

Human-induced climate change is already happening. People – particularly poor people – struggle with its impacts every day. Whilst world leaders argue over how to tackle this immense issue, one thing must be agreed on now: the level of change the world needs to avoid.

For millions, 'safe' levels of change have already been exceeded and international efforts must be ramped up to support the affected communities. But above 2°C the impacts will become progressively less manageable, perhaps uncontrollable.

This paper explains why global average temperature rise **must** be kept as far below 2°C as possible (from pre-industrial levels), based on a review of evidence of the impacts at different temperature ranges. It explains how impacts on water resources, food production and ecosystems become catastrophic above that threshold, and how dangerous feedback mechanisms are much more likely to kick in, resulting in even faster warming.

TWO DEGREES, ONE CHANCE

The urgent need to curb global warming

WORLD GOVERNMENTS MUST:

- Agree to keep global temperature rise as far below 2°C as possible and commit to the necessary binding targets to reduce emissions
- Establish frameworks and mechanisms for adaptation that deliver sufficient and accessible funds and support to the most vulnerable countries and communities.

Rich industrialised countries, who have both historic responsibility and the capacity to act, must take the lead.

CURRENT WARMING

Since the industrial revolution began more than 150 years ago, the average global surface temperature has risen by 0.76°C.¹ Scientific consensus is now firmer than ever that most of this warming is the result of human activities which release greenhouse gases, and that the planet is already committed to substantially more warming.

FUTURE WARMING

Whilst some amount of warming is 'loaded' into the climate system due to past emissions, how much it warms relates to how fast emissions are reduced (or allowed to increase further). If greenhouse gas concentrations were held constant at present levels (which would require very rapid emission reductions) warming would continue at about 0.1°C per decade for a few decades and then at a much slower rate thereafter. But if emissions continue to grow at their current rate, then average global temperatures could rise by 2–3°C in the next 50 years or so. Business as usual could see average global temperature eventually exceed 5 or 6°C in this century², with much higher levels of warming in the high northern latitudes and Arctic.² These figures are averages³, and the **rate** of global temperature change is outside of any change experienced in the last 10 000 years, and most likely much longer.

The crucial issue is how to curb further emissions in order to keep global warming below dangerous levels.

Today, the observed impacts of global warming are becoming increasingly and rapidly obvious. They take the form of changing seasons, abnormal weather, heat waves, droughts, floods, marked changes in the behaviour of animals and plants. The world's poorest people living in places where the climate is already at its most extreme – such as the Inuit in the Arctic, pastoralist people in northern Kenya and across the Sahel, indigenous people and settlers in the Western Amazon – are already feeling serious impacts upon their lives and livelihoods. These are the communities least responsible for greenhouse gas emissions and who, because of poverty, isolation and political marginalisation, are too often those least equipped to adapt. This is all happening when global average temperatures have not yet exceeded 1°C. Whilst not all of these changes can yet be rigorously attributed to human-induced climate change, they are consistent with what is expected and compel us to take them as warning signs of the first order.

Risks rise rapidly with temperature. Once temperature increase rises above 2°C up to 4 billion people could be experiencing growing water shortages. Agriculture could cease to be viable in parts of the world, particularly in the tropics, and millions more people will be at risk of hunger. This rise in temperature could see 40–60 million more people exposed to malaria in Africa. The warmer the temperature, the faster the Greenland ice sheet will melt, accelerating sea-level rise. Above 2°C, the risk of a disintegration of the West Antarctic ice sheet rises significantly, as does the greater danger of 'tipping points' for soil carbon release and the collapse of the Amazon rainforest.

2°C is a clear limit that cannot be exceeded – the world must act with urgency.

DANGEROUS CLIMATE CHANGE AND 2 DEGREES

The ultimate objective of the UN Framework Convention on Climate Change (which created the Kyoto Protocol) is to stabilise greenhouse gas concentrations to ‘prevent dangerous anthropogenic (man-made) interference within the climate system’ while allowing ‘economic development to proceed in a sustainable manner’. But what is dangerous? In 2001 the Inter-Governmental Panel on Climate Change (IPCC) produced a diagram (see **Figure 1**) to illustrate how the risks of adverse impacts from climate change increase with the magnitude of climate change. The research upon which this was based, and further studies since, confirmed the EU Environment Minister’s 1996 decision that staying below 2°C, while by no means ‘safe’, would likely limit the worst effects of climate change and therefore avoid the most ‘dangerous’ climate change. In 2005 this became the official position of the EU Heads of Government.⁴ (However, the Alliance of Small Island States has registered that this level of warming is too high for the security and continued existence of many of their members.)

