



Research Paper

# Climate Change: History, Causes, Evidence, Impacts, and Adaptation Measures

Dr Satinder Kaur

Associate Professor, Department of Geography, S.R. Government College for Women, Amritsar

**Abstract:** Climate change refers to the long-term shifts in temperatures and weather patterns. Last decades of human history were marked by extreme events of heat, forest fires, cold waves, cyclones, lightning, heavy rain, floods, and landslides, resulting in large-scale death and destruction. The present paper examines the natural and anthropogenic causes and evidence of climate change. It tries to visualize the possible effects of global climate change on mankind and also highlights the different methods of mitigation in addressing climate change.

**Key words:** Climate change, Cyclones, Forest fires, Anthropogenic causes

## I. Introduction

Climate change refers to long-term shifts in temperatures and weather patterns. Such shifts can be natural, due to changes in the sun's activity or large volcanic eruptions. But since the 1800s, human activities have been the main driver of climate change, primarily due to the burning of fossil fuels like coal, oil, and gas. It is one of the most pressing global challenges faced by mankind in recent times. Though it is a natural phenomenon, but has been aggravated due to anthropogenic causes like increased production of trace gases, burning of fossil fuels, and has resulted in severe implications for food production, water supply, natural ecosystem, health, air quality, etc. At the global level, it has led to rising global sea level, an increase in global temperature, and melting of ice. Since India has a vast geography that supports a large population, which is dependent on activities associated with climate like agriculture, forestry thus to tackle climate change and to make people and infrastructure adaptable to a changing environment Indian government needs to take prompt, short-term term and long-term measures. Taking into consideration the criticality of climate change, the paper discusses elaborately the impact, evidence, causes, and measures to adapt to climate change.

The objective of this research is to assess several natural causes of climate change and to view how they have impacted the Earth's atmosphere over the years and how climate change has intensified after Industrial Revolution. The various implications of climate at the global, regional, and local levels are discussed. Furthermore, the paper aims to assess mitigation and adaptation strategies employed by various nations and international organisations to address climate change.

**Research methodology:** This research paper uses secondary data to analyse the impact, causes, and evidence of climate change. The study relies on data obtained from sources like International organizations such as the Intergovernmental Panel on Climate Change (IPCC) oct 23 2018, World Bank, and United Nations Framework Convention on Climate Change (UNFCCC) 1992, Reports like "Global Climate Highlights 2022- Copernicus", "State of the Global Climate 2022-WMO", Climate databases, academic publications and government reports and policy documents.

### Structure of paper:

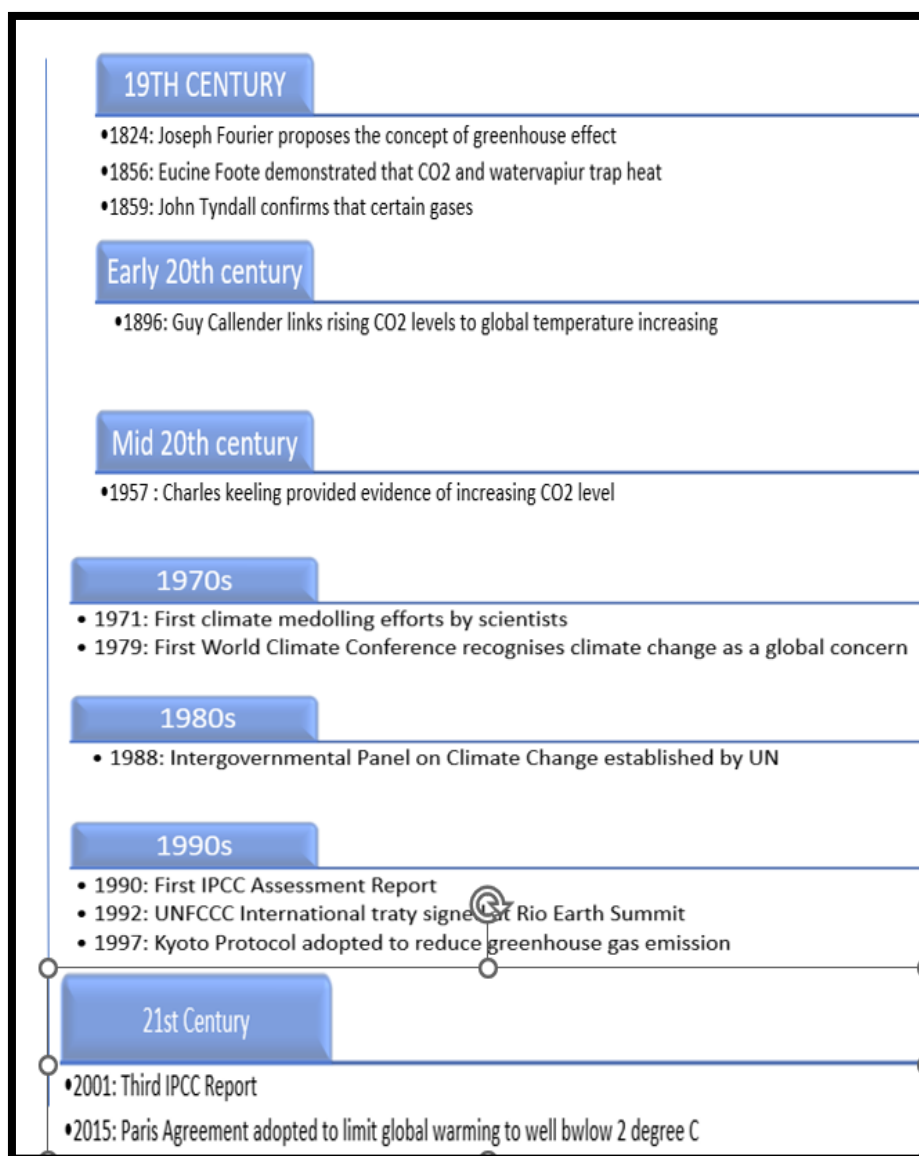
The paper is divided into the following sections-

