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Climate Change Reference Guide

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Climate Change Reference Guide

by Alice McKeown and Gary Gardner

At the heart of climate change is the greenhouse effect, in which molecules of various gases trap heat in Earth's atmosphere and keep it warm enough to support life. Carbon dioxide and other "greenhouse gases" (GHGs) are an important part of Earth's natural cycles, but human activities are boosting their concentrations in the atmosphere to dangerous levels. The result is rising global temperatures and an unstable climate that threatens humans, economies, and ecosystems.

This is an updated version of the reference guide that originally appeared in State of the World 2009: Into a Warming World*, published by the Worldwatch Institute.*
For more information about the book, please visit www.worldwatch.org/stateoftheworld.

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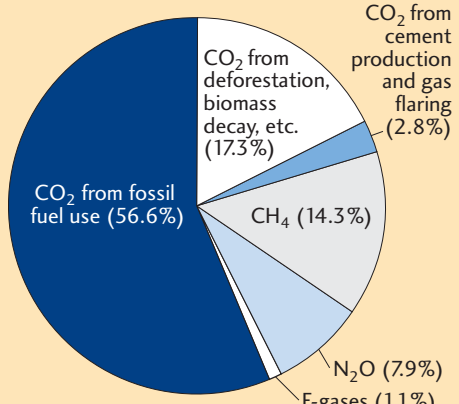
Global Emissions of Greenhouse Gases

The primary human-generated greenhouse gases are carbon dioxide, methane, fluorinated gases (including CFCs), and nitrous oxide. Greenhouse gases are only one source of climate change; aerosols such as black carbon and land use changes such as deforestation also affect warming.

Greenhouse Gas		Generated by
Carbon Dioxide (CO_2)		Fossil fuel combustion, land clearing for agriculture, cement production
Methane (CH_4)		Livestock production, extraction of fossil fuels, rice cultivation, landfills, sewage
Nitrous Oxide (N_2O)		Industrial processes, fertilizer use
F gases	Hydrofluorocarbons (HFCs)	Leakage from refrigerators, aerosols, air conditioners
	Perfluorocarbons	Aluminum production, semiconductor industry
	Sulfur Hexafluoride (SF_6)	Electrical insulation, magnesium smelting

Share of Global Emissions, in Carbon Dioxide Equivalent, 2004



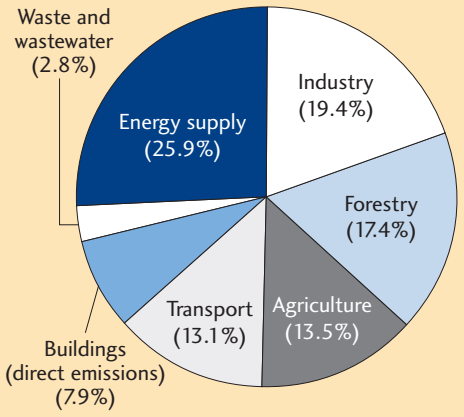
Source: IPCC

Greenhouse Gas Sources, by Sector

Greenhouse gases come from a broad range of human activities, including energy use, changes in land use (such as deforestation), and agriculture.

Source	Sample Emission-generating Activities
Energy Supply	Electricity and centralized heat generation, resource extraction, and grid base transmission/ distribution
Industry	Production of metals, pulp and paper, cement, and chemicals; petroleum refining
Forestry	Deforestation, decomposition of biomass that remains after logging
Agriculture	Crop and livestock production
Transport	Travel by car, freight truck, plane, train, or ship
Residential and Commercial Buildings	Heating, cooling, and electricity
Waste	Landfills, incineration, wastewater

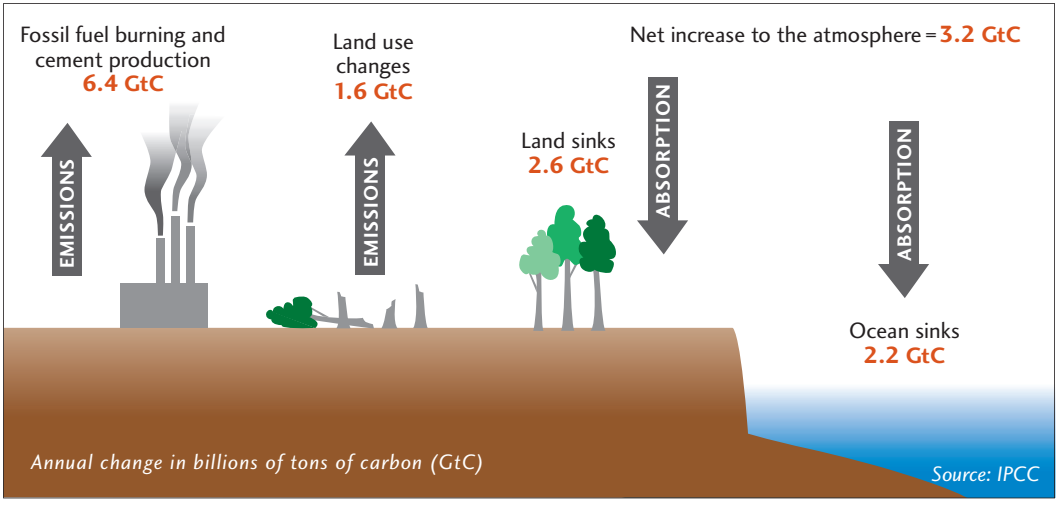
Emissions by Sector, in Carbon Dioxide Equivalent, 2004



