to a terrifying 86%. Yields of global vegetables and legumes could fall by 35% due to water scarcity and increased salinity and ozone. Food shocks will be felt across the globe and, as a result, the risk of civil unrest, and even societal collapse, would be expected to increase dramatically.

According to Rachel Warren, Professor of Global Change and Environmental Biology at the University of East Anglia: "We have already observed impacts of climate change on agriculture. We have assessed the amount of climate change we can adapt to. There's a lot we can't adapt to even at 2ºC. At 4ºC the impacts are very high and we cannot adapt to them".

Not worth the risk: why we need to apply the Precautionary Principle

"If you got in a plane with a one in 100 chance of crashing you would be appropriately scared. But we are experimenting with the climate in a way that throws up probabilities of very severe consequences of much more than that."
Sir David King, Former UK Chief Scientist and Former UK Special Representative for Climate Change

Climate modelling is about making predictions about *how likely* it is that something terrible will happen in the future if we don't take radical action now. It is impossible for science to tell us with *absolute certainty* what will happen, but we can say that certain things - such as more extreme weather, rising sea levels, crop failures and water scarcity - are "extremely likely" to happen. Other aspects, such as tipping points, are more uncertain, but if they do occur would cause catastrophic and irreversible damage. In other words, we can say that if we don't act now, we *risk* global catastrophe, even if we can't say exactly *when* it might occur.

However, some people say that if the impacts of climate change are not *proven*, no matter how bad they may be we shouldn't risk potential economic harm by taking action. They say "come back to us when you're *certain*".

This is where we need to apply what's known as the Precautionary Principle. The Precautionary Principle advises us that "when an activity raises threats of harm to human health or the environment, precautionary measures should be taken, even if some cause and effect relationships are not fully established scientifically." In other words, if there's a *plausible risk* that a certain activity may have environmentally harmful consequences, it is better to control that activity NOW rather than wait for incontrovertible scientific evidence that it will cause harm. We have seen people applying the Precautionary Principle in making significant changes to their lifestyles and their routine due to the *risk* of catching the COVID-19 coronavirus.

Yet the vast unknowable risks to which we are potentially exposed as a result of human-caused climate change and ecosystem breakdown are many orders of magnitude greater than those posed by coronavirus. Whilst they may be less immediate and tangible than the risks of catching coronavirus, these risks are *incredibly serious* and the consequences *potentially devastating*. It is therefore extremely unwise to wait until all the evidence is in before acting *radically* to head off such risks. In fact, by the time scientists are *certain* about exactly what will happen next, it will almost certainly be too late to stop it.

Rapidly reducing greenhouse gas emissions may indeed cause significant disruption to our lives and even possible economic harm. Yet *not* doing so risks catastrophic impacts on our planet, with incalculable suffering and the deaths of hundreds of millions, if not billions, of our fellow human beings. That could never be worth the risk. Nothing is worth risking everything for.

Part 6: Enough is enough… How are our governments letting us down?

What are governments ‘supposed’ to be doing to address the ecological crisis?

“There is no question we are losing biodiversity at a truly unsustainable rate that will affect human wellbeing both for current and future generations”
Robert Watson, chair of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)

Humans rely on wildlife for food, shelter, medicines and pollination of crops (see section on why we should care about the loss of our wildlife), making biodiversity loss an emergency in its own right. But, in addition, degradation of the world’s ecosystems is also making a significant contribution to climate change. This is due to the release of greenhouse gases from ploughed soil, dried out peatlands, the burning of trees and the conversion of natural ecosystems to livestock farming and intensive agriculture - and to the subsequent reduction in their ability to capture carbon from the atmosphere. It is therefore vital that governments urgently address the ecological emergency as well as the climate crisis.

The most high profile attempt to slow species loss and damage to ecosystems is the Aichi Targets of the Convention on Biological Diversity. In 2010 many countries united to draw up this 10 year plan.

The Aichi Targets were supposed to come to fruition in 2020 but most of the targets have not been achieved. There are some apparent successes, such as the rapid increase in land protected for biodiversity, but, even here, many of the new protected areas are poorly designed and are failing to protect species against harm from humans. The international community is now drawing up a new 10 year plan and there is much discussion about the details of these new targets and how to improve them. However, there is little talk about the lack of will on the part of governments to change their activities in ways that can achieve lasting change.

This attitude needs to change fast if we are to preserve a healthy natural world for future generations. After all, once a species goes extinct, it's gone forever. If whole ecosystems collapse, it will not only be a tragic loss of some of the great wonders of

the natural world, but will harm human societies for generations. As the latest IPBES report says: “Nature is essential for human existence and good quality of life. Most of nature’s contributions to people are not fully replaceable, and some are irreplaceable.”

What are governments ‘supposed’ to be doing to address the climate crisis?

“While adaptation is now urgent and there are many adaptation opportunities, climate science tells us that further warming and risk increase can only be stopped by achieving zero net greenhouse gas emissions.”
McKinsey Global Institute Climate Risk and Response Report, 2020

The Paris Agreement

In 2016 the Paris Agreement was drawn up by negotiators from almost every country in the world as part of the United Nations Framework Convention on Climate Change. The Agreement commits governments “to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C.” A total of 189 countries have given their formal consent to the agreement, as well as the European Union. See section on the promises of the Paris Agreement.

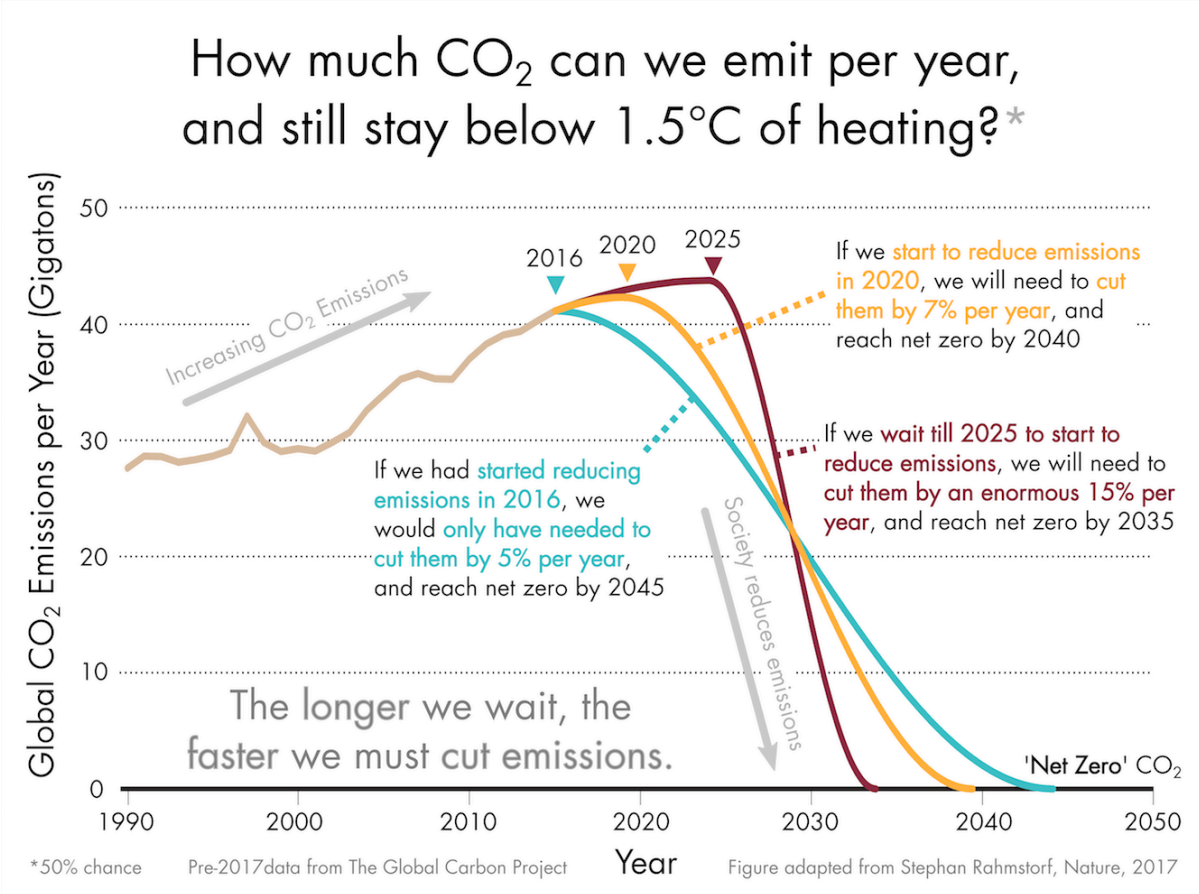
Net zero by 2050

In 2018, a special report from the IPCC laid out the human costs of failing to limit heating to 1.5°C above pre-industrial levels. The report showed that even though 1.5°C of heating is not without risk, the impacts of 2°C or more are much, *much* worse.

In order to have even a *50:50 chance* of remaining below 1.5°C heating, the report stated that global carbon dioxide emissions must now “decline by about 45% from 2010 levels by 2030, reaching net zero around 2050”. This means that, by 2050, any further carbon emissions must be balanced with carbon removal.

