UNIT 6
CLIMATE CHANGE

6.1 CLIMATE CHANGE: CAUSES AND EFFECTS

6.1.1 Definition of Climate Change

- **Climate** is the long-term average of patterns and trends in weather, including day-to-day, year-to-year, and even longer time periods.
- **Climate change:**
  - Is the global phenomenon of **climate transformation** characterized by the **changes** in the **usual climate of the planet** (temperature, precipitation, and wind) that are especially **caused** by **human activities**.
  - Is the large-scale changes in global, regional, and local weather patterns that result from the long-term increase in the Earth's average surface temperature caused by a significant increase in the levels of greenhouse gases are produced by the use of fossil fuels.
  - Is a systematic change in the long-term state of the atmosphere over multiple decades or longer.
  - Is **natural variations** in atmospheric conditions.
  - It is the significant variation of weather patterns over long periods**.**

6.1.2 Causes of Climate Change

- The causes of climate change can be categorized into two. These are,
  - **Natural causes** and
  - **Manmade (anthropogenic) causes**

1. Natural Causes

- The earth's climate is grossly influenced and changed through natural causes such as:
  - Ocean current, Volcanic eruptions, Cloud condition, the earth's orbital changes and Solar variations

2. Anthropogenic causes

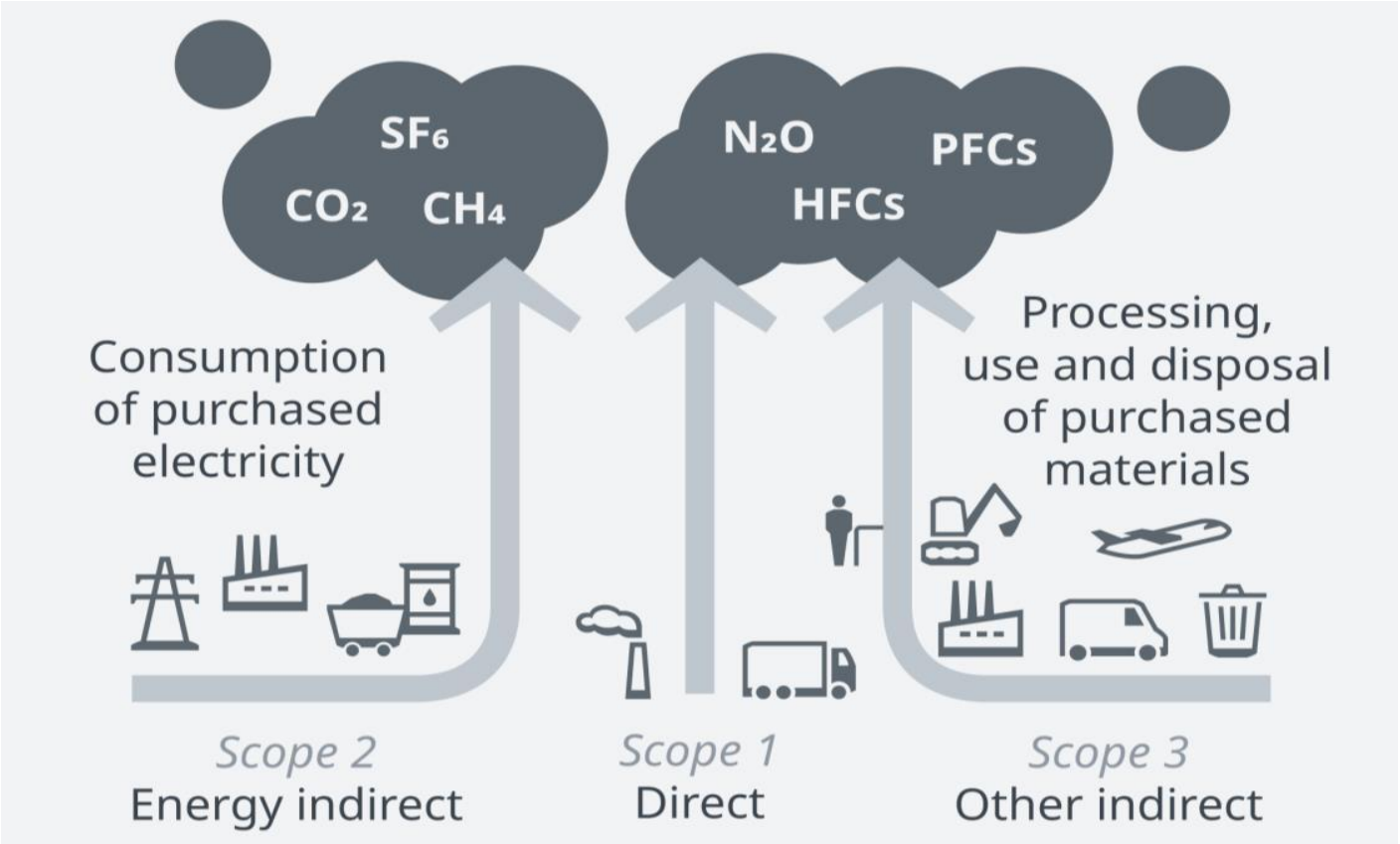
- Climate is changing due to man-made **greenhouse gases** from burning fossil fuels.
- **Deforestation** and **farming livestock** add pressure to greenhouse gases which increases the concentration of atmospheric CO2 by more than 40%, with over half the increase occurring since 1970.

