Geography Optional 2024

CLIMATE CHANGE CAUSES & MITIGATION

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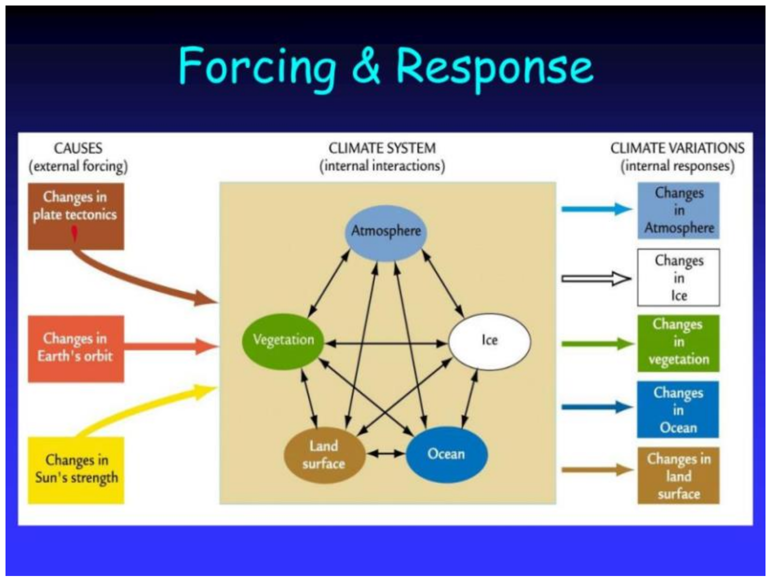
Changes in the state of the Earth's climatic system can occur externally (from extraterrestrial systems) or internally (from ocean, atmosphere and land systems) through any one of the described components. For example, an external change may involve a variation in the Sun's output which would externally vary the amount of solar radiation received by the Earth's atmosphere and surface. Internal variations in the Earth's climatic system may be caused by changes in the concentrations of atmospheric gases, mountain building, volcanic activity, and changes in surface or atmospheric albedo.



The work of climatologists has found evidence to suggest that only a limited number of factors are primarily responsible for most of the past episodes of climate change on the Earth. These factors include:

- Variations in the Earth's orbital characteristics.
- Atmospheric carbon dioxide variations.
- Volcanic eruptions
- Variations in solar output.

The greenhouse effect: natural and enhanced

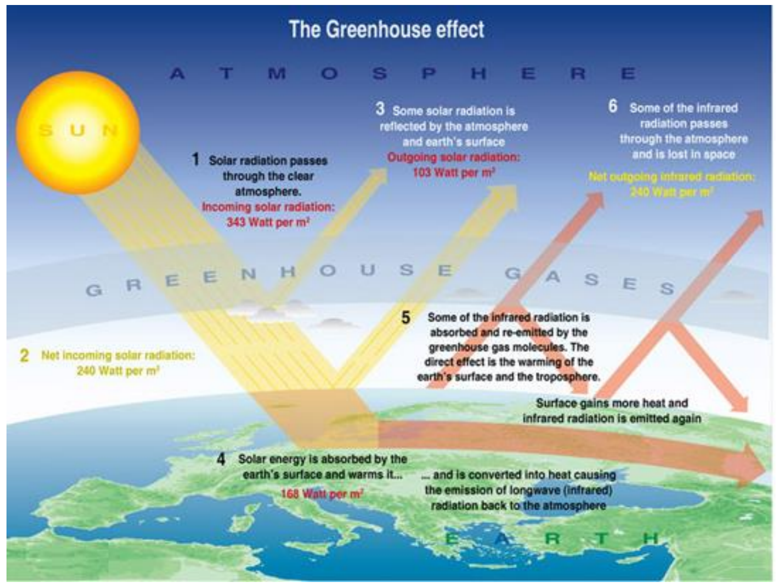
The 'natural' greenhouse effect makes life as we know it possible on Earth. Without this effect, the average temperature would be about – 18°C (well below the freezing point of water), rather than its current 14°C.

Earth's surface temperature is determined by the radiative balance, the net difference between the energy gained from incoming sunlight and the amount lost into space as infrared radiation. The Earth's atmosphere acts like a transparent blanket, letting in light but trapping some of the heat it generates. Without an atmosphere, all of this energy would be lost to space.

This natural effect relies on 'greenhouse' gases in our atmosphere allowing sunlight to pass through, and trapping some of the resulting heat energy that radiates back up from the Earth's surface.

The greenhouse effect describes how certain gases in our atmosphere increase the temperature on Earth's surface by preventing some of the energy radiating from the planet's surface from being lost into spaceThe human-induced build-up of greenhouse gases in the atmosphere is known as the 'enhanced' greenhouse effect or 'anthropogenic climate change'.

Since the start of the Industrial Revolution in about 1750, human activities such as the burning of fossil fuels, including coal and oil, have dramatically increased the concentration of greenhouse gases in our atmosphere. As a result, the rate of heat-loss from the Earth has slowed, creating a warming effect. More than 85 per cent of the additional heat in our atmosphere is absorbed by the oceans.



The enhanced greenhouse effect is expected to change many of the basic weather patterns that make up our climate, including wind and rainfall patterns and the incidence and intensity of storms.

Every aspect of our lives is in some way influenced by the climate. For example, we depend on water supplies that exist only under certain climatic conditions, and our agriculture requires particular ranges of temperature and rainfall.

Greenhouse gases

The most important greenhouse gases are water vapour and carbon dioxide (CO2). Both are present at very small concentrations in the atmosphere. Water vapour varies considerably in space and time because it has a short 'lifetime' in the atmosphere. Because of this variation, it is difficult to measure globally averaged water vapour concentration. Carbon dioxide has a much longer lifetime and is well mixed throughout the atmosphere. The current concentration is about 0.04 per cent. Other greenhouse gases in our atmosphere include methane, nitrous oxide and chlorofluorocarbons.

Water vapour accounts for about half the present-day greenhouse effect, but its concentration in the atmosphere is not influenced directly by human activities. The amount of water in the atmosphere is related mainly to changes in the Earth's temperature. For example, as the atmosphere warms it is able to hold more water. Although water vapour absorbs heat, it does not accumulate in the atmosphere in the same way as other greenhouse gases; it tends to act as part of a feedback loop rather than being a direct cause of climate change. (Read more about feedback in Climate systems).

Carbon dioxide is the largest single contributor to human-induced climate change. NASA describes it as 'the principal control knob that governs the temperature of Earth'. Although other factors (such as other long-lived greenhouse gases, water vapour and clouds) contribute to Earth's greenhouse effect, carbon dioxide is the dominant greenhouse gas that humans can control in the atmosphere.

The two most abundant gases in the atmosphere are nitrogen (comprising 78 per cent of the dry atmosphere) and oxygen (21 per cent), but they have almost no greenhouse effects.

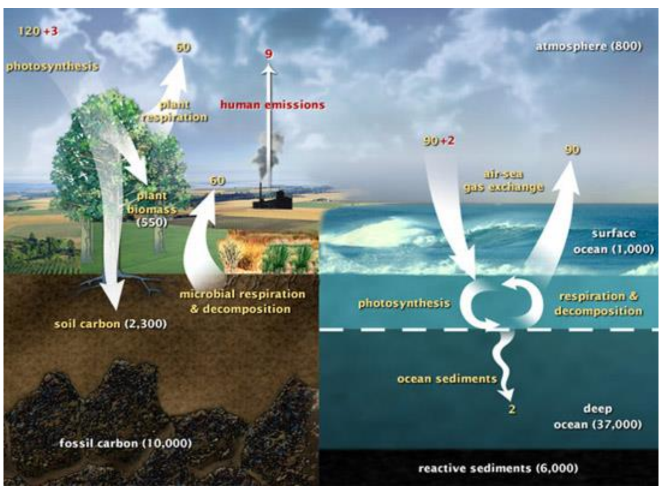
Carbon dioxide and the carbon cycle

All living organisms contain carbon, as do gases (such as carbon dioxide) and minerals (such as diamond, peat and coal). The movement of carbon between large natural reservoirs in rocks, the ocean, the atmosphere, plants, soil and fossil fuels is known as the carbon cycle.

The carbon cycle includes the movement of carbon dioxide:

- into and out of our atmosphere
- between the atmosphere, plants and other living organisms through photosynthesis, respiration and decay
- between the atmosphere and the top of the oceans.

On longer time scales, chemical weathering and limestone and fossil fuel formation decrease atmospheric carbon dioxide levels, whereas volcanoes return carbon to the atmosphere. This is the dominant mechanism of control of carbon dioxide on timescales of millions of years.