The 2019 UN Emissions Gap Report stated that we need to start reducing emissions by 2020 *at the absolute latest* and that there then must be unprecedented, rapid reductions in global carbon emissions of around 8% per year from 2020 to 2030.

The longer we wait to start reducing emissions, the faster the cuts we will have to make, and / or the sooner we will have to get to net zero. In other words, every year counts.



It's not just WHEN we get to net zero, it's HOW

The thing is, aiming for net zero by 2050 (which we are not currently doing anyway, despite what has been promised - see section on how our governments are making the climate crisis worse, not better) is not going to be enough by itself. It is crucial that we *also* start reducing our emissions NOW. This is because the longer we delay on making the necessary drastic cuts in our emissions, the more we will be forced to rely on the additional use of negative emissions technologies to get us to net zero (by sucking in hundreds of billions of tons of carbon dioxide from the air). This is simply not realistic. For example, carbon dioxide would need to be absorbed from the air by growing bioenergy crops on an area the size of India (using

already-stretched resources such as water and competing with land for growing food) and 'carbon capture and storage' techniques would need to be employed on an absolutely staggering scale to safely store this carbon underground.

At present, these futuristic negative emissions technologies barely exist, and we certainly do not know if it will be possible to deploy such technologies at the massive scale that is needed in time. Even the experts have divided opinions, and studies show that, in some cases, they might even lead to more carbon dioxide being emitted than being drawn in. Indeed, the European Academies' Science Advisory Council warned in a report in 2018: "Negative emission technologies may have a useful role to play but, on the basis of current information, not at the levels required to compensate for inadequate mitigation measures".

If we rely on our ability to use such technologies in the future, we risk backing our children into a corner now that they can't get out of. According to the Precautionary Principle, betting the safety of future generations on negative emission technologies that do not currently exist is a *disastrous diversion* from making the necessary cuts to emissions NOW. (See section on not worth the risk: why we need to apply the Precautionary Principle).

Even the scenario proposed by the UN Emissions Gap Report - that of reducing emissions by 2020 *at the absolute latest* followed by rapid reductions in global carbon emissions of around 8% per year from 2020 to 2030 - still relies on the use of *some* negative emissions technologies in the second half of the century. If instead we want to play it safer and not assume that these and other future technologies will be able to draw in and store carbon, we will need to start reducing emissions right now *even faster* than the UN suggested - more like by 15% every year.

And all of this is to give us just a *50:50* chance of staying below 1.5°C heating.

Why net zero by 2050 isn't actually fast enough

Even if we start reducing emissions now and get to net zero by 2050, that only gives us a 50:50 chance of staying below 1.5°C heating. What if we want a two in three chance?

For a 66% chance of staying below 1.5°C heating, as of January 2018 we only had 420 gigatons of global carbon budget left to emit. As of July 2020, that figure is down to 310 gigatons - and shrinking fast. At today's rates of emissions, we will have entirely exhausted that remaining carbon budget in less than *eight years from now*.

In fact, the IPCC recommends shrinking the global carbon budget *even further*, by an additional 100 gigatons, to account for the long-term risk of carbon feedback loops and tipping points (see sections on feedback loops and tipping points). This would give us far less time, meaning that at the current rate of emissions we would use up the budget for a 66% chance of staying below 1.5°C heating in more like *five years.*

The bottom line is that the better a shot we want at a safe climate for our children, the smaller the carbon budget we have left, and the faster the emission cuts that are required. And the more we drag our heels and delay in making the necessary cuts to emissions now, the steeper the cuts we will have to make in the future.

Why richer countries need to get to net zero MUCH sooner than 2050

It is important to be aware that the discussion so far has been talking about how fast average *global* emissions need to come down. But the thing is, we are not all equally responsible for climate change. The wealthiest 10% of the world's population are responsible for over 50% of the current emissions, whereas the poorest 50% are only responsible for 10% of emissions. It therefore makes sense that most of the cuts in carbon emissions and resource consumption should be done by the richer sections of societies across the world. Indeed, if developed nations such as the UK, EU, US, China and India were all to aim for net zero by 2050, together they would use up so much of the remaining budget that the rest of the world would not be able to produce *any carbon dioxide at all* after around 2030. Instead, richer countries need to be aiming for net zero much sooner than this.

Plus, not only do richer countries have a disproportionately higher level of emissions today, but they also have the biggest *historic responsibility*. This is because carbon dioxide accumulates in the atmosphere (see section on greenhouse gases), so what a country emitted in the past matters as much as what they are emitting today.

It's also important to realise that many of the countries that have done the least to cause climate change will face the worst impacts. This brings us to the idea of 'climate justice' - whereby those most responsible for climate change support those most vulnerable to its impacts, so that those who are least responsible for the problems don't end up having to pay to fix them. This is true both within countries and between countries. Indeed, many low-income countries that have done little to cause climate change are already suffering from some of its most devastating

impacts. These countries need our support NOW, and will need our further support to adapt to what is coming.

These issues lead to the concept of *climate equity*, in which countries need to address climate change "in accordance with their common but differentiated responsibilities and respective capabilities and their social and economic conditions". In other words, climate equity dictates that richer countries should decarbonise faster and help low income countries transition to a low carbon technology without first having to build new fossil fuel infrastructure. Plus, it is unrealistic to expect low- and middle-income countries to decarbonise if they don't think the high-income countries are pulling their weight. This principle of climate equity is enshrined within the Paris Agreement, but it has too often been neglected.

Recent research by Professor Kevin Anderson has shown that if we properly take equity into account (to ensure a "fair" split of total global carbon emissions), and do not rely on negative emissions technologies, the absolute *minimum* that richer countries such as the UK or Sweden need to be doing to meet the Paris Agreement is to get to zero emissions by 2035-2040. This would require over 10% reductions per year, and, crucially, is an awful lot sooner than the recent 2050 target that the UK signed up to. And even *that* will only give us a measly 1 in 3 chance of staying below 1.5°C.

If we want to also aim for a more ambitious target of a 2 in 3 chance of staying below 1.5°C heating, a recent report concluded that the UK and other high-income countries should be aiming for net zero emissions around 2025, in line with Extinction Rebellion's Second Demand.

As Professor Kevin Anderson says; "Very sadly, I think XR [Extinction Rebellion] and indeed much of the language forthcoming from the Youth Climate Strikes, is more in line with the science and commitments enshrined in the Paris Agreement than the public statements made by many climate academics."

How our governments are making the climate crisis worse, not better!

Not only are governments not doing everything in their power to bring global greenhouse gas emissions down in line with the Paris Agreement, they are supporting further *increases* in emissions.

Whilst it is true that some climate policies have indeed been implemented over the past few years and it is therefore hoped that the absolute worst-case scenarios are now less likely, according to the latest UN Emissions Gap Report the government policies in place right now are so *woefully inadequate* that they do not leave us in a much better position than if we had no policies in place at all. Global carbon emissions continue to shoot up and the situation is getting worse not better.

It's important to note here that whilst there has been a recent drop in emissions due to the COVID-19 pandemic, the short term effects on climate will be minimal and unless concerted effort is taken to stop fossil fuel development in the recovery period it will only be a temporary dip in a long-term upward trend.

Emissions from shipping and aviation are on course to reach dangerous levels

A recent report from Climate Action Tracker (a collaboration between German-based Climate Analytics and the New Climate Institute that measures government action against the "safe" target set by the Paris Agreement), revealed that emissions from the international shipping and aviation sectors are on course to reach *dangerous levels* - as determined by the Paris Agreement. Before the COVID-19 pandemic, shipping and aviation accounted for around 5% of all emissions, yet by 2050 these sectors are forecast to contribute a whopping 40%.

The report found that whilst shipping emissions will drop by 18-35% in 2020 due to the pandemic, by 2030 the industry could return to pre-Covid levels, and that the shipping industry is already likely to exceed its own 2030 climate target and soar above its 2050 goal.

Bill Hare, CEO and Senior Scientist at Climate Analytics, told Reuters: "There is tremendous potential for the international shipping industry to decarbonise completely and reach zero emissions by 2050, yet there is very little sign of this sector is moving anywhere near fast enough."

The report also warned that, in spite of the fact that emissions due to air travel have dropped by 45-60% due to the pandemic, aviation emissions are forecast to double or even triple over the whole 2015-2050 period.

Governments are still subsidising fossil fuels

“What we are doing [with fossil fuel subsidies] is using taxpayers’ money - which means our money - to boost hurricanes, to spread droughts, to melt glaciers, to bleach corals. In one word: to destroy the world.”
António Guterres, United Nations Secretary-General

According to the International Monetary Fund (IMF), "fossil fuels account for 85% of all global subsidies," and reducing these subsidies "would have lowered global carbon emissions by 28% and fossil fuel air pollution deaths by 46%, and increased government revenue by 3.8% of GDP."

Yet despite repeated pledges to end fossil fuel subsidies by 2025, governments from the seven largest advanced economies in the world continue to provide at least US$100 billion each year to support the production and consumption of oil, gas and coal. Globally, these energy sources get more than $370 billion a year in support, compared with $100 billion for renewable energy sources.