- ***Examples of human activities that contribute to climate change:***
- **Burning fossil fuels:** The combustion of coal, oil, and natural gas for energy production releases CO2 into the atmosphere.
- **Deforestation:** clearing forests reduces the number of trees that absorb CO2, contributing to higher atmospheric CO2 levels.
- **Industrial processes:** manufacturing and industrial activities release greenhouse gases such as CH4 &N2O into the atmosphere.
- **Agricultural practices:** Farming methods like rice cultivation and livestock farming release methane, while the use of fertilizer emits nitrous oxide.
- **Land use change:** Conversion of land for urbanization agricultural alters ecosystem, affecting the carbon cycle and contributing to climate change.

The Greenhouse Effect

- **GHGs** act like a **blanket** or car windshield to **trap the sun's energy and heat**, rather than letting it reflect back into space. **This leads to global warming and climate change**.
  - The world is now warming faster than at any point in recorded history. Warmer temperatures over time are changing weather patterns and disrupting the usual balance of nature.
- **GHGs** are sometimes called "**climate active pollutants**" because most have additional notable effects on human health.
  - There are **many GHGs**, each with a different ability to trap heat and a different half-life in the atmosphere.
- **Greenhouse gases are:**
  - Carbon dioxide (CO_2), Methane (CH_4), Water vapors, Nitrous oxide (N_2O), as well as halogenated compounds such as CFCs.
  - ***These gases are commonly known as greenhouse gases due to their heat-trapping capacity.***

Figure 6.1: Source-Path relationship of greenhouse gases



- Greenhouse gases act similarly to the glass in a greenhouse:
  - they absorb the sun's heat that radiates from the Earth's surface, trap it in the atmosphere and prevent it from escaping into space.
  - Greenhouse gases allowing sunlight to pass into the 'greenhouse,' but blocking Earth's heat from escaping into space.
  - **The greenhouse effect keeps the Earth's temperature warmer.**

