SECTION C
CLIMATOLOGY AND METEOROLOGY

Introduction:

Climatology is the study of weather conditions as they exist over a long period of time
Is the scientific study of the long term weather conditions
It refers to the scientific study of climate

Meteorology is the scientific study of the atmosphere that focuses on weather processes and fore casting.

Weather is the conditions of the atmosphere which occur at a place at a specific time period from hour to hour or day to day.

Climate is the average weather conditions of an area observed and recorded over a long period of time about 30 years.
It involves systematic observation, recording and processing of the various elements of climate to arrive at standardized climatic mean or average.
Elements of weather and climate are

- Temperature
- Atmospheric pressure
- Humidity
- Wind (speed and direction)
- Rainfall
- Cloud cover
- Sunshine

Differences between weather and climate

Weather	Climate
Describes the atmospheric conditions at a specific place and time	Describes the average atmospheric conditions of a place over a specific period of time
Is defined as the day to day state of the atmosphere, and it is shot term variation	Is defined as statistical weather information that describes the variation of weather at a given place for a specified time interval
Weather conditions are measured over a short period e.g a few hours or days	Climate conditions are measured over many years e.g 30 years
Is determined by real time measurements of atmospheric pressure, wind speed & direction, humidity, precipitation, cloud cover and other variables	Climate is determined by averaging weather data over periods of 30 years
Weather changes abruptly within a shot period	Climate changes slowly and gradually over many years
Weather varies from one place to another within a region	Climate remains uniform over a large area
Most weather elements are measured by weather instruments	Climatic elements are not measured but calculated from the recorded weather data

Layers of the atmosphere

An atmosphere is a layer of gases surrounding a planet or other material body of sufficient mass that is held in a place by the gravity of the body
The envelope of air that completely surrounds the earth is known as the atmosphere
The atmosphere extends to about 1000Km from the surface of the earth. But 99% of the total mass of the atmosphere is found within 32Km . This is because the atmosphere is held by the gravitational pull of the earth.
Composition of the atmosphere

- Nitrogen =78%
- Oxygen. =21%
- Argon =0.93%
- Carbon dioxide =0.03%
- Neon =0.0018%
- Helium =0.0005%
- Ozone. =0.0006%
- Hydrogen =0.00005%

There are four distinct layers of the atmosphere
The four main layers of the atmosphere are classified according to changes in temperature, the layers are;

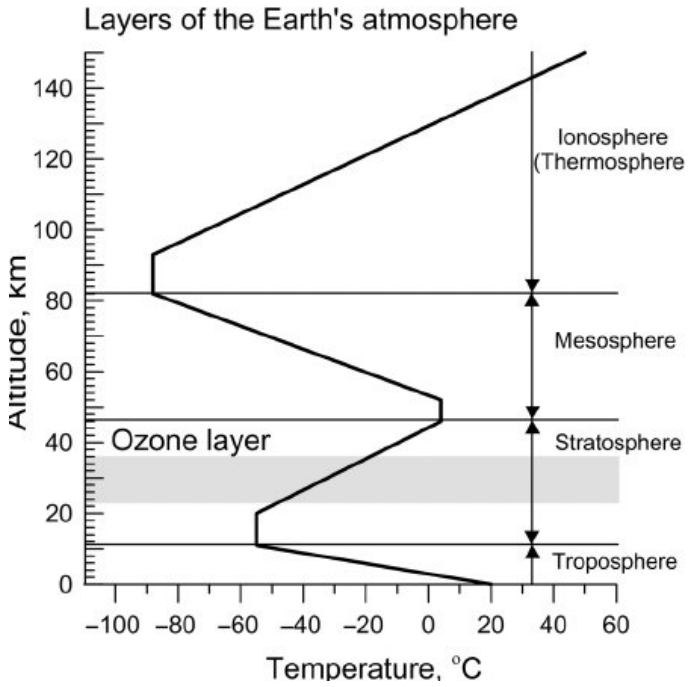
a) The troposphere is the inner or lowest layer. It extends from earth's surface to between 9 and 16 Km above the surface. As altitude increases in troposphere the temperature decreases. At the top of the troposphere the temperature stops increasing and lowers to about -60 degrees Celsius. It is called tropopause.
The troposphere is the shallowest layer of atmosphere but it contains most of the atmosphere's mass and all earth's weather.

