Review

Climate change for gastroenterologists: understanding the basics

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ABSTRACT

The healthcare sector is a significant producer of greenhouse gas emissions. Gases that contribute to climate change include carbon dioxide, methane, nitrous oxide and chlorofluorocarbons. Climate change will impact the types and prevalence of diseases seen in clinical practice. Practising preventive medicine in gastroenterology can protect population health and reduce the need for health services, thus reducing the carbon footprint of the health sector. Increasing patient empowerment, making care pathways leaner and minimising the environmental impact of treatments and interventions could also make healthcare more sustainable.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The healthcare sector is a significant producer of greenhouse gas (GHG) emissions.
⇒ Gases that contribute to climate change include carbon dioxide, methane, nitrous oxide and fluorinated GHGs.

WHAT THIS STUDY ADDS

⇒ Practising preventive medicine in gastroenterolgy can protect population health, reduce the need for health services and reduce the carbon footprint of the health sector.
⇒ Additional reductions in the carbon footprint can be achieved by empowering patients and making care pathways more efficient.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This article aims to give gastroenterologists the understanding of climate change they might need in order to join the conversation, and take action on this, in their workplace.

INTRODUCTION

Numerous climate records were broken in 2023 and climate scientists predict that the pace of global warming may increase unpredictably.[1] It will be difficult to keep the Earth's warming within a 1.5°C limit above preindustrial levels, considered a critical turning point at which climate change impacts are likely to turn from destructive to catastrophic. A temperature rise of no greater than 1.5°C was adopted by the 2015 Paris Climate Agreement as a desirable target, with a commitment to holding the increase in global average temperature to well below 2.0°C.[2] However, preventing every increment of warming beyond this threshold will bring enormous benefits to human populations. Models predict that a 2.0°C rise in temperature will cause 2.6 times more people to experience a severe heatwave at least once every 5 years, compared with 1.5°C of warming.[3] It can be all too easy to feel that it is too late to make a difference, or that actions at individual or organisational level are not effective in the face of such an enormous challenge. Yet we know that the carbon footprints of many individuals and organisations add up and that lifestyle changes can make a significant contribution to reducing carbon emissions, especially if we make changes to activities that have the highest carbon footprint. As gastroenterology teams, in addition to the action we can take as individuals (whether that be through making lifestyle changes, lobbying or working with our local community on this) we also have the opportunity to make changes to the way we practise medicine, to prioritise disease prevention and to lobby our work organisations to take climate action. In gastroenterology, we can reduce our carbon footprint at work by practising

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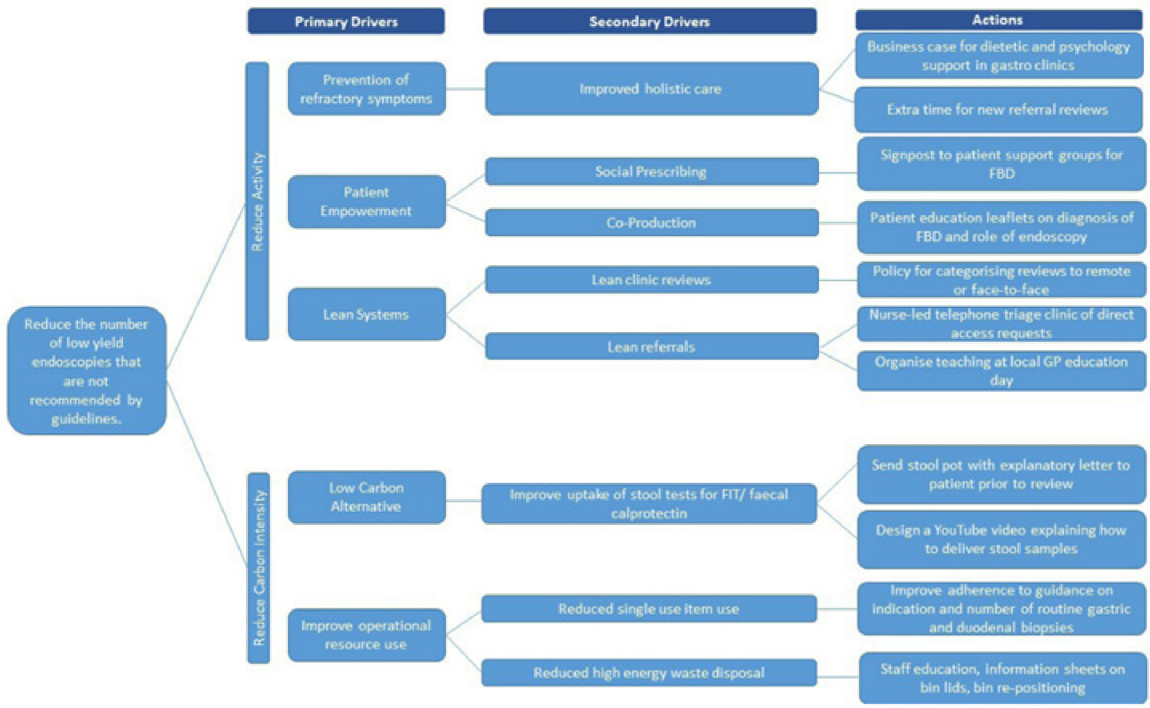

