# Water quality

Water quality generally refers to condition of water, including physical, chemical and biological characteristics.

Water quality is assessed using the various factors

Concentration of dissolved oxygen
Bacteria levels
Amount of salt (salinity)
Amount of material suspended in the water (turbidity)
Concentration of microscopic algae
Heavy metals concentration

# Water quality: challenges

Water is key resource for sustenance and survival of life cycle on earth. However, water quality is continuously deteriorating in both developed and developing countries.

Globally, at least 4 billion people do not have access to safe drinking water.

This count in south Asian region alone is 1.7 billion.

In 2015, 1.8 million people died from diseases related to water pollution.

The number of dead zones in the world’s coastal oceans has increased almost exponentially, from 49 in the 1960s to 405 in 2008, covering 245,000 $km^2$.

# Water quality: challenges

**54%**
of India
Faces
**High** to
**Extremely**
**High**
Water Stress

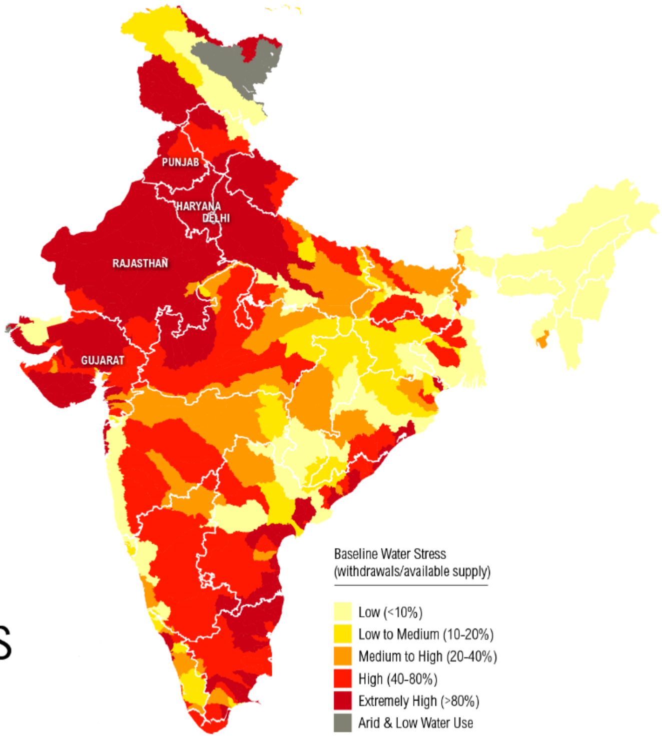


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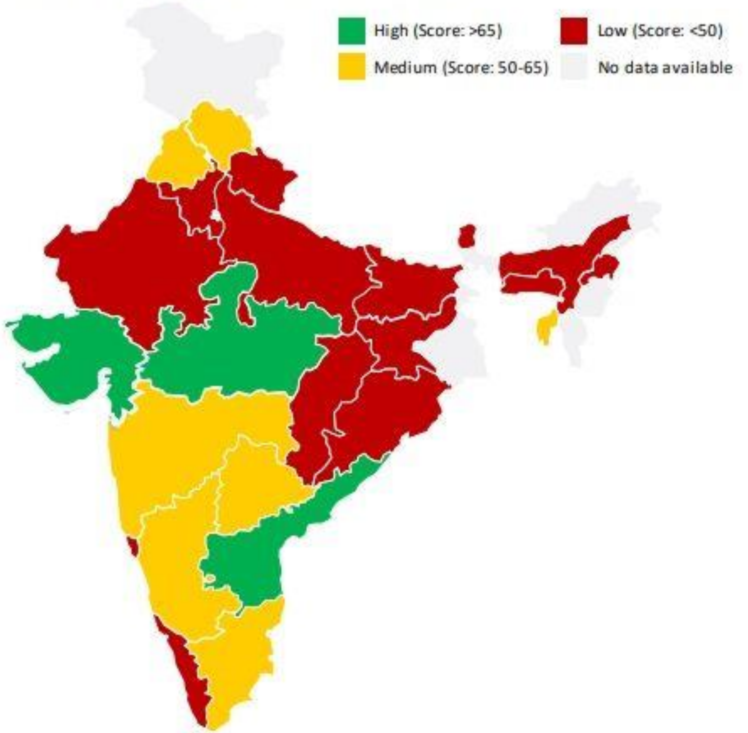
**Figure 2: High-, medium-, and low-performing states on water resource management**
*Classification according to Composite Water Index Scores (FY 16-17)*



# Water quality: management

Water sampling

Physical and chemical analysis

Biological analysis

Hydrological analysis

Sediment analysis

Management of water resources

# Water sampling

**Depth-integrated**: Equal parts of water are collected at predetermined depth intervals between the surface and the bottom.

**Area-integrated**: Samples taken at various sampling points spatially distributed in the water body (at one depth or at predetermined depth intervals).

**Time-integrated**: Water collected at a sampling station at regular time intervals.

**Discharge-integrated**: Samples are at regular intervals over the period of interest at a particular rate of discharge.

# Physical and chemical analysis

**pH value**: Water from different sources can have a pH value ranging from 5.0 to 8.5.

**Biological oxygen demand (BOD)**: It defines the requirement of the oxygen necessary for the aerobic activities of the micro-organism.

**Chemical oxygen demand (BOD)**: It is the estimate of oxygen required for the portion of organic matter in wastewater that is subjected to oxidation.

**Color**: Pure water is colorless. Colored water can indicate pollution or organic substances.

**Turbidity**: Pure water is clear and does not absorb light. Turbidity may be an indication of water pollution.

# Physical and chemical analysis

**Taste and odor**: Pure water is always tasteless and odorless. Presence of taste or smell may indicate water pollution.

**Temperature**: Temperature is not directly used to evaluate whether water is drinkable or not. However, in natural water systems like lakes and rivers, the temperature is a significant physical factor that determines water quality.

**Solids**: Amount of solids dissolved in the water directly influences the water quality. If the dissolved solids in the water exceed 300 mg/l, it adversely affects living organisms.

# Biological analysis

The principal risk associated with water supplies is that of infectious disease. Bacterial analysis such as *total coliforms*, or *Fecal streptococci* can give an estimate of pathogens in the water.

