# UNIT 9: GLOBAL WARMING AND CLIMATE CHANGE

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## 9.1 LEARNING OBJECTIVES

After going through this unit, you will be able to-

- define the concept of Climate Change and Global Warming
- explain the nature of the particular challenges posed by climate change and Global Warming
- discuss their consequences on human life and the planet
- discuss ways to mitigate and to tackle Climate Change and Global Warming.

## 9.2 INTRODUCTION

In the previous unit, we have already discussed about some of the the contemporary environmental problems. In this unit, we shall discuss two major environmental concerns of our time i.e Global Warming and

Climate Change. Tackling climate change and Global Warming are two major challenges facing the world. They are also intimately related. Human activities fundamental to development - industry, land use, energy generation and transport - are root causes of anthropogenic climate change. Conversely, climate change impacts hold the greatest threat for the livelihood activities and development prospects of poor and marginalized people.

Our understanding of the origins of global warming comes from the work of Jean-Baptiste Joseph Fourier, a French scientist, who in the early part of the nineteenth century calculated the energy that reaches the earth from the sun, in the form of sunlight, which is absorbed and then reflected back. When he calculated the amount of energy reaching the earth and then reflected back from the earth surface he got the finding that the earth should be frozen. Therefore he made the conclusion that the atmosphere of the earth acts like a mantle, keeping a portion of the reflected energy and heat, which makes the planet habitable. He speculated that CO2 acted as the mantle in the earth's atmosphere.

Later scientists working on global warming tried to find out which atmospheric elements trapped the sun energy and heat. They concluded that the major gases like Nitrogen and Oxygen that composes the atmosphere offers no barrier to the heat loss. So therefore those gases that trapped the heat, which later came to be termed as the 'greenhouse gases', were found to be carbon dioxide, nitrous oxide, hydrofluorocarbons, sulphur hexafluoride, methane and water vapour which were present in relatively small amounts in the atmosphere. The scientists came up with the calculation of 'parts per million' (ppm) to measure the level of greenhouse gases in the atmosphere, since there proportion are so small. The tiny proportion of these gases manages to keep the temperature suitable for habitation, therefore the greenhouse gases created by human industry can have a severe effect on the climate.

Over the past 150 years or so, greenhouse gases in the atmosphere have progressively increased with the expansion of industrial production. The average world temperature has increased by 0.74 degrees since 1901.

We know from geological studies that world temperatures have fluctuated in the past, and that such fluctuations correlate with CO2 content in the air. The evidence shows, however, that at no time during the past 650,000 years has the CO2 content of the air been as high as it is today. It has always been below 290ppm. By early 2008, it had reached 387ppm and is currently rising by some 2ppm each year.

## 9.3 GLOBAL WARMING AND CLIMATE CHANGE

The terms global warming and climate change sometimes appear to be used interchangeably. Strictly speaking, global warming is just one aspect of climate change, and is indeed an important driver of climate change. Apparently small increases in average global temperatures can lead to very large changes in other aspects of local and global climates. Changes in these other aspects of the climate - in averages in precipitation, winds, clouds, humidity, and in temporal and spatial variation and variability - may then have multiple impacts.

### 9.3.1 Climate change: Meaning and Definition

The term 'climate change' refers to change in the longer term pattern of behavior of the atmosphere over millennia or, more recently, as a result of natural processes or human activity. Climate is distinguished from weather, which is the specific behavior of the climate at a particular time. More particularly weather is the state of atmosphere at any given time denoting short time variation. There are many possible ways in which climate may be described. These are generally associated with averages or variability in temperature, precipitation, wind and cloud. Historically Earth's climate has never been static.

- **Climate Change: Definitions given by various Agencies**

  The distinction between natural and human caused climate change is reflected in the different definitions of climate change. Each definition points to climate change policy in a particular direction, which is a reflection of the particular agencies policy of reflecting climate change and its impact.

