

Why Climate Classification?

Climate classification is a way to categorize regions based on similar climatic conditions, such as temperature, humidity, and solar radiation.

The purpose of climate classification is to help people better understand Earth's climates by simplifying and clarifying the differences and similarities between geographic areas.

Classification schemes use environmental data to identify patterns and connections between climatic processes.

They are also valuable in the study of climate change, allowing for the analysis of projected changes in climate types and seasonality over time. Additionally, climate classifications can be used to structure and analyze in identifying regional clusters and assessing the role of regional climate factors.

The Koppen climate classification system is the most widely used system for classifying the world's climates. Its categories are based on the annual and monthly averages of temperature and precipitation.

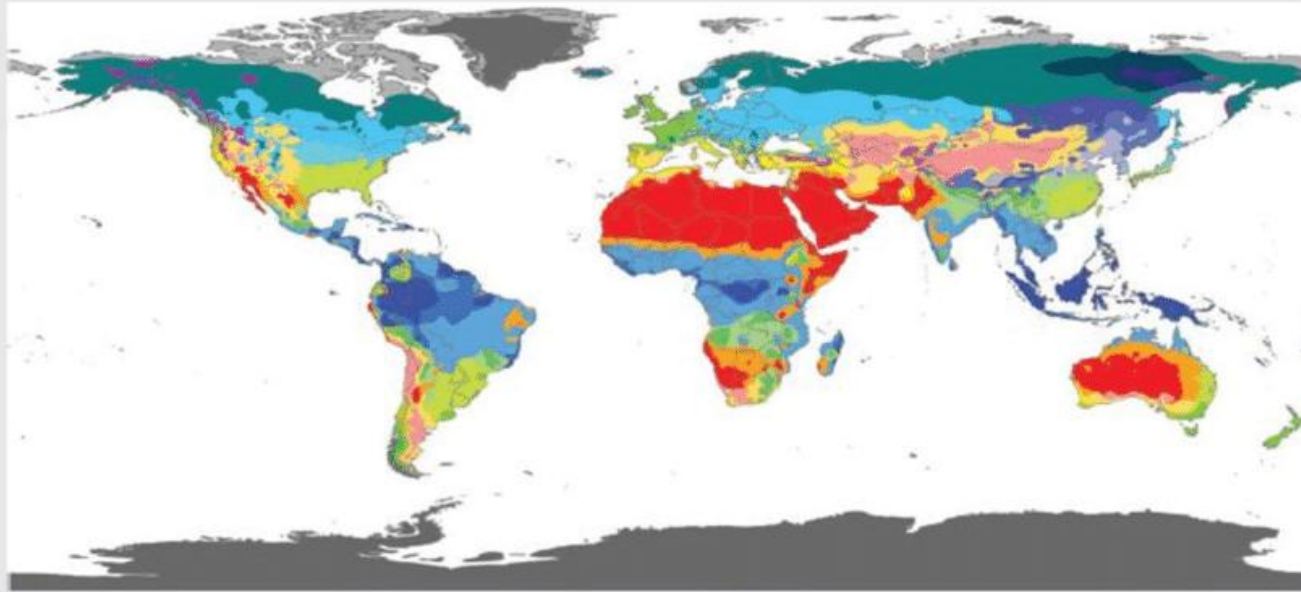
Climate Groups According to Koeppen

<i>Group</i>	<i>Characteristics</i>
A - Tropical	Average temperature of the coldest month is 18° C or higher
B - Dry Climates	Potential evaporation exceeds precipitation
C - Warm Temperate	The average temperature of the coldest month of the (Mid-latitude) climates years is higher than minus 3°C but below 18°C
D - Cold Snow Forest Climates	The average temperature of the coldest month is minus 3° C or below
E - Cold Climates	Average temperature for all months is below 10° C
H - High Land	Cold due to elevation

Climatic Types According to Koeppen

<i>Group</i>	<i>Type</i>	<i>Letter Code</i>	<i>Characteristics</i>
A-Tropical Humid Climate	Tropical wet	Af	No dry season
	Tropical monsoon	Am	Monsoonal, short dry season
	Tropical wet and dry	Aw	Winter dry season
B-Dry Climate	Subtropical steppe	BSh	Low-latitude semi arid or dry
	Subtropical desert	BWh	Low-latitude arid or dry
	Mid-latitude steppe	BSk	Mid-latitude semi arid or dry
	Mid-latitude desert	BWk	Mid-latitude arid or dry
C-Warm temperate (Mid-latitude) Climates	Humid subtropical	Cfa	No dry season, warm summer
	Mediterranean	Cs	Dry hot summer
	Marine west coast	Cfb	No dry season, warm and cool summer
D-Cold Snow-forest Climates	Humid continental	Df	No dry season, severe winter
	Subarctic	Dw	Winter dry and very severe
E-Cold Climates	Tundra	ET	No true summer
	Polar ice cap	EF	Perennial ice
H-Highland	Highland	H	Highland with snow cover

Koeppen's climate classification Map



Af: Tropical - Rainforest
Am: Tropical - Monsoon
Aw: Tropical - Savanna
BWh: Arid - Desert Hot
BWk: Arid - Desert Cold
BSh: Arid - Steppe Hot
BSk: Arid - Steppe Cold
Csa: Temperate - Dry Hot Summer
Csb: Temperate - Dry Warm Summer
Cwa: Temperate - Dry Winter Hot Summer
Cwb: Temperate - Dry Winter Warm Summer
Cwc: Temperate - Dry Winter Cold Summer
Cfa: Temperate - Hot Summer Without Dry Season
Cfb: Temperate - Warm Summer Without Dry Season
Cfc: Temperate - Cold Summer Without Dry Season

Dsa: Cold - Dry Hot Summer
Dsb: Cold - Dry Warm Summer
Dsc: Cold - Dry Cold Summer
Dsd: Cold - Dry Summer Very Cold Winter
Dwa: Cold - Dry Winter Hot Summer
Dwb: Cold - Dry Winter Warm Summer
Dwc: Cold - Dry Winter Cold Summer
Dwd: Cold - Dry Winter Very Cold Winter
Dfa: Cold - Hot Summer Without Dry Season
Dfb: Cold - Warm Summer Without Dry Season
Dfc: Cold - Cold Summer Without Dry Season
Dfd: Cold - Very Cold Winter Without Dry Season
ET: Polar - Tundra
EF: Polar - Frost

A TROPICAL HUMID CLIMATES

Tropical wet	Af	(Wet all year)
Tropical savanna	Aw	(Dry winter; wet summer)
Tropical monsoon	Am	(Dry winter; very wet summer)

B DRY CLIMATES

Subtropical desert	BWh	("Hot" desert)
Midlatitude desert	BWk	("Cold" desert)
Subtropical steppe	BSh	("Hot" semiarid)
Midlatitude steppe	BSk	("Cold" semiarid)

C MILD MIDLATITUDE CLIMATES

Mediterranean	Csa	(Hot, dry summer)
	Csb	(Warm, dry summer)
	Cfa	(Wet all year; hot summer)
Humid subtropical	Cwa	(Dry winter; hot summer)
	Cwb	(Dry winter; warm summer)
	Cfb	(Wet all year; warm summer)
Marine west coast	Cfc	(Wet all year; cool summer)

D SEVERE MIDLATITUDE CLIMATES

Humid continental	Dfa	(Cold winter; wet all year; hot summer)
	Dfb	(Cold winter; wet all year; warm summer)
	Dwa	(Cold, dry winter; hot summer)
	Dwb	(Cold, dry winter; warm summer)
Subarctic	Dfc	(Cold winter; no dry season; cool summer)
	Dfd	(Very cold winter; no dry season)
	Dwc	(Cold, dry winter; cool summer)
	Dwd	(Very cold, dry winter)

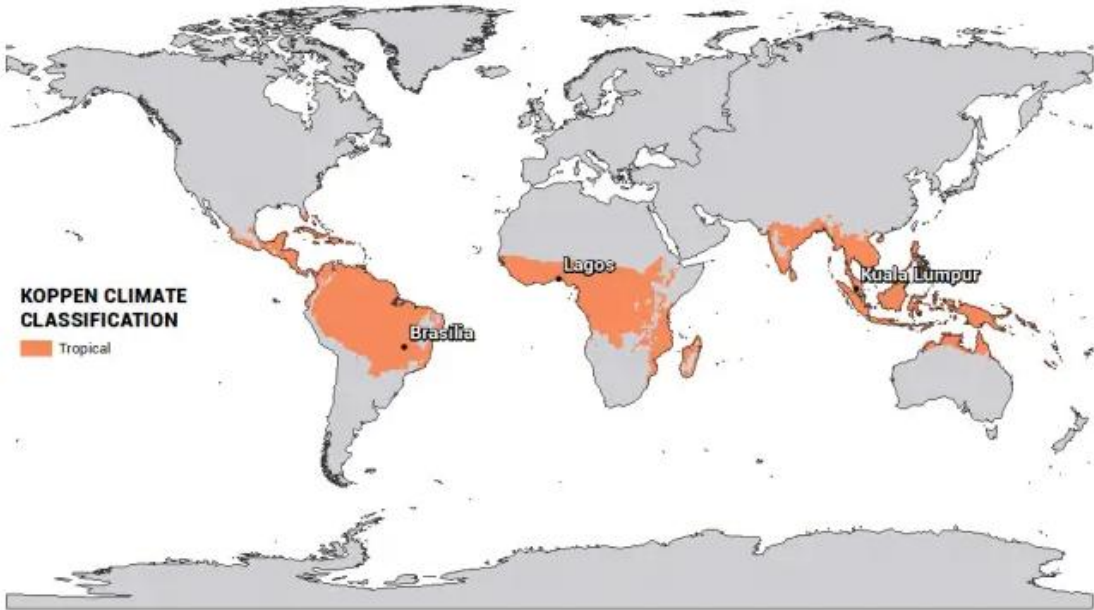
E POLAR CLIMATES

Tundra	ET	(Polar tundra; no true summer)
Ice cap	EF	(Polar ice cap)