Figure 1 Principles of sustainable clinical practice.[14] FBD, functional bowel disorders; FIT, faecal immunochemical test; GP, general practitioner.

preventive medicine, helping patients achieve lifestyle modifications which benefit both health and the planet. In this article, we would like to give you the tools to do this so that you have the confidence to join the conversation, wherever you might be working. We explain why healthcare has a significant impact on a nation's carbon footprint; how health can be impacted by climate change and provide simple explanations of common climate science terms.

Agricultural human settlements emerged after the last glacial ice age, about 11 700 years ago, and developed as a consequence of predictable environmental conditions. The stable climate and the abundant biodiversity of this Holocene epoch allowed urban settlements to grow across most parts of the world. Greenhouse gases (GHGs) have built up in the atmosphere since the Industrial Revolution in the 1850s (figure 1), driven by colonialism, unsustainable development patterns and resource extraction.[4] GHGs that contribute most powerfully to climate change include carbon dioxide (CO_2), methane and nitrous oxide (N_2O).

Climate change and pollution (in its various forms of air, water and soil pollution) are two sides of the same coin but are often addressed separately, when in fact they have joint sources and exert combined pressures on the environment and health.

As well as driving climate change, the extraction and burning of fossil fuels is also a major source of air pollutants. Many air pollutants contribute to climate change by affecting the amount of incoming sunlight that is reflected or absorbed by the atmosphere, with some pollutants warming and others cooling the Earth. These short-lived climate pollutants include methane (which does not have direct human health effects, however, it is a precursor to ozone, which causes asthma and other respiratory diseases), black carbon (a component of fine particulate matter and the primary driver of air-pollutant induced mortality), ground-level ozone and sulfate aerosols.

Water pollution and climate change are also inextricably linked, with extreme weather events making water supplies more unpredictable, more scarce, more polluted or all three.[5] Conversely, healthy aquatic ecosystems can lower greenhouse gas emissions and provide protection against climate hazards.

Lastly, the pollution and degradation of soil (the second-largest carbon sink after the oceans, as well as being a source of CO_2) affects its capacity for carbon sequestration, and conversely, disruptive weather patterns worsen soil erosion and release of pollutants.

With an estimated 9 million deaths globally estimated to be caused by pollution each year,[6] of which 6.5 million are attributed to air pollution, this is an enormous public health problem, which has some of the same drivers as the climate and biodiversity crises and must be addressed synchronously.