Source: IPCC

The Carbon Cycle

Carbon flows among land, sea, and the atmosphere. But human activities since the mid-eighteenth century have changed carbon flows in ways that have lasting implications for the climate. This graphic depicts changes to global carbon flows in the 1990s relative to the preindustrial state.



Carbon, Carbon Dioxide, and Carbon Dioxide Equivalents

Carbon, the basis of life on Earth, is at the center of the climate crisis. Carbon is found in solid, liquid, and gaseous form. CO_2 is the most prevalent of human-generated greenhouse gases. CO_2 is so dominant that all other greenhouse gases are evaluated in terms of their equivalency to CO_2.

Indicator	Carbon	Carbon Dioxide	Carbon Dioxide Equivalent
Molecular makeup	One atom of carbon	One atom of carbon and two atoms of oxygen	A measurement, not a chemical element, so no molecular formula
Symbol	C	CO_2	CO_{2eq} or CO_{2e}
Description	Carbon cycles among land, sea, air, and biological systems and is the building block of many but not all greenhouse gases	A gaseous form of carbon, CO_2 is the breath people exhale, the fizz in soda—and part of the exhaust from burning fossil fuels. Most human carbon emissions are in the form of CO_2	A unit of measurement that compares the global warming contribution of other greenhouse gases to that of carbon dioxide, for standardization
Calculation	One ton of carbon = 3.67 tons of carbon dioxide	Not typically converted to other units. Measured as emissions and as a concentration in the atmosphere	Quantity of a greenhouse gas multiplied by its global warming potential

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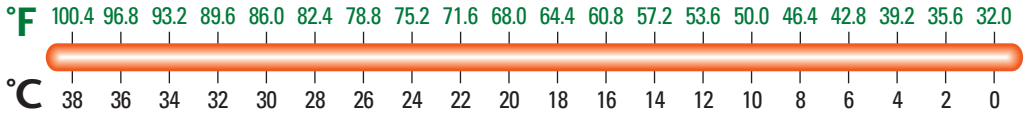
Global Warming Potential of Selected Greenhouse Gases

Global warming potential (GWP) expresses a gas's heat-trapping power relative to carbon dioxide over a particular time period (this table uses the common 100-year frame). A methane molecule, for example, has 25 times the warming potential of a carbon dioxide molecule over a 100-year period, and some gases are hundreds or thousands of times more powerful. However, carbon dioxide is a more stable molecule and lasts longer in the atmosphere than most of the other greenhouse gases, and is also emitted in far greater quantities.

Greenhouse Gas	Global Warming Potential
Carbon Dioxide	1
Methane	25
Nitrous Oxide	298
Hydrofluorocarbons	124 – 14,800
Perfluorocarbons	7,390 – 12,200
Sulfur Hexafluoride	22,800

