



# GHGs, Rainfall and Climate Change

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## Why in News?

A recent study has revealed that unprecedented **increase in [greenhouse gases](#)** can **decrease rainfall** in the **equatorial region**.

- This can further lead to replacement of [India's biodiversity hotspots](#) consisting of [evergreen forests](#) in the [Western Ghats](#), northeast India and the [Andamans](#) into **deciduous forests**.

## What has the Recent Study Revealed?

- **About:**
  - The study pointed out the impacts of **increased greenhouse gases**, specifically high levels of atmospheric **carbon dioxide**, on rainfall patterns and vegetation in equatorial regions.
  - The study used **fossil pollen** (from **Lignite Mine** of Kutch) and **carbon isotope** data from the **Eocene era (54 million years ago, a period of global warming)**.
  - The study used data from **deep time hyperthermal events** that are considered potential analogs for future climate predictions.
    - **Extreme climate warmth (hyperthermal) events** through **deep-time (geological time)** offer insights into how the Earth may respond to present-day warming related to **greenhouse gas emissions**.
- **Impact on Rainfall and Vegetation Shifts:**
  - During the Eocene era, when atmospheric CO<sub>2</sub> concentrations exceeded 1000 parts per million by volume (ppmv) near the equator, there was a significant **decrease in rainfall** which led to increase in **deciduous forests**.
- **Relevance to Current Climate Change:**
  - The study draws parallels between past climatic conditions (Eocene era) and potential future scenarios under **increased greenhouse gas emissions**.
  - Insights from the study may contribute to **strategies for mitigating the impacts of climate change** on rainforests and other sensitive ecosystems.

## What is Previous Evidence of Climate Change?

- Geological records document alternating periods of **glacial and warmer inter-glacial phases**.
- In the distant geological past, approximately **500-300 million years ago** during the **Cambrian, Ordovician, and Silurian periods**, Earth's climate was notably **warmer**.
- During the **Pleistocene epoch**, the Earth underwent cycles of glaciation and interglacial periods, with the last major glacial peak occurring around **18,000 years ago**. The current interglacial period began approximately **10,000 years ago**.
- The most recent glacial period spanned from about **120,000 to 11,500 years ago**. Since then, Earth has been in the interglacial period known as the [Holocene epoch](#).
- In regions with high **altitudes and latitudes**, geological features and sediment deposits bear evidence of the advance and retreat of glaciers indicating fluctuations between **warm and cold periods**.

- **Glacial periods** are characterised as **colder, dustier, and generally drier** compared to interglacial periods. These cycles of glaciation and inter-glacials are discernible in numerous paleoclimate records from both **marine and terrestrial environments** worldwide.
- **Interglacial periods** tend to occur during periods of peak solar radiation in the Northern Hemisphere summer.
- **Indian Context:**
  - India also witnessed alternate **wet and dry periods**.
  - Archaeological findings show that the Rajasthan desert experienced **wet and cool climate** around **8,000 B.C.**
  - In the period **3,000-1,700 B.C.** the region had higher rainfall after which the dry conditions prevailed.



