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World Climate and Climate Change [UPSC Geography Notes]

World Climate and Climate Change are important topics for the UPSC exam Geography and environment segments. Every year, many questions are asked from this domain and it can be a scoring section for you. In this article, you can read about world climate, the Koeppen classifications and climate change. For more Geography notes for the <u>IAS exam</u>, click on the links at the end of the article.

Koppen's Scheme for Classification of Climate

It is an empirical classification scheme devised by Wladimir Köppen in 1918. It is based on the mean annual and the mean monthly temperature and precipitation data for areas around the world. He identified a close relationship between the distribution of vegetation and climate. He selected certain values of temperature and precipitation and related them to the distribution of vegetation, and used these values for classifying the climates. Most revised climate classifications are based on Koppen's system of classification.

• Koppen recognised five broad climate groups (four of them are based on temperature and one on precipitation), which are further subdivided into subgroups based on seasonal characteristics of temperature and precipitation. The groups are designated by capital letters A, B, C, D and E, and the subgroups are denoted by small letters - f, m,w and s.

Group	Characteristics		
A - Tropical	The average temperature of the coldest month is greater than 18°C, large annual rainfall, precipitation is greater than evaporation.		
B - Dry Climate	Potential evaporation exceeds precipitation.		
C - Warm Temperate	The average temperature of the coldest month is greater than minus 3°C but less than 18°C (mid-latitude).		
D - Cold Snow Forest Climate	The average temperature of the coldest month is minus 3°C or below.		
E - Cold Climate	The average temperature for all months is below 10°C.		
H - Highland (mountain climate)	Cold due to elevation.		

Koppen's Climate Groups (five groups + 1 group)

- The subgroup refers to dryness.
 - 'f' corresponds to no dry season (moist, adequate precipitation)



- 'm'- monsoon climate (rainforest climate)
- 'w' dry season in winter
- \circ 's' dry season in summer
- The letters a, b, c, d, h and k denote variations in temperature.
- The B Dry Climates are subdivided using capital letters 'S' for steppe or semi-arid and 'W' for desert.

Koppen's Climatic Types

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

Group A - Tropical Humid Climate



This type of climate exists between the Tropic of Cancer and the Tropic of Capricorn (23.5°N and 23.5°S). The sun's position being vertical makes the climate hot and humid. Annual rainfall is high and the annual range of temperature is low. This group is divided into three subgroups.

- Tropical wet climate (symbol Af) -
 - This type of climate is present near the equator. Amazon basin in South America, Western Equatorial Africa and islands of East Indies experience tropical wet climate.
 - It is characterised by abundant rainfall throughout the year and uniformly high temperatures.
 - Tropical evergreen forests with dense canopy cover and large biodiversity are found in this climate.
- Tropical monsoon climate (symbol Am) -
 - This climate is found in the Indian subcontinent, Northern Australia and the North-Eastern part of South America.
 - Winter is dry and heavy rainfall occurs mostly in summer.
- Tropical wet and dry climate (Aw) -
 - The wet season is shorter and the dry season is longer with drought being very severe. Temperature is high throughout the year and diurnal ranges of temperature are greatest in the dry season.
 - Deciduous forest and tree shredded grasslands occur in this climate.
 - This type of climate occurs north and south of Af type of climatic regions. It is found to the north and south of the Amazon forest in Brazil and adjoining parts of Bolivia and Paraguay in South America, Sudan and south of Central Africa.

Read more on the Group A climate in the link.

Group B - Dry Climate

This type of climate covers a large area of the planet extending over latitudes from 15°- 60°N and S of the equator. The Dry Climate is characterised by very low rainfall that is not sufficient enough for the growth of plants. Evaporation exceeds precipitation and there is constant water deficiency. This group is divided into subgroups:

- 1. Subtropical Steppe (BSh) and Subtropical Desert (BWh) Subtropical steppe receives slightly more rainfall than the desert, sufficient enough for the growth of sparse grasslands. 'h' refers to hot and dry (mean annual temperature is greater than 18°C).
- 2. Mid Latitude Steppe (BSk) and Mid Latitude Desert (BWk) 'k' refers to cold and dry (mean annual temperature is less than 18°C).

Also read: <u>Koppen's Classification Group B Climates</u>



Group C - Warm Temperature (mid-latitude) Climate

This type of climate is characterised by warm summers with mild winters. This type of climate extends from $30^{\circ}-50^{\circ}$ of latitude mainly on the eastern and western margins of the continents. This group is divided into four subgroups:

- Humid subtropical climate (Cwa) -
 - \circ The third letter 'a' refers to a hot summer (greater than 22°C).
 - It occurs mainly in the North Indian plains and South China interior plains.
- Mediterranean climate (Cs) -
 - This type of climate is characterised by hot dry summer and mild rainy winter due to westerly winds.
 - This climate is found around the Mediterranean Sea, along the west coast of continents in subtropical latitudes between 30°-40° latitude. For example Central California, Central Chile, along the coast in southeastern and southwestern Australia.
 - The monthly average temperature in summer is about 25°C and in winter below 10°C. The annual precipitation ranges from 35 to 90 cm.
- Humid subtropical climate (Cfa) -
 - This type of climate occurs in the eastern regions of the continents in the subtropical latitudes.
 - Cfa climate occurs in the eastern United States of America, north-eastern Argentina, southern and eastern China, southern Japan, coastal South Africa and the eastern coast of Australia.
 - The climate is characterised by rainfall throughout the year. The annual averages of precipitation vary from 75 to 150 cm. Summers are hot with a mean monthly temperature of around 27°C and in winter the temperature ranges between 5° and 12°C.
- Marine west coast climate (Cfb) -
 - 'b' refers to a warm summer ($< 22^{\circ}$ C).
 - The temperature is moderate due to the influence of the sea and winters are warmer than for its latitude.
 - In summer, the mean temperature ranges from 15°- 20°C and in winter, the temperature ranges from 4° to 10°C.
 - Precipitation occurs throughout the year and varies from 50 250 cm.
 - Mainly occurs in north-western Europe, west coast of North America, north California, southern Chile, south-eastern Australia and New Zealand.