The carbon cycle, showing the movement of carbon between land, the atmosphere and the oceans. Yellow numbers are natural fluxes and red numbers are human contributions in gigatonnes of carbon per year. White numbers indicate stored carbon

Because the carbon cycle is essentially a closed system, any decrease in one reservoir of carbon leads to an increase in others. For at least the last several hundred thousand years, up until the Industrial Revolution, natural sources of carbon dioxide were in approximate balance with natural 'sinks', producing relatively stable levels of atmospheric carbon dioxide. 'Sinks' are oceans, plants and soils, which absorb more carbon dioxide than they emit (in contrast, carbon sources emit more than they absorb).

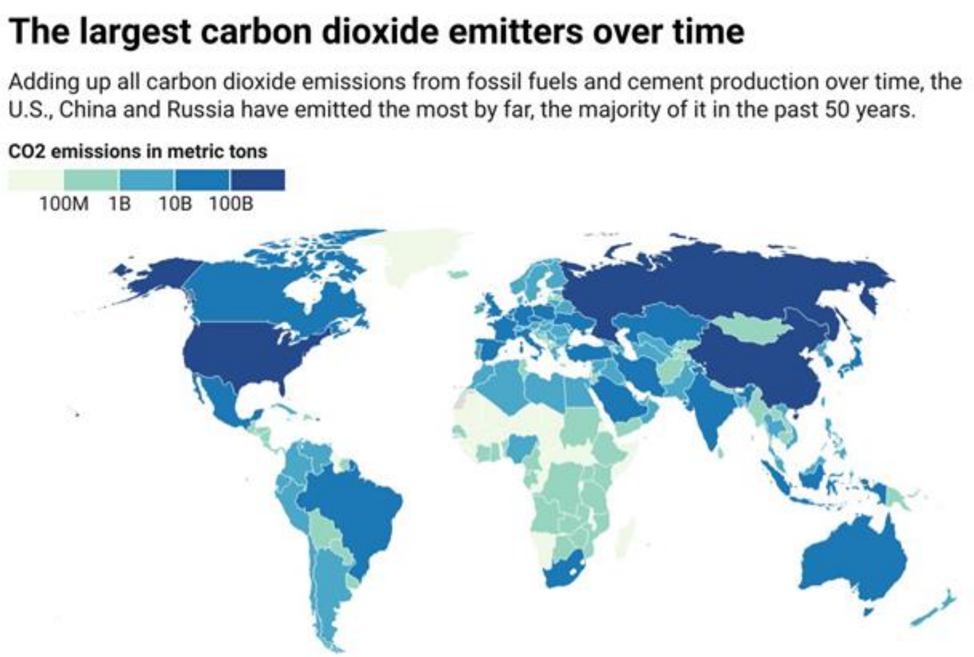
Increases in greenhouse gases due to human activities

Carbon dioxide is being added to the atmosphere faster than it can be removed by other parts of the carbon cycle.

Since the Industrial Revolution there has been a large increase in human activities such as fossil fuel burning, land clearing and agriculture, which affect the release and uptake of carbon dioxide. According to the most recent Emissions Overview, carbon dioxide and other greenhouse gases are produced in NSW by the following activities or sources:

- stationary energy sources, such as coal-fired power stations (47 per cent)
- transport (18 per cent)
- coal mines (12 per cent)
- agriculture (11 per cent)
- land use (7 per cent)
- land change (3 per cent)
- waste (2 per cent).

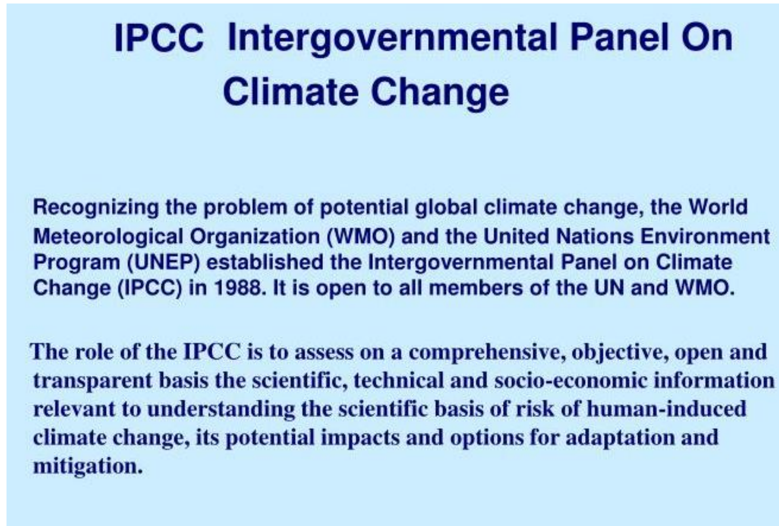
Carbon dioxide released into the atmosphere from burning fossil fuels carries a different chemical fingerprint from that released by natural sources such as respiration and volcanoes. This makes it possible to identify the contribution of human activity to greenhouse gas production.



The Intergovernmental Panel on Climate Change (IPCC)

It is the leading international body for the assessment of climate change. It was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988 to provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts. In the same year, the UN General Assembly endorsed the action by WMO and UNEP in jointly establishing the IPCC.

The IPCC reviews and assesses the most recent scientific, technical and socio-economic information produced worldwide relevant to the understanding of climate change. It does not conduct any research nor does it monitor climate related data or parameters.



As an intergovernmental body, membership of the IPCC is open to all member countries of the United Nations (UN) and WMO. Currently 195 countries are Members of the IPCC. Governments participate in the review process and the plenary Sessions, where main decisions about the IPCC work programme are taken and reports are accepted, adopted and approved

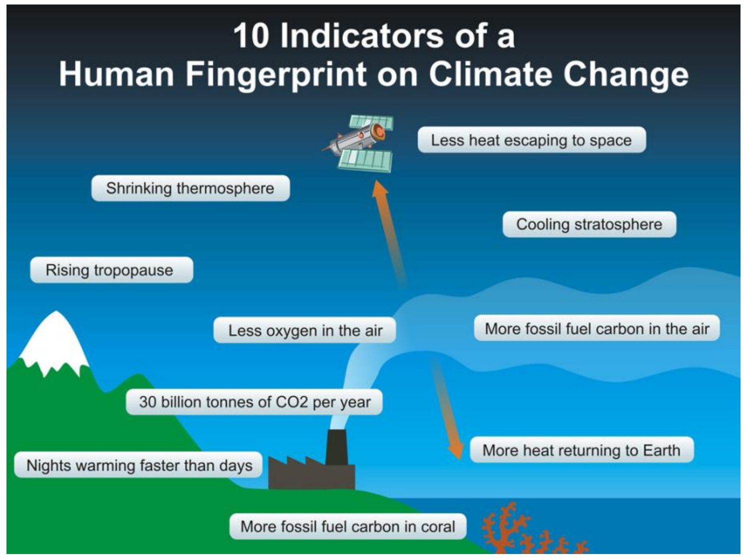
This Synthesis Report is based on the reports of the three Working Groups of the Intergovernmental Panel on Climate Change (IPCC), including relevant Special Reports. It provides an integrated view of climate change as the final part of the IPCC's Fifth Assessment Report (AR5). The Synthesis Report is based on the reports of the three Working Groups of the Intergovernmental Panel on Climate Change (IPCC), including relevant Special Reports. It provides an integrated view of climate change as the final part of the IPCC's Fifth Assessment Report (AR5).

Observed Changes and their Causes

1. **Human influence on the climate system is clear,** and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems
2. **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

Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850. The period from 1983 to 2012 was likely the warmest 30-year period of the last 1400 years in the Northern Hemisphere, where such assessment is possible (medium confidence). The globally averaged combined land and ocean surface temperature data as calculated by a linear trend show a warming of 0.85 [0.65 to 1.06] °C .Ocean warming dominates the increase in energy stored in the climate system, accounting for more than 90% of the energy accumulated between 1971 and 2020 (high confidence), with only about 1% stored in the atmosphere.

Averaged over the mid-latitude land areas of the Northern Hemisphere, precipitation has increased since 1901 (medium confidence before and high confidence after 1951). For other latitudes, area-averaged long-term positive or negative trends have low confidence. Observations of changes in ocean surface salinity also provide indirect evidence for changes in the global water cycle over the ocean (medium confidence). It is very likely that regions of high salinity, where evaporation dominates, have become more saline, while regions of low salinity, where precipitation dominates, have become fresher since the 1950s.