b) The stratosphere extends from the top of the troposphere (tropopause) to about 50Km above earth's surface. The lower stratosphere is cold at about -60degrees Celsius . However, the stratosphere gets warmer towards the top because its upper limits contains a layer of Ozone. Ozone absorbs energy (ultraviolet radiations of the sun) from the sun and converts it to heat.
This layer is free from clouds and associated weather phenomena, hence it provides ideal flying conditions for large jet planes
The stratopause separates the stratosphere and the overlying mesosphere.

c) The mesosphere is the layer of earth's atmosphere above the stratosphere. It extends from 50Km to 80Km above earth's surface. Temperatures fall as you go higher up in the mesosphere. The top of the mesosphere is the coldest part of the atmosphere with temperatures near -90 degrees Celsius. The end of this layer is known as mesopause.

d) Thermosphere is outer most layer of earth's atmosphere. It extends from 80Km out ward into space with no definite outer limit. The air in the thermosphere is very hot, up to 2000 degrees Celsius because energy from the sun strikes the thermosphere first. Air in thermosphere has very low density.
The thermosphere also protects eath's surface from meteors and obsolete satellite because they burn up as they fall toward earth through this layer.
Thermosphere is divided into two layers;

The lower layer of thermosphere is the **ionosphere** with electrically charged gas molecules because of sun's energy.
Exosphere is the outer layer of thermosphere. Satellites orbit earth in this layer. They communicate long distance telephone and television signals and watch weather from far out in the atmosphere.
Exosphere gradually merges with interplanetary space.



FACTORS INFLUENCING THE CLIMATE OF E.AFRICA

The climate of E.Africa varies from one region to another ranging from Equatorial to Tropical, Semi arid and MoS5ntane climate although the region is located across the equator.

The variations in E.Africa's climate are as a result of the following factors:

a. **Altitude**
It refers to the height of the land above sea level. High altitude areas especially highlands like Mt Rwenzori, Mt Elgon, Mt Kenya and Mt Kilimanjaro experience cool temperatures because temperatures decrease with increase in altitude and heavy rainfall ranging between 1000-1500mm resulting into montane climate. Cool temperatures in high altitude areas are due to the effect of the environmental lapse rate i.e For every 1000metres of ascent, temperatures fall by 6.5^{o}c. Equally, high altitude areas experience low pressure because pressure reduces with an increase in altitude. It is also due to a small column of air pressing down on the earth's surface. High altitude areas experience low humidity due to the cool temperatures

On the other hand, low altitude areas such as the rift valley region, the foothills of mountains and coastal areas experience hot temperatures due to intense heating by both solar and terrestrial radiation as well as the excessive impurities in the air such as dust particles, water molecules and carbondioxide which absorb heat that is radiated in the low altitudes. This explains why Mombasa is hotter than Nairobi. Low altitude areas experience high pressure because pressure increases with a decrease in altitude. This is also because of a big column of air pressing over the earth's surface. Low altitude areas such as the Nyika plateau in Kenya are dry, receiving rainfall of less than 700mm. Low altitude areas experience high humidity due to the high rates of evapotranspiration as a result of hot temperatures

b. **Latitude**

It is the angular distance of an area as measured from the equator. E.Africa lies astride the equator. Its location explains the generally hot temperatures experienced throughout the year. Areas near the equator experience hot temperatures, heavy rainfall with a bi modal (double rainfall pattern), low atmospheric pressure and high humidity due to the effect of the overhead sun twice a year leading to equatorial climate e.g around the lake Victoria basin.