Indeed, rather than being phased out - as called for by international institutions such as the G20, the International Energy Agency, and the Organization of Economic Cooperation and Development (OECD) and The European Union - fossil fuel subsidies are actually *increasing*. A report from the International Monetary Fund (IMF) estimated that, in 2017, global fossil fuel subsidies were $5.2 trillion (that’s 6.5% of global GDP), up by half a trillion from 2015. (It’s important to note though that these particular subsidies include ‘externalities’ - such as climate damages, and health care costs.) An Overseas Development Institute study found that, from 2014 to 2017, global subsidies for coal-fired power increased almost three-fold, to $47.3 billion per year.

The largest subsidisers are China ($1.4 trillion in 2015), the United States ($649 billion) and Russia ($551 billion). European Union subsidies are estimated to total 55 billion euros annually. A report from the European Commission in 2019 found that the UK has the biggest fossil fuel subsidies of the whole of the European Union (see section on what the UK government is doing to make emissions worse).

Governments are approving NEW fossil fuel projects

“*For policy makers who think of climate change as a long-term future issue this should be a wake-up call. Whether we succeed or fail in containing warming to 2°C is determined by what we do now, not in future decades*.”
Professor Cameron Hepburn of Oxford University

There is enough carbon embedded in *already-operating* oil, gas and coalfields to take us way beyond 2°C heating, let alone 1.5°C. Indeed, the total greenhouse gas emissions that we are already committed to if we use our *existing* fossil fuel infrastructure for as long as it was designed for is enough to exceed our carbon budgets. According to a recent study: “no new emitting electricity infrastructure can be built after 2017 for this [2°C] target to be met, unless other electricity infrastructure is retired early or retrofitted with carbon capture technologies”.

What this means is that, if we are to meet the Paris Agreement, not only must we not build any *new* fossil fuel infrastructure, but also some of our *existing* infrastructure will need to be retired early - a financial risk that has not been properly priced by investors. Mark Carney, the former Governor of the Bank of England, has warned “the exposure of U.K. investors, including insurance companies, to these shifts is potentially huge.”

In recent years, the use of coal has been going down globally, but total carbon dioxide emissions have continued to rise due to increased burning of oil and gas instead. Compared to coal, oil and gas do indeed release about 50% less carbon dioxide per unit of energy when they burn, but if energy usage goes up we can still see an overall increase in emissions. In addition, there is the problem of methane leakage from the oil and gas industry, which somewhat offsets the benefit of switching over to using them. Methane is an extremely powerful greenhouse gas (see section on greenhouse gases) and, for some very badly managed fracking sites, this can actually be worse for the environment than burning coal.

Despite all this, according to an NGO Global Witness report in April 2019, over the next decade the global oil and gas industry are planning on spending a further $4.9 trillion on exploration and extraction. Indeed, a September 2019 report revealed that global oil and gas companies have approved about $500 billion investment in major projects that undermine the climate targets of the Paris Agreement - around one tenth of the $5 trillion being spent over next decade. The study found that “no major oil company is investing to support its goals of keeping global warming “well below” 2°C and to “pursue efforts” to limit it to a maximum of 1.5°C.”

Some fossil fuel companies say they plan to offset their emissions by preserving, replanting or growing new forests. Whilst it’s true that we now need to urgently see massive reforestation and peat restoration programmes (as they are the only large-scale carbon capture processes currently available to us), these need to be done *in parallel* with massive cuts in fossil fuel carbon emissions, not as an offset for business as usual. According to the IPCC, even if we were to plant a whopping one billion hectares (10 million square km) of new forest - that’s an area of forest the size of the United States of America comprising more than one trillion trees - we’d still

need to be reducing emissions to net zero by 2050 if we want even a 50:50 chance of keeping global heating below 1.5°C. Plus, some of the proposed tree-planting schemes risk damage to other ecosystems - for example, planting non-native trees in plantations on the Brazilian Cerrado rather than mixed native woodlands. As Professor Simon Lewis put it: “The use of forests as an offset is largely a marketing tool for companies to try to continue with business as usual.”

Banks are financing the fossil fuel industry

Bank financing of fossil fuels has actually INCREASED every year since the Paris Agreement was signed in 2016. Since then, the world’s 35 leading investment banks have invested a colossal $2.7 trillion (£2.2 trillion) in the fossil fuel industry. The US bank JP Morgan Chase has been the largest financier of fossil fuels since the Agreement, providing over £220bn of financial services to extract oil, gas and coal. UK-based Barclays and HSBC have invested a whopping £158 billion in fossil fuel industries since the Paris Agreement, making them the worst offenders in Europe. In 2018 alone, $654 billion was spent funding fossil fuels, with the three worst UK banks investing $110 billion between them (see section on what the UK government is doing to make emissions worse).

The way that governments invest money in emerging from the coronavirus crisis is crucial

The International Energy Agency (IEA) has calculated that governments are planning to spend $9tn (£7.2tn) globally in the next few months on rescuing their economies from the coronavirus crisis. According to Fatih Birol, executive director of the IEA, the stimulus packages created this year will determine the shape of the global economy for the next three years, and within that time emissions must start to fall sharply and permanently, or climate targets will be out of reach. We are at a crossroads and governments have to act now.

Is the UK government doing enough?

“The concern is whether we will spend another decade doing worthy things but not enough... and we will blow through the 1.5°C mark very quickly. As a consequence, the climate will stabilise at the much higher level.”
Mark Carney, former Governor of The Bank of England

Climate scientists and activists in the UK often get asked: “But I’ve heard that carbon emissions are already falling here in the UK, doesn’t that mean that the UK government is already doing enough?”

In a word, no.

UK emissions are falling - but only in some sectors

Firstly, it should be clarified that the UK has indeed seen a reduction in emissions over the past decade (30% over 11 years) but that’s been almost entirely due to reductions in the *power sector*, plus some small reductions in the industry and waste sectors.

Even in the power sector, the reduction in emissions is not entirely down to switching to renewable energy sources. In fact, the main reason that emissions have been falling is because over the past few decades we have been switching over from burning coal to burning mostly gas. In the last decade, even gas usage has dropped by 20% and coal burning has gone down by almost 80%, as renewables have started to play a larger part in the UK’s energy mix. Whilst this is good news, it certainly doesn’t tell the whole story. We are now reaching the limits of the emissions cuts that can be delivered through reductions in the power sector. If we are going to reduce emissions at the rate we need to, other sectors now need to play their part too.

Yet progress there has been painfully slow. Outside of the power sector, land transport emissions have stayed the same for the past 10 years and buildings emissions have only fallen by a tiny amount, just 14% over 12 years. This is not likely to get any better, as houses are still being built that are supplied by fossil fuels and will need retrofitting to run without them: a whopping one million such homes have been built in the last 12 years.

The bottom line is that emissions don’t just urgently need to fall across *all* sectors - including land transport, buildings aviation, shipping, and agriculture and land use - but they need to fall by *far more* than they are currently doing.

UK figures don’t account for aviation, shipping or embedded emissions

The other issue is that the UK's official carbon accounting figures only refer to our *territorial* emissions - those generated here in the UK.

Firstly, they do not include carbon emissions due to *shipping* or *aviation*, which each have a huge impact on global warming. Indeed, internationally these sectors are on track to take us to dangerous levels of warming, despite short-term reductions due to the coronavirus pandemic. See section on emissions from shipping and aviation.

Secondly, the UK's official carbon accounting figures don't take into account emissions contained within the goods we import, caused by their manufacture overseas and their transport to the UK - so-called *embedded emissions* from trade. These emissions have an enormous impact on global emissions. For example, 50% of our food is imported, and 70-80% of our fruit and vegetables. Some reports even suggest that, if we include the imported ingredients in products that are processed in the UK, up to 80% of all our food relies on foreign imports. Not to mention fast fashion and electrical goods. Not only do these imported goods produce huge amounts of fossil fuel emissions when they are being made or harvested, they also produce even more emissions when they are transported to the UK, often by air.

A staggering 90% of UK emissions associated with the consumption of manufactured products are embedded within them, so only 10% goes into our official carbon accounting figures. 8% of the UK embedded emissions for manufactured products come from China.

In October 2019 the Office for National Statistics reported the UK had become the biggest net importer of carbon dioxide emissions per capita in the G7 group of wealthy nations – outstripping the US and Japan – as a result of buying goods manufactured abroad. According to a World Wildlife Fund report, nearly half of the UK's carbon footprint comes from emissions released overseas.

UK emissions are not falling nearly fast enough

Overall, the UK has seen a 30% reduction in *territorial* emissions over the past 11 years, which works out at just over 3% each year. If we include imported emissions, UK emissions have reduced by 18% over 9 years, which is just over 2% per year.

However, if we want to get to global net zero by 2050 (which would still only give us a 50:50 chance of staying below 1.5°C heating), we now need to see an *8% reduction* in global emissions every year. And even that figure still relies on the use

of negative emissions technologies that barely exist, so we should really be reducing global emissions far faster than this (see section how we get to net zero emissions by 2050). Plus in the UK and other wealthy nations, we need to be reducing emissions *even faster* (see section on why richer countries need to get to net zero MUCH FASTER than 2050).