THE HEALTH SYSTEM IS PART OF THE PROBLEM

Like many global healthcare systems, the National Health Service (NHS) itself contributes significantly to national GHG emissions. Health systems account for around 4.6% of the total GHG emissions worldwide,[7] meaning if they were one country, health systems would be the fifth largest emitter. The NHS in England

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Table 1 Climate change and human health

	Health effects worldwide	Health effects in the UK	Gastroenterology specific effects
Extreme weather effects such as droughts, heat waves, flooding, wildfires and storms.	Worldwide, in 2021,127 million more people experienced moderate or severe food insecurity because of heatwaves and droughts, putting millions of people at risk of malnutrition.[12]	In the UK, one in six properties are at risk of flooding, including 7% of hospitals.[32] The heatwave of 2022 was responsible for nearly 3000 excess deaths.[33] In a high-emission scenario, by the 2070s around 21 000 people will die from heat each year.[34]	The global syndemic of malnutrition, obesity and climate change.[12 35] There is a potential for climate-related anxiety and mental health problems to contribute to excess alcohol consumption. Severe weather events such as flooding or heatwaves could impact on local healthcare services, resulting in delays in treatment or important procedures such as endoscopy.
Effects on the planet's life-support systems, such as rising sea levels and safe water availability; pollution of water, air and soil.	Changing patterns of zoonotic and vector-borne disease (eg, malaria, dengue fever), reduced pollination and crop failure leading to food shortages.[12]	Increased risk of food insecurity, increased reliance on ultraprocessed foods and micronutrient deficiencies. Potential for new and emerging diseases (the relationship between infectious diseases and temperature is still being elucidated). Higher temperatures increase the risk of incidence of some bacterial infections causing gastrointestinal disease.[36]	Food shortages increase risk of malnutrition and in turn associated obesity (both are associated with MAFLD).[16] Possible changes or increases in chemical exposure due to climate change, some of which (including VOCs and heavy metals) are associated with liver disease.[37]
	9 million deaths annually caused by pollution, 6.5 million attributable to air pollution. More than 90% of these occur in low-income and middle-income countries[6]	Estimated annual adult premature mortality attributable to exposure to fine particle emissions in the UK is 48 625.[38]	There is increasing evidence that airborne pollutants are a risk factor for inflammatory bowel disease[39] and colorectal cancer,[40] and that they can alter the gut microbiome and immune function.[41]
Effects mediated by social systems	Unemployment, rising food prices, supply chain disruption, pressure on health services, conflict or forced migration.	Poverty, widening health inequalities, cost to NHS and society, migration	Gaps in care for those with long-term conditions, delays in diagnosis, lack of access to routine vaccinations etc. in transient/migrant communities.

MAFLD, metabolic dysfunction-associated fatty liver disease; NHS, National Health Service; VOCs, volatile organic compounds.

has pledged to be net zero by 2040 for emissions that it controls directly and net zero by 2045 for emissions that it can influence,[8] aiming to become the world's first net-zero health service.

Sustainable clinical practice aims to improve health while reducing the environmental impact of healthcare. There were approximately 1.5 million endoscopic procedures carried out in the UK in 2020.[9] Endoscopy has a high carbon footprint and sustainable changes in endoscopy practice can have significant health, financial and sustainability benefits. The British Society of Gastroenterology, together with the Joint Advisory Group for gastrointestinal (GI) Endoscopy and the Centre for Sustainable Healthcare, has noted the need to minimise the environmental impact of endoscopy.[10]

EFFECTS OF CLIMATE CHANGE ON HEALTH

The climate crisis has been called 'the most important health threat of the century.[11] Despite all our technological and scientific progress, we depend on the health of the planet for our survival: it provides us with the air we breathe, the water we drink, nutrition and shelter. Anthropogenic climate change is no longer a distant possibility—in 2023, temperatures were the highest for 100 000 years, and people across the world have already begun to experience health consequences due to climate change,[12] as detailed in table 1.