H HIGHLAND CLIMATES

	H	(High elevation climates)
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1. Tropical (A)



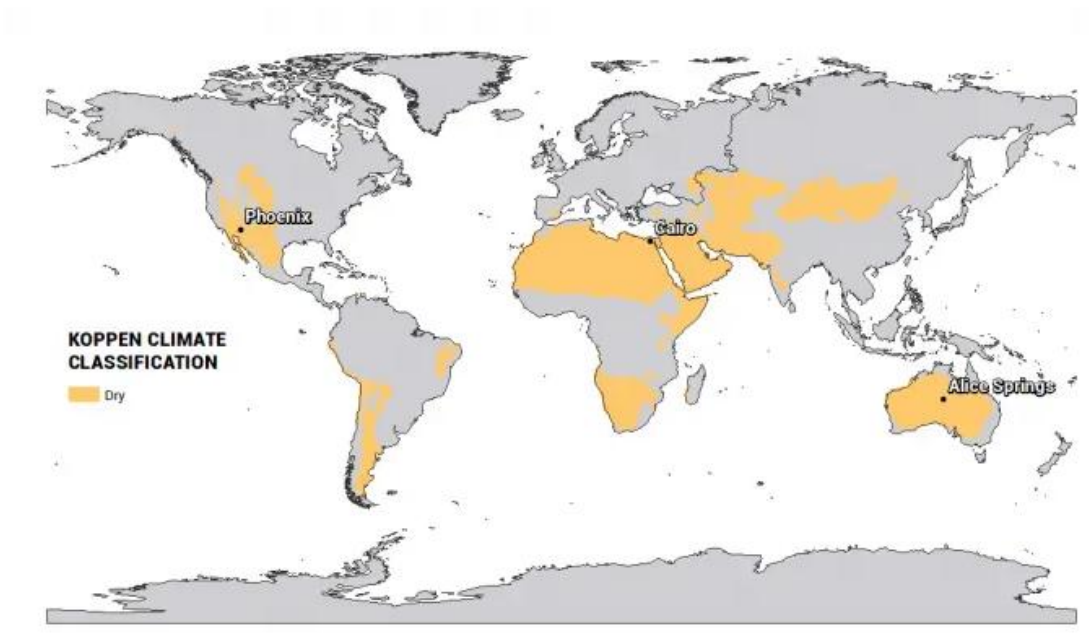
Sub divisions of tropical climates based on precipitation

Climate Type	Criteria
Tropical (A)	The lowest mean monthly temperature is greater than 18°C.
Tropical rainforest (Af)	Precipitation in the driest month is at least 6 cm or greater.
Tropical monsoon (Am)	Precipitation in the driest month is less than 6 cm but more than 4% of total annual precipitation.
Tropical wet and dry savannah (Aw)	Precipitation in the driest month is less than 10 cm and less than 4% of total annual precipitation.

warm all year round for tropical climates. This type of climate exists near the equator from 15°N to 15°S latitude.

Tropical climates sustain a healthy portion of high temperature (+18°C) with its lowest mean monthly air temperature greater than 18 °C.

2. Dry (B)

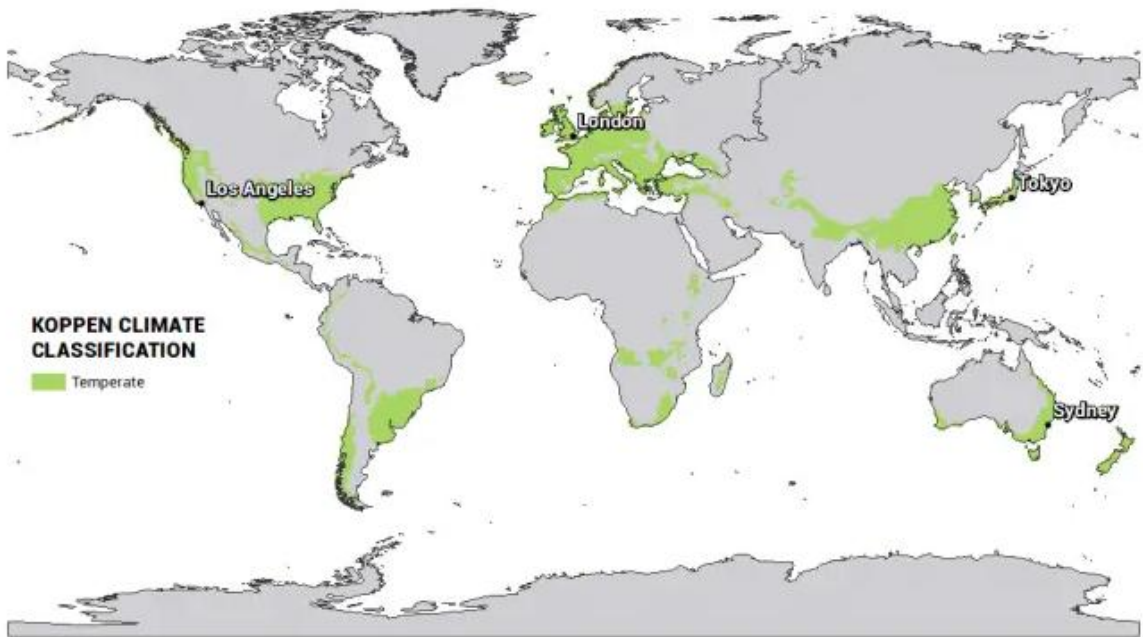


Sub divisions of Dry climates based on precipitation

Climate Type	Criteria
Arid desert (BW)	Annual precipitation is less than 50% of the precipitation threshold.
Semi-arid steppe (BS)	Annual precipitation is more than 50% of the precipitation threshold.

Dry climates are the only category in the Koppen climate classification that not entirely based on temperature. They are also characterized by having a shortage of water with a low annual mean precipitation rate because water evaporates quickly from its temperatures.

3. Temperate (C)



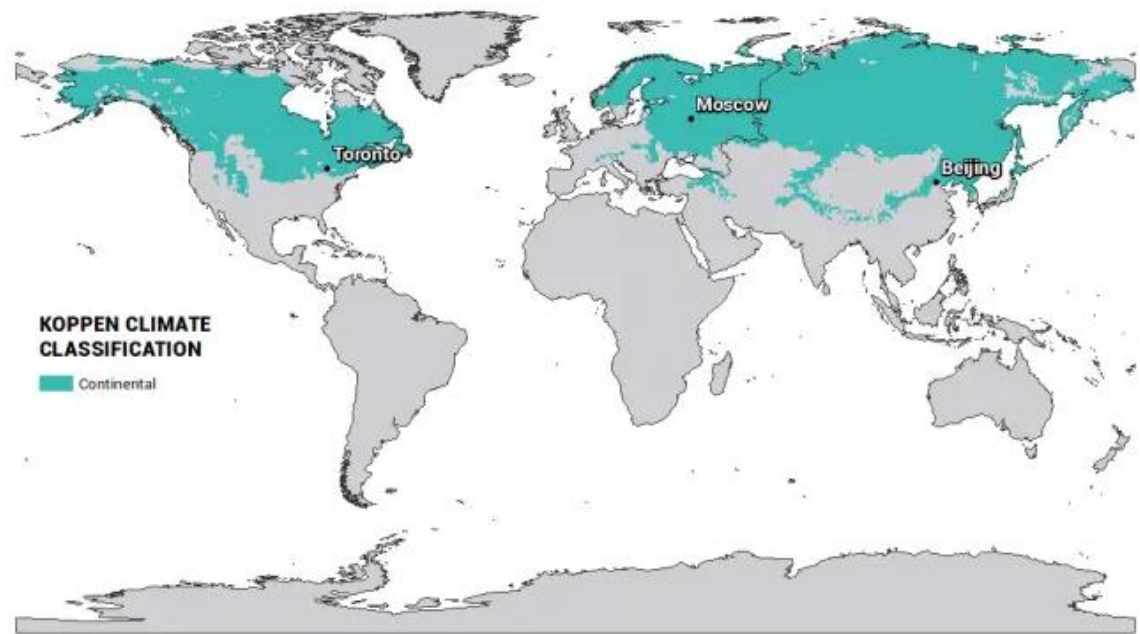
Sub divisions of Temperate climates based on precipitation

Climate Type	Criteria
Mild temperate dry summer (Cs)	Precipitation in the driest month of summer is less than 1/3 the amount in the wettest winter month.
Mild temperate dry winter (Cw)	Precipitation in the driest month of winter is less than 1/10 of the amount in the wettest summer month.
Mild temperate humid (Cf)	Does not satisfy Cs or Cw climate types.

