

Introduction to Climate Change

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Key concepts, causes, impacts, and responses

1. What Is Climate Change?

Term	Definition
Climate	Long-term (30+ years) average of temperature, precipitation, wind, etc., for a region.
Weather	Short-term atmospheric conditions (hours to days).
Climate Change	A statistically significant alteration in the mean state of the climate or its variability, persisting for decades or longer.
Global Warming	The observed increase in Earth's average surface temperature, primarily due to human-driven greenhouse gas (GHG) emissions.

Bottom line: Climate change includes global warming *and* changes in precipitation patterns, extreme-event frequency, sea-level rise, and ecosystem shifts.

2. The Science Behind Climate Change

2.1 The Greenhouse Effect

1. **Solar radiation** reaches Earth – some is reflected, most is absorbed.
2. **Surface emits infrared (IR) radiation** back toward space.
3. **Greenhouse gases (GHGs)** (CO₂, CH₄, N₂O, water vapor, etc.) absorb and re-emit IR, trapping heat.
4. **Result:** Average surface temperature ~33°C warmer than it would be without GHGs.

2.2 Radiative Forcing

- **Definition:** Change in the balance between incoming solar radiation and outgoing infrared radiation, measured in watts per square meter (W/m²).
- **Positive forcing** – warming; **negative forcing** – cooling.

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- Key contributors (2023 data):

Gas / Factor	Radiative Forcing ($\text{W}\cdot\text{m}^{-2}$)
CO_2 (current)	+2.1
Methane (CH_4)	+0.5
Nitrous oxide (N_2O)	+0.2
Halocarbons	+0.3
Aerosols (cooling)	-0.4
Land-use change	-0.1

2.3 Climate Feedbacks

Feedback	Direction	Example
Water vapour feedback	Positive	Warmer air holds more water vapor $\rightarrow$ more IR absorption.
Ice albedo feedback	Positive	Melting ice reduces surface reflectivity $\rightarrow$ more solar absorption.
Cloud feedback	Complex (positive & negative)	Changes in cloud cover/type affect both reflection and trapping of radiation.
Carbon cycle feedback	Positive	Warming soils release more CO_2 and CH_4 .

3. Major Sources of Greenhouse Gas Emissions

Sector	Primary GHGs	Representative Sources
Energy	CO_2	Fossil fuel electricity generation, oil & gas extraction.
Industry	CO_2 , N_2O , HFCs	Cement, steel, chemical production, refrigerants.
Transportation	CO_2 , CH_4 (from fuel leakage)	Cars, trucks, aviation, shipping.
Agriculture	CH_4 , N_2O	Enteric fermentation, rice paddies, synthetic fertilizers.

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Sector	Primary GHGs	Representative Sources
Land-Use Change	CO ₂ , CH ₄	Deforestation, peatland drainage.
Waste	CH ₄ , CO ₂	Landfills, wastewater treatment.

*Global share (2022, IPCC AR