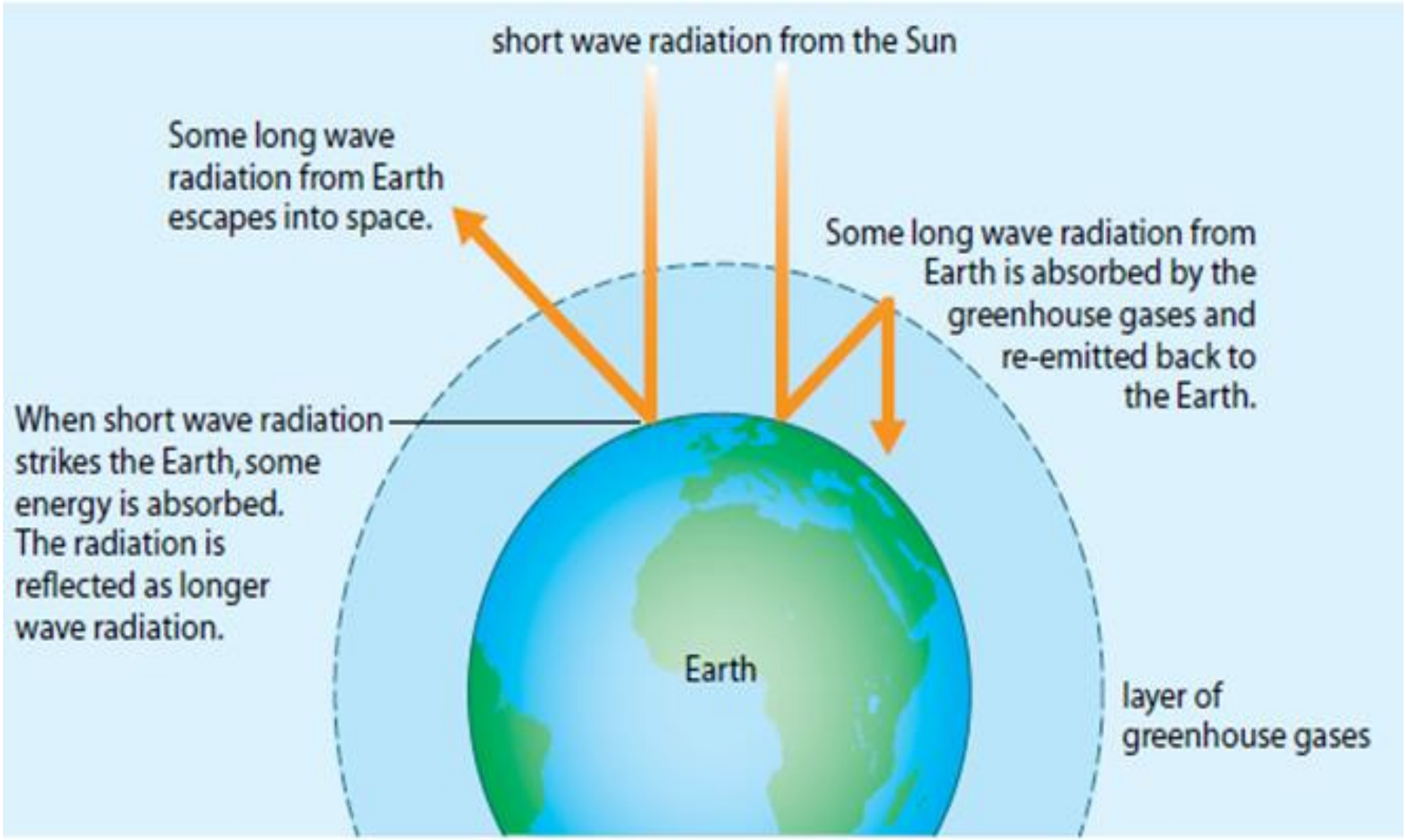


Figure 6.2: Global warming caused by greenhouse gases

Table 6.1. Types of greenhouse gases and their major sources

GHG Categories	Major Sources
Carbon dioxide (CO_2)	Fossil Fuel Combustion, deforestation, Decomposition of dead vegetation by microorganisms, cement production (when calcium carbonate is heated generating lime and carbon dioxide).
Methane (CH_4)	Landfills, Rice paddies, Digestive tracts of cattle and sheep
Nitrous Oxide (N_2O)	Fertilizer, combustion of fossil fuels , animal waste
Hydrofluorocarbons (HFCs)	Semiconductor manufacturing and other industrial processes
Perfluorocarbons (PFCs)	Same as HFCs, plus aluminium melting
Sulfur hexafluoride (SF_2)	Electrical transmission systems, magnesium and aluminium production

- Main anthropogenic source of **methane**:
  - **Rice paddies**: as rice grows in swampy conditions, known as paddy fields, methane is released.
  - **Cattle**: Cows produce methane during their digestive processes. A single cow can release from 100–400 liters of methane per day.
  - **Anaerobic decay of organic waste in landfills**: improper waste management.
- **Carbon dioxide (CO_2)**
- CO_2 is the GHG responsible for greatest amount of warming to date.
- The majority of CO_2 is released from the incomplete combustion of fossil fuels-coal, oil, and gas used for electricity production, transportation and industrial processes.
  - It absorbs and radiates heat wormed by sunlight and thermal infrared energy (heat).
  - It absorbs less heat per molecule than methane and nitrous oxide but it is abundant stays in the atmosphere much longer.

- Without this natural greenhouse effect, the Earth's average annual temperature would be below freezing instead of close to 60°F.
  - CO_2 contribute 2/3(67%) of the earth`s total energy imbalance.
- Concentration of atmospheric CO_2 increased by more than 40% with over half the increase occurring since 1970.
- Naturally, CO_2 is exchanged continually between the atmosphere, plants, and animals through photosynthesis, respiration, gas exchange and decomposition.
  - Without human activity a very small (1%) of CO_2 emitted from fossil fuels, and volcanic eruption in balanced by equivalent volume from the chemical weathering of rocks.
  - The natural process add CO_2 to the atmosphere slowly compared to the human activities

Global Warming

- **Global warming** is an increase in the temperature at the surface of the earth including the ocean and atmosphere as a result of an increased greenhouse effect.
- **The major cause of global warming is the greenhouse gases.**
  - An increase in the levels of greenhouse gases such as carbon dioxide, nitrous oxides, CFCs and methane in the atmosphere.
  - As a result more heat is trapped by the atmosphere and the temperature at the surface of the earth increases.
  - Greenhouse gases absorb some of the outgoing radiation of Earth and re-radiate it back towards the surface.
- **The second major cause of global warming is the depletion of ozone layer**.
  - This happens mainly due to the presence of chlorine- containing source gases.

- ***The effect of global warming include:***
  - Results in drought and scarcity of water supply
  - Rising of sea levels will devastate agricultural and fishing activities.
  - Causing the ice and glaciers to melt rapidly, melting of polar ice caps will lead to flood.
- ***Methods of preventing global warming include:***
  - Reducing the use of fossil fuels
  - Use alternative energy source, such as solar power and biofuels
  - Carbon sequestration, capturing CO2 and store it underground, rather than left it go into the atmosphere.
  - Managing the farming of cattle and rice.
  - Stopping deforestation and
  - Replanting trees can also help by using up some of the carbon dioxide.

6.2 Effect of Climate Change

- **Climate change** destabilizes the earth's temperature equilibrium and has far-reaching effects on human beings and the environment.
- ***The direct consequences of man-made climate change include:***
  - Rising maximum temperatures
  - Rising sea levels
  - Higher ocean temperatures.
  - An increase in heavy precipitation and shrinking of glaciers
  - Thawing of permafrost.
- ***The indirect consequences of climate change which affect humans and environment include:***
  - An **increase in hunger and water crises**, especially in developing countries
  - **Health risks** due to the rising air temperatures and heat waves
  - **Economic crisis**

- **Increasing spread of pests and pathogens**
- **Loss of biodiversity** due to limited adaptability of flora and fauna.
- **Ocean acidification** due to increased HCO_3 concentrations in the water as a consequence of increased CO_2 concentrations.