If the average temperature of the warmest month is higher than 10°C and the coldest month is between 18° and 0°C, then it's considered a temperature climate.

These types of climates are common along the edge of continents.

4. Continental (D)



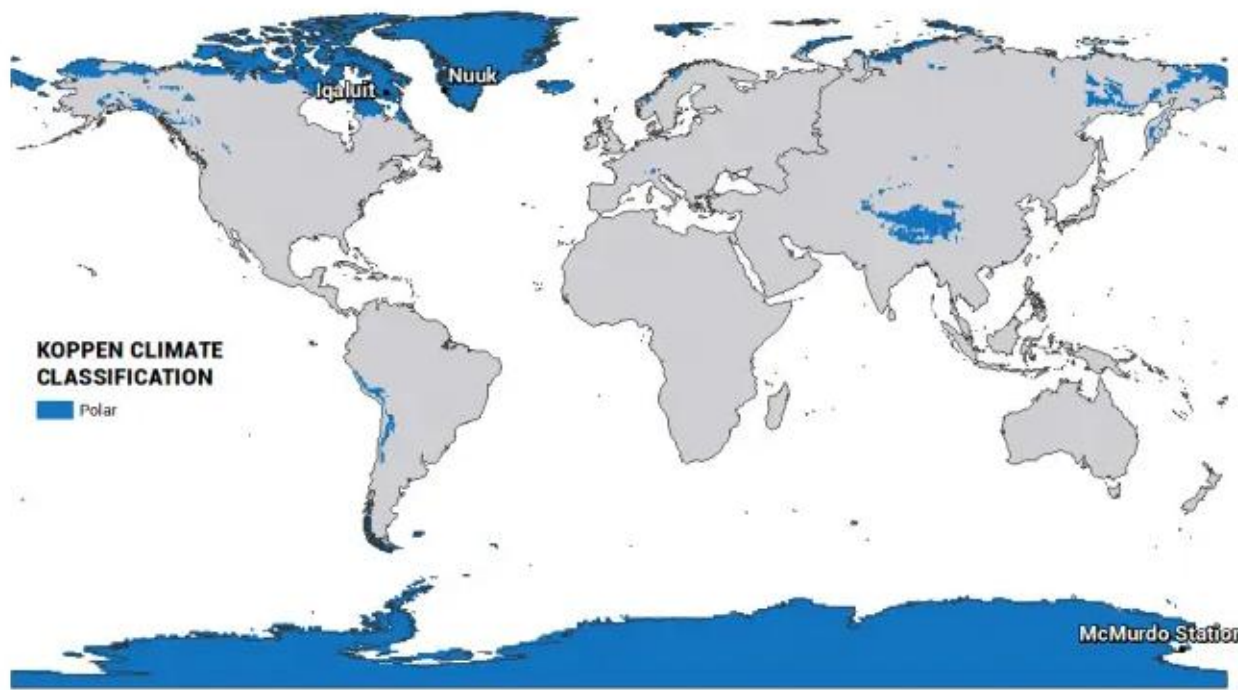
Continental climates are usually situated in the interior of continents. They have at least one month with an average temperature below 0°C. Likewise, at least one-month averages above 10 °C.

Typically, continental climates range from 40° to 75° latitudes in the northern and southern hemispheres. However, this type of climate type is rare in the southern hemisphere.

Sub divisions of Continental climates based on precipitation

Climate Type	Criteria
Continental dry summer (Ds)	Precipitation in the driest month of summer is less than 1/3 the amount in the wettest winter month.
Continental dry winter (Dw)	Precipitation in the driest month of winter is less than 1/10 of the amount in the wettest summer month.
Continental humid (Df)	Does not satisfy Ds or Dw climate types.

5. Polar (E)



Climate Type	Criteria
Tundra (ET)	The average temperature in the warmest month is between 10° and 0°C.
Ice Cap (EF)	The average temperature of the warmest month is 0°C or below.

Polar climates endure frigid temperatures year-round. The average temperature of the warmest month in polar climatic zones is below 10°C.

Typically, these types of climates occur in the polar regions, generally greater than 70° latitude in the northern and southern hemispheres.

Regional Climates

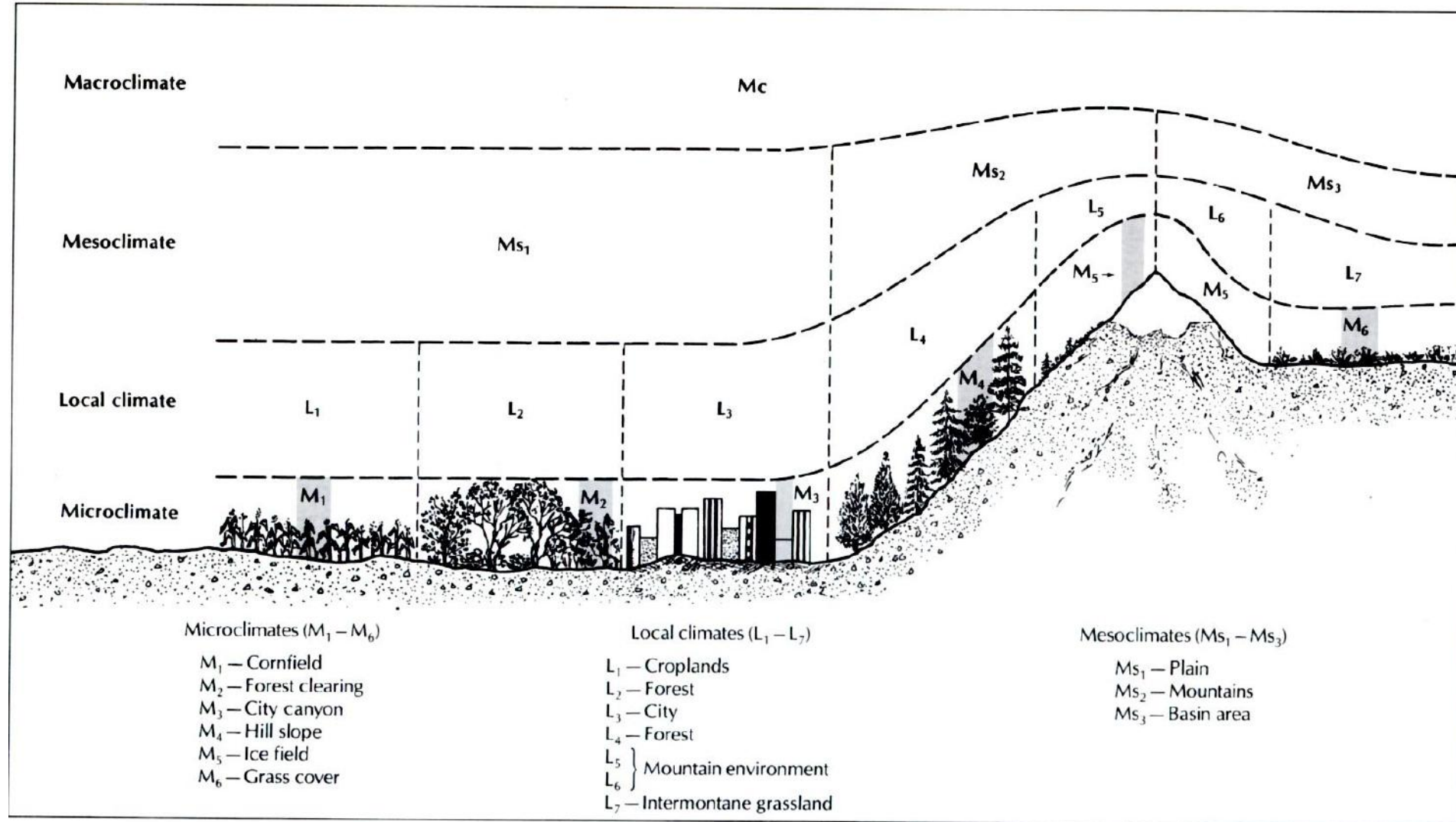
Macro-climate: Large horizontal area of extends for $4 \times 10^8 \text{ m}^2$ and up to 6000 m vertically
Continental in Scale

Meso-climate: Area extends - 10^3 m^2 up to $4 \times 10^8 \text{ m}^2$ – Sub continental in Scale

Local climate – A group of microclimates that characterize a specific region – 10^3 to 10^8 m^2 in size