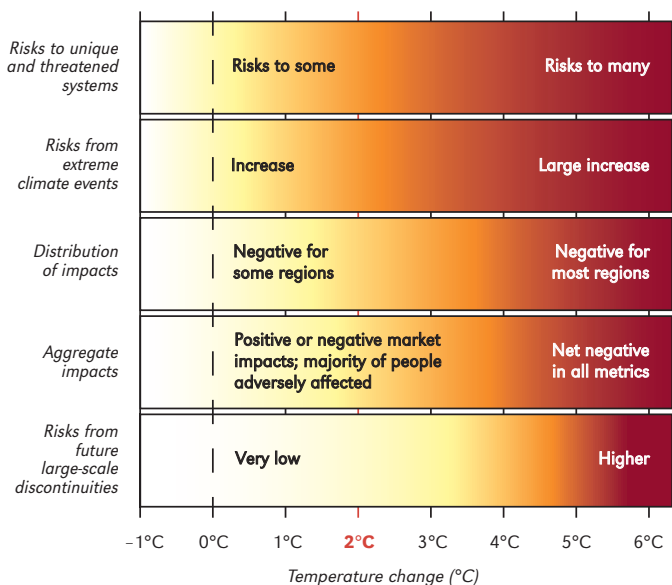


Figure 1: Five reasons for concern with increasing temperature change with climate change. White indicates small impacts, yellow indicates negative impacts for some systems or low risks and red means negative impacts or risks that are more widespread and/or greater in magnitude. Source: IPCC, 2001.

- The impacts at different temperatures are pointers to what is likely to happen based on current scientific understanding. But because the atmosphere and ecosystems are extremely complex, and because we don’t know exactly how society will respond, it can be difficult to say precisely what will happen at any given temperature. This paper is based upon a review of evidence on the impacts at different temperature ranges.

- Climate change isn’t happening in isolation. There are many other factors that interact to cause a specific environmental impact (e.g. decrease in crop yields), including natural variability in weather patterns and local land practices. The challenge is that climate change, superimposed on vulnerability due to poverty, makes existing problems and challenges – like deforestation, desertification, declining food security, and the wiping out of fish stocks – much worse.

THE PRESENT: 0–1°C

At almost 0.8°C average temperature change compared to pre-industrial revolution (with most happening in the last 40 years or so), significant impacts are already being experienced. Poor people who are directly affected by these changes already require support to enable them to adapt.

WATER

Around one third of the world’s population live in countries experiencing moderate to high water stress.^{2,5} Rainfall patterns are directly affected as temperature rises and the water cycle alters. During the past century there has been increased rainfall in some parts of the world, but drying in others.⁶ This equates to increased flooding in some areas, and droughts in others. In the past few decades, more intense droughts that last longer have been experienced in the semi-arid sub-tropics, and over wider areas than before.

As a result of current climate change, the timing of supply is being altered in many rivers that are fed by glaciers and snow because of accelerated melting.² Millions of people are dependent on such rivers for their water supply, particularly during the dry season. Accelerated retreat of glaciers has been recorded across all the major ice-capped ranges in Asia (where air temperatures in the highlands are rising at twice the global average). For example, virtually all glaciers in China are showing substantial melting. The area covered by glaciers in the Andes has been reduced by nearly a quarter in the last 30 years.² Many large cities (such as La Paz/El Alto, Lima, Quito) and 40% of agriculture in Andean valleys rely to a considerable extent on these melt-water supplies.

FOOD

Food production is highly sensitive to climate change because crop yields depend very much on temperature and rainfall patterns. Two thirds of the poorest people in the world live in rural areas and rely on agriculture for their livelihood. Around 800 million people are currently at risk of hunger (about 12% of the world’s population).²

In cooler environments (mid- and high-latitudes) temperature change up to several degrees can result in an increase in productivity for many crops. But in drier, tropical (lower latitude) regions crop productivity decreases even with small temperature rises. There is already evidence of reduced growing seasons in parts of Africa that are having detrimental effects on crops.⁷ In southern Africa the dry season is getting longer and rainfall more unpredictable. Overall, there are negative impacts recorded on smallholders, subsistence farmers and fishing communities, people ill-equipped to deal with – and highly vulnerable to – even the slightest change for the worst.

HEALTH

The World Health Organisation estimates that climate change is already responsible for over 150,000 deaths each year. This is through an increase in cases of diarrhoea, malaria and malnutrition, predominantly in developing countries.⁸ In addition, there is increased death from heat waves, floods and droughts.⁷

Rising temperatures interact with other man-made causes of the spread of disease like population movement and land use changes (notably deforestation).

In 2003 a heat wave that has been linked to climate change struck Europe and left over 20,000 people dead, 12,000 in Paris alone. It was mainly the elderly and the weak that died, highlighting that it is the most vulnerable who are most at risk to the effects of climate change. Analysis has projected that such summers are likely to be the norm by the middle of the 21st century.⁹ Severe heat waves are increasingly being reported from many places, including Russia, China, India, Vietnam and central America.

LAND

At current temperature, sea-level rise combined with human development is contributing to the loss of coastal wetlands and mangroves and increasing damage from flooding in many places around the world.⁷ More than 200 million people live in coastal floodplains² and as many as 100 million people live in areas below sea-level and/or are subject to storm surge.¹⁰ In Bangladesh one quarter of the population (about 35 million people) live within the coastal floodplain.² But it's not just coastal areas that are at risk from flooding. The number of glacial lakes is increasing with melting, and settlements in mountain regions are at risk if those lakes burst or overflow their banks.⁷

Weather-related disasters have been increasing in both number and ferocity over recent years. In fact they have soared in the last 40 years from 1,110 during the 1970s to 2,953 between 1993–2002. The number of people whose lives have been affected by storms and floods rocketed from 740 million to 2.5 billion people over the same period.^{11,12} This upward trend in disasters reflects a range of factors; one of the main reasons being that more people are living in vulnerable conditions. But climate change is increasingly playing a role.