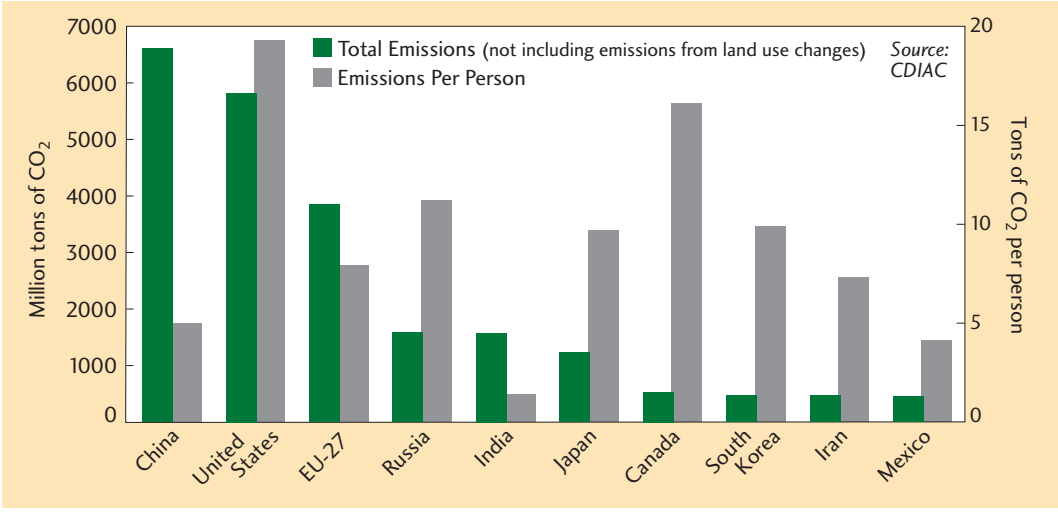
Temperature Conversion

Changes to global temperature caused by climate change are usually measured in degrees Celsius. One degree Celsius is equal to 1.8 degrees Fahrenheit—meaning that a 2-degree Celsius rise is 3.6 degrees Fahrenheit. Actual temperature readings in the different scales are easily compared when placed side by side.



Top 10 CO_2-Emitting Nations, Total and Per Person, 2007

National emissions levels vary greatly. Among the top 10 emitters, China generates nearly 15 times more CO_2 than Mexico does. The 10 leading emitters generate many more times the emissions of most developing countries, although emissions in those countries are rising rapidly and could soon overtake the annual emissions in industrial countries. The top 10 emitting nations also exhibit a broad range of emissions per person. Wealthy countries tend to emit more carbon dioxide per person than poor countries do.



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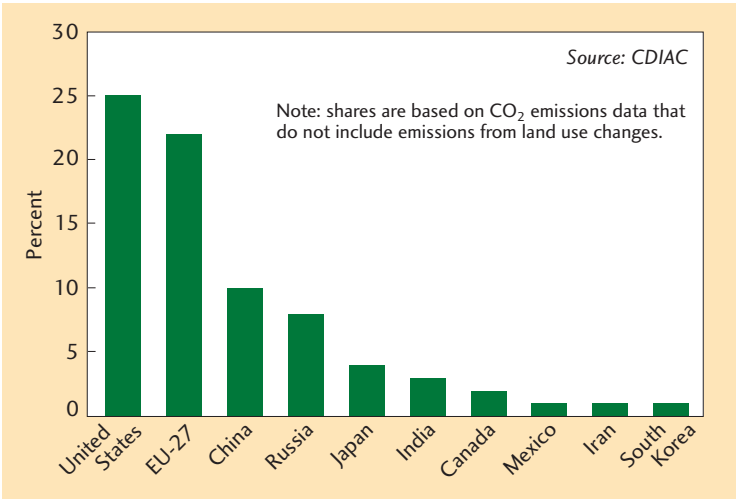
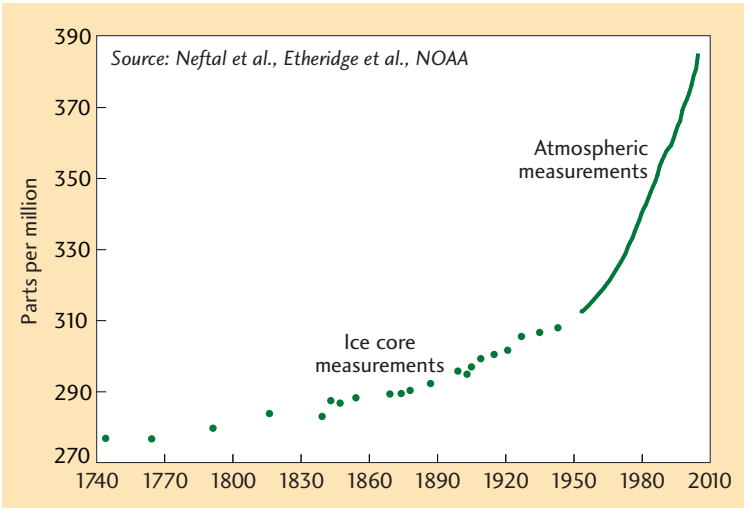
Top 10 CO_2-Emitting Nations' Share of Global CO_2 Emissions, 1950–2007



Over time, early industrializing nations typically have emitted more carbon dioxide to the atmosphere than nations that industrialized later. But some developing countries emit large quantities of greenhouse gases through changes in land use, especially through forest clearing for crop production. Contemporary data for emissions resulting from land use changes by country are not available, but would push Indonesia and Brazil into the top 10 emitters when all emissions sources are considered.