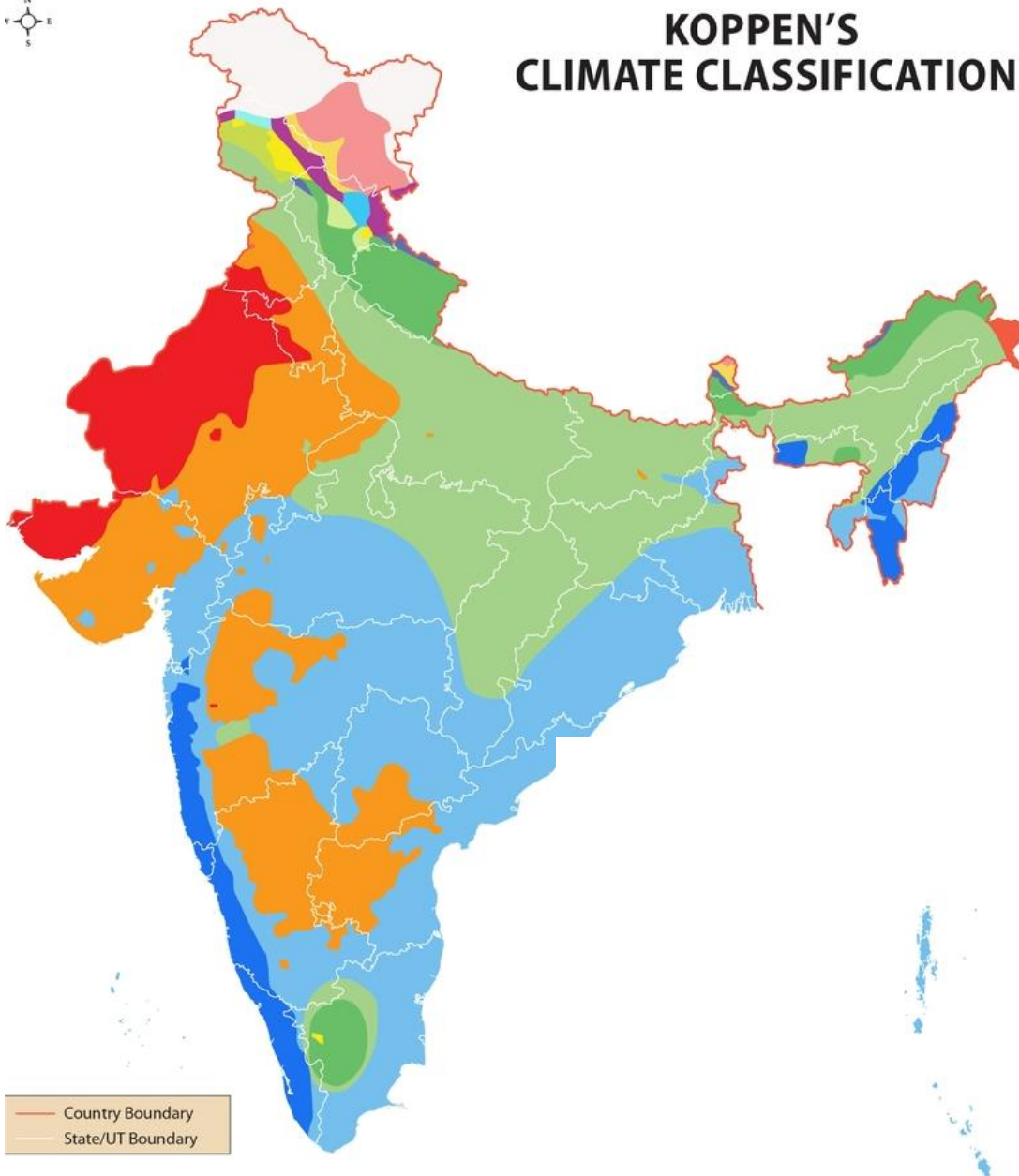
Microclimate – The smallest category – 1 to 10^8 m^2 in size - An individual field or park

Schematic of climatic scales of study

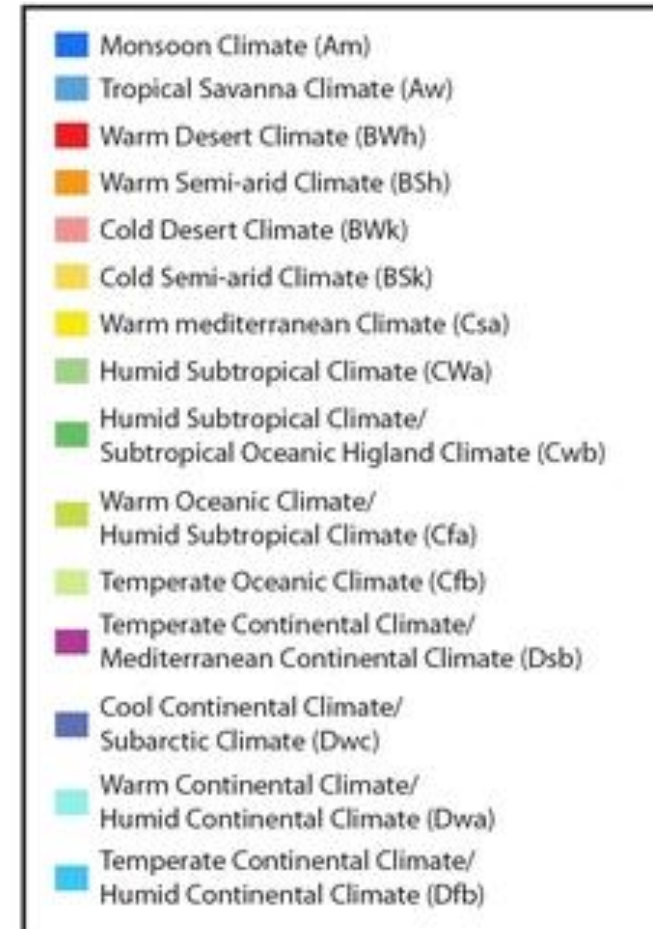




KOPPEN'S CLIMATE CLASSIFICATION



Indian Climate Classification



Climate change and variability

Climate change: Any permanent change in weather phenomena from the normals of a long period average is referred as climate change. Eg. The global temperature has increased by 2.0 to 3.0 C and increase in CO₂ from 180ppm to 350ppm.

Climate variability: The temporal changes in weather phenomena which is part of general circulation of atmosphere and occurs on a yearly basis on a global scale.

What Is Climate Change ?

Climate means the **usual condition of the temperature, humidity, atmospheric pressure, wind, rainfall, and other meteorological elements in an area of the Earth's surface for a long time for about thirty years.**

Climate change is the **global phenomenon of climate transformation** characterized by the changes in the usual climate of the planet (regarding temperature, precipitation, and wind) that are **especially caused by human activities.**