On the other hand, areas far from the equator such as Northern Uganda and Southern Tanzania experience cool temperatures as well as wet and dry conditions (mono modal/single rainfall pattern) because the sun's rays are scattered (spread) over a wide area and reach the earth's surface at acute angles causing less heating. Temperate and polar areas experience temperate climate due to their far distance from the equator

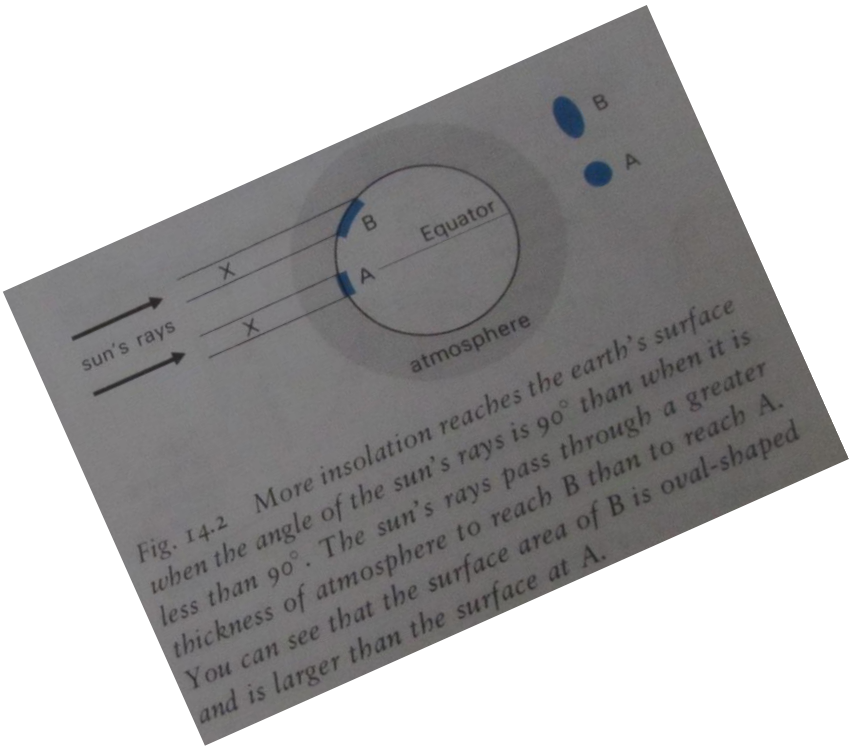


Fig. 14.2 More insolation reaches the earth's surface when the angle of the sun's rays is 90° than when it is less than 90°. The sun's rays pass through a greater thickness of atmosphere to reach B than to reach A. You can see that the surface area of B is oval-shaped and is larger than the surface at A.

c. Relief

It refers to the physical appearance of the landscape in an area. Highland areas such as Mt Rwenzori, Mt Kenya and Mt Kilimanjaro experience heavy rainfall and cool temperatures on the wind ward sides while dry conditions are experienced on the lee ward sides. This is because mountains act as barriers towards the movement of moist winds thereby forcing them to rise upwards to the condensation level leading to rainfall on the wind ward side while the descending dry winds resulting into dry conditions on the lee ward side. For instance Masai land in Tanzania lies on the lee ward side of Usambara and Pare mountains.

Lowland areas on the other hand experience low and un reliable rainfall due to the absence of relief barriers to trap the moving moist winds in areas such as Turkanaland in Northern Kenya, Karamoja in North eastern Uganda and the Albert flats

d. Continentality (Distance from the sea)

Areas near the sea (water bodies) such as the coastal areas of E.Africa and lake Victoria basin experience heavy rainfall due to the effect of land and sea breezes. The sea breeze occurs during day time where cold moist air moves from the sea towards the adjacent land while the land breeze occurs at night involving cold moist winds from the land blow towards the sea. This modifies the temperatures over the land and the sea respectively thereby causing the formation of convectional rainfall as warm air rises towards the condensation level.

Water bodies also recharge the atmosphere with moisture through evaporation resulting into heavy rainfall in the adjacent areas e.g the lake Victoria basin.

Areas far away from water bodies like North eastern Uganda and Central Tanzania are hot and dry due to the absence of water bodies

e. Prevailing winds

They are defined as local winds which blow from sub tropical areas of high pressure into areas of low pressure in the tropics.