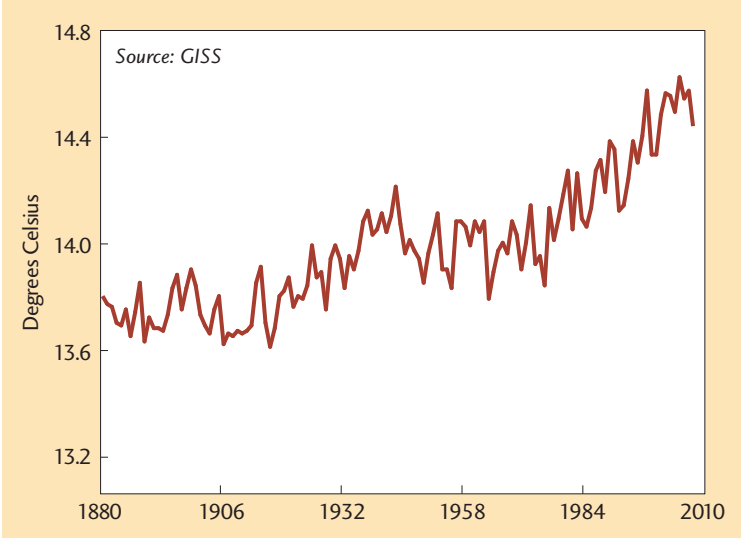
Concentration of CO_2 in Earth's Atmosphere, 1744–2008

Since the mid-eighteenth century fossil fuel use and cement production have released billions of tons of CO_2 to the atmosphere. Carbon dioxide levels in the atmosphere before the Industrial Revolution were some 280 parts per million (ppm). By 2007, levels had reached 384 ppm—a 37-percent increase.



Average Global Temperature at Earth's Surface, 1880–2008

Average global temperature increased by 0.74 degrees Celsius between 1906 and 2005. In its 2007 Assessment, the Intergovernmental Panel on Climate Change (IPCC) predicted an additional rise of 1.8–4.0 degrees Celsius this century, depending on how much and how soon greenhouse gas emissions are curbed.



Climate Tipping Elements

Scientists believe that several "climate tipping elements" could destabilize the planet's climate by setting off chain reactions—"positive feedbacks"—that accelerate other climate changes. Once a tipping element is triggered by crossing a threshold or tipping point, there is no turning back even if all greenhouse gas emissions were to end. Some tipping elements, such as the loss of Arctic summer sea ice, may be triggered within the next decade if climate change continues at the same rate. Others—the collapse of the Atlantic ocean current, for instance—are thought to be many decades away.

Tipping Element	Expected Consequences
Loss of Arctic summer sea ice	Higher average global temperatures and changes to ecosystems
Melting of Greenland ice sheet	Global sea level rise up to 7 meters
Collapse of West Antarctic ice sheet	Global sea level rise up to 5 meters
Collapse of the Atlantic ocean current	Disruptions to Gulf Stream and changes to weather patterns
Increase in El Niño events	Changes to weather patterns, including increased droughts, especially in Southeast Asia
Dieback of boreal forest	Severe changes to boreal forest ecosystems
Dieback of Amazon forest	Massive extinctions and decreased rainfall
Changes to the Indian summer monsoon	Widespread drought and changes to weather patterns
Changes to the Sahara/Sahel and the West African monsoon	Changes to weather patterns, including potential greening of the Sahara/Sahel—one of the few positive tipping elements

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The 10 Warmest Years on Record, 1880–2008

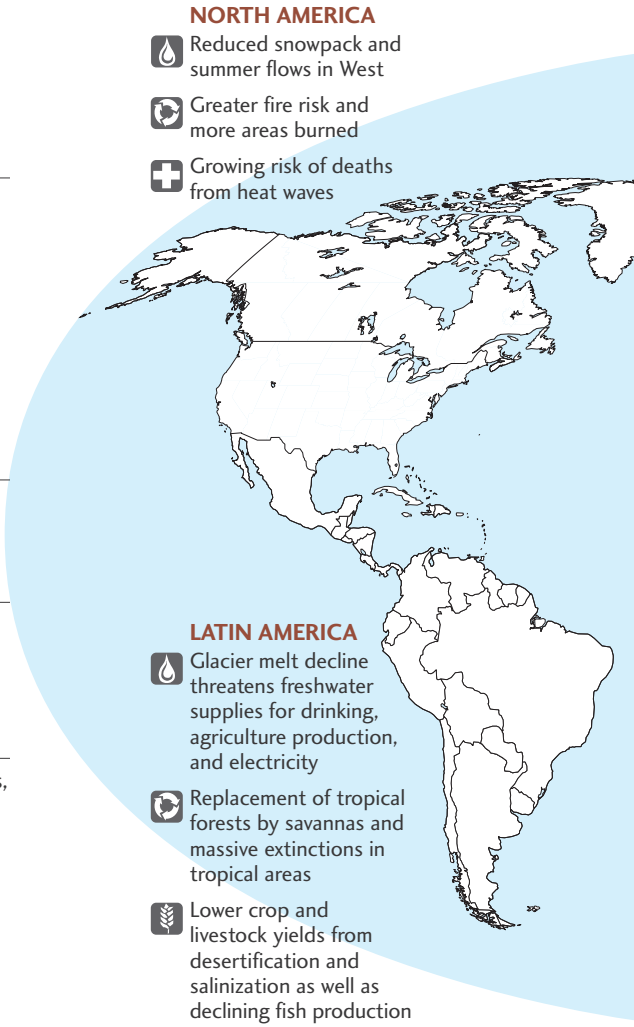
Direct temperature readings dating back to the nineteenth century show that the last 10 years had 8 of the 10 warmest years on record.