The Intergovernmental Panel on Climate Change (IPCC) definition on Climate change refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity.

In contrast, the United Nations Framework Convention on Climate Change (UNFCCC) refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.

## 9.3.2 Global Warming: Meaning And Causes

Global warming is the slow increase in the average temperature of the earth's atmosphere because an increased amount of the energy (heat) striking the earth from the sun is being trapped in the atmosphere and not radiated out into space.

- **Causes of Global Warming**

  It is well established that global warming and climate change result from human activity (anthropogenic), Scientists attribute current atmospheric warming to human activities that have increased the amount of carbon containing gases in the upper atmosphere and to increased amounts of tiny particles in the lower atmosphere.

  Specifically, gases released primarily by the burning of fossil fuels and the tiny particles produced by incomplete burning trap the sun's energy in the atmosphere. Scientists call these gases "greenhouse gases" (GHGs) because they act like the wrong way reflective glass in our global greenhouse. Scientists call the tiny particles 'black carbon' (soot) and attribute their warming effect to the fact that the resulting layer of black particles in the lower atmosphere absorbs heat like a black blanket.

Scientists date the beginning of the current warming trend to the end of the 18th or beginning of the 19th century when coal first came into common use. This warming trend has accelerated as we have increased our use of fossil fuels to include gasoline, diesel, kerosene and natural gas, as well as the petrochemicals (plastics, pharmaceuticals, fertilizers) we now make from oil. Experts attribute the current warming trend to the use of fossil fuels because using them releases into the atmosphere stores of carbon that were sequestered (buried) millions of years ago. The addition of this "old" carbon to the world's current stock of carbon, scientists have concluded, is what is heating our earth which causes global warming.



**CHECK YOUR PROGRESS**

**Q1:** Which gases are the major component of 'Greenhouse gases'?

**Q2:** What did the scientist come up to measure the level of greenhouse gases present in the atmosphere?

**Q3:** How does different agencies define 'climate change'?

**Q4:** In what way does human activity impact climate change and global warming?

## 9.4 IMPACT OF GLOBAL WARMING AND CLIMATE CHANGE

Warming of the climate system is unequivocal and can now be firmly attributed to human activity. Numerous long-term changes in climate have been observed at continental, regional and ocean basin scales, including changes in arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves and the intensity of tropical cyclones.

Impact of Global warming can be seen in the adverse impact of the following phenomenon:

- **Melting Glaciers:** Since the early twentieth century, with few exceptions, glaciers around the world have been retreating at unprecedented rates. Some scientists attribute this massive glacial retreat to the Industrial Revolution, which began around 1760. In fact, several ice caps, glaciers and ice shelves have disappeared altogether in this century. Many more are retreating so rapidly that they may vanish within a matter of decades.
- **Rising Sea Levels:** Sea-level rise is a major effect of climate change. It has drawn international attention, because higher sea levels in the future would cause serious impacts in various parts of the world. Shrinking land ice - glaciers, ice caps, and ice sheets contributed about half of the total global sea level rise between 1972 and 2008, but its contribution has been increasing since the early 1990s as the pace of ice loss has accelerated. Recent studies suggest that land ice loss added nearly half an inch to global sea level from 2003 to 2007, contributing 75 to 80 percent of the total increase during that period.
- **Flooding:** Heavy downpours are increasing in many parts of the world, especially over the last three to five decades. The heaviest rainfall events have become heavier and more frequent, and the amount of rain falling on the heaviest rain days has also increased. Since the 1990's, the amount of rain falling in very heavy precipitation events has been significantly above average.
- **Droughts:** Higher temperatures lead to increased rates of evaporation, including more loss of moisture through plant leaves. Even in areas where precipitation does not decrease, these increases in surface evaporation and loss of water from plants lead to more rapid drying of soils if the effects of higher temperatures are not offset by other changes (such as reduced wind speed or increased humidity). As soil dries out, a larger proportion of the incoming heat from the sun goes into heating the soil and adjacent

air rather than evaporating its moisture, resulting in hotter summers under drier climatic conditions.