CLIMATE ACTIONS IN CLINICAL PRACTICE

Medical ethics is founded on the principle of non-maleficence or not causing harm.[13] In the context of a changing climate, this involves preventing the emission of carbon dioxide and other GHGs. Opportunities for sustainable clinical practice include patient empowerment (which can improve disease management as well as reduce the need for outpatient appointments and emergency admissions), developing lean pathways and reducing waste from medications, consumables and energy, and considering low-carbon alternatives where possible, for example, switching to treatments and technologies that are environmentally friendly and using digital technology/telemedicine to reduce transport demands (e.g., for outpatient clinics).[14] Figure 1 illustrates these opportunities using an endoscopy example.

Primary and secondary disease prevention can directly reduce healthcare activity. Health professionals are ideally placed to hold decision-makers accountable and to advocate for 'human-centred climate action that safeguards human health above all else'.[12] Examples of effective disease prevention in gastroenterology might include campaigning for effective public health interventions such as policy action to reduce consumption of alcohol (e.g., with interventions such as minimum unit pricing), ultra-processed foods and foods with added sugar, and advocating for climate change interventions with associated health benefits such as increased active transport.[15] Increased active transport has the potential to reduce obesity, which has been shown to be associated with metabolic dysfunction-associated fatty liver disease (MAFLD), gastrointestinal cancers and inflammatory bowel disease.[16]

In addition, clinicians are well placed to lobby their professional organisations to reduce GHG emissions, for example, by proposing more sustainable food options and promoting active transport schemes for NHS staff.

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GLOSSARY

Greenhouse gases

GHGs are a set of gases that accumulate in the lower layer of the atmosphere and, as a result of their chemical structure, are able to absorb heat and to radiate it in all directions (including downwards). They thereby prevent some of the solar energy absorbed by the planet's surface and atmosphere from being re-emitted into space, leading to an increase in the Earth's surface temperature. Many GHGs occur naturally in the atmosphere and their warming effect has allowed life on Earth to exist by maintaining surface temperatures at 33° warmer than they would otherwise be.

However, in the past decades, the greenhouse effect in the atmosphere has been boosted and altered our planet's climate, leading to a rise in average temperatures, a change in ocean heat content, sea ice extent, sea levels, and climate patterns such as El Niño. GHGs have built up in the atmosphere since the Industrial Revolution in the 1850s, driven by unsustainable development patterns and resource extraction[4]. GHGs that occur both naturally and through human activity include CO_2, methane (CH_4) and nitrous oxide (N_2O). These three gases are the most important contributors to climate change. Fluorinated GHGs (the fourth most important) are solely anthropogenic.

Global warming potential

The global warming potential (GWP) allows comparisons of the global warming impacts of different gases. It is the ratio of the warming caused by a gas relative to the warming caused by the same mass of CO_2, usually over a 100-year average time. CO_2, by definition, therefore, has a GWP of 1.

Carbon dioxide

CO_2 contributed to 80% of increased heating impacts between 1990 and 2021[17] and has risen steadily during the 20th and 21st century, with a rapid increase since 1960 (figure 2). The increases have been caused mostly by the burning of fossil fuels (coal, oil and natural gas) as well as changes in land use (destruction of peatlands alone contributes to 5% of anthropogenic CO_2 emissions), deforestation and wildfires. Although CO_2 makes up only a small proportion of our atmosphere, changes in its concentration make a huge difference to the greenhouse effect. From preindustrial times to 2022, the concentration increased from 285 parts per million (ppm) to 417 ppm (figure 2).

Methane

Methane, with a GWP of 27–30 over 100 years, is more potent as a GHG than CO_2 and is responsible for about 30% of the rise in global temperatures since the Industrial Revolution.[18] Methane occurs naturally where organic materials, such as plant and animal wastes, break down in an anaerobic environment. The stomach of a cow, a landfill site and a marsh are all prime examples of methane-producing environments.

Two-thirds of all anthropogenic methane comes from agriculture, and about half of that amount comes from rice crops, with livestock such as cows, pigs and chickens accounting for the rest. The energy sector releases methane into the atmosphere as a by-product of generating power from coal, oil, natural gas and biofuels. A spike in methane concentrations in the atmosphere in the past 10 years is likely to be linked to fracking (extraction of shale gas)[19] and the release of methane from thawing permafrost in the Arctic.