Ranking	Year	Ranking	Year
1	2005	6	2007
2	1998	7	2004
3	2002	8	2001
4	2003	9	2008
5	2006	10	1997

Expected Impacts of an Unstable Climate

Climate changes are already occurring today and will continue to accelerate as greenhouse gas concentrations rise over time. While climate change is global, the impacts are felt differently from region to region.

System or Condition	Changes
Fresh Water	• Increased droughts • Increased heavy precipitation events and flooding • Decreased drinking and freshwater supplies and availability • Glacier melt decline • Increased salinization of freshwater sources
Ecosystems	• Massive extinctions • Animal and plant migration • Increased wildfires, flooding, and drought • Decreased forest coverage, expanding arid lands, and other similar changes • Ocean acidification and coral reef bleaching • Spread of exotic, invasive plants and animals
Food and Agriculture	• Reduced crop yields • Shifting growing zones • Increasing hunger and malnutrition • Declining fish yields
Health	• Increased deaths due to floods, heat and cold waves, storms, fires, and drought • Changes in the distribution of certain infectious diseases, including malaria • Increased cardiorespiratory diseases • Increased disease spread from contaminated and polluted drinking water supplies • Increased diarrheal disease • Increased malnutrition
Coasts	• Increased coastal flooding, especially in low-lying islands and heavily populated delta regions • Increased soil erosion • Increased intensity and strength of tropical storms



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Expected Impacts of an Unstable Climate

EUROPE

- Coastal flooding, more frequent inland flash floods, and mountain glacier melt
- Widespread extinctions and species loss
- Declining crop production in the South with potential increases in the North
- Growing risk of deaths from heat waves, especially in Central, Southern, and Eastern regions

ASIA

- One billion people at risk from decreasing freshwater supplies
- Declining crop production, including decreased yields of up to 30 percent by 2050
- Greater fire risk

SOUTH AND EAST ASIA

- Rising mortality from diarrheal disease and potential massive spreading of cholera
- Heavily populated regions at risk from flooding
- Widespread loss of coral reefs and mangroves

AFRICA

- 75–250 million people without access to fresh water by 2020
- Severe reductions in crop yields and fisheries production
- Heavily populated delta regions at risk from flooding

AUSTRALIA AND NEW ZEALAND

- Widespread lack of access to fresh water
- Increased droughts and fires and significant loss of biodiversity, including Great Barrier Reef
- Heavily populated coastal regions at risk from flooding and strong storms

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Avoiding Dangerous Effects of Climate Change

Scientists talk about several potential climate stabilization levels that could help minimize the negative effects of climate change. Policymakers rally around these different stabilization points, using them to develop policies to rein in greenhouse gas emissions. But not everyone agrees on the same stabilization points, and recent studies indicate that the levels may need to be lower than once believed.

Potential Stabilization Points	Details
Global temperature increase of 2 degrees Celsius	According to the IPCC, the risks and threats of climate change increase dramatically when global temperature rises more than 2 degrees Celsius (3.6 degrees Fahrenheit). Government leaders and nongovernmental organizations have embraced 2 degrees as the maximum rise allowable if the worst effects of climate change are to be avoided.
Global greenhouse gas reductions of 15–20 percent below baseline levels within the next 10–20 years	Reduction needed to limit global temperature rise to 2–3 degrees Celsius, according to the IPCC. This goal suggests that carbon dioxide concentrations must peak by 2015–20 and then fall. Many policymakers use a variation of this number to set guidelines for action.
Atmospheric CO_2 at 350 ppm	NASA climate scientist James Hansen and his colleagues argue that many global warming tipping points have already been passed. Although current concentrations of CO_2 in the atmosphere exceed 380 parts per million, these scientists believe that atmospheric concentrations need to drop to 350 ppm or lower as soon as possible.
Atmospheric CO_2 at 450–550 ppm	U.K. economist Nicholas Stern advises that the uppermost stabilization levels for atmospheric concentrations of CO_2 should not exceed 450–550 parts per million in order to avoid global economic collapse. Based on climate models, this stabilization point takes into account predictions about technological developments and the time needed for widespread action.

The Diplomatic Road to Copenhagen

Fifteen years after international climate negotiations began at the Rio Earth Summit in 1992, the Bali Road Map and Action Plan outlined the steps needed to reach a new international climate agreement in Copenhagen by the end of 2009. While a large share of climate negotiating takes place at Conference of the Parties to the Framework Convention (COP) meetings, two working groups are also laboring on the new agreement throughout 2009: the Ad Hoc Working Group on Further Commitments for Annex 1 Parties under the Kyoto Protocol (AWG-KP) and the Ad Hoc Working Group on Long-term Cooperative Action under the Convention (AWG-LCA). Discussions take place outside the Convention framework as well, and international negotiations are expected to continue beyond Copenhagen.