- **Heat waves:** Heat waves are periods of abnormally hot weather lasting days to weeks. The number of heat waves has been increasing in recent years. This trend has continued in 2011 and 2012, with the number of intense heat waves being almost triple the long-term average. The recent heat waves and droughts in Texas (2011) and the Midwest (2012) set records for highest monthly average temperatures.
- **Increasing Tornados, Cyclones and Hurricanes:** A significant global increase (95% significance level) can be found in all storms with maximum wind speeds from 175 km/h. Storms of 200 km/h and more have doubled in number, and those of 250 km/h and more have tripled. Although some of the trends may be owing to improved observation techniques, this provides some evidence that a global increase in the most intense tropical storms due to global warming is not just predicted by models but already happening. There has been a substantial increase in most measures of Atlantic hurricane activity since the early 1980s, the period during which high quality satellite data are available. These include measures of intensity, frequency, and duration as well as the number of strongest (Category 4 and 5) storms. The recent increases in activity are linked, in part, to higher sea surface temperatures in the regions that hurricanes form in and move through. Numerous factors have been found to influence these local sea surface temperatures, including natural variability, human-induced emissions of heat-trapping gases, and particulate pollution.

The 100-year linear warming trend (1906-2005) was 0.74°C, with most of the warming occurring in the past 50 years. The warming for the next 20 years is projected to be about 0.2°C per decade. Continued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in

the global climate system during the 21st century that would very likely be larger than those observed during the 20th century.

## 9.4.1 Projections of Future Changes in Climate

Projections of future changes in climate indicate the following:

- Increasing atmospheric carbon dioxide concentrations lead to increasing acidification of the oceans;
- Snow cover projected to contract, widespread increases in thaw depth over most perma frost regions;
- Sea ice projected to shrink in both the Arctic and the Antarctic, and arctic late-summer sea ice may disappear almost entirely by the latter part of the 21st century;
- Hot extremes, heat waves and heavy precipitation events very likely to continue to become more frequent;
- Changes in precipitation patterns, with increase being very likely in high latitudes, while decreases are likely in most subtropical land regions;
- Anthropogenic warming and sea level rise would continue for centuries due to the time scales associated with climate processes and feedbacks, even if greenhouse gas concentrations were to be stabilized.

Global warming leading to climate change has many adverse impacts on the earth. Warming is greater over land areas than over the oceans, and is higher at northern latitudes than elsewhere. Very recent studies show that the temperatures of the oceans are rising several times faster than was thought likely a few years ago. Higher temperatures produce more acidity in the water, which could seriously threaten marine life. Warmer seas release more CO2, accelerating the global warming effect.

## 9.4.2 Examples of Impact of Global Warming

A few Examples of Global Warming effect:

- **Melting Ice caps in the Artic:** Satellite data, available since 1978, show that the annual average Arctic sea ice coverage is shrinking

by nearly 3 per cent per decade, with larger decreases in the summer of over 7 per cent. The Arctic ice-cap is less than half the size it was 50 years ago. Over that time, average temperatures in the Arctic region have increased by about seven degrees, a result of a specific feedback cycle that exists there. The sun's rays strike the Arctic at a sharper angle than elsewhere over the summer, at a time when the ice is giving way to open water, which absorbs more solar radiation.