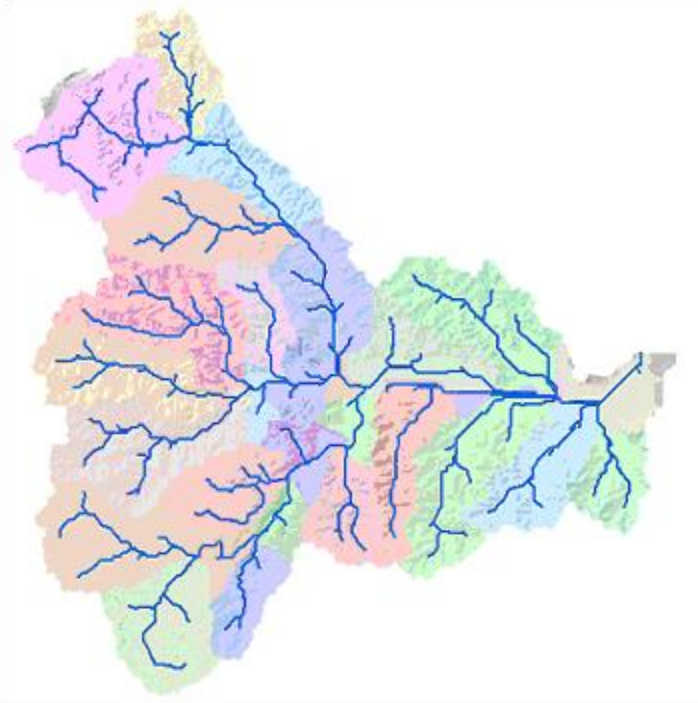
Changes in the physical and chemical nature of freshwaters (both artificial or natural) can produce diverse biological effects ranging from the severe (such as a total fish kill) to the subtle (for example changes in enzyme levels or sub-cellular components of organisms).

The reactions of individual organisms, such as behavioral, physiological or morphological changes, can also be studied as responses to stress or
adverse stimuli.

# Hydrological analysis

Variations in hydrological conditions have important effects on water quality. In rivers, such factors as the discharge, the velocity of flow, turbulence, and depth will influence water quality.

In case of groundwater, hydrogeological conditions of water-bearing rocks or aquifers have a significant influence on the quality of water.



# Sediment analysis

Sediments play an important role in elemental cycling in the aquatic environment. They are responsible for transporting a significant proportion of many nutrients and contaminants. They also mediate their uptake, storage, release and transfer between environmental compartments.

Most sediment in surface waters derives from surface erosion and comprises a mineral component, arising from the erosion of bedrock, and an organic component arising during soil-forming processes.

Organic component may be added by biological activity within the water body.

For the purposes of aquatic monitoring, sediment can be classified as deposited or suspended.

# Management of water resources

This refers to "equitable and efficient management and sustainable use of water and recognizes that water is an integral part of the ecosystem, a natural resource, and a social and economic good, whose quantity and quality determine the nature of its utilization" (UN) or "process of planning, developing, and managing water resources, in terms of both water quantity and quality, across all water uses" (World Bank).

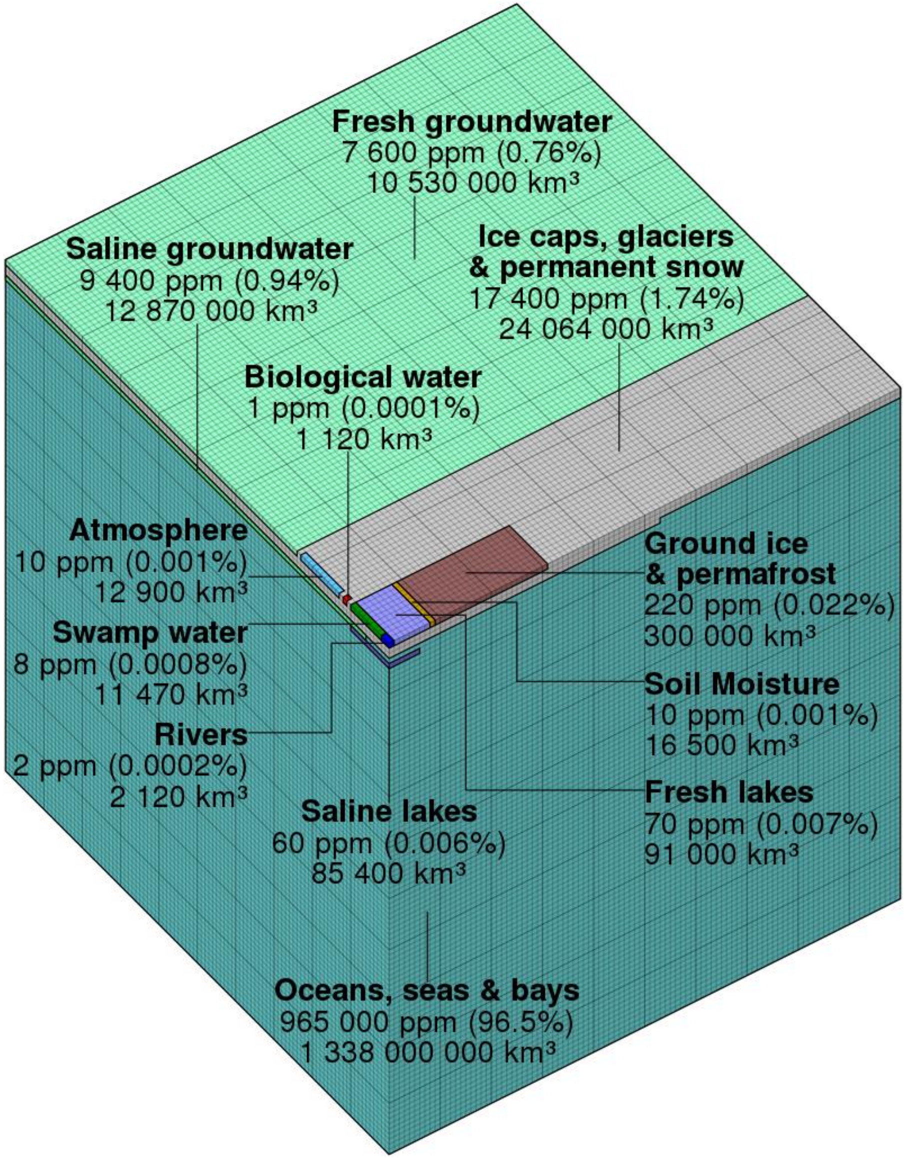
Water resources management seeks to harness the benefits of water by ensuring there is sufficient water of adequate quality for drinking water and sanitation services, food production, energy generation, inland water transport, and water-based recreational, as well as sustaining healthy water-dependent ecosystems and protecting the aesthetic and spiritual values of lakes, rivers, and estuaries (WB).