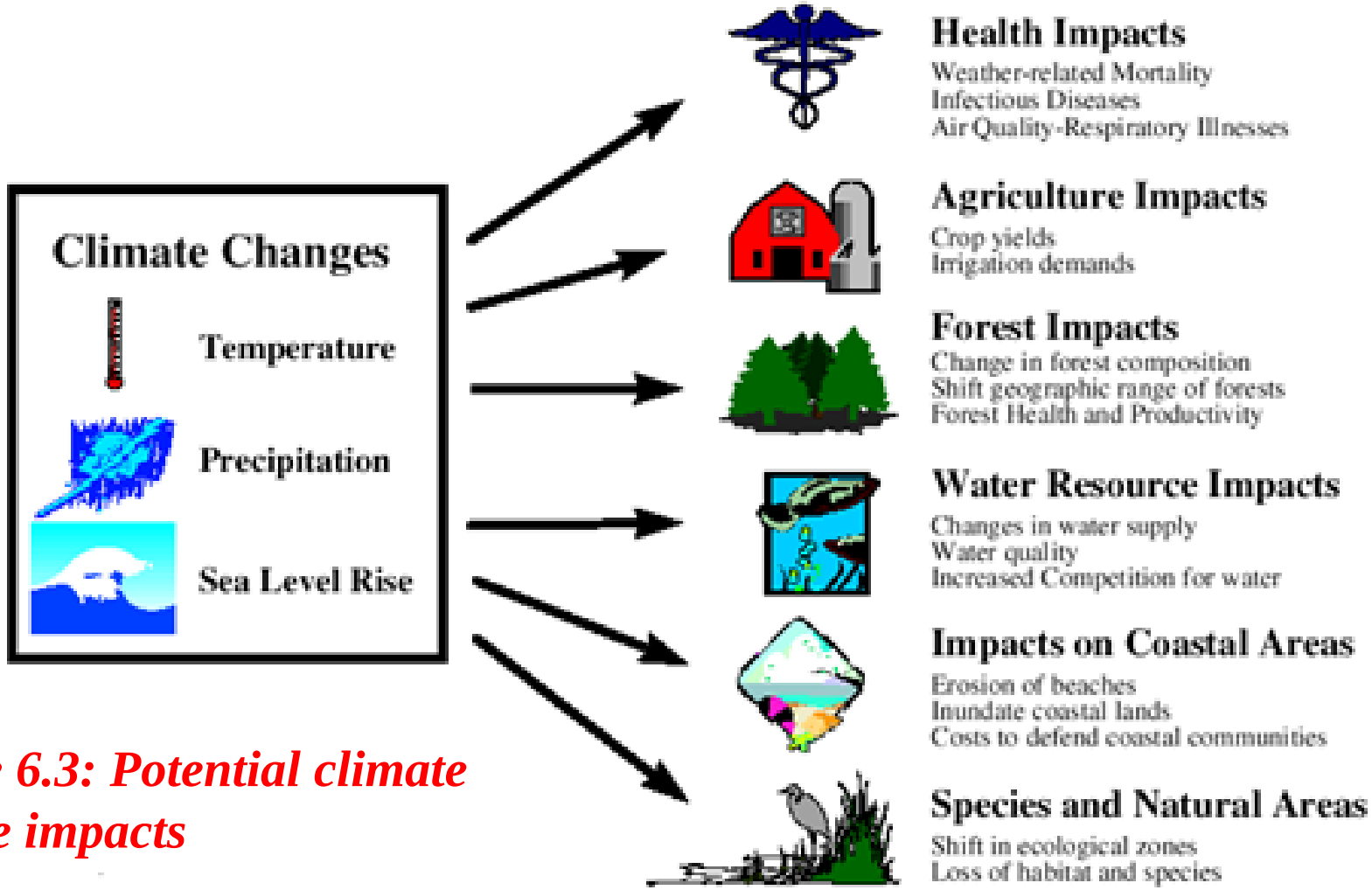


Figure 6.3: Potential climate change impacts

6.2.1 Effects of Climate Change on Biodiversity

- Biodiversity provides immense direct benefits to humans with at least 40% of the world's economy being derived from biological resources.
- ***Maintaining biodiversity provides:***
  - Food security
  - Opportunities for economic development
  - New pharmaceuticals and other medical advances
  - Maintain health and material wealth
  - Social relations
  - Freedom of choice and action

Figure 6.4: Changes in rainfall patterns can damage land, plants and animals

- Climate change combined with land use change and the spread of exotic (alien) species are likely to become the dominantly direct driver of biodiversity loss. Because it destructs habitat of several species.

6.2.2 Effect of climate change on Agriculture

- Agricultural biodiversity refers to all components of biological diversity of relevance to food and agriculture. It includes: Plants, Animals and Microbial genetic resources.
- Climate change can disrupt food availability, reduce access to food, and affect food quality.
- ***Climate change affects agriculture by altering:***
  - Growing seasons
  - Pest and disease pressure
  - Precipitation patterns (can lead to: Floods, Soil erosion and affecting crop productivity)