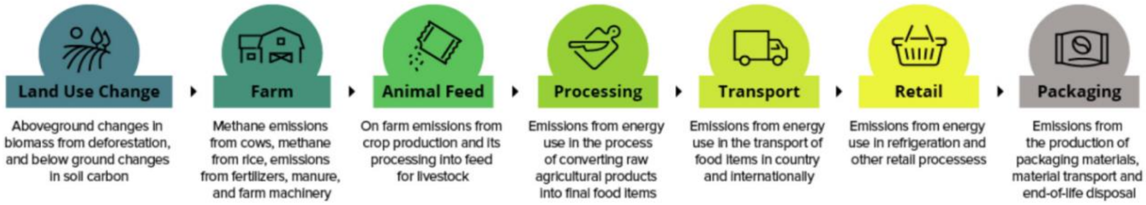


Glaciers have continued to shrink almost worldwide (high confidence). Northern Hemisphere spring snow cover has continued to decrease in extent (high confidence). There is high confidence that permafrost temperatures have increased in most regions since the early 1980s in response to increased surface temperature and changing snow cover.

3. Anthropogenic greenhouse gas emissions have increased since the pre-industrial era, driven largely by economic and population growth, and are now higher than ever. This has led to atmospheric concen trations of carbon dioxide, methane and nitrous oxide that are unprecedented in at least the last 800,000 years. Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and are extremely likely to have been the dominant cause of the observed warming since the mid-20th century.

Anthropogenic greenhouse gas (GHG) emissions since the pre-industrial era have driven large increases in the atmospheric concentrations of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) .Emissions of CO_2 from fossil fuel combustion and industrial processes contributed about 78% of the total GHG emissions increase from 1970 to 2020, with a similar percentage contribution for the increase during the period 2000 to 2020 (high confidence)

There is a vast difference in greenhouse gases (GHG) that are produced across various food types.



4. In recent decades, **changes in climate have caused impacts on natural and human systems on all continents and across the oceans**. Impacts are due to observed climate change, irrespective of its cause, indicating the sensitivity of natural and human systems to changing climate

Evidence of observed climate change impacts is strongest and most comprehensive for natural systems. In many regions, changing precipitation or melting snow and ice are altering hydrological systems, affecting water resources in terms of quantity and quality (medium confidence). Many terrestrial, freshwater and marine species have shifted their geographic ranges, seasonal activities, migration patterns, abundances and species interactions in response to ongoing climate change (high confidence). Some impacts on human systems have also been attributed to climate change, with a major or minor contribution of climate change distinguishable from other influences. Assessment of many studies covering a wide range of regions and crops shows that negative impacts of climate change on crop yields have been more common than positive impacts (high confidence). Some impacts of ocean acidification on marine organisms have been attributed to human influence

5. Changes in many extreme weather and climate events have been observed since about 1950. Some of these changes have been linked to human influences, including a decrease in cold temperature extremes, an increase in warm temperature extremes, an increase in extreme high sea levels and an increase in the number of heavy precipitation events in a number of regions.

It is very likely that the number of cold days and nights has decreased and the number of warm days and nights has increased on the global scale. It is likely that the frequency of heat waves has increased in large parts of Europe, Asia and Australia. It is very likely that human influence has contributed to the observed global scale changes in the frequency and intensity of daily temperature extremes since the mid-20th century. It is likely that human influence has more than doubled the probability of occurrence of heat waves in some locations. There is medium confidence that the observed warming has increased heat-related human mortality and decreased cold-related human mortality in some regions.

Impacts from recent climate-related extremes, such as heat waves, droughts, floods, cyclones, and wildfires, reveal significant vulnerability and exposure of some ecosystems and many human systems to current climate variability (very high confidence).

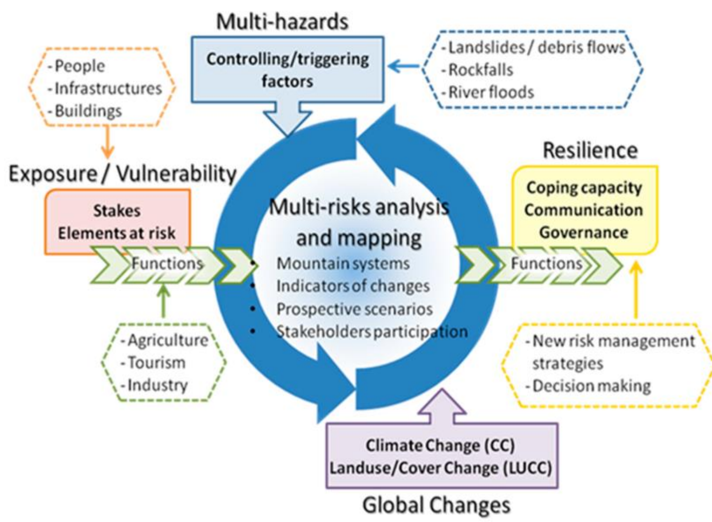
Future Climate Changes, Risks and Impacts

Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems. Limiting climate change would require substantial and sustained reductions in greenhouse gas emissions which, together with adaptation, can limit climate change risks.

Cumulative emissions of CO2 largely determine global mean surface warming by the late 21st century and beyond. Projections of greenhouse gas emissions vary over a wide range, depending on both socio-economic development and climate policy.

Anthropogenic GHG emissions are mainly driven by population size, economic activity, lifestyle, energy use, land-use patterns, technology and climate policy. The Representative Concentration Pathways, (RCPs) which are used for making projections based on these factors, describe four different 21st century pathways of GHG emissions and atmospheric concentrations, air pollutant emissions and land-use.

Surface temperature is projected to rise over the 21st century under all assessed emission scenarios. It is very likely that heat waves will occur more often and last longer, and that extreme precipitation events will become more intense and frequent in many regions. The ocean will continue to warm and acidify, and global mean sea level to rise.



Changes in precipitation will not be uniform. The high latitudes and the equatorial Pacific are likely to experience an increase in annual mean precipitation. In many mid-latitude and subtropical dry regions, mean precipitation will likely decrease, while in many mid-latitude wet regions, mean precipitation will likely increase

Climate change will amplify existing risks and create new risks for natural and human systems. Risks are unevenly distributed and are generally greater for disadvantaged people and communities in countries at all levels of development.

Risk of climate-related impacts results from the interaction of climate-related hazards (including hazardous events and trends) with the vulnerability and exposure of human and natural systems, including their ability to adapt. Rising rates and magnitudes of warming and other changes in the climate system, accompanied by ocean acidification, increase the risk of severe, pervasive and in some cases irreversible detrimental impacts.

A large fraction of species faces increased extinction risk due to climate change during and beyond the 21st century, especially as climate change interacts with other stressors (high confidence). Most plant species cannot naturally shift their geographical ranges sufficiently fast to keep up with current and high projected rates of climate change in most landscapes

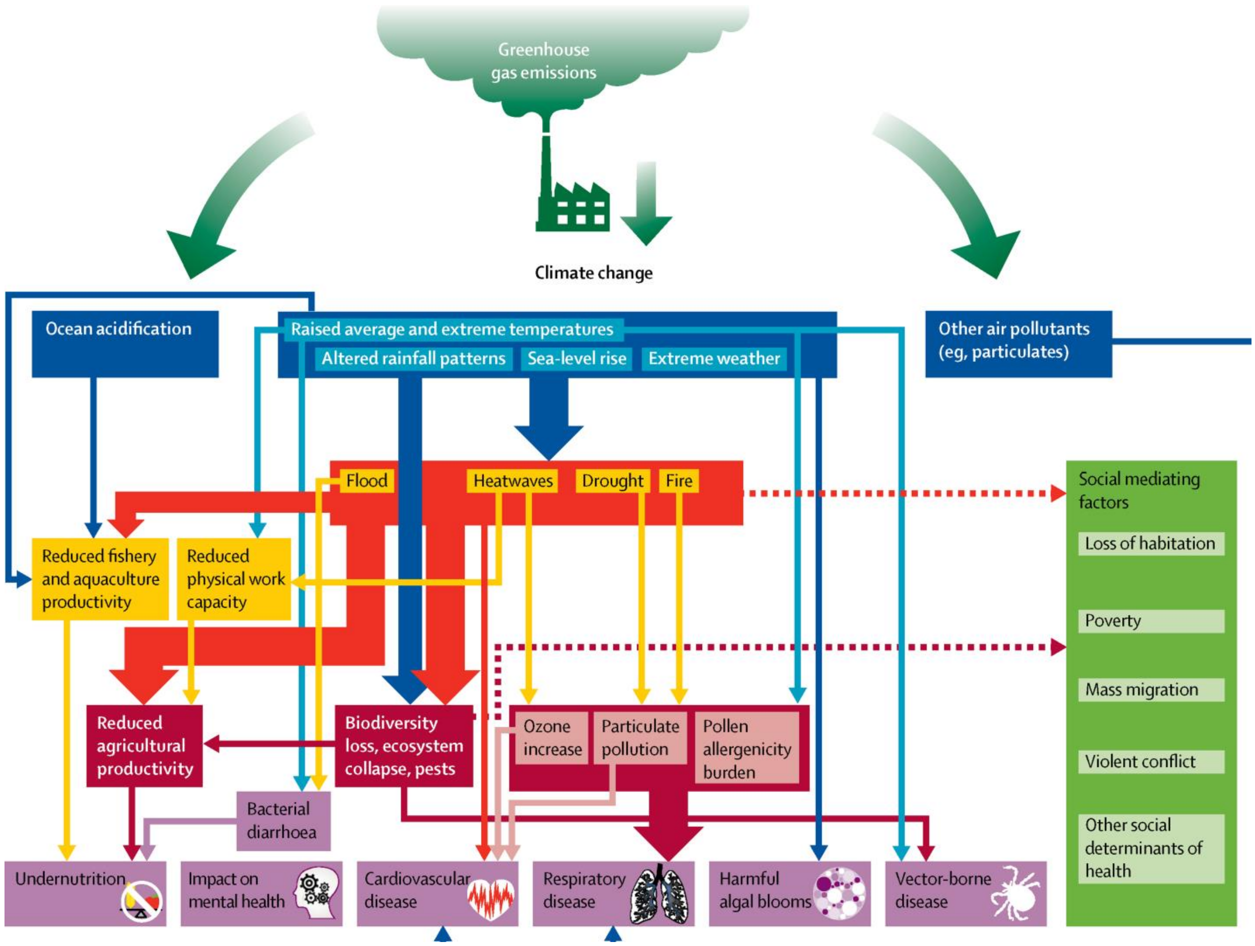
Climate change is projected to undermine food security .Due to projected climate change by the mid-21st century and beyond, global marine species redistribution and marine biodiversity reduction in sensitive regions will challenge the sustained provision of fisheries productivity and other ecosystem services (high confidence). For wheat, rice and maize in tropical and temperate regions, climate change without adaptation is projected to negatively impact production for local temperature increases of 2°C or more above late-20th century levels, although individual locations may benefit (medium confidence)