# Water conservation

World will face a 40% shortfall between forecast demand and available supply of water by 2030.

Feeding 9 billion people by 2050 will require a 60% increase in agricultural production, (which consumes 70% of the resource today).

Climate change will worsen the situation by altering hydrological cycles, making water more unpredictable and increasing the frequency and intensity of floods and droughts.



# Water conservation

Water conservation refers to the careful use and preservation of water supply.

**Decreasing run-off losses**: Large amount of water loss occurs due the water runoff. This can be prevented by enabling the infiltration of water in soil or ground. Run off loss can be prevented by

(a) Contour cultivation: Creating small furrows and ridges across the slopes

(b) Bench terracing: It involves construction of a series of benches.

(c) Water spreading: It is done by channeling or lagoon-levelling.

**Reducing evaporation losses**: Evaporation losses can be controlled via a variety of physical, chemical or biological methods such as Shade cloth, chemical monolayers or aquatic plants such as lily etc.

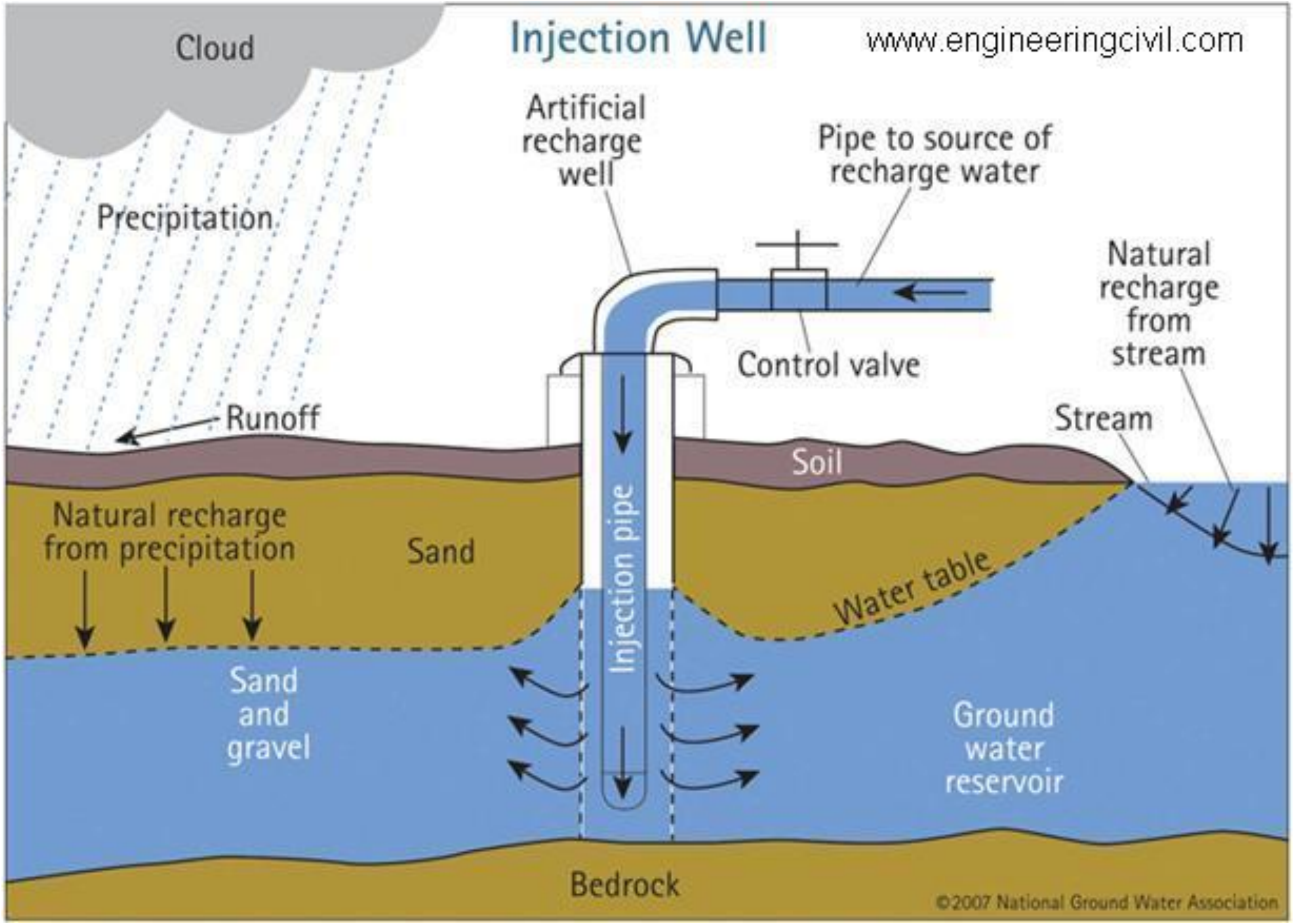
# Water conservation

**Storing water**: Creation of non-natural reservoirs can be an effective method to harvest the rain water.

**Reducing irrigation losses**: (a) Use of lined or covered canals to reduce seepage, (b) Irrigation in early morning or late evening to reduce evaporation losses, (c) Sprinkling irrigation and drip irrigation to conserve water by 30-50%, (d) Growing hybrid crop varieties with less water requirements and tolerance to saline water help conserve water, or (e) Leave some ground idle and apply the saved water to high- value crops.

**Reuse of water**: (a) Treated wastewater can be used for ferti-irrigation, or (b) Using grey water from washings, bath-tubs etc. for watering gardens, washing cars or paths help in saving fresh water.