1992—2007

June 1992
Earth Summit: Rio de Janeiro, Brazil
United Nations Framework Convention on Climate Change (UNFCCC) adopted

December 1997
Third Conference of the Parties: Kyoto, Japan
General framework of the Kyoto Protocol adopted to control greenhouse gas emissions through 2012

July 2001
Sixth Conference of the Parties (COP6bis): Bonn, Germany
Produced the Bonn Agreement, which finalized important elements of the Kyoto Protocol

October 2001
Seventh Conference of the Parties: Marrakesh, Morocco
Produced the Marrakesh Accords, which outlined how the Kyoto Protocol would be implemented

February 2005
Kyoto Protocol entered into force 90 days after at least 55 parties to the Convention, representing at least 55 percent of Annex 1 countries' total 1990 carbon dioxide emissions, had ratified it

December 2007
Thirteenth Conference of the Parties: Bali, Indonesia
Bali Road Map and Action Plan for a new climate agreement adopted

2009

March
Seventh Session of the AWG-KP and Fifth Session of the AWG-LCA: Bonn, Germany
Continuation of UN climate change negotiating process

May
World Business Summit on Climate Change: Copenhagen, Denmark
Business leaders, scientists, economists, government representatives, and other leaders will work on recommendations to inform the Copenhagen process

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June
Eighth Session AWG-KP and Sixth Session of the AWG-LCA: Bonn, Germany
Continuation of UN climate change negotiating process

July
Group of 8 (G8) Summit: La Maddalena, Italy
Climate change will be discussed at this meeting of leaders of major industrialized nations

August
World Climate Conference 3: Geneva, Switzerland
Science-based meeting to help decision makers manage the opportunities and risks of extreme climate change and improve local communities' capacity to adapt to climate change

September
Ninth Session of the AWG-KP and Seventh Session of the AWG-LCA: Bangkok, Thailand
Continuation of UN climate change negotiating process

September
United Nations General Assembly Meeting: New York, USA
Heads of State and Government will discuss negotiations for a new climate agreement

December
Fifteenth Conference of the Parties: Copenhagen, Denmark
Goal is to adopt a new international climate agreement

39 Key Terms for Understanding Climate Change

Adaptation: Changes in policies and practices designed to deal with climate threats and risks. Adaptation can refer to changes that protect livelihoods, prevent loss of lives, or protect economic assets and the environment. Examples include changing agricultural crops to deal with changing seasons and weather patterns, increasing water conservation to deal with changing rainfall levels, and developing medicines and preventive behaviors to deal with spreading diseases.

Additionality: Emissions reductions that are greater than would have occurred under a business-as-usual scenario. For example, in order for emission credits to be awarded, projects under the Clean Development Mechanism and Joint Implementation must show that any emissions reductions are in addition to what would have occurred without the project. Additionality can also be used to describe other added benefits from the projects, including funding, investment, and technology.

Annex countries: Groups of nations (for example, Annex 1 or Annex B) with different obligations under international climate agreements. Under the U.N. Framework Convention on Climate Change, Annex 1 countries include industrial countries and economies in transition that agreed to reduce their greenhouse gas emissions to 1990 levels collectively. Annex 2 countries are industrial countries that committed to help developing countries by providing them with technology, financial assistance, and other resources. Annex B countries have assigned emission reduction targets under the Kyoto Protocol. The category non-Annex 1 includes countries that are the most vulnerable to climate change. Some countries are included in more than one Annex.

Anthropogenic emissions: Greenhouse gas emissions that are caused by human activities. Also includes emissions of GHG precursors and aerosols.

Atmospheric concentration: A measure used by climate scientists to register the level of greenhouse gases in Earth's atmosphere. Atmospheric concentration is most often measured in parts per million of carbon dioxide and can be tracked over time to understand trends and make projections.

Baseline: A level or year against which subsequent greenhouse gas emission levels and concentrations are measured, especially in the context of emission reductions. For example, the Kyoto Protocol calls for 5-percent reductions in human-caused greenhouse gases below 1990 levels (the baseline) by the 2008–12 period.

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Black carbon: Soot and other aerosol particles that come from the incomplete combustion of fossil fuels. Black carbon increases atmospheric warming by lowering the reflectivity of snow, clouds, and other surfaces and by absorbing heat from the sun. Some scientists believe that black carbon plays a large role in climate change and that reducing it may be one of the best opportunities to slow climate change in the short run.