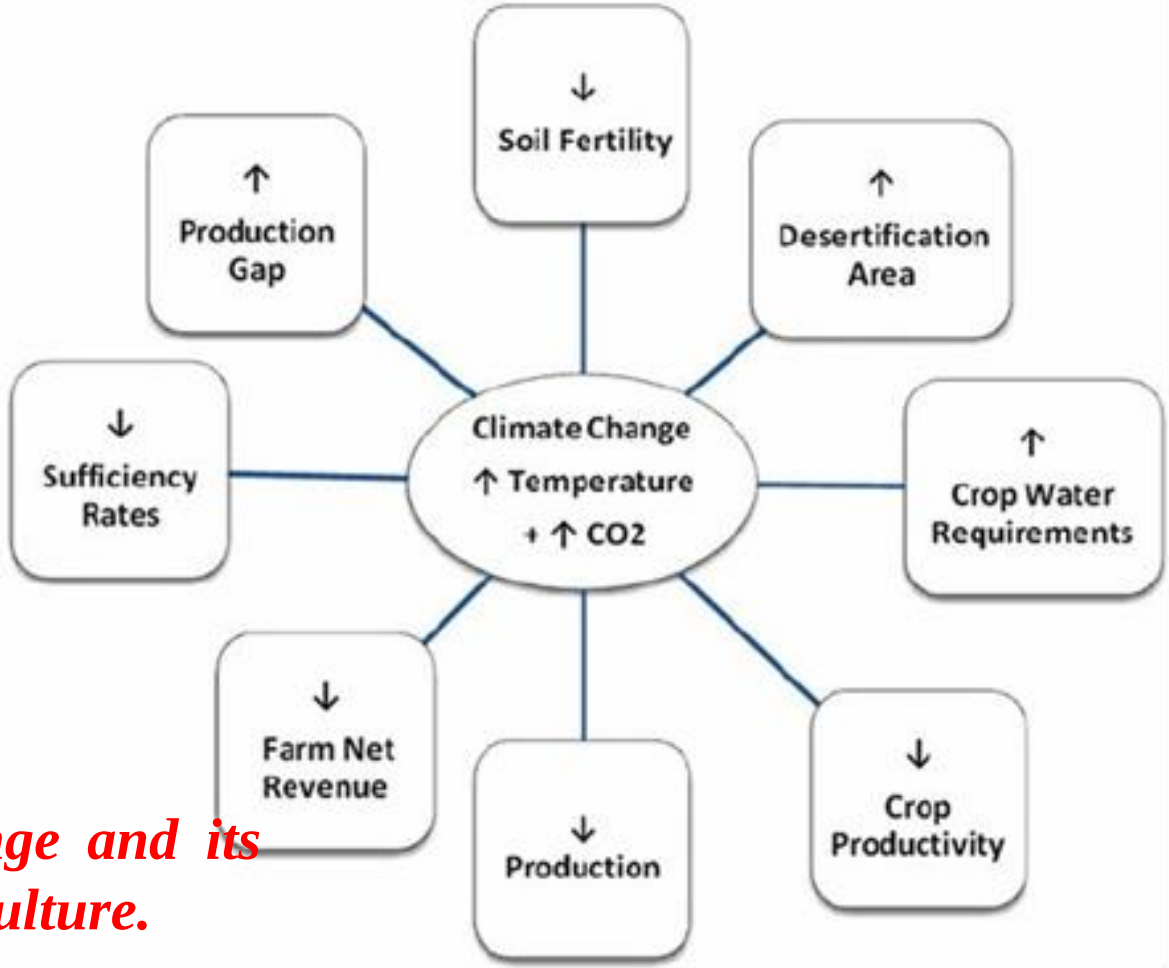


Figure 6.5: Climate change and its potential impacts on Agriculture.

6.2.3 Effect of climate change on Forest Productivity

- Climate change could alter the frequency and intensity of forest disturbances such as:
  - Pest outbreaks
  - Invasive species
  - Wildfires and
  - Storms
- These disturbances can reduce:
  - Forest productivity and
  - Change the distribution of tree species
- In some cases, a forest can recover from a disturbance while in other cases, existing species may shift their range or die out replaced by new forests.
  - Insect outbreaks often defoliate, weaken, and kill trees.
  - Warm temperatures and drought conditions during the early summer triggered wild fire.

6.2.4 Climate Change and Natural Disasters

6.2.4.1 Climate Change and Natural Disasters

- Climate hazards are natural events in weather cycles.
  - With the increasing global surface temperatures, the possibility of more droughts and increased intensity of storms likely to occur.
  - As more water vapor is evaporated into the atmosphere, it becomes fuel for more powerful storms to develop.
- **Natural disasters includes:**
  - Earthquakes
  - Tsunamis
  - Cyclones /hurricane/
  - Droughts
  - Wildfires
  - High winds and
  - Flooding

Figure 6.6. Heavy rains and storms caused damage and flooding to the Lietchuor camp in Ethiopia, Gambella region.

Figure 6.7 Dust storms in Eastern Ethiopia

6.2.4.2 Melting Ice and Rising Seas

- When water warms up, it expands.
  - At the same time global warming causes polar ice sheets and glaciers to melt.
  - The combination of these changes is causing sea levels to rise, resulting in flooding and erosion of coastal and low lying areas.

6.2.4.3 Extreme Weather, Shifting Rainfall

- Heavy rain and extreme weather events are becoming more frequent.
- This can lead not only to floods and decreasing water quality but also to decreasing availability of water resources in some regions.

Figure 6.8 Failed crops as a result of climate change, Ethiopia

6.2.4.4 Risks of Climate Change for Human Health

- Climate change is already having an impact on health:
  - An increase in heat-related deaths in some regions of the Earth.
  - A decrease in cold-related deaths in other parts of the world.
  - Increase in the spread of water-borne illnesses and disease vectors.

