

Climate Mitigation Strategies, Global Measures, India's Role

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Climate change mitigation refers to the actions taken to reduce or prevent the emission of greenhouse gases (GHGs) and enhance activities that remove these gases from the atmosphere. It is one of the two primary responses to climate change, the other being adaptation.

The global framework for mitigation is guided by the **United Nations Framework Convention on Climate Change (UNFCCC)**, whose ultimate objective is to stabilize greenhouse gas concentrations at a level that prevents dangerous human interference with the climate system.

Strategies to Mitigate Climate Change

Climate change mitigation strategies focus on reducing greenhouse gas emissions and enhancing natural systems that absorb carbon. These strategies combine technological innovation, policy mechanisms, and sustainable practices to limit global warming. Effective mitigation requires coordinated efforts at local, national, and global levels.

1. Carbon Sequestration

Carbon sequestration involves capturing and storing carbon dioxide from the atmosphere to reduce its concentration and slow **global warming**. It can be achieved through both natural processes and advanced technologies.

- Natural sequestration occurs through forests, soils, and oceans absorbing carbon
- Biochar application in soil enhances long-term carbon storage
- Direct Air Capture (DAC) technology removes CO₂ directly from ambient air
- Helps in achieving long-term climate goals like net-zero emissions
- Reduces the carbon footprint of heavy industries like cement and steel
- **Depleted oil and gas fields** can be used to store captured CO₂ safely underground
- **Saline aquifers (deep underground saltwater reservoirs)** are among the largest potential storage sites
- **Unmineable coal seams** can store CO₂ while enhancing methane recovery
- **Barren and degraded lands** can be converted into carbon sinks through afforestation and soil restoration
- **Basalt rock formations** can mineralize CO₂ into stable carbonates for permanent storage

2. Carbon Sink

A carbon sink is any system that absorbs more carbon than it emits, playing a crucial role in regulating atmospheric CO₂ levels. Strengthening carbon sinks is essential for long-term climate stability.

- Forests act as major carbon sinks through photosynthesis
- Oceans absorb nearly 25-30% of global CO₂ emissions
- **"Blue carbon"** ecosystems (mangroves, seagrasses, salt marshes) store large carbon reserves
- **Soil carbon** storage can be enhanced through sustainable agricultural practices
- Urban green spaces also contribute to carbon absorption
- Conservation and restoration of ecosystems increase sink capacity
- Climate change can weaken sinks (e.g., forest fires, ocean warming)

3. Carbon Credit

Carbon credits are market-based instruments that allow countries or companies to trade emission allowances. They promote cost-effective emission reduction through economic incentives.

- 1 Carbon Credit = Permission to emit 1 tonne of CO₂ or equivalent greenhouse gases
- Based on the **cap-and-trade mechanism** where emission limits are fixed
- Originated under the Kyoto Protocol through mechanisms like Clean Development Mechanism (CDM)
- Further strengthened under the Paris Agreement which promotes global carbon markets (Article 6)
- Governments allocate emission caps to industries and sectors
- Companies emitting less can **sell surplus credits** in the carbon market
- Companies exceeding limits must **buy additional credits**, ensuring accountability
- Encourages adoption of **renewable energy and cleaner technologies**
- Facilitates **international cooperation** in emission reduction

- Helps in achieving long-term goals like **net-zero emissions**
- Requires strong **Monitoring, Reporting, and Verification (MRV)** systems
- Criticism includes risks of **greenwashing, double counting, and inequitable benefits**

4. Carbon Offsetting

Carbon offsetting allows individuals or organizations to compensate for their emissions by investing in environmental projects elsewhere. It is widely used by businesses to achieve carbon neutrality.

- Funds projects like afforestation, renewable energy, and clean cooking solutions
- Helps balance unavoidable emissions
- Must meet criteria like additionality, permanence, and no leakage
- Promotes sustainable development in developing regions
- Supports community development and job creation
- Easy to implement compared to structural emission reductions
- Criticism includes lack of transparency and over-reliance

5. Carbon Tax

Carbon tax is a market-based policy instrument that imposes a direct fee on carbon emissions to reduce the use of fossil fuels. It follows the “**polluter pays principle**” by making emitters financially responsible for their emissions. This encourages a shift toward cleaner energy and sustainable practices.

- Encourages industries and consumers to **reduce emissions** and adopt cleaner alternatives
- Provides **government revenue** that can be invested in renewable energy and climate adaptation
- Helps internalize environmental costs into economic decision-making
- Can be introduced gradually to allow industries time to transition
- The European Union has implemented strong carbon pricing mechanisms under its Emissions Trading System (EU ETS)
- The EU is also introducing the **Carbon Border Adjustment Mechanism (CBAM)** to impose carbon costs on imports from countries with weaker climate policies
- Countries like Sweden, Canada, and France have successfully implemented carbon taxes
- Carbon tax helps reduce dependence on fossil fuels and promotes **green innovation**
- Can impact low-income groups if not designed with equity measures (like subsidies or rebates)

6. Geo-Engineering

Geo-engineering refers to large-scale, deliberate interventions in the Earth’s climate system aimed at reducing global warming. It is considered a supplementary or last-resort strategy when mitigation efforts are insufficient.