Nitrous oxide

N_2O, with a GWP of 273 over a 100-year period, accounts for about 7% of the overall greenhouse effect, and its contribution to global warming is increasing due to human activities, the biggest source being fertilisers used in agriculture. Catalytic converters in cars convert polluting, smog-causing NO_x gases produced by burning car fuel into N_2O, which is not harmful to human health directly but contributes to

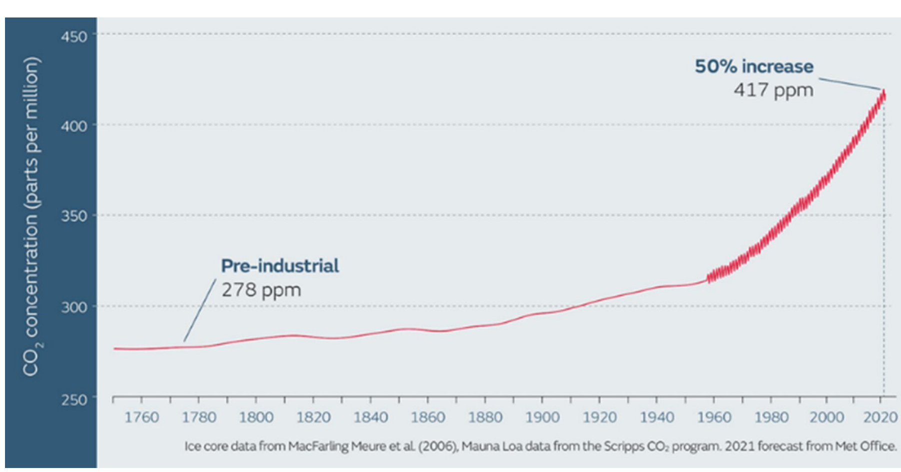

Figure 2 Carbon dioxide concentration 1760–2020. Source: UK Met Office.[42] Contains public sector information licensed under the Open Government Licence V.3.0. CO_2, carbon dioxide; ppm, parts per million.

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the greenhouse effect. And so, of course, does N_2O, as an anaesthetic agent. Using 500 mL of N_2O every minute for a procedure lasting an hour will warm the atmosphere by an equivalent of 16 kg CO_2, that is, the same as driving a small car 106 km.[20] As well as being a GHG, N_2O is currently the single greatest ozone-depleting substance (ODS).

Fluorinated GHGs

Fluorinated greenhouse gases (F-gases) are man-made gases used in industry and they have high very high GWPs, in the thousands or tens of thousands. There are four main categories: hydrofluorocarbons (HFCs), perfluorocarbons, sulfur hexafluoride and nitrogen trifluoride.

HFCs are used in refrigerants, aerosol propellants, foam-blowing agents, solvents and fire retardants. Their major emission source is their use as refrigerants—for example, in air conditioning systems. They were developed as substitutes for chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) because they do not deplete the ozone layer. HFCs are potent GHGs with high GWPs.

Modern anaesthetic gases include CFCs (isoflurane) and HFCs (sevoflurane and desflurane) and are potentially damaging to the earth's ozone layer as well as contributing to global warming. There are differences between these agents in terms of their GWP: one bottle of sevoflurane (250ml), with a GWP of 130, during anaesthesia is the CO_2 equivalent of driving 196 km in an average petrol fuelled car, compared with the desflurane (GWP of 2540) equivalent of driving 3539 km.[21] The atmospheric concentration of desflurane has been increasing in recent years.[22] In the UK, anaesthetic gases represent 2% of the NHS carbon footprint.[8]

Ozone-depleting substances

ODSs are chemicals that, once emitted, reach the upper atmosphere and destroy the protective ozone layer. Examples include halons (used in fire extinguishers), methyl bromide (used in pest control) and HCFCs (used in fridges and air conditioning systems). Globally, there has been a phase down of ODS since the 1989 Montreal Protocol.[23]

Carbon cycle

The carbon cycle is a natural cycle which, in the ideal situation, creates a balance between carbon emitters, such as humans, and carbon absorbers, such as trees. The carbon cycle is in balance when roughly the same amount of carbon that's being pumped into the air is being sucked out by something else. Plants, soil and the oceans act as carbon sinks, the ocean being the biggest carbon sink on Earth, absorbing 25% of all CO_2.[24] The second-largest carbon sink is vegetation, the most effective being tropical forests, which photosynthesise all year round, sequestering carbon in the process.