The UK government is missing its own targets

The UK Committee on Climate Change (CCC) is an independent, statutory body whose role is to advise the government on climate change and to report to Parliament on progress made in reducing greenhouse gas emissions and preparing for and adapting to the impacts of climate change. In May 2019 the CCC had given recommendations to the UK government that in order to reach the Paris Agreement and global net zero carbon by 2050, the UK must get to net zero total greenhouse gas emissions by 2050. A few months later, in July 2019, the CCC released a damning report that warned that, in spite of Parliament declaring a climate emergency, the government was failing to cut emissions fast enough. It found that, over the previous year, the government had delivered just 1 of 25 critical policies needed to get emissions reductions back on track and that only 7 out of 24 indicators showing underlying progress were on track.

At the time, the CCC chairman Lord Deben, told the BBC: "The whole thing is really run by the government like a Dad's Army. We can't go on with this ramshackle system." The Committee, as well as other departments such as the Ministry of Defence, warned that action must be taken across all branches and levels of government. The government was accused of utter hypocrisy in Parliament declaring a “climate emergency” in 2019 but the UK government still failing to meet its own targets for reducing emissions and instead investing in MORE fossil fuel infrastructure in other countries (see section on how the UK government is making things worse, not better)

Yet, one year down the road, the latest report from the CCC, published in July 2020, revealed another *staggering failure* of the government to listen to its own advisors and to meet its own targets. The new CCC report showed that, of the 21 key indicators to show progress towards meeting carbon budgets and the 2050 target, only 4 were on track. Not only that, but of the 31 milestones for actions recommended by the CCC last year in order to get to net zero by 2050, only 2 had been fully achieved and there had been partial progress on 15, with the other 14 showing no progress.

The report also stated that the carbon budgets that the UK had put in place are not consistent with getting to net zero by 2050, and that we need to see much steeper reductions in emissions. Indeed, we've been off track to meet the fourth and fifth carbon budgets (2023-2032) for four years now, which were only going to take us towards an 80% reduction in emissions by 2050 anyway, not even net zero.

What's also worrying is that a recent survey carried out by the Electrical Contractors' Association revealed that, despite their climate pledges, many English councils do not even know how much energy they use and therefore how much carbon they produce. ECA energy adviser Luke Osborne said the findings were "highly concerning" and that without immediate changes, "it is inconceivable that councils are going to become carbon neutral in less than 30 years."

According to the Joint Nature Conservation Committee, another government advisory body, the UK is also set to miss 14 out of 19 of its biodiversity targets for 2020.

Not only is the government failing to cut emissions fast enough, but it is also failing to put in place measures needed to adapt to rising temperatures - to prepare our homes, businesses and natural environment for a hotter world. In the 2019 CCC report, of 33 key sectors assessed by the Committee, not a single one showed good progress when it came to managing climate change risk. A year later, the 2020 report warned that, yet again, not a single sector had demonstrated resilience for a 2˚C hotter world, a temperature we are projected to be hitting around 2050 (see section on how hot it is likely to get and when). Terrifyingly, the report also stated that a governmental priority should now be preparing us for the possibility of a 4˚C hotter world, a situation that, in 2008, the CCC had advised the government was the threshold of "extreme danger", to be avoided at all costs.

The 2020 report also warned that even though we have seen a temporary drop in emissions due to COVID-19, we mustn't use this as an excuse to ramp up emissions again. Indeed, it is the total accumulated emissions over time that matters, not how much in any one year, and if we make this period just a blip and emissions recover it will have made almost no difference in the long run. We need to cut our emissions by far more than this *every year*. The report stated that the next few months "have huge significance", and that if we prioritise the economy without thinking about climate change we could be locking ourselves into even higher emissions in the long term.

The UK needs to be getting to net zero by 2025, not 2050

Even if we *were* on track to meet the UK government's commitment to get to net zero emissions by 2050 (a target that only accounts for emissions generated on our own territory, sweeping under the carpet all emissions from imported goods, and that, even if it was met globally, would still only give the world a 50:50 chance of staying below 1.5°C heating), which we're clearly not, it's important to realise this would still give the UK a much larger share of the global carbon budget than other countries.

Not only does the UK emit more than twice as much per person than the global average (vastly more if we take into account shipping, aviation and imports), Britain ranks fifth highest globally in terms of its historical emissions. In addition, as a wealthy nation, we have the capability to be able to turn our economy around and decarbonise more rapidly than most other countries. So, in order to give global carbon net zero 2050 a good chance of actually being achieved, many climate scientists now agree that the UK should really be getting to net zero *much sooner* than 2050, a concept known as "carbon equity". See section on why richer countries need to get to net zero MUCH FASTER than 2050.

Indeed, a recent report concluded that if we assume a "fair" split of total global carbon emissions, acknowledging the higher emissions and greater historical responsibility of the UK, avoiding reliance on negative emissions technologies and aiming for a more ambitious target of a 2 in 3 chance of staying below 1.5°C of heating, the UK needs to get net zero emissions by around 2025 to stay within our allocated budget - in line with Extinction Rebellion's Second Demand.

The UK government is making things worse, not better!

The UK government is subsidising fossil fuels

The UK government spends a huge amount of money in fossil fuel *subsidies* - measures put in place to keep fossil fuel prices for consumers below market levels, or for producers above market levels, or to reduce such costs for consumers and producers. According to a report from the European Commission in 2019, the UK has the biggest fossil fuel subsidies of the whole of the EU - whereas subsidies and incentives have been *reduced* for renewable energy technologies. The report found that the UK spends £10.5 billion a year supporting fossil fuel companies in the UK, significantly more than the £7.3 billion a year it spends supporting renewable energy.

It should be noted that the government argues that this ‘financial support’ is not technically a ‘subsidy’.

In October 2019, official government records (released through a freedom of information request) revealed that the UK government plans to spend £1 billion supporting a fracking company in Argentina - money that the government had previously committed to spending on green energy.

Another government report published in June 2019 found that over the past five years, the UK has spent £2.5 billion on fossil fuel projects - the vast majority being in low- and middle-income countries. Analysis by the investigative environmental journalism outlet DeSmog UK found that in 2018 alone, Britain increased its support for fossil fuel projects overseas to almost £2 billion - an eleven fold increase over the previous year - whilst support for renewable energy fell to £700,000.

In October 2019, the UK government was accused of “utter hypocrisy” by environmental campaign group Global Witness after it rejected calls from MPs to stop spending billions on overseas fossil fuel projects while claiming to be a leader in the fight against global heating. Parliament’s Environmental Audit Committee warned the UK government that it is sabotaging its climate credentials by paying out “unacceptably high” oil and gas subsidies in developing nations.

The UK government is approving NEW fossil fuel projects

Not only are UK emissions not being cut nearly fast enough, but the government has also recently approved exploitation of *new* oil fields in The North Sea, and the opening of four new gas-fired turbines at Drax power station - in spite of a ruling from its Planning Inspectorate that they should be blocked due to their impact on climate change.

The opening of the Woodhouse Colliery has also been approved, a new coal mine in Cumbria that will produce up to 8.4 million tonnes of carbon dioxide a year for 50 years. That’s more than double the current emissions from the whole of Cumbria, which are currently 3.79 million tonnes per year. And then there’s HS2, a project that has been described as one of the largest deforestation programmes since the First World War, set to destroy a total of 108 ancient carbon-storing woodlands and damage or destroy almost 700 precious wildlife sites. Of major concern is also the fact that the railway is set to emit huge quantities of carbon emissions which would take us further away from our supposed commitment to reduce emissions. Indeed, the initial environmental assessment for the project was published in 2013, before the government signed up to achieving net zero carbon emissions by 2050.

UK banks are investing in fossil fuels

In addition, a whopping 15% of global carbon emissions result from *investments* made through the City of London - one of the world's largest financial centres for fossil fuel corporations. Nine of the world's top fossil fuel investors of the last three years have global or national headquarters in the City of London. UK-based Barclays and HSBC are the worst offenders in Europe, having invested a staggering £158 billion in fossil fuel industries since the Paris Agreement in 2016.

UK banks, coal and oil corporations are expected to be contributing around 15% of the further $4.9 trillion that the global oil and gas industry are planning on spending over the next decade on exploration and extraction in new fields.

But the UK only emits 1.5% of the world's carbon, shouldn't we be focusing our efforts elsewhere?

Another thing climate scientists and activists are often asked is: "Why are you bothering targeting the UK government when the UK only produces 1.5% of the world's carbon emissions?"

Well firstly, 1.5% of global carbon emissions still works out at around *twice as much* emissions per UK person as the global average (because the UK only has approximately 0.8% of the global population). But, perhaps more importantly, there's also an awful lot that our official 1.5% doesn't include. For example, as discussed earlier, the UK's official carbon accounting figures do not include carbon emissions due to *shipping* or *aviation*, which each have a huge impact on global warming. Plus, this 1.5% only represents our *territorial* emissions - those generated here in the UK. It's vital that we realise that the impact the UK is having on global emissions is not primarily due to these emissions, but to the huge quantity of embedded emissions that are produced in the manufacture and transport of the food and materials we import from overseas (see section on embedded emissions).