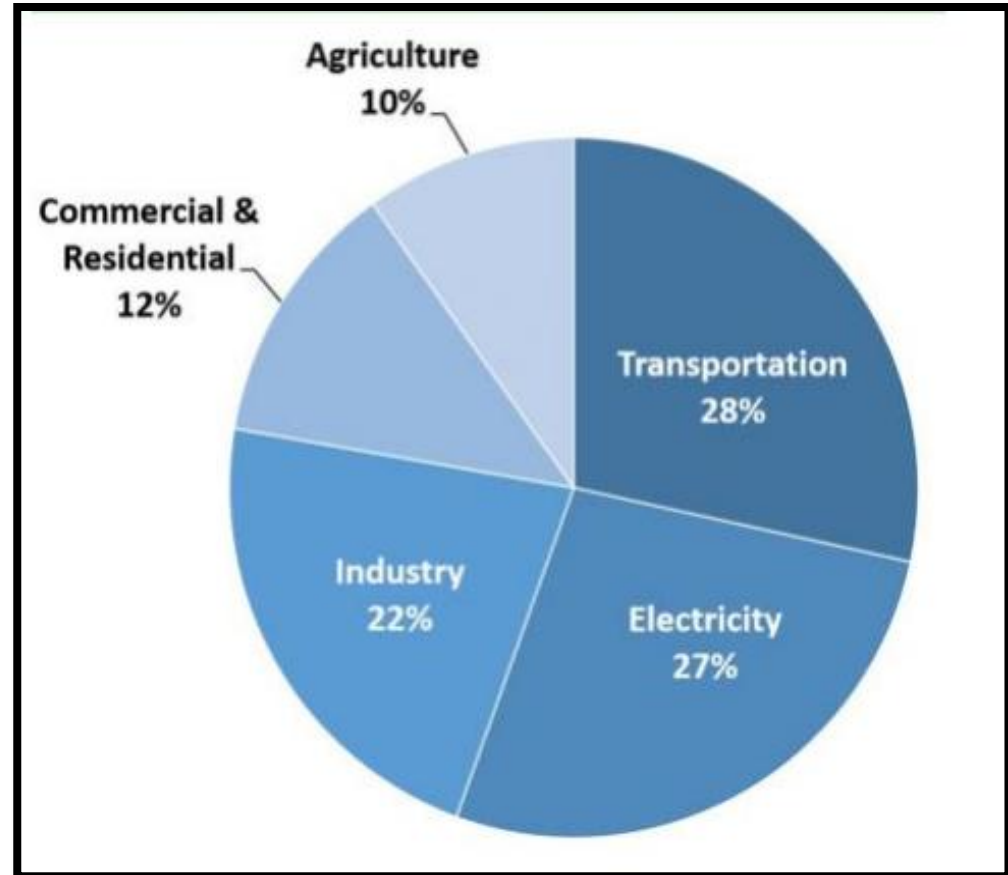
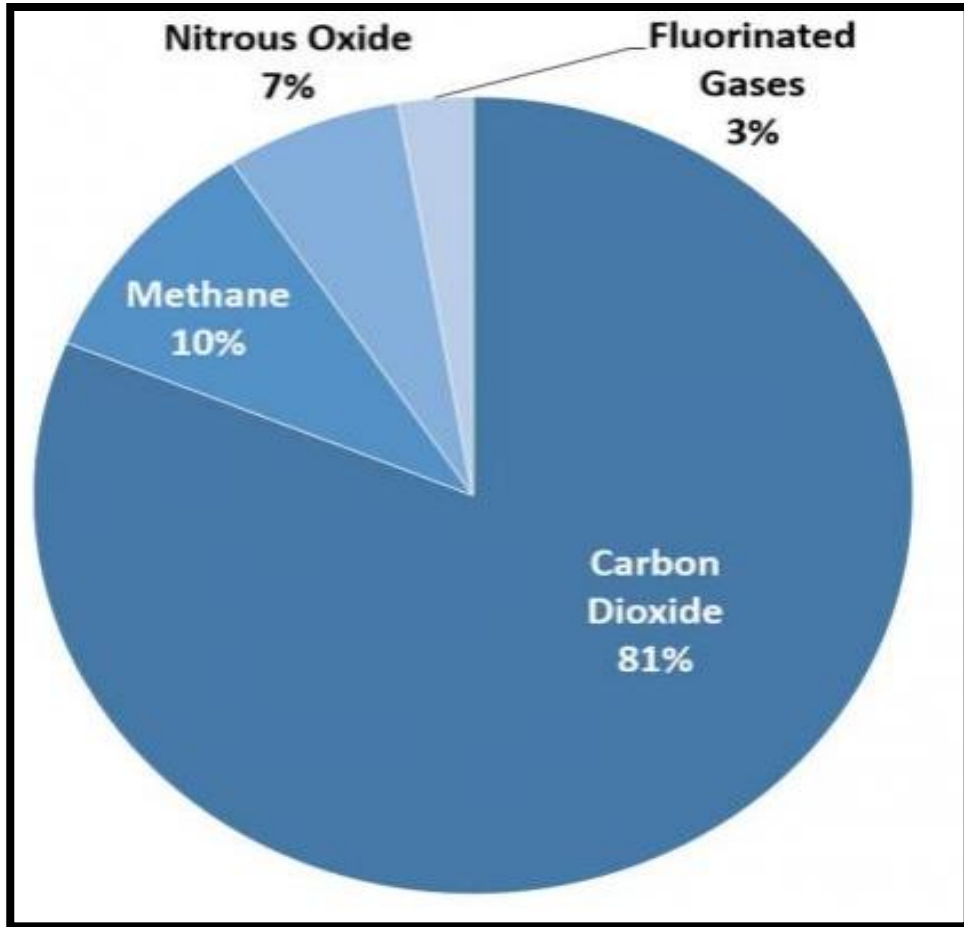
Anthropogenic Causes - Greenhouse Gases

Greenhouse gases play a vital role in the earth's climate cycles. As the planet gets hit with the sun's rays, some of the energy is absorbed, and the rest of that energy and heat gets reflected into space. Greenhouse gases in the atmosphere trap the reflected energy, redirecting it back down to the earth and eventually contributing to global warming.

- Water vapor
- Carbon dioxide (CO₂)
- Methane
- Nitrous oxide
- Chlorofluorocarbons (CFCs)

While some of these greenhouse gases, such as water vapor, are naturally occurring, others, such as CFCs, are synthetic. CO₂ is released into the atmosphere from both natural and human-made causes and is one of the leading contributors to climate change.

Greenhouse gases and their sources



Causes of climatic variability

A. External causes

- i) Solar output: An increase in solar output by 0.3% when compared to 1650 -1700AD data.
- ii) Orbital variation: 1. Earth orbit varies from almost a complete circle to marked ellipse (Eccentricity). 2. Wobble of earth's axis (Precession of equinox) 3. Tilt of the earth's axis of rotation relative to the plane of the orbit varies between 21.8° and 24.4°.

B. Internal causes

- i) Changes in the atmospheric composition. Change in the green house gases especially CO₂
- ii) Land surface changes particularly the afforestation and deforestation
- iii) The internal dynamics of southern oscillation – changes in the sea surface temperature in western tropical Pacific (El-Nino/La-Nina) coupled with Southern Oscillation Index, the Tahiti minus Darwin normalized pressure index leading to the ENSO phenomena
- iv) Anthropogenic causes of climate variation in green house gases and aerosols.