ECOSYSTEMS

Recent warming is badly affecting ecosystems. This includes earlier timing of spring events such as leaf unfolding, bird migration and egg-laying. Plant and animal species are on the move to cooler climates (the poles or higher altitudes) as their habitats get hotter. One study predicts that a mere 1°C rise could cause at least 10% of land-dwelling species to face extinction.² Whatever threatens the survival of complex ecosystems also ultimately threatens human societies, starting with the people who most directly rely on natural resources for their livelihoods.

Coral reefs are a key vulnerable habitat. They are hugely important ecosystems, particularly for humans as a major nursery ground for commercial fishing. The functioning of corals requires water temperature to stay below 30°C. Once this is exceeded, the corals become bleached and die unless cooler waters return. Bleaching has been observed around the world since about 1980 and it will become more frequent, with slow recovery. Particularly vulnerable are reefs in the southern Indian Ocean, the Caribbean and the Great Barrier Reef.² Coral damage is exacerbated by reckless over-fishing and destructive fishing practices.

ICE

The Arctic region is currently warming at twice the global rate.¹ In Alaska and Siberia the temperature has risen 2–3°C in the last 50 years. There are a number of observable changes; snow is melting earlier, lakes are draining away as the frozen ground underneath them defrosts, glaciers are thinning, and sea-ice is melting.¹³ These changes have a significant impact on Arctic ecosystems where animals depend on sea ice for most or all of the year. This is affecting people like the Inuit who live, often by hunting, in these regions.¹⁴

The changes at the Arctic also highlight an important phenomenon – positive feedbacks. This means that, once started, some events that occur at the lower end of change (1°C), may themselves actually cause climate change to accelerate, fuelling the problem and causing temperatures to increase more rapidly. In the Arctic:

- Snow melting earlier means that more summer heat goes into the air and ground (rather than into melting snow). This raises temperatures even higher and warming becomes self-reinforcing.
- Open ocean absorbs up to 95% of incoming solar radiation compared to ice which can reflect more than 80%. When sea-ice starts melting more open sea is revealed and more solar heat is absorbed. This raises temperatures, meaning it will be more difficult for the ice to re-form the next winter. This sort of positive feedback could have global consequences as the poles play a significant role in the dynamics of the world's climate.

The higher temperatures get, the more these positive feedbacks will fuel additional global warming.

THE IMMEDIATE FUTURE: 1–2°C

Projections for greenhouse gas emissions make it clear that even with drastic action taken now, temperature increase greater than 1°C is inevitable. The impacts outlined in the previous section will obviously only intensify and more positive feedbacks may also kick in. People need help to prepare for the changes outlined here, especially those who are the most vulnerable.

WATER

Hundreds of millions of people will be exposed to increased water stress as temperature climbs.⁷ In the Andes small glaciers will disappear completely with warming in the range of 0.5–1.5°C, threatening water supplies for around 50 million people.² In Asia millions of lives will be affected with a predicted strengthening of the summer monsoon as temperatures rise, making it warmer and wetter. Monsoon rains play a crucial role for agriculture and industrial production throughout South and East Asia. In India these rains provide 75–90% of annual rainfall.² Water availability could therefore increase for around 2 billion people. But flood risk would probably increase as rain falls in more intense bursts. In August 2005, 1 metre of rain fell in just 24 hours in Mumbai. With water contaminated, hundreds suffered from dysentery and cholera.²

FOOD

Crop productivity could still be increasing in mid to high latitudes. For example, northern parts of the US may become increasingly important winter wheat and potato producing areas. Higher yields of crops of fruit and vegetables may be common across Europe. But in other parts of the world, the story will be bleak. Maize is a staple crop for millions in developing countries, but lower yields are predicted right across South America (in every country except Chile and Ecuador). Building on current trends, most of Africa is expected to experience big declines in yields.¹³

Increasing numbers of people will inevitably be displaced by such profound impacts on water and food availability. Droughts, floods, sea-level rise, expanding deserts, food and health crises already contribute to large displacements of people. For example, in Nigeria desertification is forcing farmers and herdsmen to move, either into other areas where the land is habitable, or to the cities.¹⁵ Research by the Red Cross shows that more people are currently displaced by environmental disasters than war, and by 2010 the UN estimates that there could be as many as 50 million people escaping the effects of environmental deterioration.⁸ Some Small Island States may disappear altogether. Whether such movement is within countries (often to cities) or across borders, a host of challenges will follow. Conflict is a likely consequence, particularly where competition for resources is severe.

HEALTH

In northern latitudes warming may imply fewer deaths overall, because cold-related deaths in the winter are reduced. But globally it is expected that these benefits will be outweighed by the negative health effects from rising temperatures, especially in developing countries.⁷

In warm, wet conditions vector-borne diseases like malaria and dengue fever thrive. An estimated 450 million people are already exposed to malaria in Africa today, with around 1 million dying annually as a result. With higher temperatures insects are able to move to higher altitudes and latitudes, and changes in mosquito distributions and abundance would have profound impacts on the proportion of the world at risk from malaria.

LAND

Sea-level rise

Predictions for sea-level rise have generally focused on a 0–1 metre rise during the 21st century.¹⁶ The main factors contributing to sea-level rise are:

- the expansion of the oceans as a result of heat
- melting glaciers mainly from Greenland and Antarctica and
- change in water storage on land.

