3.1 GLOBAL WARMING AND CHANGING ENVIRONMENT

- Global warming is a slow and steady rise in Earth's surface temperature. Temperatures today are 0.74 °C (1.33 °F) higher than 150 years ago.
- Global warming is a long-term rise in the average temperature of the Earth's climate system; an aspect of climate change shown by temperature measurements and by multiple effects of the warming.
- Increase in average air and ocean temperatures since 1900 caused mainly by emissions of greenhouse gases (GHGs) in the modern industrial economy.
- In the modern context the terms global warming and climate change are commonly used interchangeably, but climate change includes both global warming and its effects, such as changes to precipitation and impacts that differ by region.
- The greenhouse effect is the process by which radiation from a planet's atmosphere warms the planet's surface to a temperature above what it would be without its atmosphere. If a planet's atmosphere contains radiatively active gases (i.e.,greenhouse gases) they will radiate energy in all directions.
- The largest human influence has been the emission of greenhouse gases such as carbon dioxide, methane, and nitrous oxide.
- As the climate warms, it changes the nature of global rainfall, evaporation, snow, stream flow and other factors that affect water supply and quality. Specific impacts include: Warmer water temperatures affect water quality and accelerate water pollution.

Effects of global warming include :

- Rising sea levels
- Regional changes in precipitation
- More frequent extreme weather events such as heat waves, and
- Expansion of deserts.

Surface temperature increases are greatest in the Arctic, with the continuing retreat of glaciers, permafrost, and sea ice. Overall, higher temperatures

bring more rain and snowfall, but for some regions droughts and wildfires increase instead.

Climate change impacts humans by, amongst other things,

- Threatening food security from decreasing crop yields,
- The abandonment of populated areas and
- Damage to infrastructure due to rising sea levels.

Environmental impacts include,

- The extinction or relocation of ecosystems as they adapt to climate change
- With coral reefs
- Mountain ecosystems, and
- Arctic ecosystems most immediately threatened.

Because the climate system has a large "inertia" and greenhouse gases will remain in the atmosphere for a long time, climatic changes and their effects will continue to become more pronounced for many centuries even if further increases to greenhouse gases stop.

Physical drivers of climate change:

- By itself, the climate system may generate changes in global temperatures for years to decades or centuries at a time. Other changes emanate from so-called external forcings.
- These forcings are "external" to the climate system, but not necessarily external to Earth. Examples of external forcings include changes in the composition of the atmosphere (e.g., increased concentrations of greenhouse gases), solar luminosity, volcanic eruptions, and variations in Earth's orbit around the Sun.
- Attributing detected temperature changes and extreme events to man-made increases in greenhouse gases requires scientists to rule out known internal climate variability and natural external forcing.

Greenhouse gases:

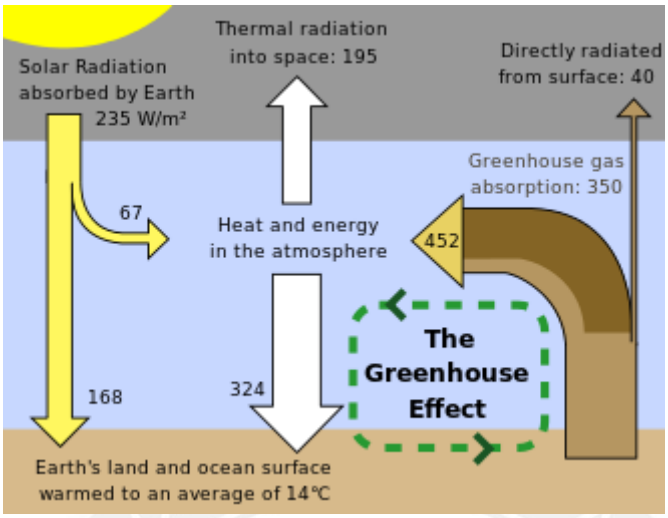

Figure 3.1.1 Greenhouse gases

[Source:https://images.app.goo.gl/Wb95qapoWmNX8nxa9]

- Greenhouse gases trap heat radiating from Earth to space. This heat, in the form of infrared radiation, gets absorbed and emitted by these gases in the planet's atmosphere thus warming the lower atmosphere and the surface.
- On Earth, an atmosphere containing naturally occurring amounts of greenhouse gases causes air temperature near the surface to be warmer by about 33 °C (59 °F) than it would be in their absence.
- Without the Earth's atmosphere, the Earth's average temperature would be well below the freezing temperature of water.