Cap and trade: An approach to limiting greenhouse gas emissions that sets a maximum emissions level (a cap) for a region or nation and that requires participating emitters to obtain permits to pollute. Companies or governmental jurisdictions with extra pollution permits can sell or trade them to parties whose permits are insufficient to cover their full emissions.

Carbon capture and storage (CCS): A process in which carbon dioxide is separated and captured during energy production or industrial processes and subsequently stored (often by pumping it underground) rather than released into the atmosphere. Also known as carbon capture and sequestration.

Carbon dioxide (CO_2): The most widespread greenhouse gas. CO_2 is released to the atmosphere through natural and human activities, including fossil fuel and biomass burning, industrial processes, and changes to land use, among others.

Carbon dioxide equivalent (CO_{2eq}): A unit of measurement used to compare the climate effects of all greenhouse gases to each other. CO_{2eq} is calculated by multiplying the quantity of a greenhouse gas by its global warming potential.

Carbon dioxide intensity and carbon dioxide per capita: Alternatives to total emissions for measuring a nation's greenhouse gas emissions. Carbon intensity measures emissions per unit of gross domestic product. CO_2 per capita measures emissions per person. Both measures can be used to look at emission differences between nations. For example, while China has recently taken the lead in total greenhouse gas emissions, its per capita emissions level is far lower than that in most industrial countries.

Carbon tax: A tax levied on carbon dioxide emissions that aims to reduce the total amount of greenhouse gas emissions by setting a price on pollution. A carbon tax can be used independently or in conjunction with other emissions controls such as a carbon cap. The tax

generates revenue that can be used to underwrite further emissions reductions, technology development, cost relief for consumers, or other initiatives.

Clean Development Mechanism (CDM): A mechanism under the Kyoto Protocol that allows industrial countries to meet their emission reduction targets by investing in low- or no-emission projects in developing nations. The CDM also aims to stimulate investment in developing countries.

Climate Feedback: The mechanism whereby changes in one part of the climate system lead to changes in other parts, which in turn circle back to amplify or diminish the original change process. A rise in global temperature, for example, causes permafrost to melt and release methane, which in turn feeds back to further raise global temperature. Reinforcing effects like this are called positive feedbacks. Negative feedbacks work in the opposite direction, minimizing the original factor: temperature increase, for example, can lead to greater cloud cover which blocks the inflow of solar radiation, which in turn limits temperature increase.

Conference of the Parties (COP): Regular meetings of governments that have signed an international treaty to discuss its status and possible revision. The fifteenth COP of the UNFCCC will be held in Copenhagen 30 November – 11 December 2009.

Emission Reduction Unit (ERU): One metric ton of carbon dioxide equivalent that is reduced or sequestered. Under the Clean Development Mechanism, industrial countries earn certified emission reduction units (CERs) for projects in developing countries that can be applied toward their national reduction targets. Countries can also earn emission reduction units under the Joint Implementation mechanism.

Emission trading: A market approach to reducing greenhouse gas emissions. Trading allows parties that emit less than their allowed emissions to trade or sell excess pollution credits to other parties that emit more than they are allowed. The European Union Emissions Trading Scheme (EU-ETS) is a mandatory emission trading scheme currently in place; the Chicago Climate Exchange (CCX) is a voluntary trading program.

Forcing: Changes to the climate system that are caused by natural (volcanic eruptions, for example) or human-caused (such as greenhouse gas emissions) factors. Scientifically, radiative forcing measures changes to the natural energy balance of Earth's atmosphere that affect surface temperature. So named because it measures incoming solar radiation against outgoing thermal radiation, radiative forcing is

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expressed as a rate of energy change in watts per square meter. Human-caused forcing factors like greenhouse gases have a positive radiative forcing and cause surface temperature to heat. Other such factors, including some aerosols, have a negative radiative forcing and cause surface temperature to cool.

Global warming potential (GWP): A measurement of the relative strength and potency of a greenhouse gas as well as its projected life span in the atmosphere. GWP is based on carbon dioxide, the most common greenhouse gas, and allows comparisons among different greenhouse gases.

Greenhouse development rights: Within the context of climate change obligations, the principle that all societies have a fundamental right to reduce poverty, achieve food security, increase literacy and education rates, and pursue other development goals. Societies or countries below a certain income level are excluded from greenhouse gas emission reduction scenarios and are expected to concentrate their resources on raising their standard of living rather than lowering emissions.

Greenhouse gases (GHGs): Atmospheric gases that cause climate change by trapping heat from the sun in Earth's atmosphere—that is, produce the greenhouse effect. The most common greenhouse gases are carbon dioxide, methane, nitrous oxide, ozone, and water vapor.

Intergovernmental Panel on Climate Change (IPCC): The international scientific body established by the World Meteorological Organization and the U.N. Environment Programme in 1988 to provide an objective and neutral source of information on climate change. The IPCC releases periodic assessment reports that are reviewed and approved by experts and governments.