Until mid-century, projected climate change will impact human health mainly by exacerbating health problems that already exist (very high confidence). Throughout the 21st century, climate change is expected to lead to increases in ill-health in many regions and especially in developing countries with low income, as compared to a baseline without climate change (high confidence). By 2100, the combination of high temperature and humidity in some areas for parts of the year is expected to compromise common human activities, including growing food and working outdoors

In urban areas climate change is projected to increase risks for people, assets, economies and ecosystems, including risks from heat stress, storms and extreme precipitation, inland and coastal flooding, landslides, air pollution, drought, water scarcity, sea level rise and storm surges (very high confidence).

Rural areas are expected to experience major impacts on water availability and supply, food security, infrastructure and agricultural incomes, including shifts in the production areas of food and non-food crops around the world (high confidence).

Aggregate economic losses accelerate with increasing temperature (limited evidence, high agreement), but global economic impacts from climate change are currently difficult to estimate. From a poverty perspective, climate change impacts are projected to slow down economic growth, make poverty reduction more difficult, further erode food security and prolong existing and create new poverty traps, the latter particularly in urban areas and emerging hotspots of hunger (medium confidence). International dimensions such as trade and relations among states are also important for understanding the risks of climate change at regional scales.



Climate change is projected to increase displacement of people (medium evidence, high agreement). Populations that lack the resources for planned migration experience higher exposure to extreme weather events, particularly in developing countries with low income. Climate change can indirectly increase risks of violent conflicts by amplifying well-documented drivers of these conflicts such as poverty and economic shocks (medium confidence).

Future Pathways for Adaptation, Mitigation and Sustainable Development

Adaptation and mitigation are complementary strategies for reducing and managing the risks of climate change. Substantial emissions reductions over the next few decades can reduce climate risks in the 21st century and beyond, increase prospects for effective adaptation, reduce the costs and challenges of mitigation in the longer term and contribute to climate-resilient pathways for sustainable development.

Sustainable development and equity provide a basis for assessing climate policies. Limiting the effects of climate change is necessary to achieve sustainable development and equity, including poverty eradication. Countries' past and future contributions to the accumulation of GHGs in the atmosphere are different, and countries also face varying challenges and circumstances and have different capacities to address mitigation and adaptation. Mitigation and adaptation raise issues of equity, justice and fairness. Many of those most vulnerable to climate change have contributed and contribute little to GHG emissions. Delaying mitigation shifts burdens from the present to the future, and insufficient adaptation responses to emerging impacts are already eroding the basis for sustainable development. Comprehensive strategies in response to climate change that are consistent with sustainable development take into account the co-benefits, adverse side effects and risks that may arise from both adaptation and mitigation options.

Without additional mitigation efforts beyond those in place today, and even with adaptation, warming by the end of the 21st century will lead to high to very high risk of severe, widespread and irreversible impacts globally (high confidence). Mitigation involves some level of co-benefits and of risks due to adverse side effects, but these risks do not involve the same possibility of severe, widespread, and irreversible impacts as risks from climate change, increasing the benefits from near-term mitigation efforts.

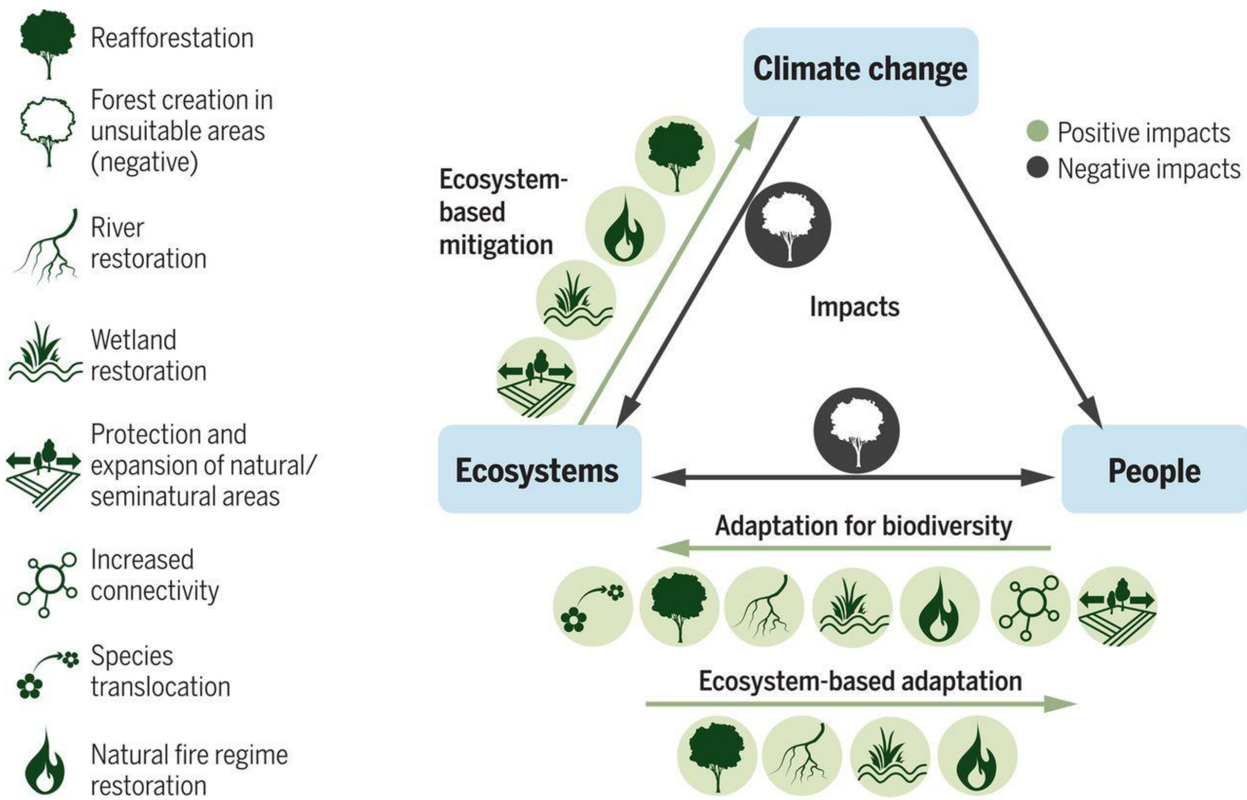
Mitigation and adaptation are complementary approaches for reducing risks of climate change impacts over different timescales (high confidence). Mitigation, in the near-term and through the century, can substantially reduce climate change impacts in the latter decades of the 21st century and beyond. Benefits from adaptation can already be realized in addressing current risks, and can be realized in the future for addressing emerging risks.

Adaptation can reduce the risks of climate change impacts, but there are limits to its effectiveness, especially with greater magnitudes and rates of climate change. Taking a longer term perspective, in the context of sustainable development, increases the likelihood that more immediate adaptation actions will also enhance future options and preparedness

Adaptation can contribute to the well-being of populations, the security of assets and the maintenance of ecosystem goods, functions and services now and in the future. Adaptation is place- and context-specific (high confidence). A first step towards adaptation to future climate change is reducing vulnerability and exposure to present climate variability (high confidence). Integration of adaptation into planning, including policy design, and decision-making can promote synergies with development and disaster risk reduction. Building adaptive capacity is crucial for effective selection and implementation of adaptation options.