Safety Rules /Precautions during Natural Disaster

- **Disaster risk management** is a comprehensive approach involving the identification of threats through implementation of the proposed mitigation measures.
- Natural disasters are catastrophic events that often occur without warning and disrupt the ecosystem by causing damage to:
  - Personal lives and Property
  - Transportation and Livelihood
- It is never possible to prevent a disaster, the damage can be minimized through timely preparation.

Figure 6.9 Elements of Comprehensive risk management

Precautions to be taken during natural disasters

Earthquakes

- The shifting of tectonic plates under the earth's crust causes earthquakes, which are responsible for mass destruction.
- ***When faced with an earthquake, these tips can be of use:***
- **If you are indoors:**
  - Take cover under a sturdy table or other pieces of furniture.
  - Stay away from glass, windows, outside doors and walls, and anything that could fall, such as lighting fixtures or furniture.
  - Stay inside until the shaking stops.
  - Do not use the elevators
- **If you are outdoors:**
  - Stay away from buildings, streetlights, and utility wires.
  - Stand in open ground until the shaking stops.

Tsunamis

- **Tsunamis** are a series of enormous ocean waves caused by earthquakes, underwater landslides, or volcanic eruptions.
- Tsunami waves range from tens to hundreds of feet tall and can travel twenty to thirty miles per hour.
- ***When faced with this phenomenon, these tips are to be followed:***
  - Learn tsunami warning via radio/TV.
  - Move inland to higher ground immediately and stay there.
  - Check for a noticeable recession in water away from the shoreline.
  - Stay away from flooded and damaged areas.
  - Keep yourself away from debris in the water.

Cyclones /Hurricane/

- Cyclones are tropical storms, caused by atmospheric disturbances around a low-pressure area.
- Are accompanied by strong winds, moving at a speed of sixty-two Kmph or more.
- ***When faced with a hurricane, keep these tips in mind:***
  - Be alert to the changing weather conditions.
  - Listen to radio/TV for the latest information.
  - Look for approaching storms
  - Look for the following warning signs: Dark, often greenish sky, Large hailstones, a large, dark, low-lying cloud (particularly if rotating), roars, similar to a freight train.
  - Take refuge in designated cyclone shelters.

Floods

- Floods are among the earth's most common and dangerous natural hazards formed due to a flow of water on areas of land that are usually dry.
- Excessive rains can damage nearby dams where tsunamis are some of its causes.
- ***When faced with flooding, these tips are to be followed:***
  - Do not attempt to walk, swim, or drive through the floods.
  - Stay clear of bridges over fast-moving water.
  - Keep an eye out for evacuation alerts.
  - Move to higher ground.

Mitigation Measures

- There are three main climate change mitigation approaches.
- The **first route** is conventional mitigation effort that employs **decarbonization to reduce CO2 emissions**.
  - The techniques include renewable energy, fuel switching, efficiency gains, nuclear power, and carbon capture storage and utilization.
- The **second route** focuses on **capturing and sequestering of CO2** from the atmosphere through:
  - Ocean fertilization, ocean alkalinity enhancement, soil carbon sequestration, afforestation and reforestation, wetland construction and restoration.
- The **third route** is the principle of **altering the Earth's radiation balance** through:
  - The management of solar and terrestrial radiation.

6.3 International Conventions

- Climate change is a long-term, global problem.
  - Long-term problems generally require stable but flexible policy implementation over time.
  - Various international conventions have continuously evolved to address the increasingly complex and changing environmental priorities of the world.