# Artificial recharge of groundwater



# Rain water harvesting

# Montreal protocol

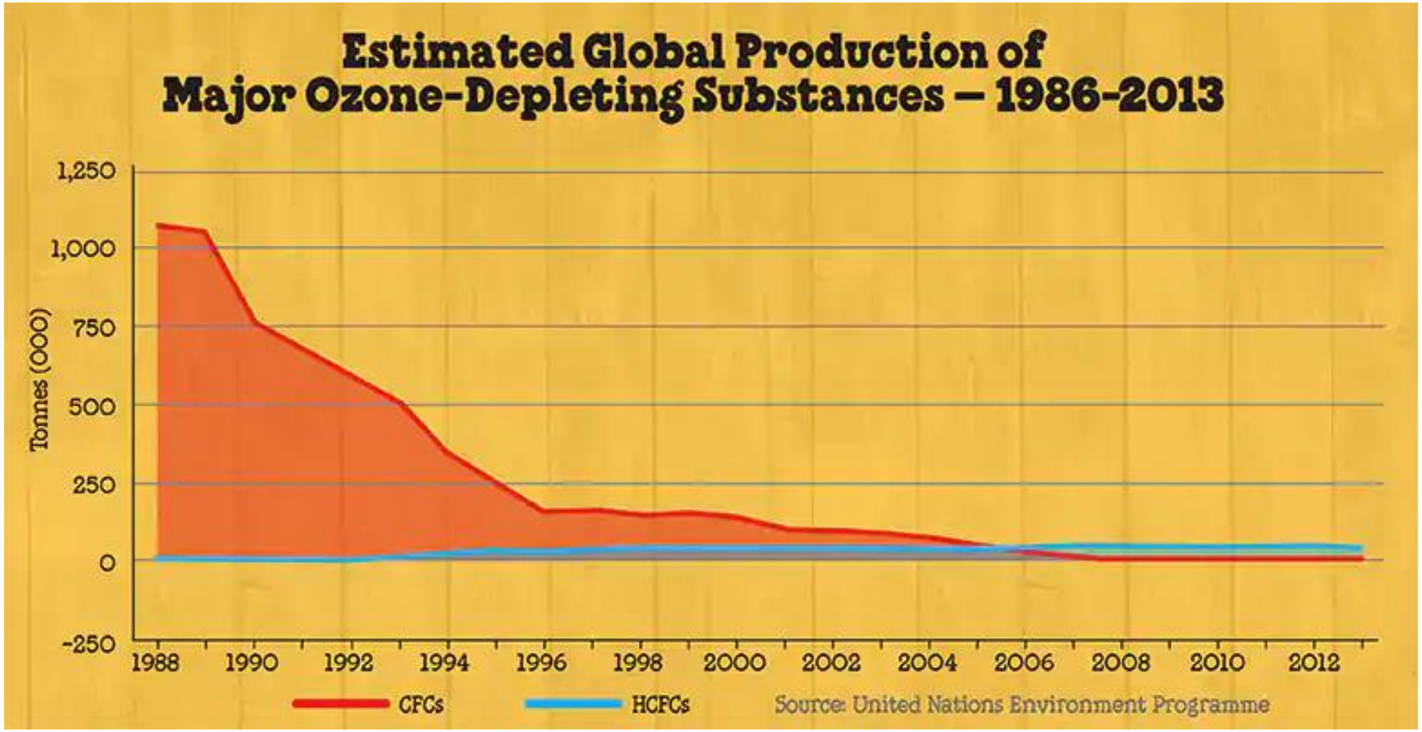
The Montreal Protocol is an environmental agreement that regulates the production and consumption of nearly 100 man-made chemicals referred to as ozone depleting substances (ODS).

It was adopted on 15 September 1987 and entered into force on 26 August 1989.

Montreal Protocol is the only UN treaty ever that has been ratified every country on Earth - all 197 UN Member States.

It has undergone nine revisions, in 1990 (London), 1991 (Nairobi), 1992 (Copenhagen), 1993 (Bangkok), 1995 (Vienna), 1997 (Montreal), 1998 (Australia), 1999 (Beijing) and 2016 (Kigali).

# Montreal protocol



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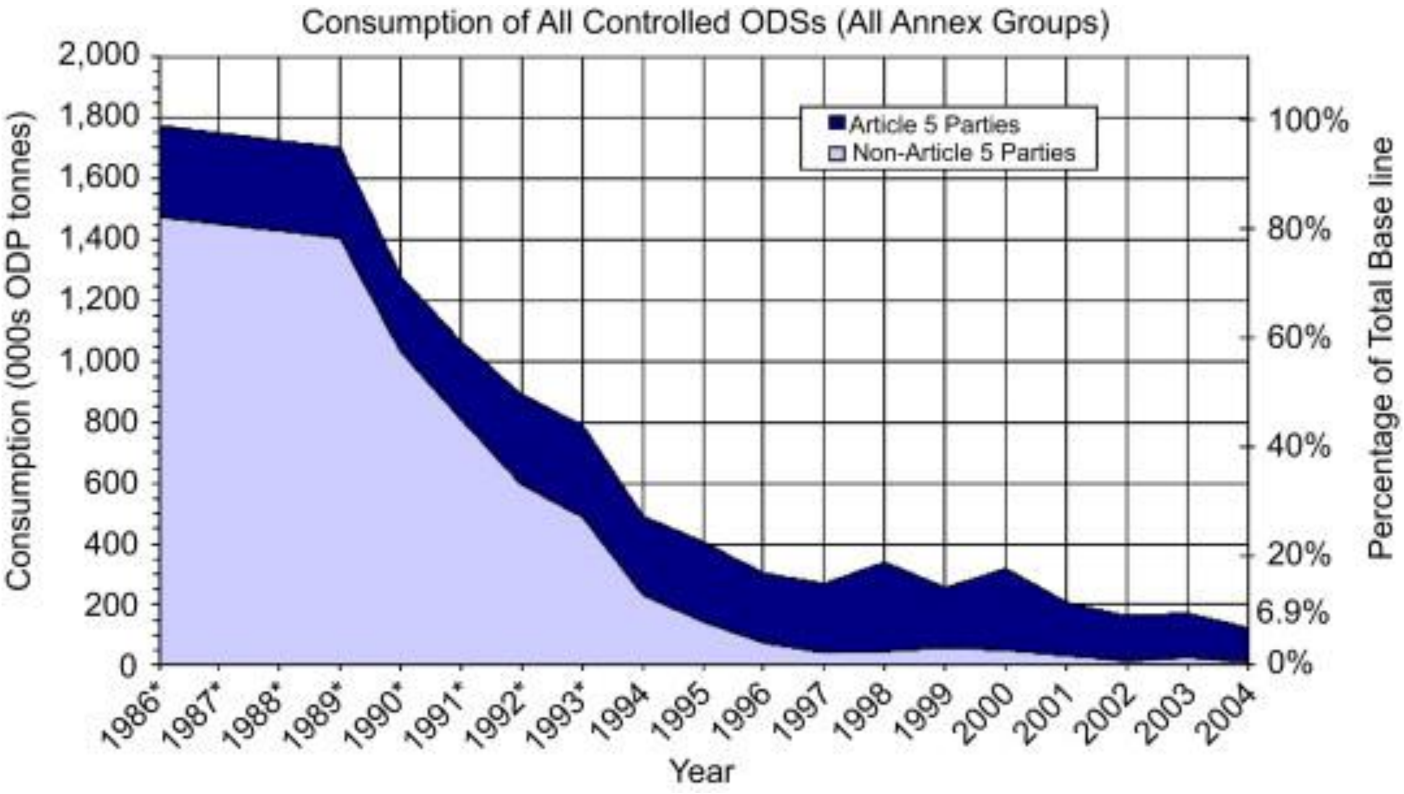