Characteristics of mitigation pathways

There are multiple mitigation pathways that are likely to limit warming to below 2°C relative to pre-industrial levels. These pathways would require substantial emissions reductions over the next few decades and near zero emissions of CO2 and other long-lived greenhouse gases by the end of the century.



Implementing such reductions poses substantial technological, economic, social and institutional challenges, which increase with delays in additional mitigation and if key technologies are not available. Limiting warming to lower or higher levels involves similar challenges but on different timescales

THREE IPCC SPECIAL REPORTS

In 2011, two IPCC Special Reports were finalized; the Special Report on Renewable Energy Sources and Climate Change Mitigation (SRREN) and the Special Report on Managing Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX). Both Special Reports were requested by governments.

Special Report on Renewable Energy Sources and Climate Change Mitigation (SRREN)

The Special Report on Renewable Energy Sources and Climate Change Mitigation (SRREN) was approved and accepted at the 11th Session of Working Group III that took place on 5-8 May 2011 in Abu Dhabi, United Arab Emirates. This report assesses existing literature on the future potential of renewable energy for the mitigation of climate change. It covers the six most important renewable energy technologies, as well as their integration into present and future energy systems. It also takes into consideration the environmental and social consequences associated with these technologies, the cost, and strategies to overcome technical as well as nontechnical obstacles to their application and diffusion. More than 130 authors and 100 contributing authors from all over the world contributed to the preparation of SRREN on a voluntary basis

Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX)

The Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX) was approved and accepted at the first Joint Session of IPCC Working Groups I and II that met on 14-17 November 2011 in Kampala, Uganda. The report assesses the effect that climate change has on the threat of natural disasters and how nations can better manage an expected change in the frequency of occurrence and intensity of severe weather patterns. It aims to be a resource for decision-makers to prepare more effectively for managing the risks of these events. A potentially important area for consideration is also the detection of trends in extreme events and the attribution of these trends to human influence. More than 80 authors, 19 review editors, and more than 100 contributing authors from all over the world contributed to the preparation of SREX.

The Special Report on Global Warming of 1.5 °C (SR15) was published by the Intergovernmental Panel on Climate Change (IPCC) on 8 October 2018. The report, approved in Incheon, South Korea, includes over 6,000 scientific references, and was prepared by 91 authors from 40 countries. In December 2015, the 2015 United Nations Climate Change Conference called for the report. The report was delivered at the United Nations' 48th session of the Intergovernmental Panel on Climate Change (IPCC) to "deliver the authoritative, scientific guide for governments" to deal with climate change. Its key finding is that meeting a 1.5 °C (2.7 °F) target is possible but would require "deep emissions reductions" and "rapid, far-reaching and unprecedented changes in all aspects of society." Furthermore, the report finds that that "limiting global warming to 1.5 °C compared with 2 °C would reduce challenging impacts on ecosystems, human health and well-being" and that a 2 °C temperature increase would exasperate extreme weather, rising sea levels and diminishing Arctic sea ice, coral bleaching, and loss of ecosystems, among other impacts. SR15 also has modelling that shows that "Global net human-caused emissions of carbon dioxide (CO_2) would need to fall by about 45 percent from 2010 levels by 2030, reaching 'net zero' around 2050." The reduction of emissions by 2030 and its associated changes and challenges, including rapid decarbonisation, was a key focus on much of the reporting which was repeated through the world

Global warming will likely rise to 1.5 °C above pre-industrial levels between 2030 and 2052 if warming continues to increase at the current rate. Anthropogenic greenhouse gas emissions have so far contributed 0.8–1.2 °C (1.4–2.2 °F) of warming. The gases which have already been emitted are unlikely to cause global temperature to rise to 1.5 °C alone, and a global temperature rise to 1.5 °C above pre-industrial levels is avoidable depending on the rate of further emissions. Climate-related risks associated with increasing global warming depend on geographic location, "levels of development and vulnerability", and the speed and reach of climate mitigation and climate adaptation practices.

Projected climate change, potential impacts and associated risks

According to the report, with global warming of 1.5 °C there would be increased risks to "health, livelihoods, food security, water supply, human security, and economic growth.

Emission pathways and system transitions consistent with 1.5 °C global warming

The report indicates that "rapid and far-reaching transitions in energy, land, urban and infrastructure..., and industrial systems", "unprecedented in terms of scale, but not necessarily in terms of speed" would require "deep emissions reductions in all sectors, a wide portfolio of mitigation options and a significant upscaling of investments in those options." Examples of actions consistent with the 1.5°C pathway include "shifting to low- or zero-emission power generation, such as renewables; changing food systems, such as diet changes away from land-intensive animal products; electrifying transport and developing 'green infrastructure', such as building green roofs, or improving energy efficiency by smart urban planning, which will change the layout of many cities."

For example, an increase of forestation by 10,000,000 square kilometres (3,900,000 sq mi) by 2050 relative to 2010 would be required.

The report says that for limiting warming to below 1.5 degree "Global net human-caused emissions of carbon dioxide (CO2) would need to fall by about 45 percent from 2010 levels by 2030, reaching 'net zero' around 2050." and even for limiting global warming to below 2°C, CO2 emissions should decline by 20% by 2030 and by 100% to 2075. Non-CO2 emissions should decline in less or more similar ways for limiting warming to 1.5°C or 2°C

APPLICABLE METHODS

1. **Carbon dioxide removal is different from reducing emissions,** as the former produces an outlet of carbon dioxide from Earth's atmosphere, whereas the latter decreases the inlet of carbon dioxide to the atmosphere. Both have the same net effect, but for achieving carbon dioxide concentration levels below present levels, carbon dioxide removal is critical. Also for meeting higher concentration levels, carbon dioxide removal is increasingly considered to be crucial as it provides the only possibility to fill the gap between needed reductions to meet mitigation targets and global emission trends.

Carbon dioxide sinks that store carbon dioxide in the Earth's crust by injecting it into the subsurface, or in the form of insoluble carbonate salts (mineral sequestration), are considered carbon negative. This is because they are removing carbon from the atmosphere and sequestering it indefinitely and presumably for a considerable duration (thousands to millions of years). However, Carbon Capture technology remains, at best, theoretical and is yet to reach more than 33% efficiency. Furthermore, this process could be rapidly undone, for example by earthquakes or mining.

Bio-energy with carbon capture & storage

Bio-energy with carbon capture and storage, or BECCS, uses biomass to extract carbon dioxide from the atmosphere, and carbon capture and storage technologies to concentrate and permanently store it in deep geological formations.

Biochar

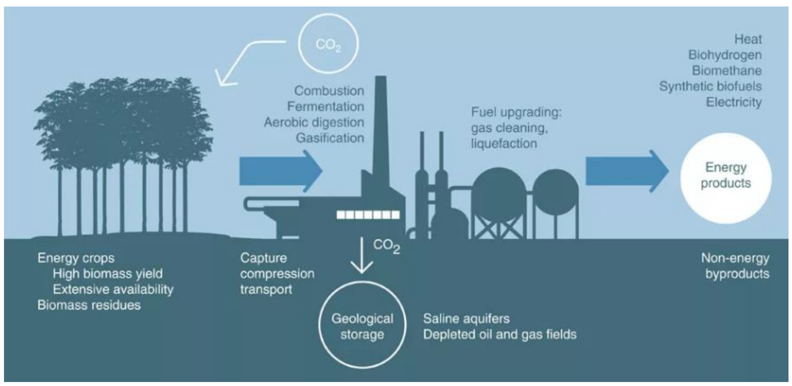
Biochar is created by the pyrolysis of biomass, and is under investigation as a method of carbon sequestration. Biochar is a charcoal that is used for agricultural purposes which also aids in carbon sequestration, the capture or hold of carbon. It is created using a process called pyrolysis, which is basically the act of high temperature heating biomass in an environment with low oxygen levels.