- History of climate change discoveries
- Causes of climate change
- Evidence of climate change
- Impacts
- Adaptation and Mitigation Measures

### HISTORY OF CLIMATE CHANGE DISCOVERIES:

Dating back to ancient times, many people have proposed that Humans could change temperatures and influence rainfall. In the 1820s, French mathematician Joseph Fourier proposed the greenhouse effect, which was further worked on by Eunice Newton Foote, John Tyndall. Their studies suggested that global temperature would increase by 5 degrees C.

#### Timeline of Climate Change Discoveries

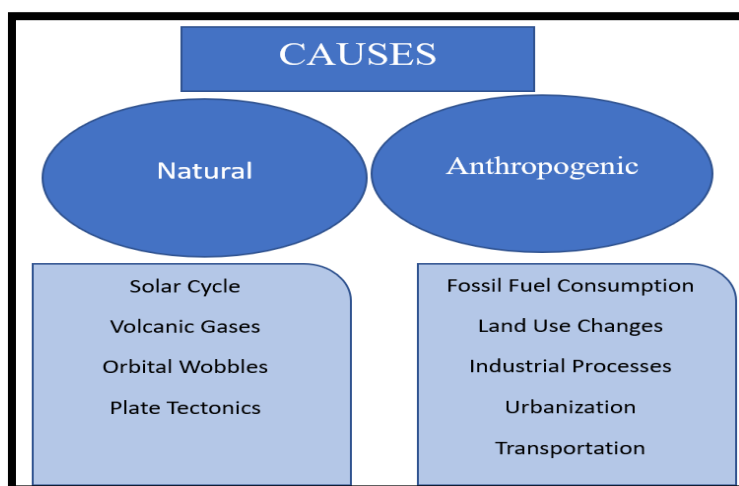


Dr. Charles Keeling provided first evidence that carbon dioxide levels are increasing. Using computer model of planet earth's climate scientists predicted doubling concentration of carbon dioxide could raise global temperature by 2-degree C. After predictions of melting ice cap, ozone hole discovery in 1988 the Intergovernmental Panel on Climate Change (IPCC) started a new era of climate research.

### CAUSES OF CLIMATE CHANGE:

**Sun Cycle:** The Sun doesn't always shine at same level of brightness, it brightens and dims slightly, taking 11 years to complete one solar cycle during which sun undergoes various changes. From solar minimum to solar maximum (e.g. - 1996 to 2001) global temperature increase 0.18 degrees C due to an increase in the Total Solar Irradiance. Conversely, from solar maximum to minimum (e.g. - 2001 to 2007), the reduced forcing from the sun cools global temperature by 0.18 degree. Thus, it can be concluded that solar cycle does impact the atmosphere of earth but the change it brings is not phenomenal to cause climate change.

**CAUSES OF CLIMATE CHANGE**



**Volcanic Gases:** During volcanic eruption huge amount of volcanic gas, aerosol droplets, and ash are injected into the atmosphere. Volcanic gases like sulphur dioxide can cause global cooling while gases like Carbon dioxide has potential to promote global warming. There's no debate that the Tobas Super Volcanic eruption 74000 years ago is Earth's largest known explosive eruption. The 1815 Tambora eruption, one of the most destructive eruptions in known geological history, was 1/12 the size. the Toba catastrophe theory is that ash from the eruption caused a volcanic winter of almost a decade and initiated a 1000-year-long cooling period across the planet.