The major greenhouse gases :

- Water vapor, which causes about 36–70% of the greenhouse effect
- Carbon dioxide(CO_2), which causes 9–26%
- Methane (CH_4), which causes 4–9%
- Ozone (O_3), which causes 3–7%.

- Human activity since the Industrial Revolution has increased the amount of greenhouse gases in the atmosphere, leading to increased radioactive forcing from CO_2, methane, tropospheric ozone, CFCs, and nitrous oxide.

- Of these emissions, 65% was carbon dioxide from fossil fuel burning and industry, 11% was carbon dioxide from land use change, which is primarily due to deforestation, 16% was methane, 6.2% was nitrous oxide, and 2.0% were fluorinated gases.
- Using life-cycle assessment to estimate emissions relating to final consumption, the dominant sources of 2010 emissions were:
  - Food (26–30% of emissions)
  - Washing, heating and lighting (26%)
  - Personal transport and freight (20%)
  - Building construction (15%).

Land use change

Changing the type of vegetation in a region impacts the local temperature by changing how much sunlight gets reflected back into space and how much heat is lost by evaporation. For instance, the change from a dark forest to grassland makes the surface lighter, and causes it to reflect more sunlight. Humans change the land surface mainly to create more agricultural land.

Aerosols and soot

Solid and liquid particles known as aerosols – from volcanoes, plankton and human-made pollutants – reflect incoming sunlight, cooling the climate. From 1961 to 1990, a gradual reduction in the amount of sunlight reaching the Earth's surface was observed, a phenomenon popularly known as global dimming, typically attributed to aerosols from biofuel and fossil fuel burning. Aerosol removal by precipitation gives tropospheric aerosols an atmospheric lifetime of only about a week, while stratospheric aerosols can remain in the atmosphere for a few years. Global aerosols have been declining since 1990, removing some of the masking of global warming that aerosols had been providing.

Incoming sunlight

As the Sun is Earth's primary energy source, changes in incoming sunlight directly affect the climate system. There has been no upward trend in the amount of the Sun's energy reaching the Earth, so it cannot be responsible for the current warming.

Effects :

Physical environmental

The environmental effects of global warming are broad and far-reaching. They include the following diverse effects:

- Arctic sea ice decline, sea level rise, retreat of glaciers: global warming has led to decades of shrinking and thinning of the Arctic sea ice, making it vulnerable to atmospheric anomalies.
- Polar amplification and increased ocean warmth are undermining and threatening to unplug Antarctic glacier outlets, potentially resulting in more rapid sea level rise.
- Extreme weather, extreme events, tropical cyclones: Data analysis of extreme events from 1960 until 2010 suggests that droughts and heat waves appear simultaneously with increased frequency.
- Changes in ocean properties: increases in atmospheric CO_2 concentrations have led to an increase in dissolved CO_2 and as a consequence ocean acidity.
- Long-term effects of global warming: On the timescale of centuries to millennia, the magnitude of global warming will be determined primarily by anthropogenic CO_2 emissions. This is due to carbon dioxide's very long lifetime in the atmosphere.
- Long-term effects also include a response from the Earth's crust, due to ice melting and deglaciation, in a process called post-glacial rebound, when land masses are no longer depressed by the weight of ice. This could lead to landslides and increased seismic and volcanic activities. Tsunamis could be generated by submarine landslides caused by warmer ocean water thawing

ocean-floor permafrost or releasing gas hydrates. Sea level rise will continue over many centuries.

Biosphere:

In terrestrial ecosystems, the earlier timing of spring events, as well as pole ward and upward shifts in plant and animal ranges, have been linked with high confidence to recent warming.

- It is expected that most ecosystems will be affected by higher atmospheric CO_2 levels, combined with higher global temperatures.
- Expansion of deserts in the subtropics is probably linked to global warming.
- Ocean acidification threatens damage to coral reefs, fisheries, protected species, and other natural resources of value to society.
- The extinction of many species and reduced diversity of ecosystems.
- Land-based ecosystems are at risk of major ecological shifts, transforming composition and structure.

Impacts on humans

The effects of climate change on human systems, mostly due to warming or shifts in precipitation patterns, or both, have been detected worldwide. The future social impacts of climate change will be uneven across the world.

Food and water

- Crop production will probably be negatively affected in low latitude countries, while effects at northern latitudes may be positive or negative.
- Global warming of around 4 °C relative to late 20th century levels could pose a large risk to global and regional food security.
- Water availability will also become more limited in regions dependent on glacier water, regions with reductions in rainfall and small islands.

Health and security

- Generally impacts on public health will be more negative than positive.