Enhanced weathering

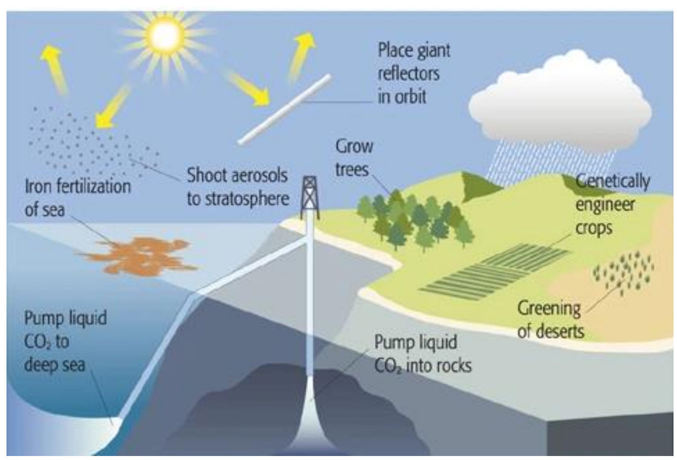
Enhanced weathering is a chemical approach to remove carbon dioxide involving land- or ocean-based techniques. One example of a land-based enhanced weathering technique is in-situ carbonation of silicates. Ultramafic rock, for example, has the potential to store from hundreds to thousands of years' worth of CO2 emissions, according to estimates.

Direct air capture (DAC)

Carbon dioxide can be removed from ambient air through chemical processes, sequestered, and stored. Traditional modes of carbon capture such as precombustion and postcombustion CO2 capture from large point sources can help slow the rate of increase of the atmospheric CO2 concentration, but only the direct removal of CO2 from the air, or “direct air capture” (DAC), can actually reduce the global atmospheric CO2 concentration if combined with long-term storage of CO2.



2. **Solar radiation management (SRM) projects** are a type of climate engineering which seek to reflect sunlight and thus reduce global warming. Proposed methods include increasing the planetary albedo, for example using stratospheric sulfate aerosols. Restorative methods have been proposed regarding the protection of natural heat reflectors like sea ice, snow and glaciers with engineering projects.



Their principal advantages as an approach to climate engineering is the speed with which they can be deployed and become fully active, their potential low financial cost, and the reversibility of their direct climatic effects.

3. Stratospheric aerosol injection The ability of stratospheric sulfate aerosols to create a global dimming effect has made them a possible candidate for use in solar radiation management climate engineering projects to limit the effect and impact of climate change due to rising levels of greenhouse gases.

Delivery of precursor sulfide gases such as sulfuric acid, hydrogen sulfide (H2S) or sulfur dioxide (SO2) by artillery, aircraft and balloons has been proposed. It presently appears that this proposed method could counter most climatic changes, take effect rapidly, have very low direct implementation costs, and be reversible in its direct climatic effects.

UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

The UNFCCC entered into force on 21 March 1994. Today, it has near-universal membership. The 197 countries that have ratified the Convention are called Parties to the Convention.

The UNFCCC is a "Rio Convention", one of three adopted at the "Rio Earth Summit" in 1992. Its sister Rio Conventions are the UN Convention on Biological Diversity and the Convention to Combat Desertification. The three are intrinsically linked. It is in this context that the Joint Liaison Group was set up to boost cooperation among the three Conventions, with the ultimate aim of developing synergies in their activities on issues of mutual concern. It now also incorporates the Ramsar Convention on Wetlands.

Preventing "dangerous" human interference with the climate system is the ultimate aim of the UNFCCC.

The **Kyoto Protocol** is an international agreement linked to the United Nations Framework Convention on Climate Change, which commits its Parties by setting internationally binding emission reduction targets.

Recognizing that developed countries are principally responsible for the current high levels of GHG emissions in the atmosphere as a result of more than 150 years of industrial activity, the Protocol places a heavier burden on developed nations under the principle of "common but differentiated responsibilities."

Under the Protocol, countries must meet their targets primarily through national measures. However, the Protocol also offers them an additional means to meet their targets by way of three market-based mechanisms.

The Kyoto mechanisms are:

International Emissions Trading

Greenhouse gas emissions – a new commodity Parties with commitments under the Kyoto Protocol (Annex B Parties) have accepted targets for limiting or reducing emissions. These targets are expressed as levels of allowed emissions, or "assigned amounts," over the 2008-2012 commitment period. The allowed emissions are divided into "assigned amount units" (AAUs).

Emissions trading, as set out in Article 17 of the Kyoto Protocol, allows countries that have emission units to spare - emissions permitted them but not "used" - to sell this excess capacity to countries that are over their targets.
Thus, a new commodity was created in the form of emission reductions or removals. Since carbon dioxide is the principal greenhouse gas, people speak simply of trading in carbon. Carbon is now tracked and traded like any other commodity. This is known as the "carbon market."

Other trading units in the carbon market

More than actual emissions units can be traded and sold under the Kyoto Protocol's emissions trading scheme. The other units which may be transferred under the scheme, each equal to one tonne of CO2, may be in the form of:

- A removal unit (RMU) on the basis of land use, land-use change and forestry (LULUCF)activities such as reforestation
- An emission reduction unit (ERU) generated by a joint implementation project
- A certified emission reduction (CER) generated from a clean development mechanism project activity

Clean Development Mechanism (CDM)

The Clean Development Mechanism (CDM), defined in Article 12 of the Protocol, allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex B Party) to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to one tonne of CO2, which can be counted towards meeting Kyoto targets.

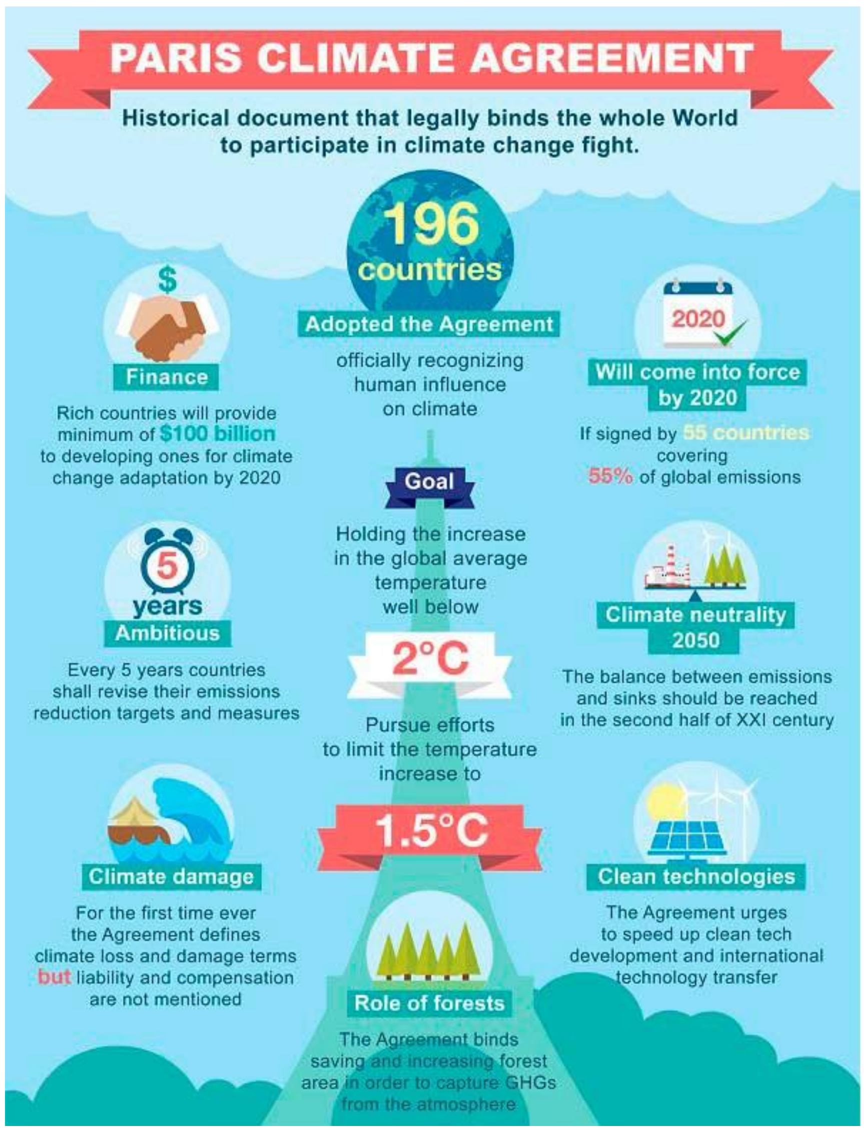
The mechanism is seen by many as a trailblazer. It is the first global, environmental investment and credit scheme of its kind, providing a standardized emissions offset instrument, CERs.

A CDM project activity might involve, for example, a rural electrification project using solar panels or the installation of more energy-efficient boilers.

The mechanism stimulates sustainable development and emission reductions, while giving industrialized countries some flexibility in how they meet their emission reduction or limitation targets.

Joint Implementation (JI)

The mechanism known as "joint implementation," defined in Article 6 of the Kyoto Protocol, allows a country with an emission reduction or limitation commitment under the Kyoto Protocol (Annex B Party) to earn emission reduction units (ERUs) from an emission-reduction or emission removal project in another Annex B Party, each equivalent to one tonne of CO2, which can be counted towards meeting its Kyoto target.