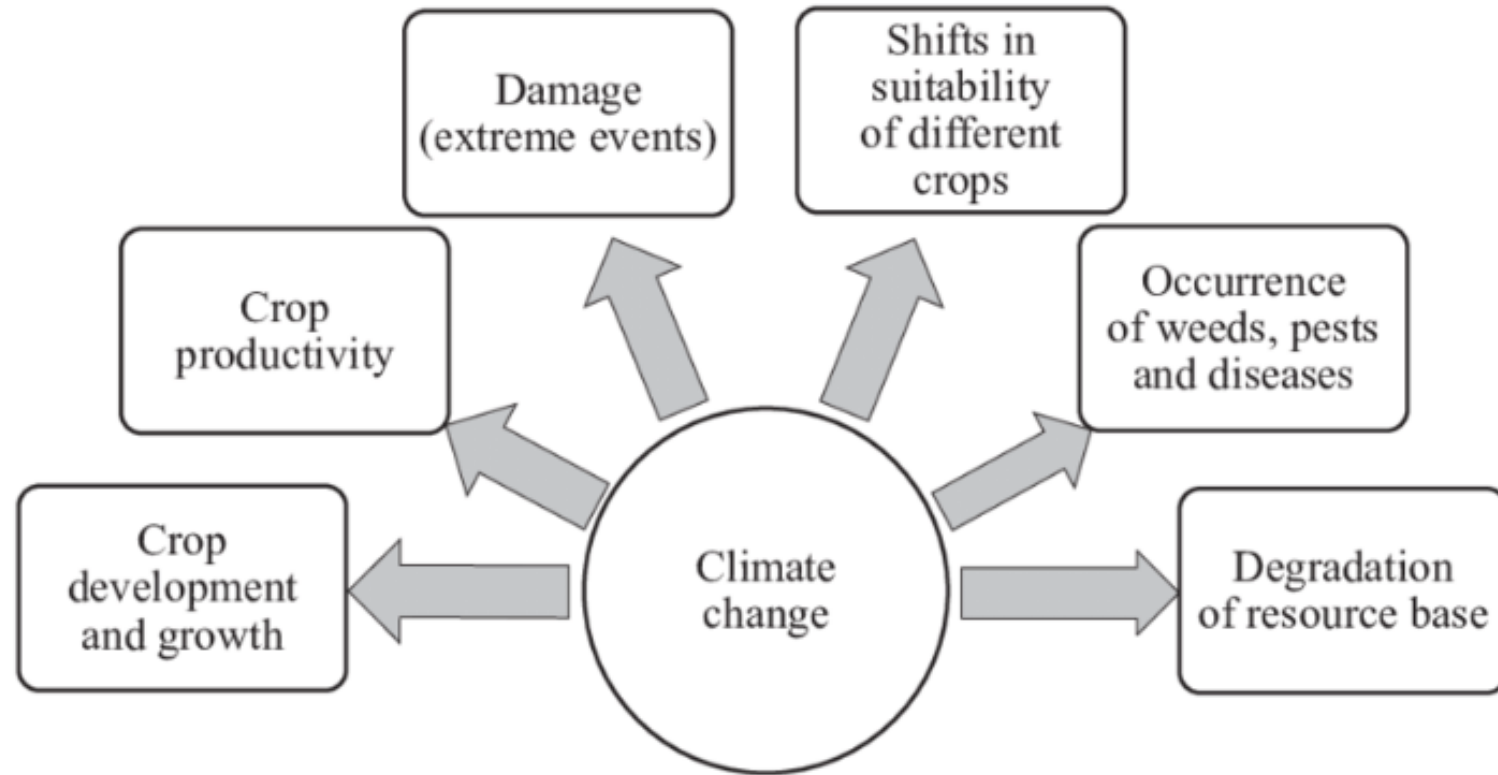
Effects of climate change

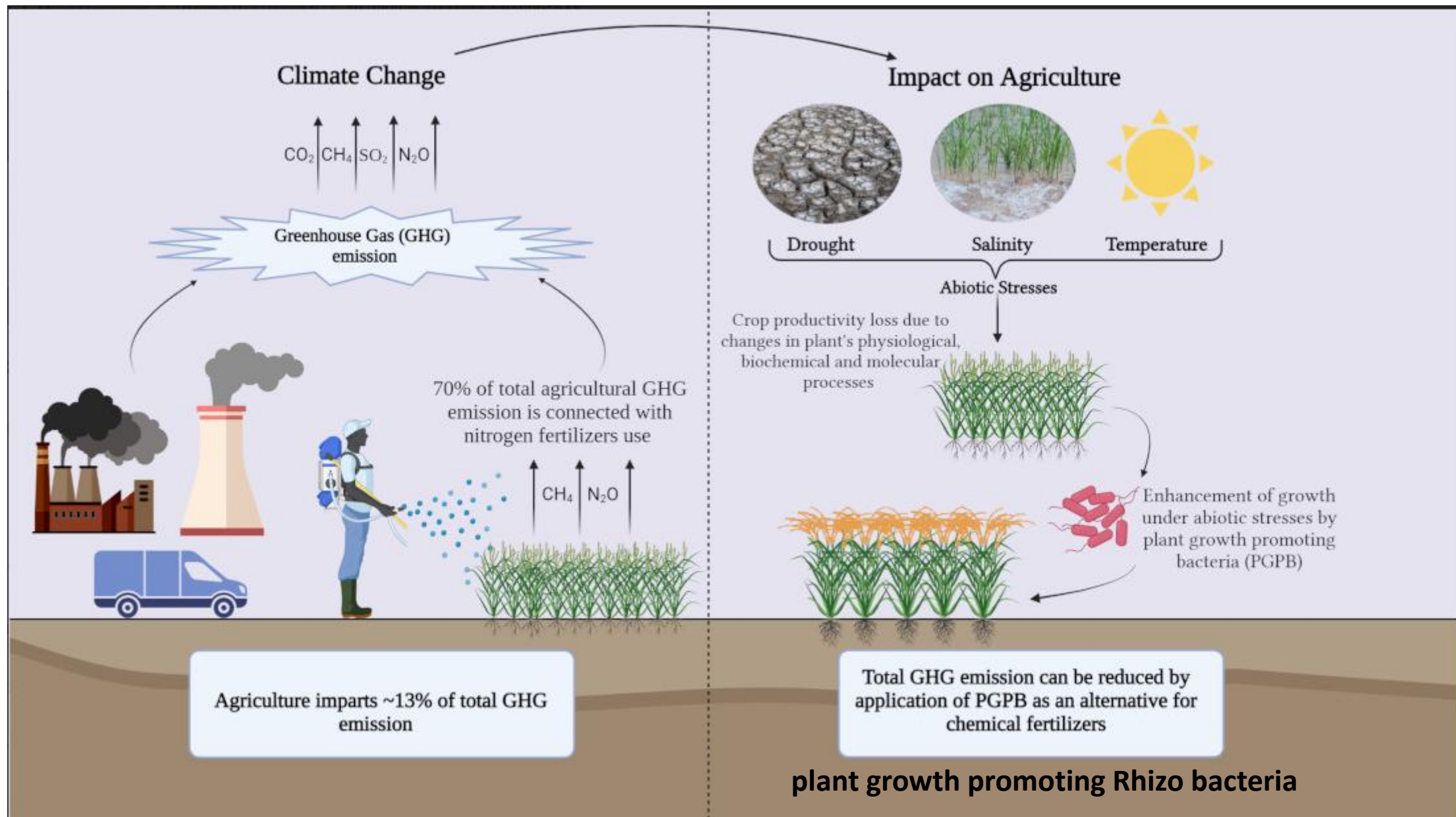
- 1. The increase concentration of CO₂ and other green house gases are expected to increase the temperature of the earth.
- 2. Crop production is weather dependant and any change will have major effects on crop production and productivity.
- 3. Elevated CO₂ and temperature affects the biological process like respiration, photosynthesis, plant growth, reproduction, water use etc. Depending on the latitude the CO₂ may either offer beneficial effect or may behave otherwise also.

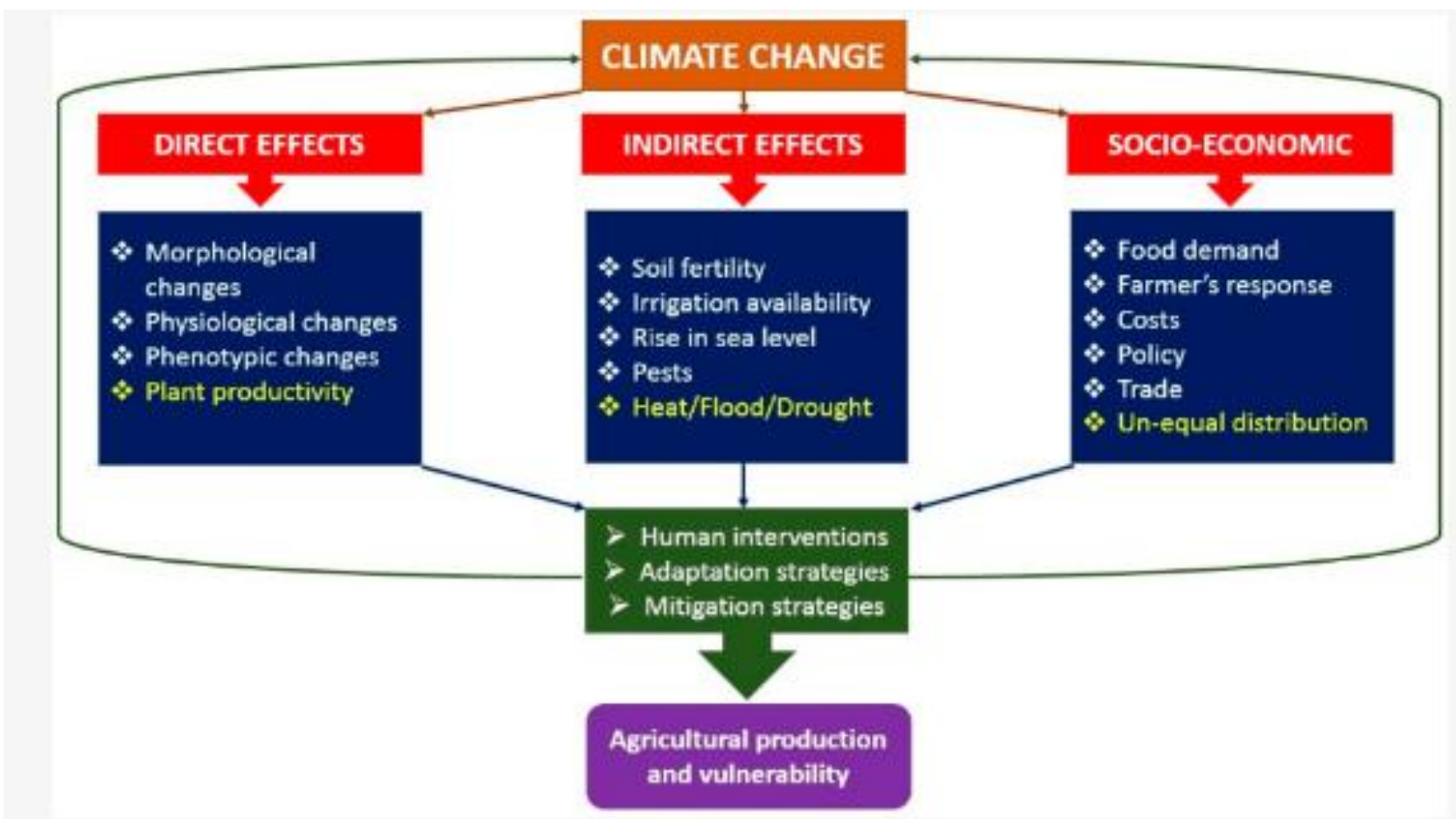
In the case of increase in the concentration of carbon dioxide in the atmosphere it will have impact on agriculture.

Plants use sunlight, carbon dioxide from the atmosphere, and water for photosynthesis to produce oxygen and carbohydrates that plants use for energy and growth. Rising levels of CO₂ in the atmosphere drive an increase in plant photosynthesis—an effect known as the carbon fertilization effect.

Studies have shown that higher concentrations of atmospheric carbon dioxide affect crops in two important ways: they boost crop yields by increasing the rate of photosynthesis, which spurs growth, and they reduce the amount of water crops lose through transpiration.







Effects Of Climate Change On Crops

POSTIVE IMPACTS

Increased productivity from warmer temperatures

Possibility of growing new crops

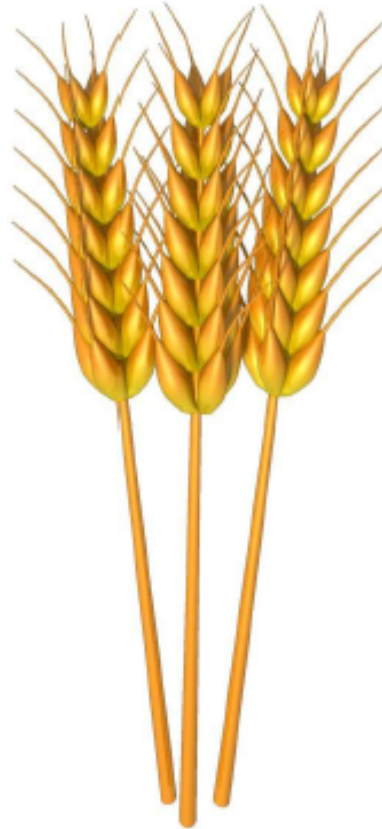
Longer growing seasons

Increased productivity from enhanced CO₂*

Accelerated maturation rates

Decreased moisture stress (for some crops)

*CO₂ fertilization only applies to some crops and will at best be a small temporary benefit for higher altitudes.