Recent data suggests that melting glaciers in Greenland and Antarctica have greater significance than previously thought and could lead to more rapid sea-level rise.¹⁷ Losses from ice sheets in both places have contributed to sea-level rise over the last few decades.¹

According to a World Bank study, continued growth of emissions could well promote a sea-level rise of 1–3 metres this century.

Experiences of poor communities

The agencies that have written this report, who work with poor people around the world, are increasingly hearing directly from the communities they work with about the impact of higher temperatures on their lives and livelihoods. Farmers in particular, in Latin America, Africa and Asia, are observing many common changes (see the *Up in Smoke* reports,¹⁸ produced by the UK Working Group on Climate Change and Development in the UK, highlighting impacts and responses to global warming). These include the following:

- Greater extremes – heat waves, longer and hotter droughts, more floods and intense, concentrated rainfall. This is increasing the numbers of both chronic, small-scale problems and major disasters.
- Changes to the seasons, generally shorter growing seasons.
- Greater uncertainty and unpredictability in weather patterns.

In combination with other pressures on the environment, these changes are increasing water shortages, and hence hardship for women and girls, who are generally responsible for fetching water. In some places hotter temperatures have benefited farmers' ability to grow fruit and vegetables. Others have lost out. Many farmers are changing their farming practices – particularly trying to grow more drought-resistant crops or varieties – but ability to change is limited by many factors, especially poverty.

Unexpectedly rapid break-up of the Greenland and West Antarctic ice sheets might produce a 5 metre rise.¹⁷ Researchers estimate that approximately 56 million people would be affected (in the 84 developing countries considered) under 1 metre of sea-level rise alone. They conclude that, *'the overall magnitudes for the developing world are sobering: within this century, hundreds of millions of people are likely to be displaced by sea-level rise (SLR); accompanying economic and ecological damage will be severe for many. The world has not previously faced a crisis on this scale, and planning for adaptation should begin immediately.'*

As temperature continues to rise, the world risks crossing a threshold level of warming beyond which melting of the ice sheets would be irreversible. Some studies suggest that a global temperature rise of 1–2 °C could begin to destabilise the ice sheets irreversibly.¹³

South and East Asia are particularly vulnerable to sea-level rise because of their large coastal populations in low-lying areas, notably Vietnam, Bangladesh and parts of China and India. Millions will be at risk around the coastline of Africa, particularly in the Nile Delta and along the west coast. Up to 10 million more people could be affected by coastal flooding each year in the 1.5–2.5°C rise range.²

Small Island States in the Caribbean and in the Indian and Pacific Oceans are acutely threatened. Whole countries may disappear. Half a million people live in archipelagos of small islands and coral atolls, such as the Maldives and the Marshall Islands (which lie almost entirely within 3 metres of sea-level). Even half a metre of sea-level rise will wash away significant portions of their land and substantially reduce their supplies of drinking water, making them uninhabitable.¹⁹ The state of Tuvalu

has already made an agreement with New Zealand to accept its citizens when sea-levels submerge the country.⁸

Hurricane intensity

Hurricane Katrina, which devastated New Orleans in August 2005, needs no introduction. A year earlier, another similarly-named hurricane received far less coverage: Hurricane Catarina which hit the coast of Brazil. Before then, not a single hurricane had ever been documented in the South Atlantic. Individual hurricanes can't be analysed in isolation, but the IPCC said in 2007 that future tropical cyclones (typhoons and hurricanes) may well become more intense as the world warms as higher sea surface temperatures provide more energy to power tropical storms.

ECOSYSTEMS

If increases in temperature exceed 1.5–2.5°C then around 20–30% of plant and animal species are likely to be at increased risk of extinction.⁷ The rate of change means they won't have time to adapt in the same way as many have been able to in the past. At the same time, human activity – land use change and ecosystem destruction – means species' ability to migrate is minimal. In the oceans, even around the 0.5–1.5°C mark there could be around 80% bleaching of coral reefs.²

Such devastation is massively significant; human beings depend on natural ecosystems which are already under severe pressure from our activities. The latest UN Ecosystem Assessment concluded that nearly two thirds of the ecosystems that humans depend on are currently being degraded or used unsustainably.²⁰

Oceans

Acidification will add to the problem of coral bleaching in the oceans. At least half the CO₂ pumped into the atmosphere ends up in the sea. Adding lots of CO₂ at a very fast rate is a problem because it dissolves in water to form an acid. Increasing ocean acidity could disrupt marine ecosystems irreversibly by making it harder for organisms like molluscs to form shells.^{2,21} It is possible that even with emissions this century resulting in 2°C change or less, parts of the Southern Ocean could effectively become toxic to some organisms by 2050.²²

THE FUTURE THAT MUST BE AVOIDED: +2°C

An increase of more than 2°C is not inevitable, but drastic and urgent action is required to avoid it and the impacts it would bring.

WATER

At this temperature South Asia, parts of northern Europe and Russia could well experience an increase in water flow of 10–20%, and more as temperatures move up towards 4°C. An estimated 1–5 billion people in South and East Asia may receive more water. A lot of the extra water will come during the wet season when it is likely to lead to more flooding. It will only be useful in the dry season if it is stored well.² Much of East Africa is set to get wetter, with countries from Somalia to Mozambique experiencing more flooding from extreme rainfall.