- **Gangotri Glacier receding:** Gangotri Glacier is situated in the Uttarkashi District of Garhwal Himalaya. Currently 30.2 kilometers (19 miles) long and between 0.5 and 2.5 kilometers (0.31 to 1.5 miles) wide, Gangotri glacier is one of the largest in the Himalaya. Gangotri has been receding since 1780, although studies show its retreat quickened after 1971. Over the last 25 years, Gangotri glacier has retreated more than 850 meters (930 yards), with a recession of 76 meters (83 yards) from 1996 to 1999 alone.
- **Floods in the U.S.A:** In the United States, floods caused 4,586 deaths from 1959 to 2005 while property and crop damage averaged nearly 8 billion dollars per year (in 2011 dollars) over 1981 through 2011. The risks from future floods are significant, given expanded development in coastal areas and floodplains, unabated urbanization, land-use changes, and human-induced climate change.
- **Bangladesh submergence of territories:** Almost one fourth of the total population of the country live in the coastal areas of Bangladesh, where majority of the population are somehow affected (directly or indirectly) by Coastal Floods / Tidal Surges, River-bank Erosion, Salinity, Tropical Cyclones etc. With the rise of Sea-level up to one meter only, Bangladesh could lose up to 15% of its land area under the Sea water and around 30 million people living in the coastal areas of Bangladesh could become Refugees because of Climate Change impacts.

### 9.4.3 Projected Future Impacts of Global Warming and Climate Change

As regards the projected impacts, more specific information is now available on the nature of these impacts, across a wide range of systems and sectors. Examples of projected impacts include:

- **Fresh water resources and their management:** Runoff and water availability are projected to increase at high latitudes and in some wet tropics, and decrease over much of the mid-latitudes and dry tropics, some of which are presently water-stressed areas. Drought-affected areas will probably increase, and extreme precipitation events, which are likely to increase in frequency and intensity, will augment flood risk. Hundreds of millions of people are projected to be exposed to increased water stress.

  **Ecosystems:** The following ecosystems are identified to be the most vulnerable, and are virtually certain to experience the most severe ecological impacts, including species extinctions and major biome changes:

  **On continents:** tundra, boreal forest, mountain and Mediterranean-type ecosystems;

  **Along coasts:** mangroves and salt marshes, due to multiple stresses;

  **In oceans:** coral reefs and the sea-ice biomes.

  The progressive acidification of the oceans is expected to have negative impacts on marine shell-forming organisms such as corals and their dependent species. An intensification and expansion of wildfires is likely globally, as temperatures increase and dry spells become more frequent and more persistent. Over the course of this century, net carbon uptake by terrestrial ecosystems is likely to peak before mid-century and then weaken or even reverse, thus amplifying climate change.

- **Food, Fiber and Forest products:** Moderate warming benefits cereal crops and pasture yields in mid- to high-latitude regions, but

even slight warming decreases yields in seasonally dry and tropical regions. Further warming has increasingly negative impacts in all regions. Increases in the frequency of droughts and floods are projected to affect local crop production negatively, especially in subsistence sectors at low latitudes. Regional changes in the distribution and production of particular fish species are expected due to continued warming, with adverse effects projected for aquaculture and fisheries.

Already rising temperatures at the equator have pushed such staple crops as rice north into once cooler areas, many fish species have migrated long distances to stay in waters that are the proper temperature for them. Different crops grow best at quite specific temperatures and when those temperatures change, their productivity changes significantly.

- **Health:** Projected severe climate change related exposures are likely to affect the health status of millions of people worldwide, particularly those least able to adapt, such as the poor, the very young and the elderly.
- **Industry, Settlement and Society:** Areas most likely to be affected are the poorer, often rapidly expanding communities near rivers and coasts, which use climate sensitive resources and are prone to extreme weather. Where extreme weather events become more intense and or more frequent, their economic and social costs are predicted to increase.



**CHECK YOUR PROGRESS**

**Q5:** In which phenomenon(s) the adverse impact of Global warming can be seen?

## 9.5 WAYS TO MITIGATE AND TACKLE GLOBAL WARMING INDUCED CLIMATE CHANGE

- **Efforts of the United Nation:** The efforts to manage climate change has been a matter of high level diplomatic negotiations involving states and international organizations. The logic for this is that global climate change affects us all, but individual countries can manage only the activities that take place within their borders; to confront a global problem, we need a global solution. As the United Nations history of these negotiations begins: "Climate change is a global challenge and requires a global solution. Greenhouse gas emissions have the same impact on the atmosphere whether they originate in Washington, London or Beijing. Consequently, action by one country to reduce emissions will do little to slow global warming unless other countries act as well. Ultimately, an effective strategy will require commitments and action by all the major emitting countries."