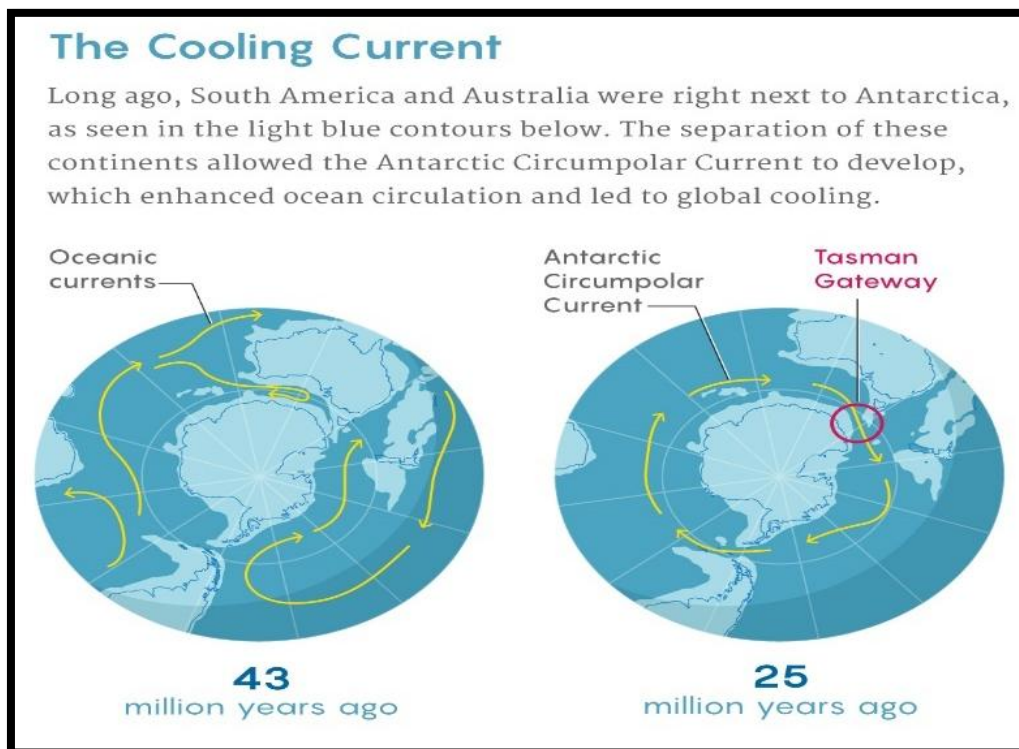
**Orbital Wobbles:** Orbital wobble refers to the slow, gradual shift in the direction of a planet's axis of rotation. A century ago, Serbian scientist Milankovitch hypothesized that changes in Earth's position relative to the Sun are a strong driver of Earth's long-term climate.

Eccentricity refers to the departure of the shape of the Earth's orbit from a perfect circle to elliptical forming perihelion (when Earth is closest to the sun) and aphelion (when Earth is farthest from the sun). Changes in eccentricity due to the pull of gravity from Jupiter and Saturn bring a change in global annual insolation but the total change is very small since variations in eccentricity are small.

The tilt in angle of the Earth's axis of rotation is known as obliquity. The angle varies by some degree over certain years. The greater Earth's axial tilt angle, the more extreme our seasons are.

Axial precession is the slow, gradual change in the orientation of Earth's axis over time. The cycle of axial precession spans about 25,771.5 years.

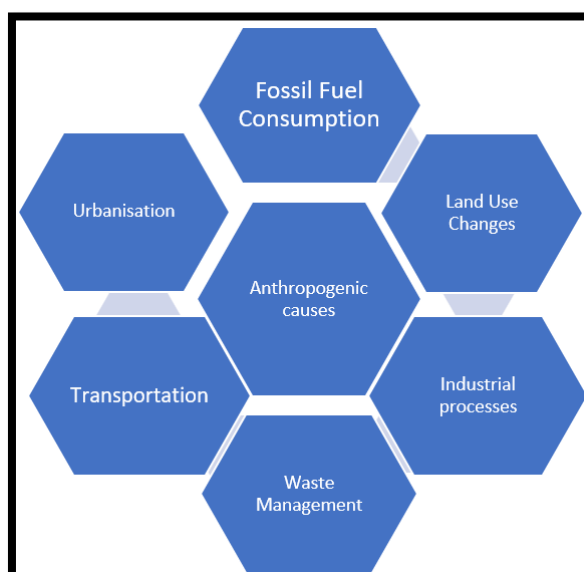
**Plate Tectonics:** Plate tectonics refers to the dynamic movement of large plates that constitute the Earth's lithosphere. They have brought a roughly 30 degrees Celsius change in temperature over the past 500 million years.