In the Mediterranean, southern Africa and parts of South America rainfall will continue to decline. At 2°C, models predict up to a 30% reduction in water in rivers in these places, with a shocking potential 50% decrease around 4°C.² This spells water shortages for millions. One study predicts for a 2–3°C rise, 1–4 billion people will be experiencing growing water shortages.² Much of this will be the result of devastating drought. The UK Hadley Centre warns that the proportion of land area experiencing extreme droughts at any one time could increase from around 3% today, to 8% by 2020 and to an incredible 30% by the end of the century.²³ Drought will probably last all year round in most of southern Africa by the time 3°C is reached. And in southern Europe serious droughts could be occurring every 10 years instead of every 100.²

At 5°C large glaciers in the Himalayas may have disappeared, affecting a quarter of China's population and hundreds of millions in Asia.² Some rivers will dry up completely. National food security will be jeopardised in countries like Pakistan with growing populations and high dependence on agriculture. Energy shortages will follow in countries like India that have a significant dependence on hydroelectric power.

FOOD

Even in areas that have benefited from temperature rise previously, crop yields are likely to begin declining in the 2–3°C range. Rainfall reduction in many parts of Africa is likely to come in the middle of the growing season and modelling studies reveal massive declines in wheat, corn and rice production in the tropics. Increasingly severe droughts in some areas will make crop production impossible. Even if some crops still benefit (for example in Canada where water is plentiful), billions of people would be suffering from drought elsewhere.

Above 3°C, China's agriculture production is likely to be severely undermined and agriculture could become non-viable in several whole areas, for example in parts of southern Africa and parts of Australia. At 3–4°C, yields of predominant crops across Africa and western Asia may fall between 15–35% (depending on the effect that increased CO₂ has on plant productivity).² In parts of India, land temperatures could be too hot for crops to survive, even if rainfall increases as a result of a more intense monsoon.¹³ Even with inevitable adaptation and technological development, it is hard to see how losing vast areas of agricultural land will not be crippling. Once temperatures increase above 3°C, 250–550 million additional people may be at risk of hunger, over half of them in Africa and western Asia.²

About one sixth of the population of the world rely on fish as their primary source of animal protein. Stocks will diminish as a result of acidification and the decline of coral reefs, denying tens of millions of people their livelihoods.

HEALTH

A 2°C rise in temperature could see 40–60 million more people exposed to malaria in Africa according to one study. This figure increases to 70–80 million at temperatures around 4°C, based on the current level of control efforts.² There may also be places where there will be a decrease in malaria prevalence, but in all scenarios Africa sees more people exposed. At 4°C an extra 1.5–2.5 billion people could be exposed to dengue fever because of climate change.² These and other health effects (for example,

malnutrition as a result of decreasing food security) will lead to immense increased suffering.

LAND

Highlighted below are the number of people potentially affected in developing countries at different levels of sea-level rise as melting of ice-sheets accelerates:¹⁷

Sea-level rise	Numbers affected in developing countries
1 metre	56 million people
2 metres	89 million people
5 metres	245 million people

In addition to the Pacific Islands, which will be disappearing at 1 metre rise, the Bahamas will be severely affected in terms of land-loss. Egypt will be hard hit, especially the Nile Delta where most of its population lives. The impact on agriculture there would be particularly severe, ranging from 13–35% losses with rises of 1–5 metres. East Asia is at very high risk, with Vietnam being particularly vulnerable. In South Asia really serious impacts are likely above a 3 metre rise and escalate dramatically. Bangladesh would experience major impacts on agriculture, population, urban area and GDP.

It's not just people but vital habitats that will be submerged. Around 30% of global coastal wetlands could be lost as temperatures rise over 3°C. Wetlands are natural sponges that provide vital protection against floods and storm surges, as well as people's livelihoods. Increased intensity of storms will add to the problem of sea-level rise.

ECOSYSTEMS

Above 2°C, the fate of major global ecosystems is bleak indeed and the potential for tipping points very high. An increasing number of species will be in decline and on their way to extinction. As 3°C temperature rise is approached, most coral reefs will be bleaching beyond recovery and many will already be dead.

But on land things will also begin to get much worse as 2°C is crossed.

The Amazon and the carbon cycle

The widespread drought that hit the western Amazon in 2005 has been linked by experts to warming of sea surface temperatures in the tropical North Atlantic compared to the South Atlantic. As this temperature gradient is expected to steepen, similar droughts will become more likely. One model predicts that with current levels of emissions, the chances of such a drought will rise from 5% now to 50% by 2030, and 90% by 2100.²⁴

Furthermore, drought encourages fires which themselves can fuel further burning as half-dead wood is left behind. Forest fires pour massive quantities of carbon dioxide into the atmosphere which in turn drives more global warming. In 1998 forest fires during a drought period released 400 million tonnes of carbon in the Amazon basin, equivalent to 5% of human emissions from fossil fuels for that whole year.¹³

Warming can generate its own momentum because as soils warm, bacteria speed up the breakdown of carbon, releasing it back into the atmosphere as CO₂. With warming around 3°C the carbon cycle could be effectively reversed – as vegetation and soils release millions of tonnes more CO₂ into the atmosphere.