Whichever way you look at it, the UK's emissions, subsidies and investments are making a huge contribution to global carbon dioxide levels and are not falling anywhere close to fast enough in order for the world to reach net zero by 2050.

Ultimately, every 1% of carbon emissions matters. In fact, every fraction of a percentage matters. Arguments that try to make the case that the emissions from a particular sector or country don't matter because they are such a small part of the total, are an example of 'whataboutism' - excuses given to avoid or delay the need to reduce emissions.

No more excuses. We have to act now.

Part 7: Act now… So what do we do?

How long do we have and is it already too late?

“Every action matters. Every bit of warming matters. Every year matters. Every choice matters.”
IPCC YouTube video, based on the IPCC Special Report on Global Warming of 1.5°C

"The good news is that the window for action is still open, if not for much longer."
Borge Brende, President of the World Economic Forum

According to the best scientific understanding, it is likely that it is still *physically possible* to stabilise global temperatures below 1.5°C of heating. But that opportunity will be gone forever if we keep emitting at the rate we are for much longer.

So what needs to happen now?

"Until you start focusing on what needs to be done rather than what is politically possible there is no hope. We cannot solve a crisis without treating it as a crisis. We need to keep the fossil fuels in the ground and we need to focus on equity. And if solutions within this system are so impossible to find then maybe we should change the system itself."
Greta Thunberg

"Start by doing what’s necessary; then do what’s possible; and suddenly you are doing the impossible."
St. Francis of Assisi

To address the climate and ecological crisis we urgently need to see huge political shifts away from our fossil fuel-based economy. We need fundamental systems change in every industry and in every area of society that is fossil-fuel dependent. We need to also address the emissions that come from changes in land use, reverse deforestation and transform agricultural practices so that we can feed the world without it costing the Earth. It is essential that we take the ecological crisis seriously

too, by protecting vulnerable ecosystems and encouraging increases in biodiversity across all parts of the globe.

All of this would take *unprecedented* transformation of global economies, the likes of which we have never seen, and that go way beyond the "optimistic policies" laid out by governments so far.

It will be hard, but it is possible. But it has to come from governmental and collective action; we cannot do this alone.

Why individual action isn't enough

"To care about climate change, all you have to be, pretty much, is a human being on planet earth"
Katharine Hayhoe, Eighth Annual Stephen H. Schneider Award for Outstanding Climate Science Communication

Reducing our individual carbon footprint - an average of 6 or so tonnes in the UK - is certainly important. Indeed, the 15.7 tonne carbon footprint of the average American is over 250 times that of the average person in several African countries. However even this amount is still *tiny* compared to the 40 billion tonnes of carbon dioxide emitted globally.

So whilst there are certainly things we can do to help - such as stopping flying, switching to a plant-based diet, buying organic fruit and vegetables (preferably grown locally or home-grown) and using more public transport, along with insulating our homes, switching to a green energy provider, choosing a bank that doesn't invest in fossil fuels and cutting down on the carbon emissions embedded in the products we buy (such as by buying clothes second hand, or at the very least boycotting 'fast fashion' and choosing items that are 'made to last' instead) - there are real limits to what can be achieved by individuals simply changing our consumption habits. Also, what choices we can make are limited by our lived environment and society - for example, we can't take a bike to work if safe bike lanes don't exist.

The recent drop in emissions from the COVID-19 lockdown highlights the limits of what changes in our behaviour can achieve: at the peak of the epidemic, global emissions dropped by just 17% - and that was with a near complete shutdown of all travel.

Even if we *could* reduce our personal emissions even further, the problem is that there are also huge amounts of emissions tied up in things we have no direct control over, such as large scale infrastructure, investments and construction (see section on approval of new fossil fuel projects). Indeed, it is estimated that about one third of all emissions are due to decisions made by governments and investors, and not directly influenced by consumer choices. Unless *these* are changed, no amount of reducing what we buy or how much we fly will come anywhere close to bringing emissions down to net zero.

The bottom line is, individual action alone is not going to get us out of this mess. What we need to see now is fundamental systems change, and that can only come from citizens and government working together to decide how to address the climate and ecological emergency. Citizens Assemblies are a proven way to help build a democratic mandate for rapid action with support of the general public.

We certainly should make what personal behaviour changes we can, not least because they send a powerful signal to governments and businesses that we are willing to change, but rather than feeling guilty about our lifestyle we need to accept that we currently live in a fossil fuel-dependent system that forces us to behave in some ways that are destroying our planet. Our unavoidable participation in this system becomes justified when it is coupled with our best efforts to bring about the transition to a truly sustainable society. So we now need to overcome our shame and our fears about our own contribution to our damaged system and focus our time, energy and efforts on driving collective change.

We urgently need a coherent response that acts across all sectors of our economy. The pace of that change that is now required means that there will be a lot of disruption, and provisions must be put in place to ensure a just-transition for workers in the most affected industries.

Mahatma Gandhi, whose mass peaceful non-violent direct action movement was a major inspiration behind Extinction Rebellion, did indeed encourage us to: “be the change you wish to see in the world”, and we must indeed make what changes we can. But not because saving our individual 6 tonnes will save the world, but because of the moral and spiritual power it will give us when advocating that our governments, businesses and societies make the radical changes necessary to save us, and what is left of nature.

The urgent need for collective action

"*It's not enough to simply pray for a better environment, you have to stand up and take action*."
Fazlun Khalid, Founder of Islamic Foundation for Ecology and Environmental Science

"The problems of the world cannot possibly be solved by skeptics or cynics whose horizons are limited by obvious realities. We need men and women who can dream of things that never were."
John F. Kennedy

The climate and ecological emergency may be the biggest challenge ever faced by humanity, but as former UN climate chief Christiana Figueres pointed out, “impossible isn’t a fact, it’s an attitude”.

Stephan Harrison, Professor of Climate and Environmental Change, University of Exeter, reminds us in a recent lecture: "We have all the resources we need to deal with this. There is nothing magical about reducing carbon dioxide in the atmosphere. There is nothing magical about the greenhouse effect. We know exactly how to deal with it. We just don’t have the political or economic will to do this.”

As American novelist and playwright James Baldwin said: “Not everything that is faced can be changed, but nothing can be changed until it is faced.”

So collectively, we must now urgently put pressure on governments to work with the general public, media and all of society to *Tell the Truth*, *Act Now*, and go *Beyond Politics* to fully address the climate and ecological emergency. Indeed, if we are to have any hope of coping with this crisis, we have to move beyond the politics that have so far held us back, and into listening and dialogue and towards unity and action. This is what a Citizens’ Assembly is all about and why it is Extinction Rebellion’s Third Demand.

Governments are due to submit their next set of pledges at COP26 in Glasgow in 2021. We need to see a concerted effort from governments across the world to take us off our current path now. If governments don’t seriously improve their policies to reduce greenhouse gas emissions in time for COP26, they won’t be *obliged* to review them again for another five years (although they CAN always take stronger action if they choose to at any time). By then it will be far too late to prevent heating of more than 1.5°C. It is crucial that COP26 agrees to the outlawing of all new investments by banks, financial institutions and governments in new fossil fuel infrastructure and production.

So let’s put pressure on governments to make this happen. And fast.

Conventional approaches of voting, lobbying, petitions and protest have failed because powerful political and economic interests prevent change. Extinction Rebellion's strategy, therefore, is one of mass, peaceful, civil disobedience: of non-violent direct action. A rebellion. Inspired by the peaceful movement led by Mahatma Gandhi.

As Christiana Figueres writes in her new book *The Future We Choose: Surviving the Climate Crisis*: "It's time to participate in non-violent political movements wherever possible."

Even scientists are now being forced to take bolder steps to try to ensure that their warnings are heard and are acted upon - after more than 40 years of being ignored or downplayed. In November 2019, over 1,700 scientists from across the globe signed a declaration written by Scientists for Extinction Rebellion in support of mass civil disobedience against government inaction over the climate and ecological emergency. The scientists who have been taking to the streets, dressed in their white lab coats, say they believe that the risk of "catastrophic and irreversible damage to our planet" means they have "a moral duty to act now… to protect humanity's only home."

So come and join us. Whoever you are and whatever your background, let's take to the streets and demand change. Sign up to your local Extinction Rebellion group, or if you're in an area without a local group, just set one up. Creating a Facebook page or hosting a public meeting are good ways to start: the basic idea is to inform and inspire new people and then get them into groups to take on roles and jobs so the whole mobilisation can grow quickly.

There's a also wide range of other forms of collective action that will contribute to finding a solution, such as working with political parties or local councils, art and culture, online activism, developing renewable energy, campaigning for changes in laws (such as making 'ecocide' law), education, research or house-to-house canvassing.

But whatever it is, please find a way to do *something*. As Coretta Scott King, American Author, Activist, and Civil Rights Leader said: "It doesn't matter how strong your opinions are. If you don't use your power for positive change, you are, indeed, part of the problem."