The winds are either moist or dry, cool or warm thus influencing the rainfall and temperature conditions of the areas where they flow to. The climate of E.Africa is mainly influenced by three (3) trade winds i.e The North east trade winds, South east trade winds and the westerlies.

The North east trade winds originate from the Arabian desert. They are therefore dry. As they blow towards E.Africa, they pick moisture from the Red sea which is later lost on the wind ward slopes of the Ethiopian highlands. The winds later continue into E.Africa as cool dry winds causing low rainfall and low humidity in areas like North eastern Uganda, North western Kenya as well as Northern Kenya in general hence semi arid climate.

The South east trade winds originate from the Indian ocean hence they are moist. They flow towards the E.African coast thereby causing heavy rainfall and high humidity. They later continue on their eastward journey towards the interior of E.Africa as dry winds causing dry conditions in Central Tanzania. They are later recharged with moisture after

crossing lake Victoria consequently causing heavy rainfall on the northern and north eastern shores of lake Victoria but leaving Ankole Masaka corridor dry.

The westerlies originate from the Atlantic ocean with a lot of moisture from the sea. They blow over the Congo basin leading to heavy rainfall on the western slopes of Mt Rwenzori. They however continue towards the lee ward slopes with areas like Kasese and the rift valley region of western Uganda as dry winds leading to semi arid climate

f. Ocean currents

They are defined as large scale movements of surface water in an ocean/sea within a defined direction.

Ocean currents are either warm or cold hence they influence the temperature and rainfall conditions of the coastal areas. The warm ocean currents such as the Mozambique current cause hot temperatures and heavy rainfall around the coastal areas of E.Africa e.g The equatorial climate between Mombasa and Dar es Salaam is due to the effect of the warm Mozambique current.

Cold ocean currents such as the Benguela current lead to low temperatures, low humidity and low rainfall in coastal areas such as Namibia

g. Coastal configuration

The alignment of the E.African coast in the North east to South west direction forces the prevailing winds and ocean currents to flow or move parallel to the coast. This leads to low humidity and low rainfall in areas like North eastern Kenya hence semi arid climate because the moisture carried by the prevailing winds and ocean currents is not deposited at the adjacent areas

h. Perturbation

This refers to the formation of a low pressure belt over the Indian ocean due to hot temperatures. Winds are therefore drawn from the interior of E.Africa towards the Indian ocean causing heavy rainfall over the ocean while leaving the coastal areas dry. The semi arid climate in North eastern Kenya is as a result of the perturbation effect

i. Rotation of the earth (Corriolis force effect)

According to Ferrel's law, any loose object or body such as a wind in the northern hemisphere flowing over the earth's surface is deflected to the right of its path after crossing the equator. The South east trade winds are therefore deflected to the right causing heavy rainfall (equatorial climate) on the northern shores of Lake Victoria and dry conditions (semi arid climate) in the Ankole Masaka corridor.

Winds blowing across Kenya from the south are deflected to the Indian Ocean causing rainfall over the sea and dry conditions in North eastern Kenya

j. Vegetation cover

Forested areas such as Mabira, Budongo and Bugoma experience heavy rainfall, high humidity and moderate temperatures. Areas with limited vegetation cover on the other hand experience low rainfall totals, low humidity and hot temperatures in areas like Turkana land and Ankole Masaka corridor

k. Human activities

A variety of man's activities like deforestation, swamp reclamation, bush burning,

overstocking and over grazing result into reduced rainfall amounts and hot temperatures. That is why semi arid climate is experienced in North eastern Uganda, North western Kenya and in some parts of Central Tanzania.

On the other hand, man's activities such as afforestation and re afforestation have restored vegetation cover resulting into increased rainfall amounts in areas such as Mt Elgon slopes, Kigezi highlands and Kenya highlands

Qn. To what extent has altitude influenced the climate of E.Africa?