Deforestation, global warming and industrial farming have all contributed to a decrease in the ability of natural carbon sinks to remove CO_2.

Global warming

Multiple independent data sets show that the Earth's average surface temperature has warmed by about 1.1°C since 1850. This warming has not happened in a smooth manner, as the climate system is complex and GHGs are not the only factor that contributes to temperature change (e.g., the El Niño event). However, the long-term temperature pattern since 1850 is clear (figure 3). The Paris Agreement goal is to keep global warming 'well below 2°C, and pursue efforts to limit it to 1.5°C'. This is considered the upper limit to avoid the worst effects of climate change.

Climate change

Climate change, in the context of the climate crisis, is the unprecedented rapid warming of Earth temperatures that has been occurring since the mid-1800s, as a result of the greenhouse effect. There has been a rapid acceleration in the last 20 years, with associated climatic changes. This is distinct from climate change as a natural process, where climate varies over much longer time spans. Temperature rise is not the only manifestation of climate change. Other consequences include water scarcity, wildfires, rising sea levels, flooding, melting polar ice, catastrophic storms and declining biodiversity.

Carbon footprint

A carbon footprint is the 'sum total of GHG emissions that had to take place in order for a product to be produced or for an activity to take place.'[25]

Biodiversity crisis

Biodiversity—the variety of life on Earth—is key to the survival of our species as it ensures the provision of biodiversity services (which include water and food and regulation of air quality). It has a two-way relationship with climate change. Healthy ecosystems can mitigate up to 37% of GHGs,[26] whereas damaged ecosystems release gases instead of storing them. Conversely, climate change is one of the main factors driving the loss of biodiversity, for example, through increasing severity of storms or temperature rises.[27] The biodiversity crisis (the recent, precipitous loss of biodiversity globally) and the climate crisis share some of the same causes (e.g., the destruction of tropical forests for livestock production), and, with pollution, form a triple planetary crisis, the interlinked parts of which need to be addressed simultaneously.

Tipping points

Tipping points in the Earth system refer to thresholds that, if crossed, lead to far-reaching, in some cases abrupt and/or irreversible changes.[28] Five major tipping

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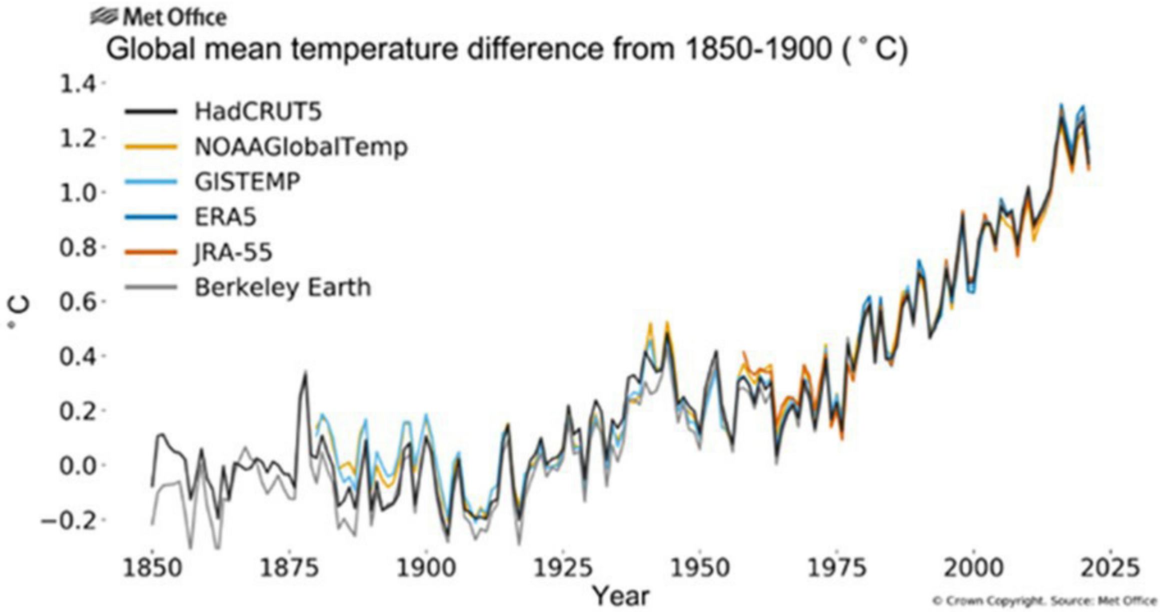