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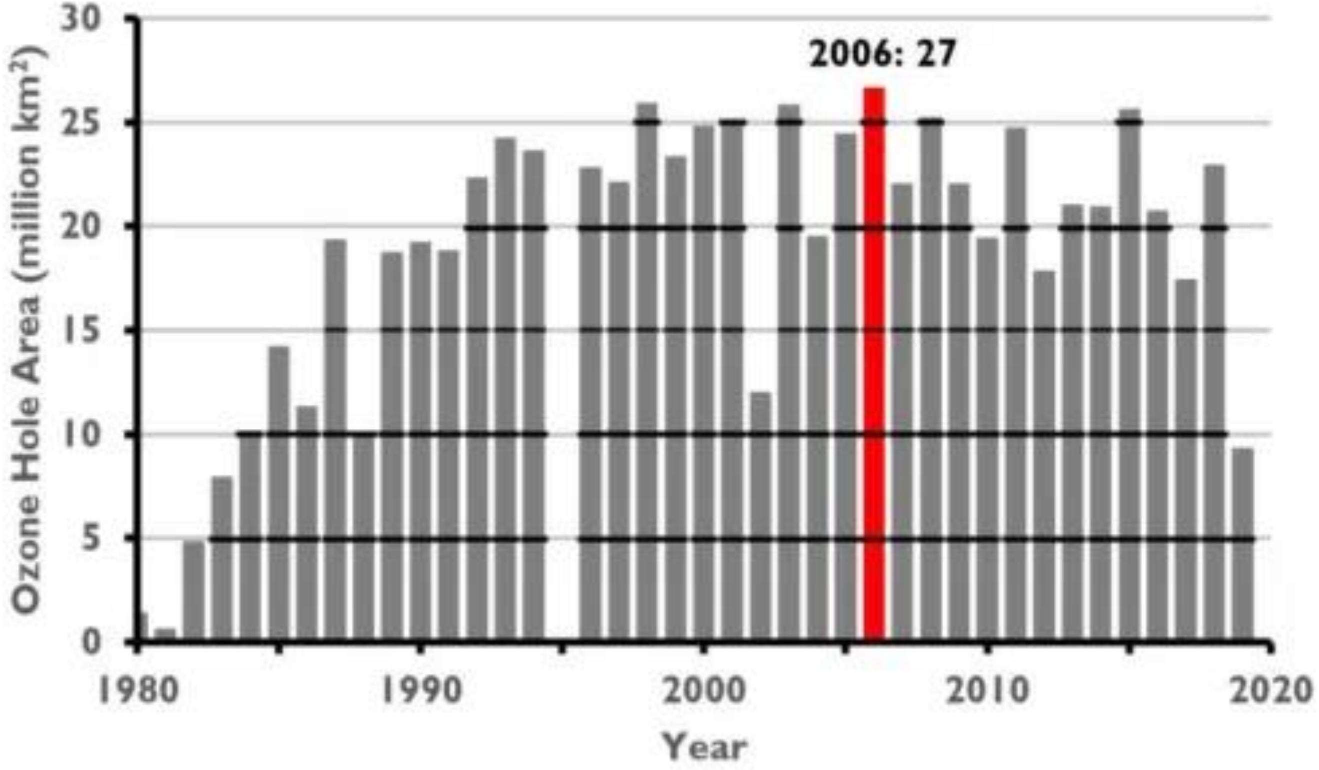


# Kyoto protocol

The Kyoto Protocol is an international agreement that aimed to reduce carbon dioxide (CO2) emissions and the presence of greenhouse gases (GHG) in the atmosphere. The essential tenet of the Kyoto Protocol was that industrialized nations needed to lessen the amount of their CO2 emissions.

The Kyoto Protocol was enacted by the United Nations Framework Convention on Climate Change (UNFCCC), in 1997 and entered into force on 16 February 2005.

As of 2012, 37 countries have signed and ratified the treaty and 191 states are participating and there are 28 articles in the Kyoto Protocol.

# Kyoto protocol

Some important articles in Kyoto protocol:

**Article 2**: Addresses emissions from fuel used for international aviation and maritime transport and encourages developed countries to pursue limited or reduced emissions from these sources.

**Article 3**: Allows developed countries to meet their targets by providing carbon sinks or removals of carbon through various forest and land management practices that are measured as changes in carbon stocks.