Indeed, however small and insignificant it may seem, what you do *will* make a difference. In the words of Mahatma Gandhi, "the difference between what we do

and what we are capable of doing would suffice to solve most of the world's problems.”

Or as the Dalai Lama said: "It is not enough to be compassionate - you must act.”

Yes. We *must* act. And we must act now. The future of our children, and our grandchildren, is at stake.

See you on the streets!

Quotes

“There is a widespread view that a 4°C future is incompatible with any reasonable characterisation of an organised, equitable and civilised global community.”
- Professor Kevin Anderson, deputy director of the Tyndall Centre for Climate Change Research. "Climate Change Going Beyond Dangerous-Brutal Numbers and Tenuous Hope" in “What Next? Climate, Development and Equity” 2012.

“We are facing a man-made disaster on a global scale. Our greatest threat in thousands of years”
- Sir David Attenborough, naturist and broadcaster. Opening ceremony of United Nations climate talks, Katowice, Poland, 3 Dec. 2018.

“Surely we have a responsibility to leave for future generations a planet that is healthy and habitable by all species”
- Sir David Attenborough, “State of the Planet with David Attenborough”, first broadcast BBC One Nov. 2000.

“This isn't just about losing wonders of nature. With the loss of even the smallest organisms, we destabilise and ultimately risk collapsing the world's ecosystems - the networks that support the whole of life on Earth.”
- Sir David Attenborough, “Climate Change: The Facts”, first broadcast BBC One 18 April 2019.

“Climate crisis is the greatest ever threat to human rights. The economies of all nations, the institutional, political, social and cultural fabric of every state, and the rights of all your people, and future generations, will be impacted.”
- Michelle Bachelet, United Nations High Commissioner for Human Rights, The Guardian, 9 Sep. 2019

“Not everything that is faced can be changed, but nothing can be changed until it is faced.”
- James Baldwin, American essayist, novelist and playwright

“The future for low-lying coastal communities looks extremely bleak… But the consequences will be felt by all of us. There is plenty to be concerned about for the future of humanity and social order”
- Professor Jonathan Bamber, Bristol University, 25 Sep. 2019.

"Global warming of 4˚C this century is quite possible and would bring massive risks to life and society - heatwaves, coastal and river flooding, droughts and more... We

don't know how society would respond to the massive risks of 4˚C global warming. Transformational change would be needed."
- Professor Richard Betts MBE, Chair of Climate Impacts at the University of Exeter and Head of Climate Impacts at the Met Office Hadley Centre, 2020.

“Soil is lost rapidly but replaced over millennia and this represents one of the greatest global threats for agriculture”
- Professor Duncan Cameron, Professor of Plant and Soil Biology at the University of Sheffield, speaking at the 21st UN Conference of the Parties in Paris, 2 Dec. 2015.

“Once climate change becomes a defining issue for financial stability, it may already be too late.”
- Mark Carney, Former Governor of the Bank of England, “Breaking the tragedy of the horizon – climate change and financial stability”, Lloyd's of London, 29 Sep. 2015

“Efforts to reverse global warming will lead to “major changes” in the UK economy. Companies that fail to respond to climate change “will go bankrupt without question”
- Mark Carney, Former Governor of the Bank of England, Channel 4 News, 31st July 2019

“The political and economic map of the world simply cannot cope with these stresses, without real change in the way nations plan, govern and commit resources. Disaster relief will likely be inadequate, insurance funds will probably fail, and vast dislocations of supplies and services are to be expected. Having a capable army and rescue services will not be enough. The threat of mass casualties, political upheaval, and conflict within and between states will certainly increase.”
- General Wesley K Clark (Ret.), Former NATO supreme allied commander for Europe. “Climate change: The next challenge for national security”, Al Jazeera, 25 June 2013

"It is not enough to be compassionate - you must act.”
- The Dalai Lama

“Global freshwater security - and therefore global food security - is at far greater risk than we ever imagined.”
- Professor Jay Famiglietti, senior water scientist at NASA’s jet propulsion laboratory, 2 April 2019.

“The shock for us was that tidal flooding could become the new normal in the next 15 years; we didn’t think it would be so soon… If you live on a coast and haven’t seen coastal flooding yet, just give it a few years. You will.”
- Dr. Melanie Fitzpatrick, Union of Concerned Scientists, USA, 18 Oct. 2014

“It’s time to participate in non-violent political movements wherever possible.”
“Impossible isn’t a fact, it’s an attitude”.

- Christiana Figueres, Former Executive Secretary of the United Nations Framework Convention on Climate Change (2010-2016), “The Future We Choose: Surviving the Climate Crisis”, Knopf published 25 Feb. 2020

"Every crisis contains both danger and opportunity. Today I believe we have to slow down our rate of production and consumption and to learn to understand and contemplate the natural world. We need to reconnect with our real surroundings."
- Pope Francis

"I see early signs of an economy that is more human. But let us not lose our memory once all this is past, let us not file it away and go back to where we were. This is the time to take the decisive step, to move from using and misusing nature to contemplating it."
- Pope Francis

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- Pope Francis

“Listen to the cry of the earth and the cry of the poor, who suffer the most. The urgent need for interventions can no longer be postponed.”
- Pope Francis, Vatican City, 30 August 2017

"Start by doing what’s necessary; then do what’s possible; and suddenly you are doing the impossible."
- St. Francis of Assisi

“The difference between what we do and what we are capable of doing would suffice to solve most of the world's problems.”
- Mahatma Gandhi

“Insect decline should be of huge concern to all of us, for insects are at the heart of every food web, they pollinate the large majority of plant species, keep the soil healthy, recycle nutrients, control pests, and much more. Love them or loathe them, we humans cannot survive without insects.”
- Professor Dave Goulson, Professor of Biology, The University of Sussex, 2019.

“Climate change is moving faster than we are - and its speed has provoked a sonic boom SOS across our world. We face a direct existential threat.”
- António Guterres, United Nations Secretary-General. Opening remarks at United Nation General Assembly, 10 Sep. 2018.

“What we are doing [by subsidising fossil fuels] is using taxpayers’ money - which means our money - to boost hurricanes, to spread droughts, to melt glaciers, to bleach corals. In one word: to destroy the world.”
- António Guterres, United Nations Secretary-General. Reuters, 28 May 2019.

"We have all the resources we need to deal with this. There is nothing magical about reducing carbon dioxide in the atmosphere. There is nothing magical about the greenhouse effect. We know exactly how to deal with it. We just don’t have the political or economic will to do this.”
- Professor Stephan Harrison, Professor of Climate and Environmental Change, University of Exeter, “Climate Change: Current state of the Science”, Exeter, 9 March 2019.

“We are in a planetary emergency.”
- Professor James Hansen, former Director of the NASA Goddard Institute for Space Studies, US Congress testimony, 23 June 1988.

“Tipping points are so dangerous because if you pass them, the climate is out of humanity’s control: if an ice sheet disintegrates and starts to slide into the ocean there’s nothing we can do about that.”
- Professor James Hansen, former Director of the NASA Goddard Institute for Space Studies, 23 Nov. 2009.

"There is tremendous potential for the international shipping industry to decarbonise completely and reach zero emissions by 2050, yet there is very little sign of this sector is moving anywhere near fast enough."
- Bill Hare, CEO / Senior Scientist at Climate Analytics, 24 June 2020.

“The path that the world chooses today will irreversibly mark our children’s futures. We must listen to the millions of young people who have led the wave of school strikes for urgent action.”
- Stella Hartinger, Cayetano Heredia University, Peru, author of the 2019 Lancet Countdown Report, The Guardian, 13 Nov. 2019.

"Climate change is accelerating more rapidly and dangerously than most of us in the scientific community had expected or that the IPCC in its 2007 Report presented."
- Sir John Haughton, Former Co-Chair of the IPCC, Former Director General of the UK Met Office, “Climate Safety in Case of Emergency…”, Public Interest Research Centre, 2008.

"To care about climate change, all you have to be, pretty much, is a human being on planet earth"
- Professor Katharine Hayhoe, Eighth Annual Stephen H. Schneider Award for Outstanding Climate Science Communication, 22 Jan. 2019.

"For policy makers who think of climate change as a long-term future issue this should be a wake-up call. Whether we succeed or fail in containing warming to 2°C is determined by what we do now, not in future decades."
- Professor Cameron Hepburn of Oxford University, 30 March 2016.

"We basically have three choices: mitigation, adaptation and suffering. We're going to do some of each. The question is what the mix is going to be. The more mitigation [(reduction of emissions)] we do, the less adaptation will be required and the less suffering there will be."
- Professor John Holdren, former President of the American Association for the Advancement of Science, on publication of IPCC fourth assessment report, 29 Jan. 2007.

"Everything that is expected to result from global climate change driven by greenhouse gases is not only happening, but it's happening faster than anybody expected."
- Professor John Holdren, Science and Technology advisor to President Barack Obama, director of the Woods Hole Research Center, in "Climate Wars" by Gwynne Dyer, Oneworld publications, 2011.