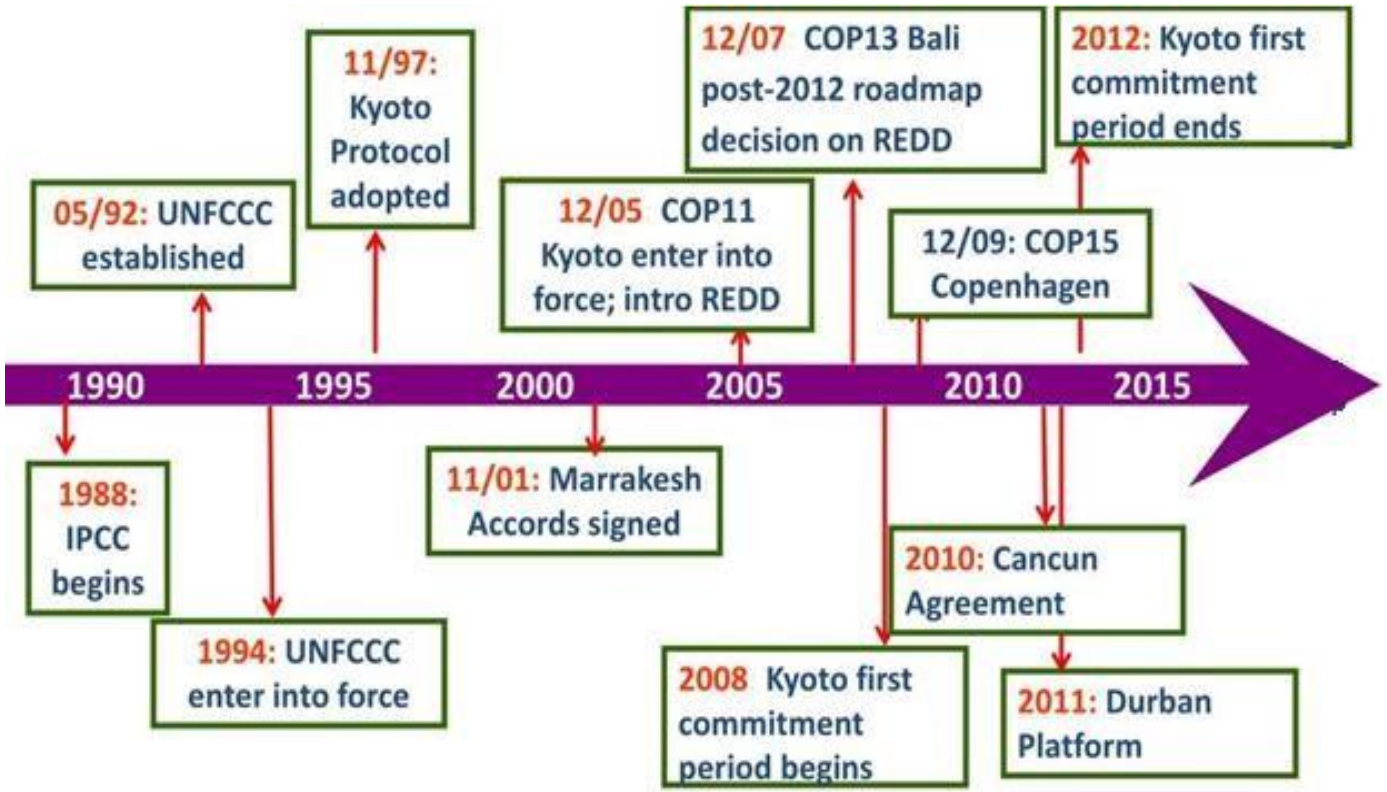


Figure 6.10 Climate Policy Timeline

Copenhagen (COP15) Policy

- The Copenhagen climate change conference, also known as **COP15took** place in December 2009 in Copenhagen, **Denmark**.
  - The conference aimed to negotiate a **global agreement on climate change to succeed the Kyoto protocol**, which was set to expire in 2012.
- For the first time it was decide that each country would propose a national contribution (INC, Intended Nationally Determine Contributions).
- All the 195UNFCCC countries pledge to reduce their greenhouse gas emission by **2025-2030.**
  - It aimed ``***to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty*** ``
- However, the Copenhagen conference faced challenges and controversies. It lacked legally binding commitments and detailed plans for achieving its goals

- ***The three key goals of COP15:***

1. Holding the increase in the global average temperature to well below **2ºC** above pre-industrial levels and pursuing efforts to limit the temperature increase to **1.5 º C** above pre- industrial levels.
2. Increase the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development
3. Making finance flows consistent with a pathway towards low greenhouse gas emission and climate resilient development.

The United Nations Framework Convention

- The United Nations Framework Convention on Climate Change (UNFCCC), agreed in 1992.
  - UNFCCC is the main international treaty to combat "**dangerous human interference with the climate system**", in part by stabilizing greenhouse gas concentrations in the atmosphere.

- Its objective is to prevent **dangerous man-made interference** with the global climate system.
- The UNFCCC is an international environmental treaty.
  - Ethiopia and all its member countries are among the 197 Parties of the Convention.

Kyoto Protocol on Climate Change

- The Kyoto Protocol was **adopted on 11 December 1997**
- The Kyoto Protocol operationalizes the UNFCCC by committing industrialized countries and economies in transition to limit and reduce GHG emissions in accordance with agreed individual targets.
  - That means **the Kyoto Protocol** is an international agreement that called for industrialized nations to reduce their greenhouse gas emissions significantly.
- The Doha Amendment and the Paris Climate Agreement, have also tried to curb the global-warming crisis.