**Article 6**: Empower and educate stakeholders on policies related to climate change (Awareness).

# Kyoto protocol

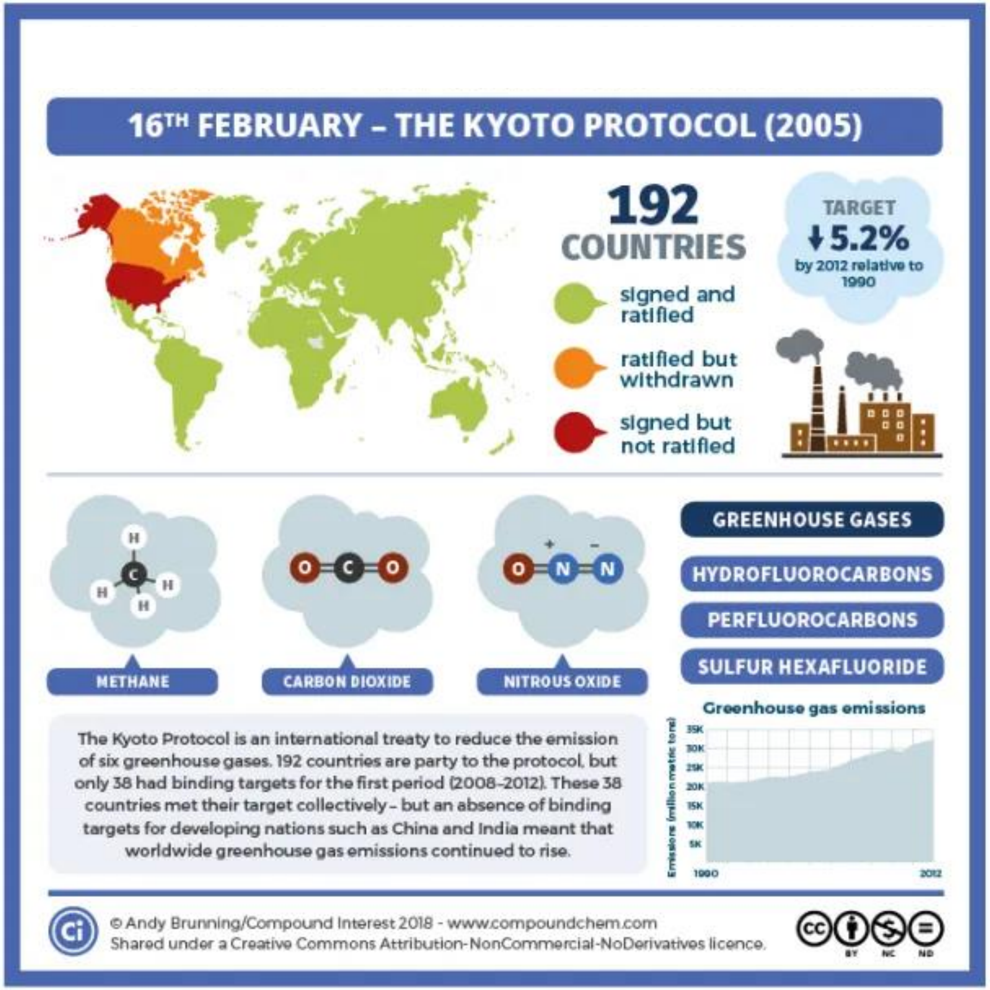
**Article 10**: Participating parties to cooperate in the promotion, development, transfer of and access to environmentally sound technologies, particularly to developing countries.

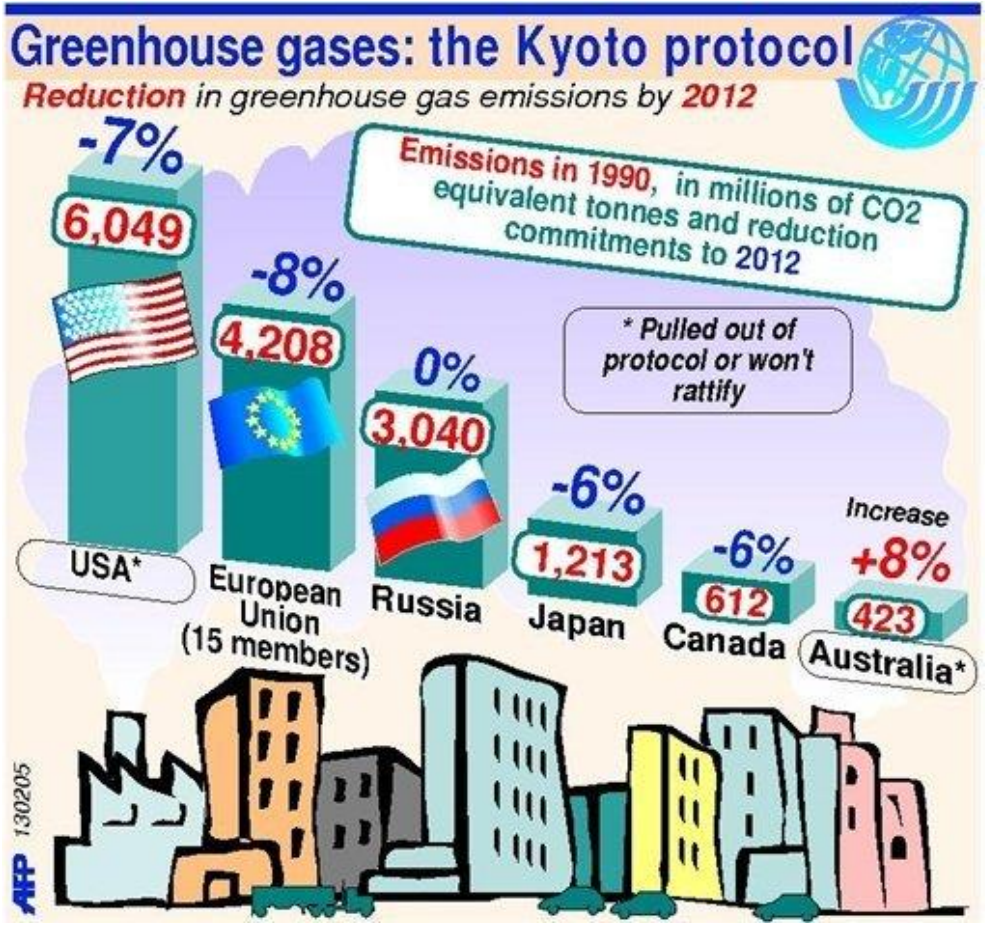
**Article 10e**: Fosters international cooperation and provides mechanisms for countries to meet their emission reduction targets in cost-effective ways.