PARIS AGREEMENT

The Paris Agreement to combat climate change became international law -- a landmark deal about tackling global warming amid growing fears that the world is becoming hotter even faster than scientists expected.

It has been signed by 195 countries and ratified by 190 as of January 2021, which seeks to limit global warming to 2 degrees Celsius (3.6 degrees Fahrenheit). While the Paris agreement is legally binding, the emissions reductions that each country has committed to are not. Instead, the agreement seeks to create a transparent system that will allow the public to monitor how well each country is doing in meeting its goals in hopes that this will motivate them to transition more quickly to clean, renewable energy like wind, solar and hydropower.

BLACK CARBON

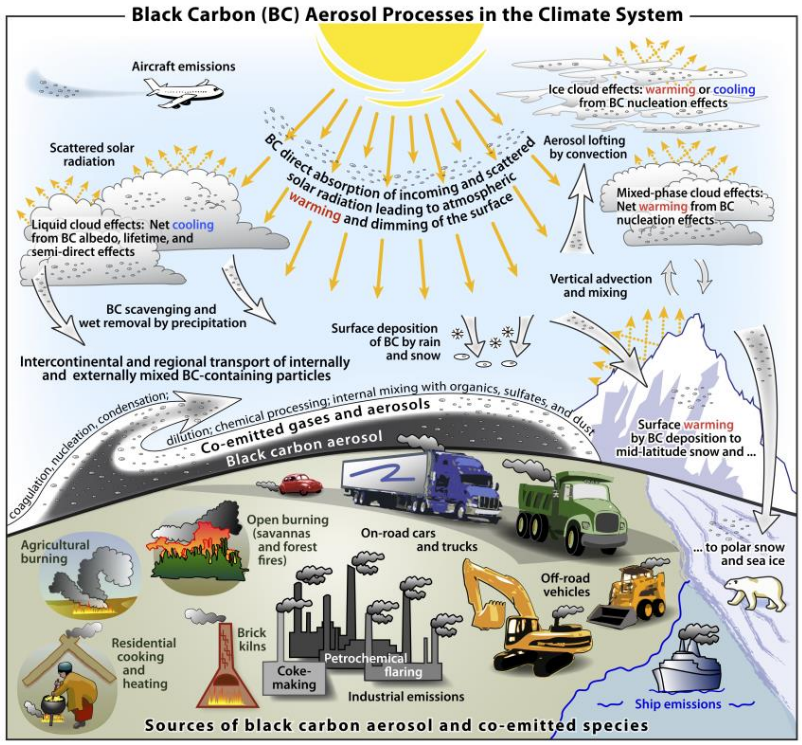
Black carbon is a potent climate-warming component of particulate matter formed by the incomplete combustion of fossil fuels, wood and other fuels. Complete combustion would turn all carbon in the fuel into carbon dioxide (CO2), but combustion is never complete and CO2, carbon monoxide, volatile organic compounds, and organic carbon and black carbon particles are all formed in the process. The complex mixture of particulate matter resulting from incomplete combustion is often referred to as soot.

Black carbon is a short-lived climate pollutant with a lifetime of only days to weeks after release in the atmosphere. During this short period of time, black carbon can have significant direct and indirect impacts on the climate, glacial regions, agriculture and human health.

Several studies have demonstrated that measures to prevent black carbon emissions can reduce near-term warming of the climate, increase crop yields and prevent premature deaths.

Primary sources of Black Carbon emissions

Black carbon emissions have been decreasing over the past decades in many developed countries due to stricter air quality regulations. By contrast, emissions are increasing rapidly in many developing countries where air quality is not regulated. As the result of open biomass burning and residential solid fuel combustion, Asia, Africa and Latin America contribute approximately 88% of global black carbon emissions.



Climate impacts

Black carbon (soot) deposited on ice -Black carbon is an important contributor to warming because it is very effective at absorbing light and heating its surroundings. Per unit of mass, black carbon has a warming impact on climate that is 460-1,500 times stronger than CO2.

When suspended in the atmosphere, black carbon contributes to warming by converting incoming solar radiation to heat. It also influences cloud formation and impacts regional circulation and rainfall patterns.

When deposited on ice and snow, black carbon and co-emitted particles reduce surface albedo (the ability to reflect sunlight) and heat the surface. The Arctic and glaciated regions such as the Himalayas are particularly vulnerable to melting as a result.

Health impacts

Relative size of particulate matter -Black carbon and its co-pollutants are key components of fine particulate matter (PM2.5) air pollution, the leading environmental cause of poor health and premature deaths.

At 2.5 micrometres or smaller in diameter, these particles are, many times smaller than a grain of table salt, which allows them to penetrate into the deepest regions of the lungs and facilitate the transport of toxic compounds into the bloodstream.

PM2.5 has been linked to a number of health impacts including premature death in adults with heart and lung disease, strokes, heart attacks, chronic respiratory disease such as bronchitis, aggravated asthma and other cardio-respiratory symptoms. It is also responsible for premature deaths of children from acute lower respiratory infections such as pneumonia.

Each year, an estimated 7 million premature deaths are attributed to household and ambient (outdoor) PM2.5 air pollution.

Impacts on vegetation and ecosystems

Black carbon can affect the health of ecosystems in several ways: by depositing on plant leaves and increasing their temperature, dimming sunlight that reaches the earth, and modifying rainfall patterns.

Changing rain patterns can have far-reaching consequences for both ecosystems and human livelihoods, for example by disrupting monsoons, which are critical for agriculture in large parts of Asia and Africa.

Solutions

Black carbon’s short atmospheric lifetime, combined with its strong warming potential, means that targeted strategies to reduce emissions can provide climate and health benefits within a relatively short period of time.

The Coalition supports implementation of control measures that, if globally implemented by 2030, could reduce global black carbon emissions by as much as 80% (UNEP & WMO 2011). Several of these emission reductions could be achieved with net cost savings. Adopting these measures would have major positive co-benefits for public health, especially in the developing world.

Household energy

- Replace traditional cooking to clean burning modern fuel cookstoves
- Replace traditional cooking and heating with clean-burning biomass stoves
- Eliminate kerosene lamps
- Replace lump coal with coal briquettes for cooking and heating
- Replace wood stove and burners with pellet stoves and boilers

Industrial production

- Modernize traditional brick kilns to vertical shaft brick kilns
- Modernize coke ovens to recovery ovens

Transport

- Use diesel particular filters for road and off-road vehicles
- Fast transition to Euro VI/6 vehicles and soot-free buses and trucks
- Eliminate high-emitting diesel vehicles

Agriculture

- Ban open-field burning of agricultural waste

Fossil fuels

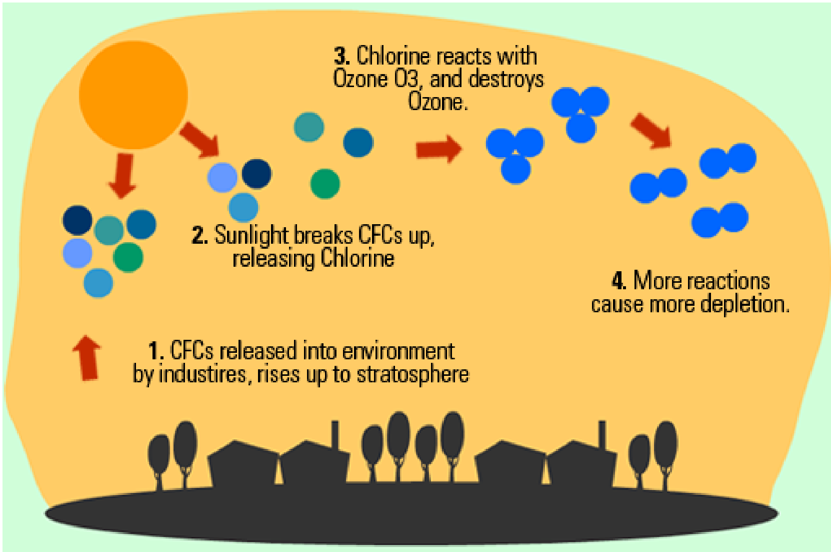
- Capture and improve oil flaring and gas production

Waste management

- Ban open burning of municipal waste

OZONE DEPLETION

Ozone layer depletion is one of the most serious problems faced by our planet earth. It is also one of the prime reasons which are leading to global warming. Ozone is a colourless gas which is found in the stratosphere of our upper atmosphere. The layer of ozone gas is what which protects us from the harmful ultraviolet radiations of the sun. The ozone layer absorbs these harmful radiations and thus prevents these rays from entering the earth's atmosphere. Ultraviolet radiations are high energy electromagnetic waves emitted by the sun which if enters the earth's atmosphere can lead to various environmental issues including global warming, and also a number of health related issues for all living organisms. Thanks to the ozone layer which protects us from these harmful rays.