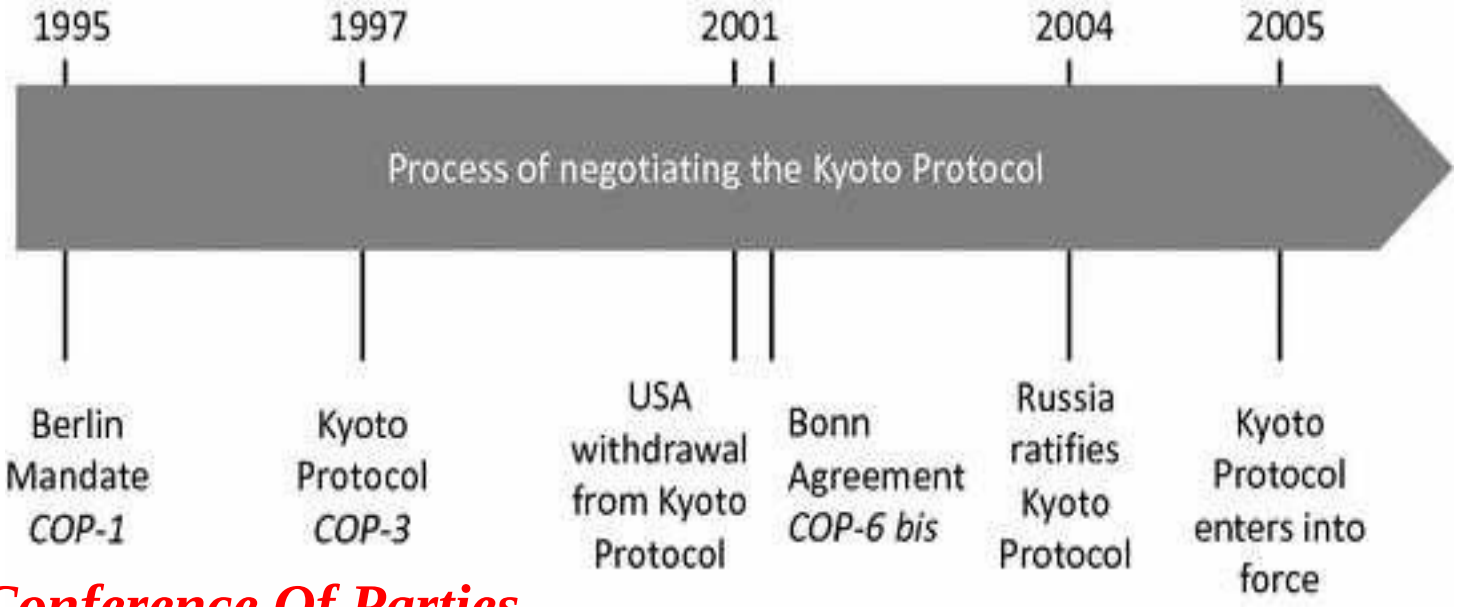
Doha Amendment

- The Doha amendment is an amendment to the Kyoto protocol, adopted during 2012 in ***Doha, Qatar***.
- It sets out new emission reduction targets for developed countries for the second commitment period of the Kyoto protocol, which runs from 2013 to 2020.

Paris Climate Agreement

- The Paris agreement was adopted in 2015.
- It aims "to limit global warming to well below $2^{o}C$ above pre-industrial level and pursue efforts to limit it to $1.5^{o}C$.
- It includes nationally determined contributions (NDCs) from each country, which outline their climate action plans.
- It took 8 years for participant countries to ratify the Kyoto protocol
- Industrialized/ developed countries would be legally obliged to cut greenhouse gas emission by 5% on 1990 levels by 2008-2012.

- Developing countries like **china, India, Brazil, and South Africa** would face no restrictions on their emission but were encouraged to adopt policies to promote greener growth.
- Kyoto also offered mechanisms to offset emission by investing in ***low-carbon projects*** in poorer parts of the world.
  - It was hailed as an***" environmentally strong and economically sound"*** **Bill Clinton US** president 1997 ***"it reflects a commitment from our generation to act in the interest of future generations"***, he said.



COP- means Conference Of Parties

Figure 6.11 The Negotiation process leading to the Kyoto Protocol

Summary of THE Kyoto Protocol and Paris Agreement on Climate Change

Kyoto Protocol

- Was adopted on 11 December 1997 and ratified in 2005.
- Legally binding agreement to decrease GHG.
- Original commitment to decrease overall emission by 5% on 1990 levels by 2008-2012.
- Only required developed/industrialized/ nations to reduce emissions.
- Targets are set but not determined time frame.

Paris Agreement

- Signed in November of 2016. New commitment are due every 5 year.
- Not legally binding commitment to reduce emission, to increase accountability.
- Overall goal to limit temperature to 1.5 degrees Celsius above pre-industrial levels.
- Asked all nations to reduce emissions.
- New set of targets declared after 5 years (these are now due in 2020).

6.3.3 The National Practice Of Implementation Conventions

Ethiopia Green Legacy Initiative

- Ethiopia is one of the world`s most drought-prone countries
- It has a high degree of vulnerability to hydro- meteorological hazard and natural disasters.
- Ethiopia`s policy response to climate change has progressively evolved since the ratification of the UNFCCC in 1994.
- It launched the national adaptation plan of action in 2007 and Ethiopian program of adaptation on climate change and nationally appropriate mitigation action in 2010.
- Moreover, Ethiopia endorsed climate resilient green economy (CRGE) strategy in 2011 to build a green and resilient economy.
- Over the years Ethiopia has implemented various programs with those policy frameworks.
- One among them and by far the most consequential has been **the green legacy initiative (GLI) launched in 2019.**

- Vision to build a green and climate resilient Ethiopia and target to plant **20 billon** seedlings within **a period of 4 years**.
- This aimed to combat the impacts of climate change by improving: Agroforestry, Forest sector development, Greening, Renewal of urban areas, Integrated water and soil resource management

Great Ethiopian Renaissance Dam (GERD)

- Hydroelectric dam on the Abay (Blue Nile) river. Under construction since 2011 in Benishangul Gumuz region.
- The purpose is to generate electricity with a capacity of **5.15 gigawatts** to relieve Ethiopia's acute energy shortage and for electricity export to neighboring countries.
- It is the largest hydroelectric power plant in Africa and it is one of the best examples in Ethiopia to support the climate resilient green economy (CRGE) strategy.
- The lake being created on the GERD will be the biggest lake in Ethiopia with the potential for fishing and irrigation development. Ethiopia exports electricity to Djibouti, Sudan, Kenya and South Sudan.