Joint Implementation (JI): An initiative of the Kyoto Protocol that allows industrial countries to earn emission reduction credits by investing in reduction projects in other industrial countries. JI is related to the Clean Development Mechanism, which involves reduction projects in developing countries. Many JI projects are located in Eastern Europe.

Kyoto Protocol: A binding agreement that requires 37 countries and the European Community to reduce their human-caused greenhouse gas emissions 5 percent collectively from 1990 levels in the period 2008–12. It was adopted in 1997 under the U.N. Framework Convention on Climate Change and lays out specific steps countries must take to comply. More than 180 countries have signed the protocol, which entered into force on 16 February 2005.

Land use, land use change, and forestry (LULUCF): Land use is the set of activities that occur on any given parcel of land, such as grazing, forestry, or urban living. Changes to land use such as converting forestland to agriculture can release significant amounts of greenhouse gases. These activities are considered during climate negotiations and when planning emission reductions.

Mean sea level: The average global sea level over time. Mean sea level eliminates variations due to tides, waves, and other disturbances. Sea level is affected by the shape of ocean basins, changes in water quantity, and changes in water density. Climate change is expected to raise sea level by increasing glacier melts and sea temperatures.

Mitigation: Policies and behaviors designed to reduce greenhouse gases and increase carbon sinks.

Models, predictions, and pathways: Tools for analyzing alternative climate futures. Scientists use climate and atmospheric modeling to understand how the climate works and how greenhouse gas concentrations and other triggers lead to climate change. Models help scientists make predictions about climate changes resulting from biological, physical, and chemical variables such as greenhouse gas emissions and land use changes. Emission pathway scenarios are developed to understand what emission limits are needed to meet climate stabilization points, such as avoiding a 2-degree rise in surface temperature.

Parts per million (ppm): A ratio-based measure of the concentration of greenhouse gases in the atmosphere. Carbon dioxide is usually measured in parts per million; in 2007 the atmospheric concentration of carbon dioxide passed 384 ppm, an increase of more than 100 ppm since 1750. Other less widespread greenhouse gases may be measured in parts per billion or parts per trillion.

Peak date: The year that atmospheric concentrations of greenhouse gases must stop growing and begin declining if a given target concentration is to be achieved.

Reducing emissions from deforestation and degradation (REDD): A policy that aims to reduce greenhouse gas emissions from deforestation and forest degradation. In principle, REDD provides financial incentives for countries to maintain and preserve forestlands as carbon sinks rather than cutting them down. In December 2007, climate change negotiators in Bali agreed to consider including REDD as part of a new climate change agreement.

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Resilience: The ability of natural or human systems to survive in the face of great change. To be resilient, a system must be able to adapt to changing circumstances and develop new ways to thrive. In ecological terms, resilience has been used to describe the ability of natural systems to return to equilibrium after adapting to changes. In climate change, resilience can also convey the capacity and ability of society to make necessary adaptations to a changing world—and not necessarily structures that will carry forward the status quo. In this perspective, resilience affords an opportunity to make systemic changes during adaptation, such as addressing social inequalities.

Sink: An activity, mechanism, or process that removes greenhouse gases, their precursors, or other small aerosols from the atmosphere. Removals typically occur in forests (which remove carbon dioxide from the atmosphere during photosynthesis), soils, and oceans.

Stabilization: The point at which the climate is stable and not undergoing additional systemic changes. Often discussed as carbon dioxide stabilization and measured as concentration of carbon dioxide in the atmosphere.

Surface temperature (global): An estimate of the average surface air temperature across the globe. When estimating climate change over time, only abnormal changes to the mean surface temperature—not daily, seasonal, or other common variations—are measured. Global surface temperature is most commonly expressed as a combination of land and sea temperature.

Technology transfer: The flow of knowledge, equipment, and resources among stakeholders that helps countries, communities, firms, or other entities adapt to or mitigate climate change.

UNFCCC: United Nations Framework Convention on Climate Change. Adopted on 9 May 1992 and signed at the Rio de Janeiro Earth Summit, the convention established general principles to stabilize greenhouse gas concentrations and prevent dangerous human-caused interference with the climate system. The treaty includes requirements such as preparing national inventories of GHG emissions and a commitment to reduce emissions to 1990 levels. The convention has nearly universal membership, with more than 190 signatory countries.

Vulnerability: The degree to which an ecosystem or society faces survival risks due to adverse climate changes. Vulnerability includes susceptibility as well as the ability to adapt. The level of vulnerability determines whether an ecosystem or society can be resilient in the face of climate change.

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Additional Information

Intergovernmental Panel on Climate Change: www.ipcc.ch

United Nations Environment Programme: www.unep.org/themes/climatechange

United Nations Framework Convention on Climate Change: www.unfccc.int

Carbon Dioxide Information Analysis Center: cdiac.ornl.gov/faq.html