From the 1970s the depletion of the ozone layer started to capture the attention of the scientists, environmentalists, and the world community at large. There had been a lot of research on this topic over these years to find out all the possible causes that lead to this problem and the effects of ozone depletion. There has been also a lot of research to find out possible solutions to this problem. Let us see some of the important causes and effects of ozone layer depletion.

Causes of ozone layer depletion

The main things that lead to destruction of the ozone gas in the ozone layer. Low temperatures, increase in the level of chlorine and bromine gases in the upper stratosphere are some of the reasons that leads to ozone layer depletion. But the one and the most important reason for ozone layer depletion is the production and emission of chlorofluorocarbons (CFCs). This is what which leads to almost 80 percent of the total ozone layer depletion.

There are many other substances that lead to ozone layer depletion such as hydro chlorofluorocarbons (HCFCs) and volatile organic compounds (VOCs). Such substances are found in vehicular emissions, by-products of industrial processes, aerosols and refrigerants. All these ozone depleting substances remain stable in the lower atmospheric region, but as they reach the stratosphere, they get exposed to the ultra violet rays. This leads to their breakdown and releasing of free chlorine atoms which reacts with the ozone gas, thus leading to the depletion of the ozone layer. Ozone depleting substances includes

- CFC and HCFCs - mostly used in refrigeration, air conditioning and heat pump systems. Only HCFCs can continue to be used for a limited period of time.Halons - used historically as fire suppression agents and fire fighting, but now only allowed in very limited situations
- Carbon tetrachloride (Tetrachloromethane) - limited solvent use in laboratories and chemical and pharmaceutical industry.
- Methyl bromide - historically used in fumigation, soil treatment, pest control, quarantine, market gardening. Methyl bromide is no longer registered for use in Ireland.
- Hydrobromofluorocarbons - historically used in fire suppression systems and fire fighting.
- Bromochloromethane - historically used in the manufacture of biocides.

Effects of ozone layer depletion

The depletion of ozone layer allows entering of UV rays from sun into the earth's atmosphere which is associated with a number of health related and environmental issues.

Skin Cancer: exposure to UV rays from sun can lead to increased risk for developing of several types of skin cancers. Malignant melanoma, basal and squamous cell carcinoma are the most common cancers caused by exposure to UV rays.

Eye Damage: UV rays are harmful for our eyes too. Direct exposure to UV rays can lead to Cataract problems, and also Photokeratitis or snow blindness.

Damage to Immune system: our immune system is also highly vulnerable to UV rays. Increased exposure to UV rays can lead to weakening of the response of immune system and even impairment of the immune system in extreme cases.

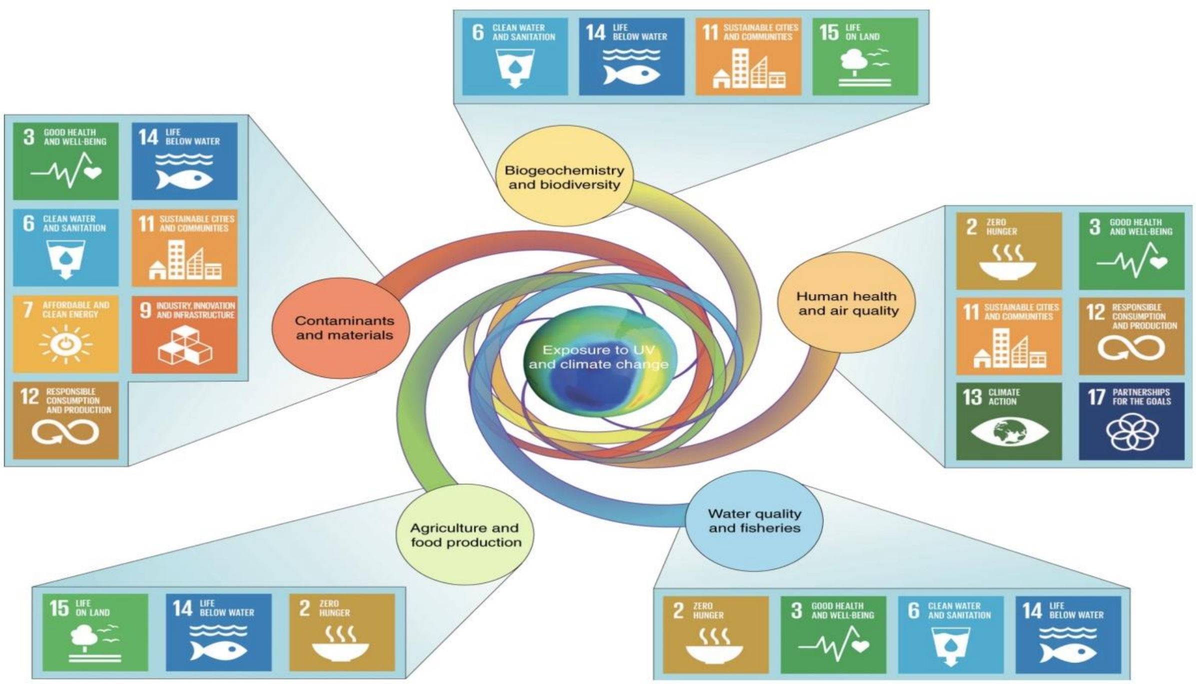
Aging of skin: exposure to UV rays can lead to acceleration of the aging process of your skin. This will result in you looking older than what you actually are. It can also lead to photo allergy that result in outbreak of rashes in fair skinned people

In humans, exposure to UV rays can also lead to difficulty in breathing, chest pain, and throat irritation and can even lead to hampering of lung function.

UV rays affect other life forms too. It adversely affects the different species of amphibians and is one of the prime reasons for the declining numbers of the amphibian species. It affects them in every stage of their life cycle; from hampering the growth and development in the larvae stage, deformities and decreases immunities in some species and to even retinal damage and blindness in some species.

UV rays also have adverse effect on the marine ecosystem. It adversely affects the planktons which plays a vital role in the food chain and oceanic carbon cycle. Affecting phytoplankton will in turn affect the whole ocean ecosystem.

UV rays will also affect the plants. UV radiations can alter the time of flowering in some plant species. It can also directly affect the plant growth by altering the physiological and developmental processes of the plants.



Effect of ozone depletion on environment

Ozone layer depletion leads to decrease in ozone in the stratosphere and increase in ozone present in the lower atmosphere. Presence of ozone in the lower atmosphere is considered as a pollutant and a greenhouse gas. Ozone in the lower atmosphere contributes to global warming and climate change. The depletion of ozone layer has trickle down effects in the form of global warming, which in turn leads to melting of polar ice, which will lead to rising sea levels and climatic changes around the world.

Ways to bring down ozone layer depletion

Ozone layer depletion is not something that affects any specific country or region. The whole world is vulnerable to its after effects. That makes it important for each and every one of us to take actions to reduce ozone layer depletion. International agreements such as Montreal protocol in 1987 have helped in reducing and controlling industrial emission of Chlofluorocarbons. More and more of such international agreements between countries is necessary to bring down ozone layer depletion. At individual level each and everyone also can contribute towards reducing ozone layer depletion. Buying and using recycled products, saving of energy, using of public transport can do a lot in combating ozone layer depletion. The most important thing that we can do is spreading awareness. Our individual efforts will go a long way in saving the earth's blanket and keep our planet earth liveable for us and our future generations.

Vienna Convention

The Vienna Convention for the Protection of the Ozone Layer was adopted in 1985 and entered into force on 22 Sep 1988. In 2009, the Vienna Convention became the first Convention of any kind to achieve universal ratification. The objectives of the Convention were for Parties to promote cooperation by means of systematic observations, research and information exchange on the effects of human activities on the ozone layer and to adopt legislative or administrative measures against activities likely to have adverse effects on the ozone layer.

The Vienna Convention did not require countries to take concrete actions to control ozone-depleting substances. Instead, in accordance with the provisions of the Convention, the countries of the world agreed the Montreal Protocol on Substances that Deplete the Ozone Layer under the Convention to advance that goal.

The Parties to the Vienna Convention meet once every three years, back to back with the Parties to the Montreal Protocol, in order to take decisions designed to administer the Convention.

National and international research and monitoring activities are reviewed at the triennial Ozone Research Managers (ORM) meetings with a view to ensuring proper coordination of the activities and to identify gaps that need to be addressed. The recommendations of the ORM meetings are forwarded for consideration to the Conference of the Parties (COP) at its triennial meetings held in conjunction with the Meeting of the Parties (MOP).

An Advisory Committee advises the Ozone Secretariat and the World Meteorological Organization on the activities of the Trust Fund for Research and Systematic Observation including prioritization, planning, development and implementation of the activities, as well as fundraising.

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