Land would move from being a net carbon sink (taking up carbon and storing it) to a net carbon source (releasing carbon). This positive carbon cycle feedback would lock the planet into faster warming, with models suggesting that warming of 5.5°C could be possible by 2100.¹³

The world's great rainforests are already being destroyed by human exploitation, especially logging for the global timber trade and for growing export crops like palm oil which is ironically being promoted as a biofuel. But the Amazon is a particular concern and may be pushed over a tipping point. Some models predict that most of the Amazon rainforest will die and become impoverished grassland in 50–100 years.²⁵

The Amazon is home to half the world's biodiversity and the Amazon river contains 20% of all the water discharged into the world's oceans. The energy released by rainfall in the Amazon is a major component of regional and even global weather systems. The Amazon rainforest contains about 10% of all carbon stored in land ecosystems. Its downfall would have widespread global ecological implications beyond the contribution to climate change.

ICE

Studies suggest that as the world approaches a temperature rise of 3°C, 80% – maybe 100% – of the sea ice at the Arctic will have been lost. Above 3°C rise even the more conservative computer models predict that it disappears completely, the first time for 3 million years.

On land, ice-caps and glaciers will continue to shrink. Once over the 2°C rise mark, the threshold for irreversible melting is much more likely to have been passed.

As the melting of frozen ground (permafrost) accelerates, large areas of Siberia, Alaska, Canada and even southern Greenland will be affected. Even at low temperature changes unstable soils will damage infrastructure and Arctic ecosystems will be severely disrupted. As soils defrost, another positive feedback mechanism kicks in. With around 500 billion tonnes of carbon currently locked up in frozen soils, more greenhouse gases will be released and global warming will be further accelerated. Where soils are wet, bacteria will produce more methane, a greenhouse gas with 23 times the global warming potential of CO₂. The extent of this feedback effect on climate change is not yet known and so isn't included in current projections.¹³

LOOKING AHEAD

HOW FAR AND FAST DO WE HAVE TO GO?

The forecasts for the economic cost of climate change in Sir Nicholas Stern's review are based on stabilising emissions at 550 parts per million in the atmosphere of CO₂ and its equivalent gases (ppm CO₂e).² But the narrative in his report draws on a wide range of studies^{26,27,28} and concludes that this level – an effective doubling of CO₂ over pre-industrial levels – carries an unacceptably high risk of exceeding 2°C of global warming.

Throughout the review, Stern considers the implications of stabilising within a range between 450 and 550ppm CO₂e. But even at 450ppm stabilisation, the literature suggests there is a risk in excess of 50% of exceeding 2°C. These are not good odds.

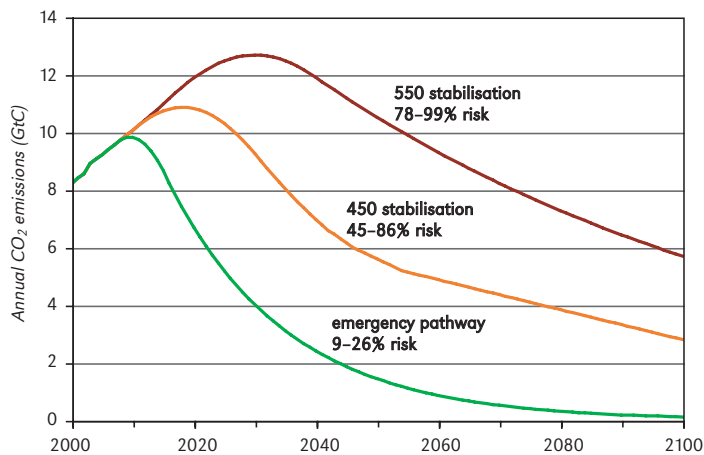


Figure 2: Carbon emission predictions
Source: Baer and Mastrandrea, *High Stakes*, IPPR, 2006.

A serious attempt to keep global warming below 2°C would require atmospheric concentration to peak at 450ppm, a level that now appears almost unavoidable, and then decline soon thereafter to less than 400ppm. To achieve this ‘peak and decline’ in levels of CO₂ in the atmosphere, substantial reductions in emissions would have to begin within the next five years and be sustained throughout the century. This is well illustrated by Paul Baer and Michael Mastrandrea in their work for the UK’s Institute of Public Policy Research, published as *High Stakes* (see Figure 2).

This work suggests that minimising the risk of exceeding 2°C would require an ‘emergency pathway’ of mitigation where consistent reductions were made in order to reduce emissions so that each year less is emitted than the earth can absorb, thereby decreasing the concentration of CO₂ in the atmosphere. Of the six different emissions ‘pathways’ considered in the report, the most stringent carries a 9–26% risk of exceeding 2°C. This pathway requires emissions globally to peak in 2010 and then contract by 5% each year thereafter, reducing concentrations to below 400ppm by the end of the century.²⁸

Clearly, any modelling exercise of this sort introduces a range of options rather than one single prescription. But the message from much of the literature is clear and stark. Climate mitigation is a game of risk and probability. In order to keep the odds as short as possible, the world – led by its richest nations and historically highest emitters – must commit to urgent, annual reductions that ultimately hold the atmospheric concentration of greenhouse gases at less than 450ppm CO₂e and then continue in order to reduce it to 400ppm CO₂e within the next 50 years.