The techniques of geo-engineering are broadly divided into two categories:

- Carbon Dioxide Removal (CDR)
- Solar Radiation Management (SRM)

Carbon Dioxide Removal (CDR) Techniques:

- **Afforestation and Reforestation** – Planting trees to absorb CO₂ naturally
- **Direct Air Capture (DAC)** – Machines that extract CO₂ directly from the atmosphere
- **Bioenergy with Carbon Capture and Storage (BECCS)** – Biomass energy generation with CO₂ capture and storage
- **Ocean Fertilization** – Adding nutrients (like iron) to oceans to stimulate phytoplankton growth that absorbs CO₂
- **Enhanced Weathering** – Spreading minerals (like basalt) to accelerate natural carbon absorption
- **Soil Carbon Sequestration** – Improving agricultural practices to increase carbon storage in soil

Solar Radiation Management (SRM) Techniques:

- **Stratospheric Aerosol Injection** – Spraying sulphate aerosols into the atmosphere to reflect sunlight
- **Marine Cloud Brightening** – Increasing cloud reflectivity over oceans
- **Space-based Reflectors/Mirrors** – Placing mirrors in space to deflect solar radiation
- **Surface Albedo Modification** – Whitening roofs, roads, and urban surfaces to reflect more sunlight
- **Cirrus Cloud Thinning** – Reducing heat-trapping high-altitude clouds

Global Measures to Curb Greenhouse Gas Emissions

Global initiatives to reduce greenhouse gas (GHG) emissions involve coordinated international agreements, scientific bodies, and policy frameworks. These efforts aim to limit global warming, promote sustainable development, and ensure collective climate action across nations.

- **Intergovernmental Panel on Climate Change (IPCC):** Established in 1988 by WMO and UNEP; provides periodic scientific assessments on climate change, impacts, risks, and mitigation/adaptation options; releases Assessment Reports guiding global policy.
- **United Nations Framework Convention on Climate Change (UNFCCC):** Signed in 1992, enforced in 1994; aims to stabilize GHG concentrations; based on CBDR principle; organizes annual COP meetings; foundation for global climate agreements.
- **Kyoto Protocol (KP):** Adopted in 1997 (COP3), enforced in 2005; legally binding targets for developed nations; aimed at 5% emission reduction from 1990 levels (2008–2012); introduced CDM, JI, and emission trading mechanisms.
- **Kyoto Greenhouse Gases:** Covers CO₂, CH₄, N₂O, HFCs, PFCs, and SF₆ as major gases targeted for reduction.
- **Paris Agreement:** Adopted in 2015 (COP21); aims to limit warming below 2°C and pursue 1.5°C; applies to all countries; introduces NDCs, global stocktake every 5 years, climate finance, and net-zero goals by mid-century.
- **Green Climate Fund (GCF):** Supports climate mitigation and adaptation projects in developing countries; established under UNFCCC; aims to mobilize \$100 billion annually; funds renewable energy, resilience, and low-carbon development.
- **REDD+:** Focuses on reducing emissions from deforestation and forest degradation; promotes conservation, sustainable forest management, and enhancement of forest carbon stocks; provides financial incentives to

developing countries.

- **International Solar Alliance (ISA):** Launched by India and France; promotes solar energy deployment in tropical countries; aims to reduce dependence on fossil fuels and improve energy access.
- **Global Methane Pledge:** Launched in 2021; aims to reduce global methane emissions by at least 30% by 2030 from 2020 levels; focuses on energy, agriculture, and waste sectors.
- **Mission Innovation:** Global initiative to accelerate research, development, and deployment of clean energy technologies; encourages public-private collaboration; aims to make clean energy affordable and accessible.

India's Measures to Curb Greenhouse Gas Emissions

- **National Action Plan on Climate Change (NAPCC):** Launched in 2008; comprehensive climate policy framework; includes 8 National Missions like Solar Mission and Green India Mission; integrates mitigation and adaptation; promotes sustainable development and state-level action plans (SAPCCs).
- **LiFE Mission:** Launched at COP26 (2021); promotes sustainable lifestyle and behavioral changes; focuses on resource conservation and circular economy; encourages global mass movement for climate action.
- **Panchamrit Targets:** Announced at COP26 (Glasgow, 2021); includes 500 GW non-fossil capacity by 2030; 50% energy from renewables; reduction of 1 billion tonnes of emissions; 45% reduction in carbon intensity; net-zero target by 2070; aligned with Paris Agreement commitments.

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