Source: doi.org/10.1016/j.palaeo.2005.07.033, Samuel Velasco/Quanta Magazine

There is no doubt that certain natural phenomenon has their impact on Earth's climate, but they are not the drivers of Climate Change that we are witnessing now. So, the major causes that have led to changes or variations in the climate are human activities.

### Anthropogenic factors causing Climate Change



## EVIDENCE OF CLIMATE CHANGE

There is unequivocal evidence that Earth is warming at an unprecedented rate. Human activity is the principal cause revealed by NASA.

### Various evidences of changing climate

1. Rising Global Temperature
2. Coastal glaciers are retreating
3. Mountain glaciers are disappearing
4. The ocean is getting warmer
5. Sea ice is shrinking
6. Sea level is rising
7. Extreme events

**Global temperature is rising:** Due to large emissions of carbon dioxide into the atmosphere and other human activities, the global temperature has risen about 1°C from pre-industrial levels. It has been confirmed by the World Meteorological Organization (WMO).

**The ocean is getting warmer:** The Ocean acts as a heat sink the excess heat present in the atmosphere driven by rising greenhouse gases, is trapped by ocean water due to its high heat capacity. The top 100m of the ocean shows warming of 0.33°C since 1969.

**Shrinking ice sheets:** Data from NASA's Gravity Recovery and Climate Experiment show Greenland lost an average of 279 billion tons of ice per year between 1993 and 2019.

**Glaciers are retreating** almost everywhere around the world.

**Extreme Events are increasing in frequency:** flooding in Tanzania, a heatwave in Saudi Arabia, wildfires in Chile, landslide in India

**Sea level is rising:** Global Sea level rose about 8 inches in the last century, as revealed by NASA.

**Ocean acidification is increasing:** since the beginning of the Industrial Revolution acidity of surface ocean water has increased by about 30%, NASA.

## MULTIDIMENSIONAL IMPACTS OF CLIMATE CHANGE



### **ENVIRONMENTAL IMPACTS OF CLIMATE CHANGE:**

Rising temperatures, increased sea level, Extreme weather events, shrinking ice sheets etc are profound environmental impacts of a changing climate.

**Economic impacts:** Due to climate change, the rainfall patterns are also changing, and the temperature is rising as a result; crop yield is impacted, which in turn raises concerns regarding food security. Heavy rainfalls can lead to more soil erosion, which is a major environmental threat to sustainable crop production. Apart from this, disasters like flooding, storms, heat stress led to infrastructure damage.

**Social impact:** Calamities caused due to Climate Change result in a large number of migrations and displacements.

e.g. The gradual submergence of low-lying islands such as Ghoramara, Lohachara (now fully submerged), and Parts of Sagar Island in West Bengal has forced thousands to migrate inland, says UNDP India Report,2021.

Scarcity of resources like water, arable land caused by to changing climate can intensify conflicts.

**Political and governance impacts:** Climate change has now become a key issue in diplomacy, trade, and global cooperation, amongst which the Paris Agreement is a landmark international climate treaty to reduce emissions of greenhouse gases. The treaty emphasized differentiation but common responsibility. India has also taken an active role in climate diplomacy since its large population is dependent on climate-related activities, the most significant amongst which is the International Solar Alliance, founded by India and France.

**Psychological impacts:** climate-related disasters have created havoc in the past, leading many to migrate and displace from their original place, and this has become a major cause of anxiety, depression, and trauma among the victims.

**Cultural impacts:** Climate change doesn't just affect the environment and the economy. It also deeply influences culture, tradition, and identities

e.g. Rising sea level threatened sacred groves, temples, and community lands in Sundarbans. As a result of coastal erosion and a changing climate, world heritage sites located at coasts like Venice (Italy), Easter Island (Chile) are also at risk.

### **MITIGATION AND ADAPTATION STRATEGIES**

Mitigation refers to actions aimed at reducing greenhouse gas emissions to lessen the impacts of climate change, while adaptation focuses on adjusting to the unavoidable impacts of climate change that are already happening or are expected.

### **NATION-WISE CLIMATE POLICIES:**

**INDIA:** National Action Plan on Climate Change was released by the Prime Minister on 30<sup>th</sup> June 2018. It outlines a national strategy that aims to enable the country to adapt to climate change and enhance the ecological sustainability of India's development path. There are eight National Missions that form the core of this action plan.

**EUROPEAN UNION:** The European Union came up with the European Green Deal, which aims for climate neutrality by 2050.

**CHINA:** China is the world's largest investor in solar and wind energy. It has its National Emission Trading System launched in 2021.

**SOUTH AFRICA:** To shift from coal to renewables, they came up with the Just Energy Transition Investment Plan

Climate Change is a Global issue; as a result, countries are working not only at the national level but are also collaborating at the international level. Humankind has realised that it is no longer a distant threat but a present reality. The time for debate is over, and the time for action is now.

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