WHAT NEXT

For many people and some ecosystems, current warming is already way too much. But it is clear that 2°C marks a significant boundary. Above this, impacts on water resources, food production and ecosystems are projected to increase significantly. And there lies the greater danger of tipping points for soil carbon release and the collapse of the Amazon rainforest. This would accelerate warming to 3 and 4°C and even more carbon and methane would be released from

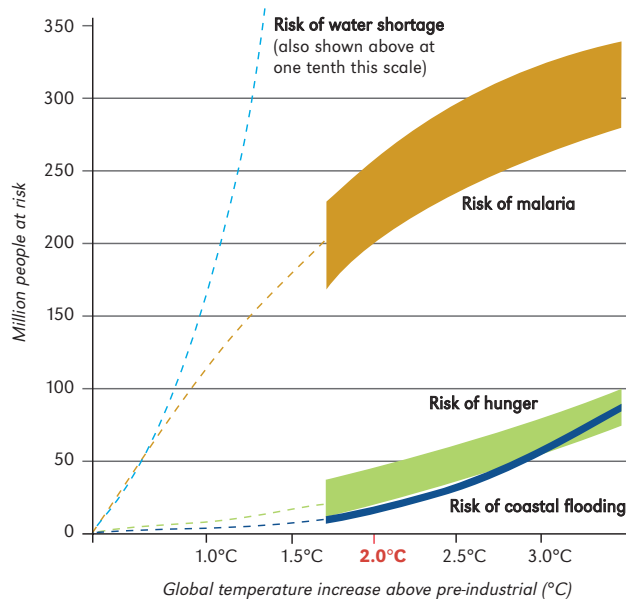
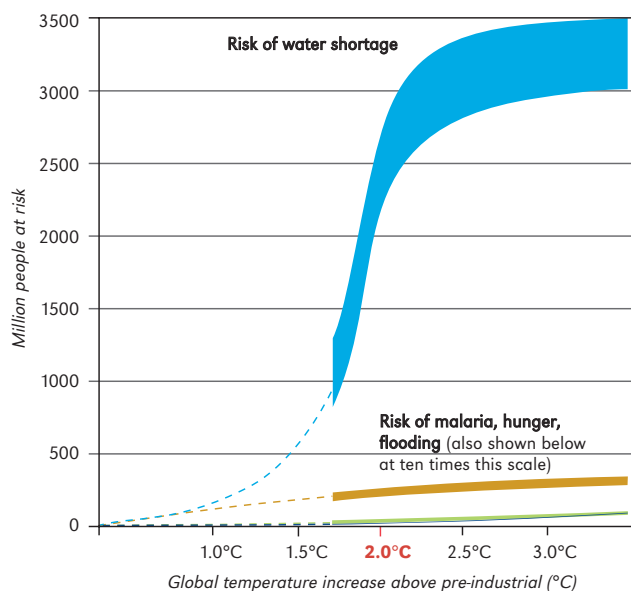


Figure 3: Millions at risk in the 2080s (illustrative for a range of impacts)
Source: Parry et al, 2001, ‘Millions at Risk’ *Global Environmental Change*. Width of curves indicate one standard deviation around the mean; dotted lines are inferred.

thawing permafrost. Above 2°C the Greenland ice-cap is likely to be completely destabilised, and sea-level will rise continually. The wide-ranging and far-reaching impacts of these changes have only been touched upon here. But the picture is clear enough to kick-start the necessary action.

It is imperative that humanity takes action to rein in global warming and to stop global temperatures rising by 2°C. This is the target determined on the basis of the science, and by observation of what is happening in the world. The path this leads the world on must therefore be followed. The precise impact on water resources, food availability, and health of billions of people will depend on how societies both North and South choose to act in bringing down emissions. In the meantime, coping with the level of change that will inevitably be experienced, particularly by the world’s poorest people, must receive the highest priority. Doing so in a way that ensures that

poor people have equitable and secure access to energy will be critical.

All societies have a common and shared responsibility in these areas. But it is the wealthiest nations who, through the process of industrialisation, have contributed the bulk of the excess greenhouse gases in the atmosphere that have caused and are causing much of current – and imminent – warming.

A number of principles combine to argue that rich industrialised countries bear special responsibilities including: historical responsibility for emissions, accumulated wealth providing greater capacity to act, and the universally accepted principle that the polluter pays. These countries must act first and most, both to mitigate their own emissions and to help poorer countries to adapt. Yet, emissions in many rich countries continue to increase.