Figure 3 Global mean temperature difference since 1850. Source: UK Met Office.[43] Contains public sector information licensed under the Open Government Licence V.3.0.

systems are already at risk of crossing tipping points at the present level of global warming, including warm-water coral reefs and permafrost regions.[29] Triggering one Earth system tipping point could trigger another, causing a domino effect of accelerating and unmanageable damage, leading to cascading stress to societies and economic systems globally, with unequal and unjust consequences. There are also positive climate tipping points which take place when certain environmental activities or changes trigger self-reinforcing mechanisms that improve the earth's capacity to absorb CO_2, lower greenhouse gas emissions or support the preservation of vital habitats. For example, increasing forest cover reduces the amount of CO_2 in the atmosphere which then sets up a positive feedback loop whereby temperatures drop and ecosystems stabilise.

Mitigation

In the context of climate change, mitigation is human intervention to reduce the sources of, or enhance the sinks of, GHGs. Examples include switching to renewable energy sources or expanding forests to act as carbon sinks.

Adaptation

In the context of climate change, adaptation is defined by the Intergovernmental Panel on Climate Change (IPCC),[30] as the process taken to 'adjust to the actual or expected climate and its effects'. It is characterised by a set of actions and processes that help societies adjust to the impacts of adverse changes to the climate. Adaptation measures include flood defences, strategies to reduce the urban heat island effect and measures to safeguard agricultural yields.

Resilience

Resilience to climate change is defined by the IPCC[30] as 'the capacity of social, economic and environmental systems to cope with a hazardous climate event, responding or reorganising in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformation'. Building climate resilience requires a multidimensional approach to enhance societies' capacities to cope with, and recover from, the impacts of climate change. In contrast to adaptation, it is more associated with a perspective and way of thinking that advocates system-wide changes and is more long-term and transformative. Resilience approaches are particularly crucial for low-income countries, in many of which a state of climate emergency has already been reached. Typically, such countries have limited capacity to adapt due to factors, including limited economic resources, low levels of technology and poor infrastructure.

Net zero

Net zero is a state of balance between carbon emissions and removals. A commitment to net zero means cutting carbon emissions to a small amount of residual emissions that can be absorbed and durably stored by nature and other CO_2 removal measures, leaving zero in the atmosphere. Net zero can be applied at an organisational, country or global level. For the planet's warming to remain within the 1.5°C target, global emissions need to be reduced by 45% by 2030 and reach net zero by 2050.[31] There is an important distinction between net zero and 'carbon neutral'. Carbon neutrality refers to an organisation achieving net-zero carbon emissions by balancing a measured

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amount of carbon released with an equivalent amount sequestered or offset (supporting projects that reduce, avoid or remove emissions elsewhere through a carbon trading mechanism). In other words, carbon neutrality does not necessarily require an abatement of emissions and may, therefore, conceal the need for wider carbon reductions that would be required in order to limit global warming.

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