"Human influence on the climate system is clear, and recent anthropogenic emissions of green-house gases are the highest in history."
- Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report, 2014.

"Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen."
- Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report, 2014.

"Every action matters. Every bit of warming matters. Every year matters. Every choice matters."
- IPCC YouTube video, based on the IPCC Special Report on Global Warming of 1.5°C.

"Nature is declining globally at rates unprecedented in human history - and the rate of species extinctions is accelerating, with grave impacts on people around the world now likely"
- Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services Report, IPBES, 2019.

"The problems of the world cannot possibly be solved by skeptics or cynics whose horizons are limited by obvious realities. We need men and women who can dream of things that never were."
- John F. Kennedy

"It's not enough to simply pray for a better environment, you have to stand up and take action."
- Fazlun Khalid, Founder of Islamic Foundation for Ecology and Environmental Science, Deutsche Welle, 2 April 2014.

“This is an emergency and for emergency situations we need emergency action.”
- Ban Ki-Moon, Former UN Secretary General, UN address, 10 Nov. 2007

“Climate change will lead to battles for food”
- Jim Yong Kim, Former President of The World Bank, World Bank statement, 7 April 2014

“If you got in a plane with a one in 100 chance of crashing you would be appropriately scared. But we are experimenting with the climate in a way that throws up probabilities of very severe consequences of much more than that.”
- Sir David King, Former UK Chief Scientist and Former UK Special Representative for Climate Change, 16 Sep 2019.

“There’s this remarkable building of this body of evidence that we’re making these storms more deleterious.”
- Dr. James Kossin, Atmospheric Research Scientist, National Oceanic and Atmospheric Administration, 18 May 2020.

“A rapidly changing climate has dire implications for every aspect of human life, exposing vulnerable populations to extremes of weather, altering patterns of infectious disease and compromising food security, safe drinking water and clean air”
- The Lancet Countdown Report “The 2018 report of the *Lancet* Countdown on health and climate change: shaping the health of nations for centuries to come”, The Lancet, Nov. 28 2018

“We’ve found that one of the most worrying impacts of climate change has already begun. This is decades ahead of even the most pessimistic climate models. Humans have been lucky so far, as tropical forests are mopping up lots of our pollution, but they can’t keep doing that indefinitely. We need to curb fossil fuel emissions before the global carbon cycle starts working against us. The time for action is now.”
- Professor Simon Lewis, University College London and University of Leeds, 4 Mar 2020.

“The use of forests as an offset is largely a marketing tool for companies to try to continue with business as usual.”
- Professor Simon Lewis, University College London and University of Leeds, 4 Mar 2020.

“Our generation is going to be responsible for the loss of one of the most majestic ecosystems on the face of the Earth. We're literally watching the death of this natural wonder.”
- Professor Michael Mann, Professor of Atmospheric Science at Pennsylvania State University, speaking about coral reefs in “Climate Change: The Facts”, first broadcast BBC One 18 April 2019.

"We are seeing increases in extreme weather events that go well beyond what has been predicted or projected in the past. We're learning that there are factors we were not previously aware of that may be magnifying the impacts of human-caused climate change... Increasingly, the science suggests that many of the impacts are occurring earlier and with greater amplitude than was predicted"
- Professor Michael Mann, Director of the Earth System Science Center at Pennsylvania State University, 26 Dec. 2017

“We know that with increased storms, increased floods, droughts and heat waves, production of food will be more problematic. Ensuring people have access to clean, safe drinking water will become much more difficult”
- Professor Mark Maslin, Professor of Climatology at University College London. “Climate Change: The Facts”, first broadcast BBC One 18 April 2019.

“While adaptation is now urgent and there are many adaptation opportunities, climate science tells us that further warming and risk increase can only be stopped by achieving zero net greenhouse gas emissions.”
- McKinsey Global Institute, “Climate risk and response: Physical hazards and socioeconomic impacts”, 16 Jan. 2020

“Greater awareness of climate risk could make long-duration borrowing more expensive or unavailable, impact insurance cost and availability, and reduce terminal values. This could trigger capital reallocation and asset repricing. This recognition could happen quickly, with the possibility of cascading consequences.”
- McKinsey Global Institute, “Climate risk and response: Physical hazards and socioeconomic impacts”, 16 Jan. 2020

“Climate change is a medical emergency … It thus demands an emergency response…”
- Professor Hugh Montgomery, director of the University College London Institute for Human Health and Performance, Lancet Commission Co-Chair, 22 June 2015.

“Climate change is the greatest security threat of the 21st century,”
- Major General Munir Muniruzzaman (Retd.), chairman of the Global Military Advisory Council on Climate Change, The Guardian, 1 Dec. 2017

“There is an air pollution pandemic”
- Professor Thomas Munzel, Specialist in Interventional Cardiology, Risk Factors and Prevention, University Medical Centre of Mainz, 3 March 2020

“Join the dots. It's happening. It's happening in your world, it's happening in my world. And let's be very clear about this - it is going to get much worse.”
- Dr Sunita Narain, Director General of The Centre for Science and Environment. “Climate Change: The Facts”, first broadcast BBC One 18 April 2019.

“You have to understand, this is also a crisis for the world. The fact is that if the poor are suffering today, then the rich will also suffer tomorrow.”
- Dr Sunita Narain, Director General of The Centre for Science and Environment. “Climate Change: The Facts”, first broadcast BBC One 18 April 2019.

“Climate change is the biggest threat wildlife will face this century”
- National Wildlife Federation, “Wildlife in a Warming World”, 2013.

“There are three factors with storms like this: rainfall, storm surge and wind. Rainfall levels are on the increase because of climate change, and storm surges are more severe because of sea level rises.”
- Dr Friederike Otto, Acting Director of the Environmental Change Institute, University of Oxford, and an Associate Professor in the Global Climate Science Programme.

“The next 20 years will be worse than the last 20 years — all indications point to that - and things will be completely nuts by the end of the century if we keep doing what we’re doing now.”
- Dr Angeline Pendergrass, National Center for Atmospheric Research (NCAR) in Boulder, Colorado, Nature, 20 Nov. 2018.

“The impact on families is going to be something that I don't think we could ever prepare for.”
- Colette Pichon Battle, Executive Director of the Gulf Coast Center for Law and Policy, speaking about rising sea levels. “Climate Change: The Facts”, first broadcast BBC One 18 April 2019.

“Unless we take evasive action, our future oceans will have fewer fish, fewer whales and frequent dramatic shifts in ecological structure will occur, with concerning implications for humans who depend on the ocean.”
- Dr Éva Plagányi, Commonwealth Scientific and Industrial Research Organisation, Australia, 5 March 2019.

“A vegan diet is probably the single biggest way to reduce your impact on planet Earth, not just greenhouse gases, but global acidification, eutrophication, land use

and water use. It is far bigger than cutting down on your flights or buying an electric car."
- Dr Joseph Poore, environmental scientist at the University of Oxford, Guardian, 31 May 2018.

"Personally I find the results alarming. Species attempt to adapt to changing environment, but they cannot do it at a sufficient pace to ensure that populations are viable. Climate change has caused irreversible damage to our biodiversity already, as evidenced by the findings of this study. The fact that species struggle to adapt to the current rate of climate change means we have to take action immediately in order to at least halt or decrease the rate."
- Dr Viktoriia Radchuk, Leibniz Institute for Zoo and Wildlife Research in Germany, Guardian, 23 July 2019.

"Sea level is rising much faster and Arctic sea ice cover shrinking more rapidly than we previously expected. Unfortunately, the data now show us that we have underestimated the climate crisis in the past."
- Professor Stefan Rahmstorf, Professor of Physics of the Oceans, Potsdam Institute for Climate Impact Research, 2009.

"What's the use of having developed a science well enough to make predictions if, in the end, all we're willing to do is stand around and wait for them to come true?"
- Professor Sherwood Rowland, Nobel prize winner in chemistry for discovering the impact CFCs have in depleting the ozone layer, "Annals of Chemistry: In The Face of Doubt" by Paul Broder, the New Yorker, 9 June 1986.

"Based on sober scientific analysis, we are deeply within a climate emergency state but people are not aware of it."
- Professor Hans Joachim Schellnhuber, Founder of the Potsdam Institute for Climate Impact Research and former chair of the German Advisory Council on Global Change (WBGU), European Research and Innovation Days event, 24 Sep. 2019

"It doesn't matter how strong your opinions are. If you don't use your power for positive change, you are, indeed, part of the problem."
- Coretta Scott King, American Author, Activist, and Civil Rights Leader

"There is a growing sense of panic in those who really understand what a 4°C world might be like."
- Professor Will Steffen, Director of the Australian National University Climate Change Institute. "Avoiding the Unadaptable: A 4°C World", Climate Commision, 2012.

"Climate change is the result of the greatest market failure the world has seen. We risk damages on a scale larger than the two world wars of the last century. What we

are talking about is extended world war. People would move on a massive scale. Hundreds of millions, probably billions of people would have to move."
- Lord Nicholas Stern, Professor of Economics and Government and Author of The Stern Review on the Economics of Climate Change, 2007. At Royal Economic Society (RED) Public lecture, Manchester, 29 Nov. 2007.