- 1 IPCC (2007) *Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Summary for Policy Makers*
- 2 Stern et al (2006) *Stern Review of the Economics of Climate Change*, HM Treasury
- 3 Even now rates of warming vary around the world; the Arctic is warming at twice the global rate, Russia has seen a rise of 2–3°C in the past 90 years, Mongolia 1.8°C in the last 60, Japan a 1°C rise in the 20th century (but 2–3°C in cities). (IPCC 2007)
- 4 'On the basis of the results of IPCC, the European Council has ... reached political consensus that an increase of 2°C of the earth's average temperature above pre-industrial levels is the maximum 'safe' level that can be envisaged.' *Winning the battle against climate change*, European Commission Background Paper, February 2005
- 5 NB: A country experiences 'severe water stress' when supply is below 1000m³ per person per year, and 'extreme water stress' when it is below 500m³. Water stress is a useful indicator of water availability but does not necessarily reflect access to safe water. (*Stern Review*, 2006)
- 6 More rain: parts of North and South America, Europe and central Asia. Less rain: Sahel, Mediterranean, southern Africa and parts of southern Asia. (IPCC 2007)
- 7 IPCC (2007) *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Summary for Policy Makers*
- 8 World Health Organisation (2006) WHO/UNEP Health and Environment Linkages Initiative (website), WHO, Geneva www.who.int/heli/risks/climate/climatechange
- 9 Houghton J (2007) *Global Warming, Climate Change and Sustainability* John Ray Initiative Briefing Paper 14, 2007
- 10 UN University (2005) 'As Ranks of "Environmental Refugees" Swell Worldwide, Calls Grow for Better Definition, Recognition, Support Hurricane intensity', UN University press statement, October 2005
- 11 Red Cross (2002, 2003) *World Disasters Reports 2002 and 2003*
- 12 See also *CRED CRUNCH Disaster Data: a balanced perspective*, September 2006: 'Floods constitute an increasingly large proportion of all disasters recorded in the EM-DAT database over the last 50 years. Greater variation in precipitation due to climate change, together with an increase in vulnerability of populations, highlights the need to shift from disaster response to risk management', Centre for Research on the Epidemiology of Disasters, Université Catholique de Louvain, Brussels
- 13 Lynas M (2007) *Six Degrees: Our Future on a Hotter Planet*, Fourth Estate, March 2007
- 14 WWF (2005) *2 degrees is too much! Evidence and Implications of Dangerous Climate Change in the Arctic*, WWF International Arctic Programme, January 2005

WORLD GOVERNMENTS MUST:

- Agree to keep global temperature rise as far below 2°C as possible and commit to the necessary binding targets to reduce emissions
- Establish frameworks and mechanisms for adaptation that deliver sufficient and accessible funds and support to the most vulnerable countries and communities.

To do otherwise is to hold the earth and all its inhabitants hostage to a future of accelerated warming with catastrophic consequences.

- 15 Brown L (2004) 'Troubling New Flows of Environmental Refugees', Earth Policy Institute, *Eco-economy updates*, 28 January 2004
- 16 For example, the latest prediction from the IPCC is 18–60cm by 2100. (IPCC, 2007)
- 17 Dasgupta S et al (2007) *The Impact of Sea Level Rise on Developing Countries: A Comparative Analysis*, World Bank Policy Research Working Paper (WPS4136), February 2007
- 18 New Economics Foundation (2004–2006) *Reports from the UK Working Group on Climate Change and Development: Up in Smoke?* (2004); *Africa – Up in Smoke?* (1 & 2, 2005 & 2006); *Up in Smoke? Latin America and the Caribbean* (2006); *Asia – Up in Smoke* (forthcoming, 2007)
- 19 Houghton J (2004) *Global Warming: The Complete Briefing*, Cambridge University Press, 3rd edition, 2004
- 20 Millennium Ecosystem Assessment (2005) *Ecosystems and Human Well-being: Synthesis*, World Resources Institute, 2005
- 21 The Royal Society (2005) *Ocean acidification due to increasing atmospheric carbon dioxide*, Policy Document 12/05, June 2005
- 22 Orr J et al (2005) 'Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms', *Nature* 437, 681–6
- 23 Burke et al (2006) 'Modelling the recent evolution of global drought and projections for the 21st century with the Hadley Centre climate model' *Journal of Hydrometeorology*, 7: 1113–1125
- 24 BBC (2007) *Amazon 'faces more deadly droughts'*, Friday 23 March 2007 <http://news.bbc.co.uk/1/hi/world/americas/6484073.stm>
- 25 See reports from *Conference: Climate change and the fate of the Amazon*, Oriol College, University of Oxford, 20–22 March 2007. Available from Environmental Change Institute website (www.eci.ox.ac.uk).
- 26 Meinshausen M (2006) 'What does a 2C target mean for greenhouse gas concentrations?' *Avoiding Dangerous Climate Change*, Chapter 28. Cambridge University Press, 2006
- 27 Hare and Meinshausen (2004) *How Much Warming Are We Committed To And How Much Can Be Avoided?*, PIK report 93, Figure 7, page 24, Potsdam Institute for Climate Impact Research
- 28 Baer and Mastrandrea (2006) *High Stakes*, Institute of Public Policy Research, 2006

For more information about what you can do:

- www.tearfund.org/climate
- www.oxfam.org.uk/climate
- www.practicalaction.org.uk
- www.christianaid.org.uk/climatechange
- www.stopclimatechaos.org
- www.icount.org.uk

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This document is endorsed by:

- ActionAid UK
- Bread for All, Switzerland
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- Christian Ecology Link, UK
- Climate Action Network Canada
- Evangelical Association of Malawi
- Evangelical Fellowship of Zambia
- Friends of the Earth England, Wales and Northern Ireland
- Greenpeace International
- Helio International
- Interchurch Organisation for Development Co-operation, The Netherlands
- Jubilee Centre, Zambia
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- World Development Movement
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