**Article 11**: Recognizes the need for funding mechanisms to assist developing countries in technology transfer.

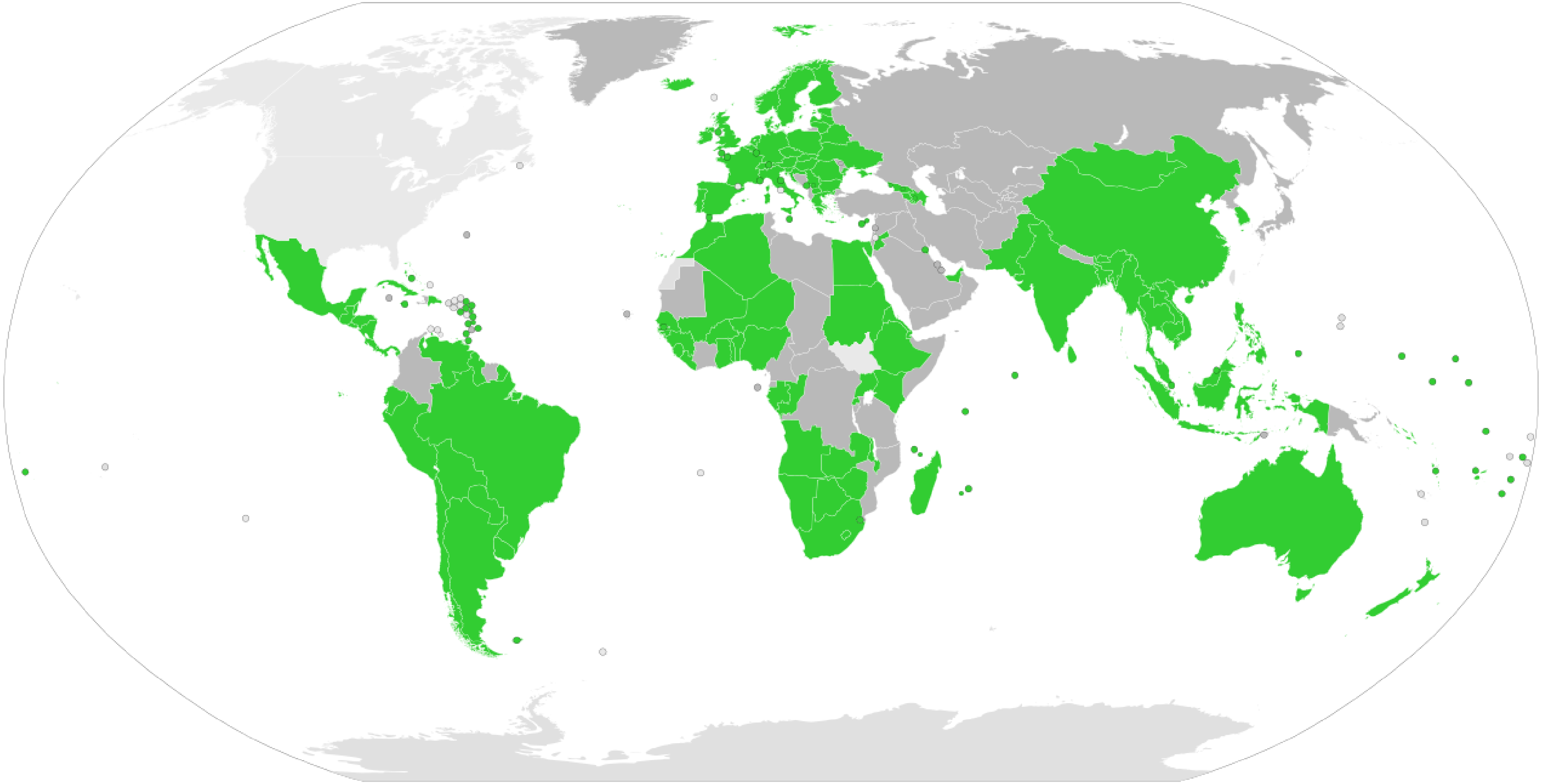
The Kyoto protocol didn't meet targeted emission reductions but increased awareness and international cooperation toward resolving the global climate crisis.

# Kyoto protocol



# Kyoto protocol



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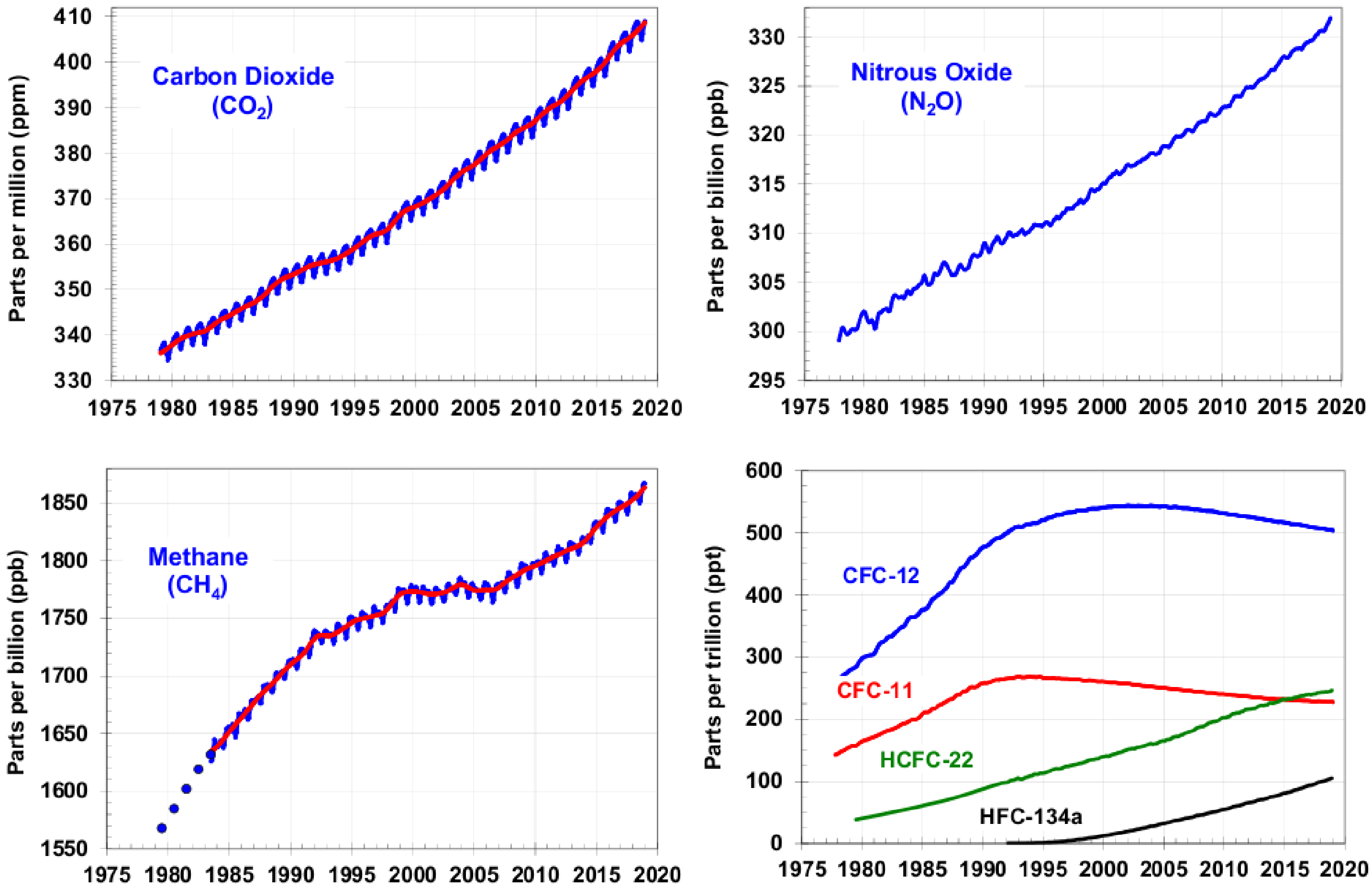

# Carbon sequestration

Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide.