"The climate emergency is our third world war. Our lives and civilization as we know it are at stake, just as they were in the Second World War."
- Professor Joseph Stiglitz, Economist, recipient of the Nobel Memorial Prize in Economic Sciences, The Guardian, 4 June 2019

"Virtually all of us are now convinced that global warming poses a clear and present danger to civilization."
- Professor Lonnie Thompson, director of the Byrd Polar Research Centre, "Climate Change: The Evidence and Our Options", The Behavior Analyst, 2010.

"Until you start focusing on what needs to be done rather than what is politically possible there is no hope. We cannot solve a crisis without treating it as a crisis. We need to keep the fossil fuels in the ground and we need to focus on equity. And if solutions within this system are so impossible to find then maybe we should change the system itself."
- Greta Thunberg, speech at UN Climate Change COP24 conference, 15 Dec. 2018.

"Forests can become lakes in the course of a month, landslides occur with no warning, and invisible methane-seep holes can swallow snowmobiles whole."
- Professor Merritt Turetsky, director of the Institute of Arctic and Alpine Research (INSTAAR) at CU Boulder, 2020.

"It really becomes difficult to see at such levels of warming how we're going to maintain our agriculture, such that the population of the world can actually feed itself."
- Dr Peter Stott, Head of the Climate Monitoring and Attribution Team at the Met Office.
"Climate Change: The Facts", first broadcast BBC One, April 2019.

"at present rates of human emissions, there will be more CO2 in Earth's atmosphere by 2025 than at any time in at least the last 3.3 million years."
- Elwyn de la Vega, University of Southampton
"Atmospheric CO_2 during the Mid-Piacenzian Warm Period and the M2 glaciation", Scientific Reports, 2020.

"Nobody expected the ice sheet to lose so much mass so quickly, things are happening a lot faster than we expected."
- Professor Isabella Velicogna, University of California, Irvine.
"The great Greenland meltdown", Science magazine, 2017

“We have already observed impacts of climate change on agriculture. We have assessed the amount of climate change we can adapt to. There’s a lot we can’t adapt to even at 2ºC. At 4ºC the impacts are very high and we cannot adapt to them.”
- Professor Rachel Warren, University of East Anglia, The Conversation, 2014

“The health of ecosystems on which we and all other species depend is deteriorating more rapidly than ever. We are eroding the very foundations of our economies, livelihoods, food security, health and quality of life worldwide.”
- Sir Robert Watson, Chair of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, on publication of IPBES 2019 report.

“There is no question we are losing biodiversity at a truly unsustainable rate that will affect human wellbeing both for current and future generations”
- Sir Robert Watson, chair of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 3 May 2019.

“Children’s bodies and immune systems are still developing, leaving them more susceptible to disease and environmental pollutants. The damage done in early childhood lasts a lifetime. Without immediate action from all countries climate change will come to define the health of an entire generation.”
- Nick Watts, Executive Director of the 2019 Lancet Countdown Report, The Guardian, 13 Nov 2019

"It is generally foolish to bet against the judgments of science, and in this case, where the planet is at stake, it is insane.”
- Professor Steven Weinberg, Nobel-Prize winning Theoretical Physicist, “Third Thoughts”, Harvard University Press, 2018.

“The future of the human race is now at stake.”
- Rowan Williams, Former Archbishop of Canterbury, 11 March 2019

“To ignore the challenge of climate change is to betray Jewish values.”
- Rabbi Jonathan Wittenberg, the Jewish Chronicle, 19 June 2017.

“…there is also no certainty that adaptation to a 4°C world is possible. A 4°C world is likely to be one in which communities, cities and countries would experience severe disruptions, damage, and dislocation, with many of these risks spread unequally. It is likely that the poor will suffer most and the global community could become more fractured, and unequal than today. The projected 4°C warming simply must not be allowed to occur”
- World Bank, “Turn Down the Heat: Why a 4°C Warmer World Must Be Avoided.” Washington, DC, 2012.

“The climate crisis has arrived and is accelerating faster than most scientists expected. It is more severe than anticipated, threatening natural ecosystems and the fate of humanity.”

- World Scientists’ Warning of a Climate Emergency, BioScience, January 2020.

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And with the support of the XR Scientists community

Please note: Individuals credited contributed to this document in a personal capacity, not as part of their role in the institution(s) listed.

Testimonials: What other scientists, political voices and readers are saying about this guide

“A fantastic communication summary of the science of climate/ecological crises. This document represents more than a year of careful work by one of the UK's most talented and dedicated science communicators, with the support of some of its most eminent climate scientists. It should be of immense help to journalists, educators and anyone who cares about human life on earth, but often has difficulty navigating the scientific knowledge. This is an immense step forward in creating an educated public on climate topics."

Professor Julia Steinberger, Professor of Social Ecology and Ecological Economics at the University of Lausanne and Lead Author of Working Group 3 of the IPCC 6th Assessment Report

"Many people have asked me if there is a reliable book or resource that tells them all they need to know about the climate and ecological crisis in an easy to understand way. Now, I can say that there is, and what's more, it's not behind a paywall! Scientists have for decades warned us of climate change and ecological breakdown in scholarly journals. Now those many warnings are integrated and brought to life in this excellent book. A must-read for anyone who wants to understand why we must act NOW."

@ScienceWarning, Dr Alison Green, Executive Director of Scientists Warning, Psychologist and former Pro Vice-Chancellor of Arden University

“Dr Grossman’s report is an outstanding summary of the evidence for the current and future impact of anthropogenic climate change on our planet and civilisation. It provides a clear explanation of changing climate processes and effects for anyone seeking a better personal understanding or needing summary material for sharing with others. Many text links take you quickly into detailed and original studies if you need them. This report left me feeling that the scientific community has generated more than enough evidence of the problem, and needs to turn now to generating more evidence for the solutions. But first, we need to reach many more people on climate change, and this report is an invaluable tool for that task.”

Professor Jeff Waage OBE, London School of Hygiene and Tropical Medicine, University of London

“This is a powerful statement on the need for action, rigorously referenced and compellingly told.”

@rpancost, Professor Rich Pancost, Head of the School of Earth Sciences at the University of Bristol, on Twitter

“This is a brilliantly written planet polemic, I shared it with friends who aren’t rebels and they are now conscious climate change fighters as a result of reading it!”
@lucierussell12, Lucie Russell, CEO of StreetDoctors charity and co-founder of The Big Issue, on Twitter

“I've been asked how well this [new book] represents current science. It correctly says emissions from current worldwide policies could lead to 4C global warming this century, with potentially dire consequences. Yes, I do find it frightening. But it's still avoidable if emissions reduce soon.”
@richardabetts, Professor Richard Betts MBE , Chair of Climate Impacts at the University of Exeter and Head of Climate Impacts at the Met Office Hadley Centre, on Twitter

*“Dear School Teachers. Here is the *ultimate guide* on the Climate and Ecological Emergency. Get informed / share the facts / use the terminology.”*
@geography_paul, Radical Geographer and Social and Environmental Activist, on Twitter

“This is a very extensive, extremely well researched Google Document with pretty much everything you need to know about the climate emergency, covering very basic questions, effects, tipping points, and required actions.”
Dense Discovery newsletter

“[This] primer on the climate and ecological emergencies is really, really important reading.”
@KetanJ0, Ketan Joshi, Climate and clean tech author and analyst, on Twitter

“An amazing document! - a clear, accessible and peer-reviewed overview of the science of the planetary emergency.”
Dr Charlie Gardner, Lecturer in Conservation Science at the Durrell Institute of Conservation and Ecology at the University of Kent

“Fantastic work, I will be sharing this doc with everyone I know. Thank you for all you’ve done, this has been badly needed and i think it has the best chance of bringing everyday people on board with the severity of the crisis.”
@Al3xB83, Alex Berry, software developer, on Twitter

*“This is horrific, but critically important reading. It’s long, I’ve only skimmed. But that was enough for me to know that every human should *at least* skim through this.”*
@watchvidoesoul, London based freelance lighting cameraman, on Twitter

“School textbooks for science and geography misrepresent, and lie about, the climate and ecological crisis. Luckily instead you can use this comprehensive, rigorously referenced and highly accessible document.”

@XREducators on Twitter

“I've been teaching a class on the Anthropocene since 2015 at Central Connecticut State University and haven't found a comprehensive treatment on climate / environmental change until today. I've had to write my own material for my class and website, so your new paper is a wonderful addition.”
Gary A. Gomby, Geological Sciences, Central Connecticut State University

In the media: Talks, articles, interviews and short films about this guide

Dr Emily Grossman’s Emergency on Planet Earth talk for the opening of the Cambridge Zero Climate Change Festival 2020.

Article in The Scotsman written by Dr Emily Grossman about the need for urgent action and why she and the team wrote this guide.

Short film: Dr Emily Grossman talking about her journey into activism and why we must Act Now.

Article about this guide on the Scientists Warning website.

Dr Emily Grossman in conversation with Dr Alison Green, Director of Scientists Warning.