  The global effort to manage climate change has been organized through what is called the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC was launched at the 1992 Rio Earth Summit to achieve GHG concentrations. It also set voluntary GHG emissions reductions that countries did not meet.

  With the failure of the Rio initiatives, the then 191 signatories to the UNFCCC agreed to meet in Kyoto in 1997 to establish a more stringent regime. The resulting Kyoto Protocol created a global trading system for carbon credits and binding GHG reductions for ratifying countries. (The US did not sign; China and India were exempt as developing countries.) So-called Conferences of the Parties (COPs) were held almost annually thereafter in places such as The Hague, Cancun and Doha without progress being made. We shall discuss in details about these international initiatives in Unit 12.

  **Some other ways of mitigating this crisis are:**

- **Push for reduced methane emissions from fracked gas:** Methane is 84 times more powerful than carbon dioxide over a 20-year time frame. Leading scientists estimate this gas alone is responsible for one-quarter of the observed changes to Earth's climate. Recent research suggests that methane emissions from the oil and gas sector (mainly fracked gas) is a much greater problem than reported. Cutting methane emissions is one of the cheapest, easiest and most effective things that governments can do right now to tackle climate change.
- **Shift to Renewable Energy:** The global push for cleaner, healthier energy is on. With costs dropping every day, renewable energy is the best choice for the environment and the economy. The solution to reduction of greenhouse gas emissions is a worldwide commitment that must be enacted across nearly every sector of industry and personal choice. Fortunately, the technology to switch to renewable energy such as solar and wind is readily available, and is now cheaper in most places than energy coming from fossil fuels such as coal and gas. The switch to renewable energy will solve a large piece of the puzzle, if we can act fast enough to implement.
- **Addressing Deforestation:** Deforestation should be prevented and replaced with sustainable forestry and land-use practices. Because plants breathe in carbon dioxide and store it, they actually remove carbon dioxide from the atmosphere. By allowing forests and other natural systems to act as carbon sinks - which is what they naturally do. We can encourage this removal of greenhouse gases from the atmosphere by ending deforestation, ocean habitat destruction and promoting sustainable forestry.

  Cutting down trees not only releases the carbon stored in that tree and in the soil, but also prevents that tree from taking carbon dioxide out of the atmosphere during the course of its life. Sustainable forestry and land use lead to carbon dioxide being taken out of the atmosphere.

- **Sustainable Development:** The definition of sustainable development that has gained popularity, after the Brundtland report (WCED, 1987) was published, was that it is 'development which meets the needs of the present without compromising the ability of future generations to meet their own needs'. The concept of sustainable development can be interpreted in many different ways, but at its core is an approach to development that looks to balance different, and often competing, needs against an awareness of the environmental, social and economic limitations we face as a society.

  All too often, development is driven by one particular need, without fully considering the wider or future impacts. We are already seeing the damage this kind of approach can cause by viewing changes in global climate resulting from our dependence on fossil fuel-based energy sources.

- **Changing how industries are run:** Individuals need to exercise their rights both as citizens and as consumers by putting pressure on their governments and on companies to make the system-wide changes that are needed.
- **Government's role:** Governments can set effective regulations to reduce carbon emissions by introducing legislation such as a carbon tax. A wide variety of national policies and instruments are available to governments to create the incentives for mitigation action.
- **Consuming moderately:** The need to check our carbon footprint to address the changes necessary for us as individual to make in order to play our part in curbing emission of GHGs in tackling global warming induced climate change. From dietary pattern to addressing the growing birth ratios, all falls under the individual's responsibility.
- World as a common forum for addressing the issue: The failure of the various international level commitments should not be seen a hindrance, rather the world needs to learn from the mistakes of the past and come together under one umbrella.