Know more about Group C Koppen's Climate Classification in the link.

Group D - Cold Snow Forest Climate



This type of climate occurs in the Northern Hemisphere between 40° - 70° north latitudes - Europe, Asia and North America. It has two subtypes:

- Cold climate with humid winters (Df) -
 - This type of climate occurs poleward of marine west coast climate and mid-latitude steppe.
 - The winters are cold and snowy, the frost-free season is short and the annual ranges of temperature are large.
- Cold climate with dry winters (Dw) -
 - It occurs mainly over northeastern Asia.
 - The development of pronounced winter anti-cyclone and its weakening in summer sets in a monsoon-like reversal of wind in this region. Poleward summer temperatures are lower and winter temperatures are extremely low with many regions experiencing below freezing point temperatures for up to 7 months in a year. Precipitation occurs in summer and annual precipitation is low, varying between 12-15 cm.

Group E - Polar Climate

Polar climate lies poleward beyond 70° latitude. It has two subtypes:

- Tundra climate (ET) -
 - This climate has tundra types of vegetation low growing mosses, lichens and flowering plants.
 - The subsoil is permanently frozen- region of permafrost.
 - The tundra regions have a very long duration of daylight during summer.
- Ice Cap Climate (EF) -
 - The temperature is below freezing even in summer. This type of climate lies over interior Greenland and Antarctica.
 - The snow ice accumulates and the mounting pressure causes the deformation of ice sheets which leads to breakage. They move as icebergs that float in the Arctic and Antarctic waters. Plateau Station, Antarctica, 79°S represents this climate.

Group H - Highland Climate

- This type of climate is found in high mountain areas. This climate contains all highland areas which are not easily characterised by other climate types.
- Highland climates are dominated by topography. The topography of a mountain affects the surrounding climate (temperature, pressure and atmospheric humidity).

Read more on Koppen's Classification - Groups E & H in the linked article.



Climate Change

Climate change is a significant variation of average weather conditions over several decades or even more. Our planet has witnessed many variations in climate since the beginning. The change in climate is a natural and continuous process.

A variety of factors, both natural and human, can influence the earth's climatic system. Natural forces that contribute to climate change include the sun's intensity, volcanic eruptions and changes in naturally occurring <u>greenhouse gases</u>. However, their influence is too small and they occur too slowly to explain the rapid warming in recent decades.

Anthropogenic causes are the main causes of the earth's rapidly changing climate. The most important anthropogenic effect on the climate is the increase in the levels of greenhouse gases in the atmosphere which leads to global warming.

Global Warming

- Global warming is a steady increase in the earth's average temperature. The greenhouse effect is one of the principal causes of global warming. The greenhouse effect is the process through which solar energy is absorbed by greenhouse gases (GHGs) instead of being reflected back into space. The gases that absorb infrared light and cause the greenhouse effect are known as greenhouse gases.
- The primary GHGs are carbon dioxide (CO₂), chlorofluorocarbons (CFCs), methane (CH₄), nitrous oxide (N₂O) and ozone (O₃). Gases like nitric oxide (NO) and carbon dioxide (CO) easily react with GHGs and affect their concentration in the atmosphere.
- Carbon dioxide (CO₂) in the atmosphere is one of the main contributors to the greenhouse effect. Its emission comes mainly from fossil fuel combustion (oil, gas and coal). Forests and oceans are carbon dioxide sinks. So, deforestation also increases the concentration of CO₂. It is increasing at about 0.5 % annually.
- Ultraviolet (UV) rays convert oxygen (O₂) into ozone (O₃) in the stratosphere and this prevents UV rays from reaching the earth's surface. Chlorofluorocarbons which are the products of human activity drift into the stratosphere and destroy the ozone layer. The depletion of ozone concentration in the stratosphere is called an ozone hole which allows the UV rays to pass through the troposphere.
- Methane is a powerful greenhouse gas that is emitted into the atmosphere by natural (wetlands and termites) as well as anthropogenic activities (rice cultivation, fossil fuel exploitation, biomass burning, etc.).
- International efforts have been initiated to reduce the emission of greenhouse gases into the atmosphere. The most important one is the <u>Kyoto Protocol</u>.
 - The Kyoto Protocol was an international treaty to extend the United Nations Framework Convention on Climate change (<u>UNFCCC</u>, 1992).



- The Kyoto Protocol was adopted in Kyoto, Japan on 11 December 1997 and came into force on 16 February 2005.
- The Kyoto Protocol implemented the objective of UNFCCC to reduce the onset of global warming by reducing GHG concentration in the atmosphere to a level that would prevent anthropogenic interference with the climatic system.
- It applied to seven GHGs carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF₆). Nitrogen trifluoride (NF₃) was added for the second compliance period during Doha Round.