NEGATIVE IMPACTS

Increased insect infestations

Crop damage from extreme heat

Planning problems due to less reliable forecasts

Increased soil erosion

Increased weed growth

More plant disease

Decreased herbicide and pesticide efficiency

Increased moisture stress (for most crops)

El-Nino and La-Nina

El-Nino is a Spanish word meaning “the boy child” (‘Child Christ’) because El-Nino occurs around Christmas time each year when the waters off the Peruvian coast warm slightly. In every three to six years, the waters become unusually warm. ‘El Niño’ is now used more widely to refer to this abnormal warming of the ocean and the resulting effects on weather. ‘El Niño’ is often coupled with ‘Southern Oscillation’ as the acronym ENSO. ‘La Niña’ is used popularly to signify the opposite of El Niño, occurring when the waters of the eastern Pacific are abnormally cold. La Niña episodes are associated with more rainfall over eastern Australia, and continuing drought in Peru. Peruvian meteorologists have objected to term La Niña-the Girl Child-because Christ is not known to have had a sister, and the term anti-ENSO is sometimes preferred.

The El-Nino event is due to decrease in atmospheric pressure over the South East Pacific Ocean. At the same time, the atmospheric pressure over Indonesia and North Australia increases. Once the El-Nino event is over, the atmospheric pressure over the above regions swings back. This sea-saw pattern of atmospheric pressure is called Southern Oscillation. Since El-Nino and Southern Oscillation are linked they often termed as ENSO.

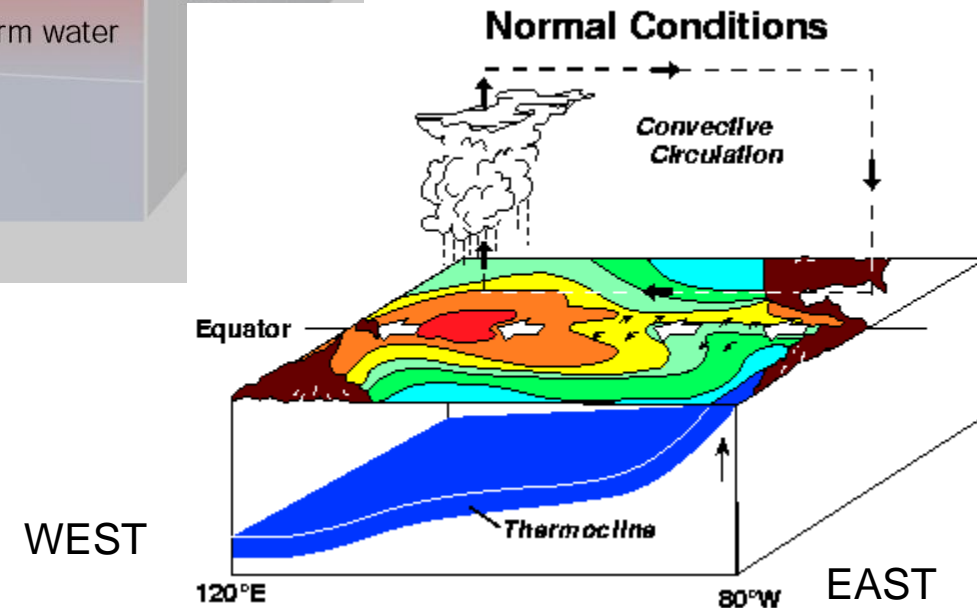
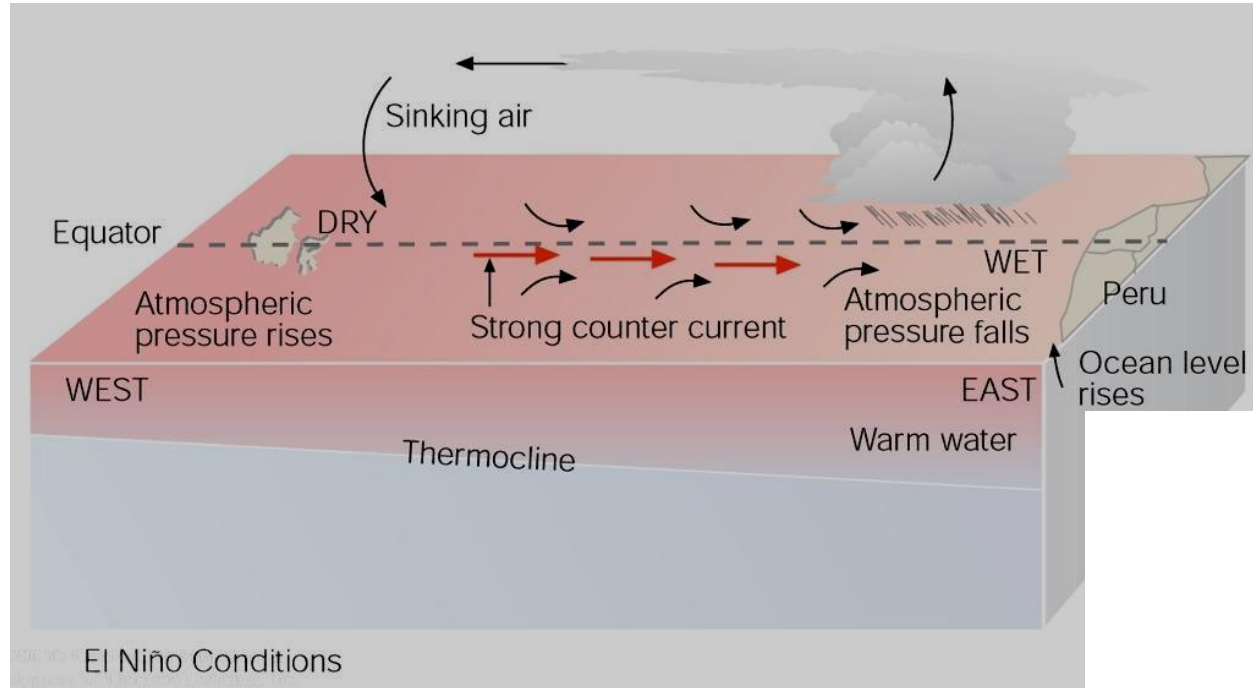
It is most important one, which represents a tendency for high atmospheric pressure over the Pacific Ocean, represents to be associated with low pressure over the Indian Ocean and vice-versa. A measure of the monsoon low pressure is the Southern Oscillation Index (SOI) represented by the difference in sea level pressure over Tahiti, an Island in South central pacific and Darwin in North Australia, which represents the northern part of the Indian Ocean. The positive SOI denotes high pressure over the central pacific and low over Indonesia, North Australia and Northern Indian Ocean. Above average rainfall is expected over India, India and Indonesia and North Australia if the SOI is positive. Drought or deficit rainfall is expected in the above countries if the SOI is negative, indicating high atmospheric pressure over Indonesia and low in the central pacific.