**CHECK YOUR PROGRESS**

**Q6:** What are the reasons behind the difficulties in managing climate change?

**Q7:** In what way can Governments around the world help in mitigating climate change and tackling global warming?



## 9.6 LET US SUM UP

- Global Warming induced Climate change represents a fundamental threat to human survival, as it is clear that development which involves large-scale emissions of GHGs, by humans, is not sustainable.
- The climate system does not have the capacity to absorb large amounts of GHGs without substantial changes in the climate, changes which undermine global natural and economic systems on which we currently depend. These include our water supplies, food systems, health, infrastructure and settlements.
- Understanding these threats requires an understanding of the science of climate change, impacts of different human activities on climate change and impacts of climate change on human activities and welfare.
- Major areas of human activity and welfare to consider here are agriculture, energy generation, transport, industry, settlement, water supplies, health, food supplies, lifestyles and vulnerabilities, and responses to disasters.



## 9.7 FURTHER READING

1) Giddens, A. (2009). The Politics of Climate Change. Cambridge, U.K : Polity Press

2) Weart, S. R. (2003). The Discovery of Global Warming. Cambridge, U.S.A. : Harvard University Press

## 9.8 ANSWERS TO CHECK YOUR PROGRESS

**Ans to Q No 1:** Carbon dioxide, nitrous oxide, hydrofluorocarbons, sulphur hexafluoride, methane and water vapour are the major components of 'Greenhouse gases'.

**Ans to Q No 2:** The scientist came up with the calculation of 'parts per million' (ppm) to measure the level of greenhouse gases in the atmosphere, since there proportion are so small.

**Ans to Q No 3:** The Intergovernmental Panel on Climate Change (IPCC) definition on Climate change refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer.

In contrast, the United Nations Framework Convention on Climate Change (UNFCCC), where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere

**Ans to Q No 4:** Scientists attribute current atmospheric warming to human activities that have increased the amount of carbon containing gases in the upper atmosphere and to increased amounts of tiny particles in the lower atmosphere. Specifically, gases released primarily by the burning of fossil fuels and the tiny particles produced by incomplete burning trap the sun's energy in the atmosphere

**Ans to Q No 5:** Experts attribute the current warming trend to the use of fossil fuels because using them releases into the atmosphere stores of carbon that were sequestered (buried) millions of years ago. The addition of this "old" carbon to the world's current stock of carbon, scientists have concluded, is what is heating our earth which causes global warming.

**Ans to Q No 6:** Managing climate change difficulties arise from two, related reasons: climate change management is viewed as expensive and it poses what we call a collective action problem.

**Ans to Q No 7:** Governments can set effective regulations to reduce carbon emissions by introducing legislation such as a carbon tax. A wide variety of national policies and instruments are available to governments to create the incentives for mitigation action.



## 9.9 MODEL QUESTIONS

**Short Questions** (Answer each question in about 150 words)

**Q1:** How does emission of GHGs lead to Global Warming and Climate Change?

**Q2:** How did the idea of Global Warming and Climate Change emerge?

**Q3:** Define Climate Change.

**Q4:** What is meant by Global Warming.

**Long Questions** (Answer each question in about 300-500 words)

**Q1:** How Global Warming induced climate change impact the planet? What are the various ways in which it has affected the earth? Give examples.

**Q2:** What are the various projections of future changes in climate? How will it impact human life?

**Q3:** What are the various ways to mitigate the effects of Global Warming? How can individuals play a part in tackling Global Warming?

**Q4:** What according to you is the biggest factor responsible for Global Warming induced Climate Change? Give justification.

**Q5:** According to you what has been the reason for failure to tackle emission of GHGs? What kind of role can Government play to address the issue?

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