# Geologic Time Scale

| Eon         | Era            | Period                       | Epoch              | MYA  | Life Forms                     |                                                                      |                                                                                               |                        |
|-------------|----------------|------------------------------|--------------------|------|--------------------------------|----------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|------------------------|
| Phanerozoic | Cenozoic (CZ)  | Quaternary (Q)               | Holocene (H)       | 0.01 | Age of Mammals                 | Extinction of large mammals and birds<br>Modern humans               |                                                                                               |                        |
|             |                |                              | Pleistocene (PE)   | 2.6  |                                |                                                                      |                                                                                               |                        |
|             |                | Neogene (N)                  | Pliocene (PL)      | 5.3  |                                | Spread of grassy ecosystems                                          |                                                                                               |                        |
|             |                |                              | Miocene (MI)       | 23.0 |                                |                                                                      |                                                                                               |                        |
|             |                |                              | Oligocene (OL)     | 33.9 |                                |                                                                      |                                                                                               |                        |
|             |                | Paleogene (PG)               | Eocene (E)         | 56.0 |                                | Early primates                                                       |                                                                                               |                        |
|             |                |                              | Paleocene (EP)     | 66.0 |                                |                                                                      |                                                                                               |                        |
|             |                |                              |                    |      |                                |                                                                      |                                                                                               | Mass extinction        |
|             |                | Mesozoic (MZ)                | Cretaceous (K)     |      |                                | 145.0                                                                | Age of Reptiles                                                                               | Placental mammals      |
|             |                |                              |                    |      |                                | 201.3                                                                |                                                                                               | Early flowering plants |
|             | Jurassic (J)   |                              |                    |      | Dinosaurs diverse and abundant |                                                                      |                                                                                               |                        |
|             |                |                              | Triassic (TR)      |      |                                | Mass extinction<br>First dinosaurs; first mammals<br>Flying reptiles |                                                                                               |                        |
|             |                |                              |                    |      |                                | Mass extinction                                                      |                                                                                               |                        |
|             | Paleozoic (PZ) |                              | Permian (P)        |      | 298.9                          | Age of Amphibians                                                    | Coal-forming swamps<br>Sharks abundant<br>First reptiles                                      |                        |
|             |                |                              | Pennsylvanian (PN) |      | 323.2                          |                                                                      |                                                                                               |                        |
|             |                |                              | Mississippian (M)  |      | 358.9                          | Fishes                                                               | Mass extinction<br>First amphibians<br>First forests (evergreens)                             |                        |
|             |                |                              | Devonian (D)       |      | 419.2                          |                                                                      |                                                                                               |                        |
|             |                |                              | Silurian (S)       |      | 443.8                          | Marine Invertebrates                                                 | First land plants<br>Mass extinction<br>Primitive fish<br>Trilobite maximum<br>Rise of corals |                        |
|             |                |                              | Ordovician (O)     |      | 485.4                          |                                                                      | Early shelled organisms                                                                       |                        |
|             |                |                              | Cambrian (C)       |      | 541.0                          |                                                                      |                                                                                               |                        |
|             |                |                              | Proterozoic        |      |                                |                                                                      |                                                                                               |                        |
|             |                |                              |                    |      |                                | Simple multicelled organisms                                         |                                                                                               |                        |
|             |                |                              |                    |      | 2500                           |                                                                      |                                                                                               |                        |
|             |                |                              |                    |      |                                |                                                                      |                                                                                               |                        |
| Archean     |                | Precambrian (PC, W, X, Y, Z) |                    |      |                                | Early bacteria and algae (stromatolites)                             |                                                                                               |                        |
|             |                |                              |                    |      | 4000                           |                                                                      |                                                                                               |                        |
| Hadean      |                |                              |                    |      |                                | Origin of life                                                       |                                                                                               |                        |
|             |                |                              |                    |      | 4600                           | Formation of the Earth                                               |                                                                                               |                        |

## UPSC Civil Services Examination, Previous Year Question (PYQ)

### **Prelims:**

**Q. Human activities in the recent past have caused the increased concentration of carbon dioxide in the atmosphere, but a lot of it does not remain in the lower atmosphere because of ? (2011)**

1. its escape into the outer stratosphere.
2. the photosynthesis by phytoplankton in the oceans.
3. the trapping of air in the polar ice caps.

**Which of the statements given above is/are correct?**

- (a) 1 and 2  
(b) 2 only  
(c) 2 and 3  
(d) 3 only

**Ans: (b)**

**Q. Which of the following phenomena might have influenced the evolution of organisms? (2014)**

1. Continental drift
2. Glacial cycles

**Select the correct answer using the code given below:**

- (a) 1 only  
(b) 2 only  
(c) Both 1 and 2  
(d) Neither 1 nor 2

**Ans: (C)**

### **Mains:**

**Q. How do the melting of the Arctic ice and glaciers of the Antarctic differently affect the weather patterns and human activities on the Earth? Explain. (2021)**