- Impacts include the direct effects of extreme weather,
- Leading to injury and loss of life; and
- Indirect effects, such as under nutrition brought on by crop failures.
- Temperature rise has been connected to increased numbers of suicides
- Climate change has been linked to an increase in violent conflict by amplifying poverty and economic shocks, which are well-documented drivers of these conflicts
- A wide range of violent behaviour including fist fights, violent crimes, civil unrest, or wars.

Livelihoods, industry and infrastructure

In small islands and mega deltas, inundation as a result of sea level rise is expected to threaten vital infrastructure and human settlements. This could lead to issues of homelessness in countries with low-lying areas such as Bangladesh, as well as statelessness for populations in island nations, such as the Maldives and Tuvalu. Climate change can be an important driver of migration, both within and between countries.

Africa is one of the most vulnerable continents to climate variability and change because of multiple existing stresses and low adaptive capacity. Existing stresses include poverty, political conflicts, and ecosystem degradation. Regions may even become uninhabitable, with humidity and temperature reaching levels too high for humans to survive.

Drivers of greenhouse gas emissions

Main drivers of increases in greenhouse gas emissions

- Gross domestic product per capita and
- Population growth

CO_2 emissions are continuing to rise due to the burning of fossil fuels and land-use change.

Changes in future emission levels of greenhouse gases, have been projected that depend upon,

- Uncertain economic
- Sociological, technological, and
- Natural developments.

In most scenarios, emissions continue to rise over the century, while in a few, emissions are reduced. Fossil fuel reserves are abundant, and will not limit carbon emissions in the 21st century.

Reducing greenhouse gases

- Near- and long-term trends in the global energy system are inconsistent with limiting global warming at below 1.5 or 2 °C, relative to pre-industrial levels.
- Current pledges made as part of the Paris Agreement would lead to about 3.0 °C of warming at the end of the 21st century, relative to pre-industrial levels. In limiting warming at below 2 °C, more stringent emission reductions in the near-term would allow for less rapid reductions after 2030, and be cheaper overall. Many integrated models are unable to meet the 2 °C target if pessimistic assumptions are made about the availability of mitigation technologies.
- Co-benefits of climate change mitigation may help society and individuals more quickly. For example,
  - Cycling reduces greenhouse gas emissions while reducing the effects of a sedentary lifestyle at the same time.
  - The development and scaling-up of clean technology, such as cement that produces less CO_2.
  - It has been suggested that the most effective and comprehensive policy to reduce carbon emissions is a carbon tax or the closely related emissions trading.
  - The best approach is having fewer children, and to a lesser extent living car-free, forgoing air travel, and adopting a plant-based diet.

- A reduction in human population growth will be sufficient to mitigate global warming.

Adaptation

- Climate change adaptation is the process of adjusting to actual or expected climate and its effects. Humans can strive to moderate or avoid harm due to climate change and exploit opportunities.

Examples of adaptation are,

- Improved coastline protection,
- Better disaster management and
- The development of crops that are more resistant.

- The adaptation may be planned, either in reaction to or anticipation of global warming, or spontaneous, i.e., without government intervention.
- The public section, private sector and communities are all gaining experience with adaptation and adaptation is becoming embedded within certain planning processes. Environmental organizations and public figures have emphasized changes in the climate and the risks they entail, while promoting adaptation to changes in infrastructural needs and emissions reductions.
- Adaptation is especially important in developing main drivers of increases in greenhouse gas emissions .

Climate change:

Climate change occurs when changes in Earth's climate system result in new weather patterns that last for at least a few decades, and maybe for millions of years. The climate system comprises five interacting parts,

- The atmosphere (air)
- Hydrosphere (water)
- Cryosphere (ice and permafrost)
- Biosphere (living things)
- lithosphere (earth's crust and upper mantle).

The climate system receives nearly all of its energy from the sun, with a relatively tiny amount from earth's interior. The climate system also gives off energy to outer space. The balance of incoming and outgoing energy, and the passage of the energy through the climate system, determines Earth's energy budget. When the incoming energy is greater than the outgoing energy, earth's energy budget is positive and the climate system is warming. If more energy goes out, the energy budget is negative and earth experiences cooling.

As this energy moves through Earth's climate system, it creates Earth's weather and long-term averages of weather are called "climate". Changes in the long term average are called "climate change". Such changes can be the result of "internal variability", when natural processes inherent to the various parts of the climate system alter Earth's energy budget.

Human activities can also change earth's climate, and are presently driving climate change through global warming.

Causes Climate change:

- **Climate variability**
  - Ocean-atmosphere variability
  - Life
- **External forcing mechanisms**
  - Human influences
  - Orbital variations
  - Solar output
  - Volcanism
  - Plate tectonics