Carbon sequestration secures carbon dioxide to prevent it from entering the Earth's atmosphere.

Carbon sequestration has drawn interest due to growing concerns about climatic change resulting from increased $CO_2$ concentrations in the atmosphere.

Carbon sequestration can occur naturally or artificially. Carbon can be stored biologically, geologically or technologically.

# Biological sequestration

Biological carbon sequestration is the storage of carbon dioxide in vegetation such as grasslands or forests, as well as in soils and oceans.

About 25% of our carbon emissions have historically been captured by Earth’s forests, farms and grasslands.

Nearly 30% of the carbon dioxide emitted from burning fossils fuels is absorbed by the upper layer of the ocean. This increases water acidity, and have adverse effect on the aquatic life.

Carbon is sequestered in soil by plants through photosynthesis and can be stored as soil organic carbon (SOC).

Soil can also store carbon as carbonates.

# Geological sequestration

Geological storage involves capturing anthropogenic $CO_2$ before it enters the atmosphere and injecting it into underground formations. Once $CO_2$ is injected deep underground (more than 800 meters.) its trapped in minute pores or spaces in the rock structure. Water resistant cap rocks above the storage zones act as seals to ensure the safe storage of $CO_2$.

Carbon dioxide can be captured from stationary sources, such as power plants and other large industrial facilities, compressed to a fluid state, and injected deep underground into permeable and porous geologic strata in which it will remain isolated for long periods of time.

# Technological sequestration

Scientists are exploring new ways to remove and store carbon from the atmosphere using innovative technologies.

**Graphene production**: The use of carbon dioxide as a raw material to produce graphene, a technological material. Graphene is used to create screens for smart phones and other tech devices.

**Direct air capture (DAC)**: A means by which to capture carbon directly from the air using advanced technology plants. However, this process is energy intensive and expensive, ranging from $500-$800 per ton of carbon removed.

**Engineered molecules**: engineered molecules act as a filter, only attracting the element it was engineered to seek. Thus, enabling effective singling out and capturing carbon dioxide from the air.

# Effect of climate change on lives on earth

Global climate is projected to continue to change over this century and beyond. The magnitude of climate change beyond the next few decades depends primarily on the amount of heat-trapping gases emitted globally, and how sensitive the Earth’s climate is to those emissions.

The Intergovernmental Panel on Climate Change (IPCC), which includes more than 1,300 scientists from across the world, forecasts a temperature rise of 2.5 to 10 degrees Fahrenheit over the next century.

Extreme weather is another effect of global warming. While experiencing some of the hottest summers on record, world is also been experiencing colder-than-normal winters.

# Effect of climate change on lives on earth

One of the primary manifestations of climate change so far is melt. North America, Europe and Asia have all seen a trend toward less snow cover between 1960 and 2015.

One of the most dramatic effects of global warming is the reduction in Arctic sea ice. Sea ice hit record-low extents in both the fall and winter of 2015.

Glacial retreat, too, is an obvious effect of global warming. Over the last 25 years, Gangotri glacier has retreated more than 850 meters, with a recession of 76 meters from 1996 to 1999 alone.

# Effect of climate change on lives on earth

In general, as ice melts, sea levels rise. In 2014, the World Meteorological Organization reported that sea-level rise accelerated 0.12 inches (3 millimeters) per year on average worldwide. This is around double the average annual rise of 0.07 in. (1.6 mm) in the 20th century. Global sea levels have risen about 8 inches since 1870.

Many species of plants and animals are already moving their range northward or to higher altitudes as a result of warming temperatures.

Migratory birds and insects are now arriving in their summer feeding and nesting grounds several days or weeks earlier than they did in the 20th century.

The combined impacts of drought, severe weather, lack of accumulated snowmelt, greater number and diversity of pests, lower groundwater tables and a loss of arable land could cause severe crop failures and livestock shortages worldwide.

# Carbon credit

Carbon credit is a permit that allows the bearer that holds it to emit a certain amount of carbon dioxide or other greenhouse gases.

Carbon credits were devised as a market-oriented mechanism to reduce greenhouse gas emissions. Companies get a set number of credits, which decline over time. They can sell any excess to another company.
Thus, "cap-and-trade" is an incentive to reduce emissions.

There are two types of carbon credits:
**Voluntary emissions reduction (VER)**: A carbon offset that is exchanged in the over-the-counter or voluntary market for credits.

**Certified emissions reduction (CER)**: Emission units (or credits) created through a regulatory framework with the purpose of offsetting a project’s emissions.

# Carbon credit market

Under Joint Implementation (JI) a developed country with relatively high costs of domestic greenhouse reduction would set up a project in another developed country.

Under the Clean Development Mechanism (CDM) a developed country can 'sponsor' a greenhouse gas reduction project in a developing country where the cost of greenhouse gas reduction project activities is usually much lower, but the atmospheric effect is globally equivalent. The developed country would be given credits for meeting its emission reduction targets, while the developing country would receive the capital investment and clean technology or beneficial change in land use.

Under International Emissions Trading (IET) countries can trade in the international carbon credit market to cover their shortfall in assigned amount units. Countries with surplus units can sell them to countries that are exceeding their emission targets under Annexure- B of the Kyoto Protocol.

# Carbon audit

A means of measuring and recording $CO_2$ emission of an organization also known as Carbon Footprint. Carbon audit is the first step to develop a Carbon Strategy (necessary for steel & car manufacturer). A carbon strategy is a long term action plan to manage and reduce the carbon emission of an organization and its clients.

For an organization carbon footprint can be of two types:

**Core footprint**: It includes power consumption (e.g., electricity, oil or natural gas) or transport (fueled transport).

**Wider footprint**: It includes materials (waste and recycling), carbon footprint in supply chain, and on the employee ends.