Definitions

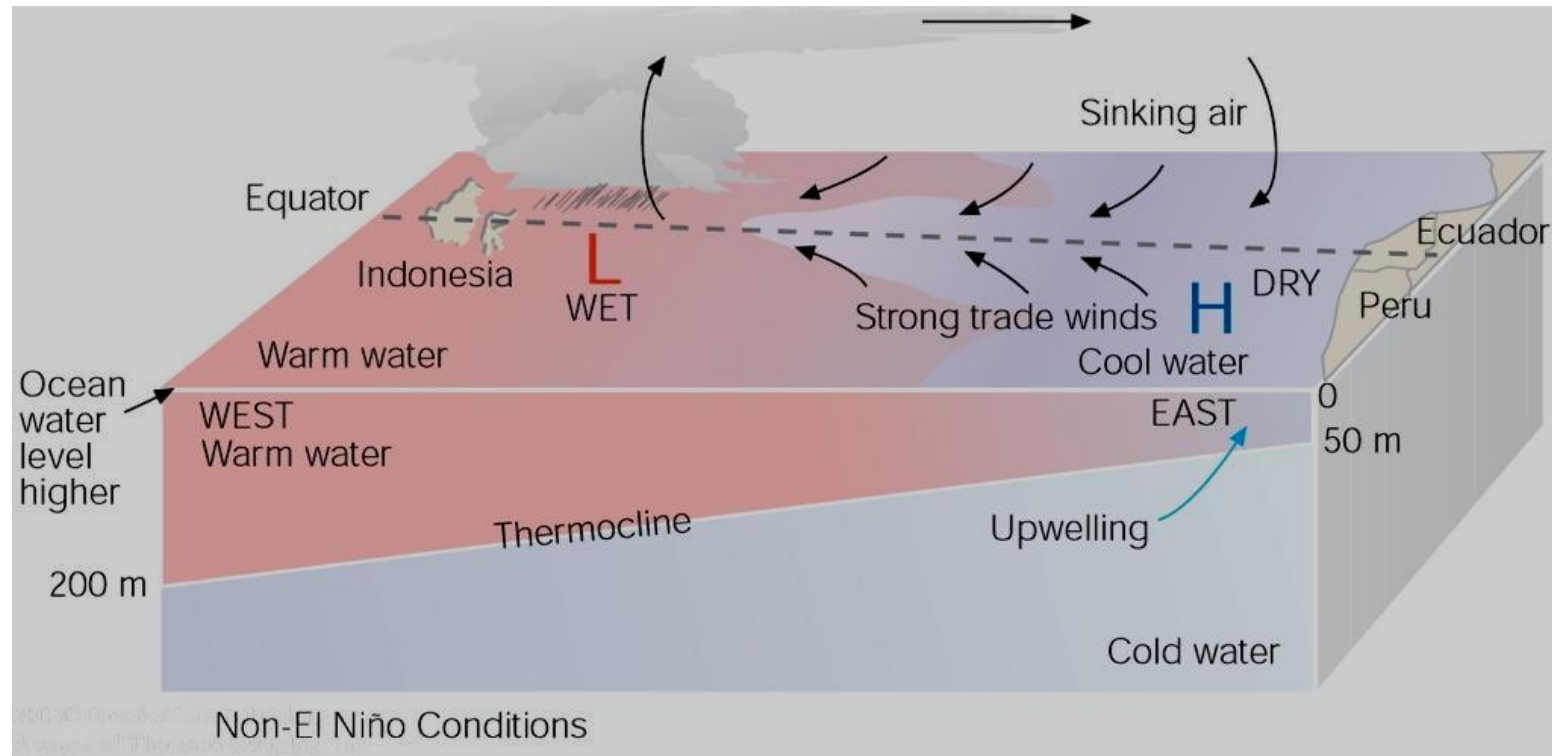
- El Niño – An anomalous warming in eastern Pacific ocean temperatures
- La Niña – An anomalous cooling in eastern and central Pacific ocean temperatures
- Southern Oscillation – Pressure fluctuations in the tropics with centers of action in the western Pacific/eastern Indian Oceans and the southeastern Pacific

Characteristics of El Niño

- Anomalous low (high) pressure in the eastern (western) Pacific
- Weak or even reversed trade winds across Pacific
- Dry (Wet) conditions in the west (east) Pacific
- Deep thermocline in the east – upwelling capped



Characteristics of La Niña



- Anomalous low (high) pressure in the western (eastern) Pacific
- Stronger than normal trade winds across Pacific
- Dry (Wet) conditions in the east (west) Pacific
- Deep thermocline in the west – shallow in the east

DIFFERENT SEASON OF INDIA – EFFECT OF WEATHER AND CLIMATE ON CROP PRODUCTION, SOIL FERTILITY AND INCIDENCE OF PEST AND DISEASE.

Different season of India

Based on the rainfall pattern and temperature distribution, the India Meteorological Department, Government of India has divided the whole year into four seasons viz.

1. South west monsoon (June – September)
2. Post Monsoon (October – November)
3. Winter (December – February)
4. Summer or Pre monsoon (March / April – May / June)

The above seasons coincide with the agricultural seasons viz.

- 1) Kharif
- 2) Rabi and
- 3) Summer

The Kharif season is nothing but the Southwest monsoon or autumn. The Rabi coincides with post monsoon and winter seasons. In summer, the cultivable land under seasonal crops is kept in many regions of the country. Wherever water is plenty, vegetables are grown in some parts of the country during summer. Spring falls between January and March. Based on temperatures, ranges, there are three distinct crops seasons in India. They are

- 1) Hot weather (Mid February – Mid June)
- 2) Kharif or rainy season (Mid June – Mid October)
- 3) Rabi (Mid October – Mid February)

In Tamil Nadu there is a slight variation in the seasons based on rainfall duration as

- 2) Winter – January and February
- 3) Summer – March to May
- 4) Rainy seasons
 - a) South west monsoon (June – September)
 - b) North east monsoon (October – December)

The criteria for division of growing seasons are broadly based on monthly precipitation and temperature. The pattern followed as

- a) Hot month – if the average temperature is above 20°C
- b) Cold month – if the mean temperature is between 0-10°C
- c) Warm month – if the mean temperature is 15-20°C

Incidence of pest and disease

Considerable crop losses caused due to pests and diseases in the humid and sub humid tropics. Many of the restrictions on productivity and geographical distribution of plants and animals are imposed by pests and diseases. The geographical distribution of pests is mainly based on climatic factors. The climatic conditions show a gradient from place to place and there is a related gradient in the abundance of a particular pest / disease. The periodic or seasonal nature of incidence and outbreaks of several pests and diseases of many crops can be ascribed to weather conditions as the triggering factors. These epidemics of diseases are principally weather dependent, either in terms of local weather conditions being favourable for growth and development of the casual organisms or the prevailing winds helping to disseminate airborne pathogens or spores of diseases such as mildew, rusts, scabs and blights.

The migration and dispersion of insect pests depend on the wind speed and direction besides the nature of air currents. Some plant pathogenic viruses suitable for the development of these vectors favour the transmission of such diseases. A surfeit of pests and diseases, which infest plants are kept in check by seasonal fluctuations in atmospheric temperature or relative humidity and other weather factors. Insect pest outbreaks occur as a result of congenial weather conditions, which facilitate their un-interrupted multiplication. The weather and climate greatly influence the quantity and quality of food provided by the host crops to the associated species of pests. The abundance or otherwise of the pestiferous species is thus dependent on climatic conditions, indirectly also.

The surface air temperature, relative humidity, dew fall, sunshine, cloud amount, wind, rainfall and their pattern and distribution are the primary weather factors influencing the incidence or outbreaks of pests and diseases of crops. In the humid tropics, the weather variables namely air temperature, intermittent rainfall, cloudy weather and dewfall may play a crucial role in the outbreaks of pests and diseases. The impact of various weather components on pests and diseases is experienced in a location and crop specific manner.

Among the major pests associated with crops, insect, mite and nematode species are of a serious nature in terms of their abundance and damage potential. If the occurrence of pest / disease in time and space can be predicted in advance with reasonable accuracy on the basis of relevant weather parameters, appropriate and timely control measures can be programmed. Appropriate insecticide / fungicide interventions can certainly reduce the pesticide load in the environment and the related pollution and health hazards.

Effect of weather and climate on Soil Fertility

Red Soil (Alfisol)

Red soils are agriculturally important found in major portion of drylands. They are generally low in organic matter, available N and P. Soil pH ranges from 5.8 to 6.7. Rooting depth of crops is limited by the presence of compact subsoil. Many crops are susceptible to even moderate droughts. These soils are having the characteristics of rapidly sealing the surface after the rainfall. Water supply in the soil is reduced by limited infiltration due to lower conductivity. Problem of crusting affects the crop establishment. Soil moisture deficit is the major factor related to rainfall climatology affecting crop production. Soil erosion is the major factor reducing the fertility due to highly variable seasonal rainfall pattern.

Black Soil (Vertisol)

Black soils in India cover an area of about 72.9 m. ha which accounts for 22.2% of the total geographical area of the country. These are generally rainfed and experience considerable fluctuations in crop production due to climate variability. The clay content of the soil ranges from 40 to 60%, occasionally going to as high as 80%. Organic carbon content remains low ranging from 0.3 to 0.7%, pH of the soil normally ranges from 7.5 to 8.6%. The cation exchange capacity is 35-50 meq/100g. Inversion takes unique feature of the vertisols or deep black soils. Vertisols are necessarily deep. The soils invariably have wide and deep shrinkage cracks on the surface that changes with variation in the soil moisture regime. The cracks remain open depending on soil moisture and evaporation. The deep black soils, because of their high clay content, expanding nature of clay and depth, have a very high water holding capacity enabling crops to with stand drought at different stages of the crop.

Laterite Soils

The texture of the topsoil is loamy or clayey with many concretions. Laterite soils are generally associated with undulating topography in regions with a relatively high annual rainfall. These soils cover 13 m. ha in India. These soils are mostly dominated in hilly and high rainfall regions and slightly acidic in nature due to leaching of bases. They are rich in Iron and Alluminium.

Alluvial soil

They are generally loamy sands or sandy loams, very deep with moderate clay content. These soils are having firmly high water holding capacity. The drainage characteristics are highly varying. Water stagnation is the major problem affecting crop productivity during heavy rainfall seasons.

Sierozemic soil

These soils are sand, loamy sand and sandy loam in texture. Soil erosion through winds is common. Since these soils are light textured, water and nutrient holding capacity is less. Sub-soil Salinity is common due to extreme aridity. Kharif or Rabi cropping is possible in deep soils. But in loamy sands and sand, only the Kharif crops can be raised.

Submontane Soil

The soils are silty loam in texture and are medium to deep. Landslides and soil erosion are common. High rainfall lead to heavy soil erosion and major portion of top fertile soils are lost.