Measurement and recording of different elements of weather

TEMPERATURE

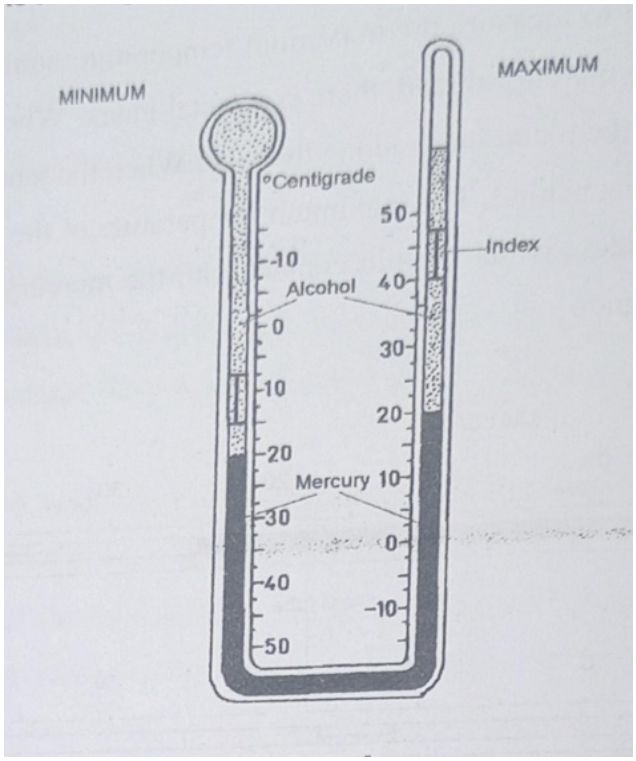
It refers to the measure of the degree of hotness or coldness of the atmosphere over a given place OR It is the amount of sensible heat or cold with in the atmosphere of a given area.

The major source of heat affecting the atmosphere and the earth's surface is solar radiation which is defined as the heat emitted and transferred to the earth's surface by the sun. However, heat is also transferred from the earth's surface into the atmosphere which is known as Terrestrial radiation.

The temperature of a place is measured using a sixth thermometer which records the maximum and minimum temperature of the day.

HOW TO MEASURE TEMPERATURE:

Temperature is measured using thermometers called the SIX's Thermometer. This thermometer has 2 scales i.e scales for maximum and minimum temperatures.



Temperature readings are taken from the six's thermometer twice a day i.e at 9:00 a.m. in the morning and 3:00 p.m. in the evening.

When temperature rises, alcohol in the left limb of the thermometer (minimum limb) expands and alcohol in the right limb (maximum limb) vaporizes to the empty space (Vacuum).

Alcohol in the left limb pushes mercury downwards which in turn pushes the metal index to the right limb to record the maximum temperature.

The maximum temperature is read at the end of the metal index in contact with or near the mercury.

When temperature falls, alcohol in the left limb condenses (liquefies). As the alcohol contracts or condenses, the alcohol in the right limb pushes mercury backwards to the left limb thereby pushing the metal index upwards in the left limb. The minimum temperature is then read from the end of the metal index closer to the mercury.

The index is re-adjusted using a magnet after readings are taken.

HOW TO RECORD TEMEPRATURE

Temperature can be recorded in several ways:

When the highest and lowest temperature is obtained, the following expressions can be made:

- **Daily Temperature**

It refers to the actual amount of heat or cold that is recorded at a weather station in a day

- **Mean Daily Temperature**

  It refers to the average of heat or cold that is recorded in a specific area in a day. ,It is obtained by;

  Mean Daily Temperature = $\frac{\text{Maximum Temperature + Minimum Temperature}}{2}$

- **Daily (Diurnal) Temperature Range**

  It refers to the difference between the highest and lowest temperature of the day

  Daily Temperature Range = Highest Temperature – Lowest Temperature

- **Mean Monthly Temperature**

  It is the average temperature of an area obtained when the sum of the mean daily temperature for a month is divided by the number of days in the month

  Mean Monthly Temperature = $\frac{\text{Sum of the Mean Daily Temperature}}{\text{Number of days in a month}}$

- **Mean Annual Temperature**

  It is the final figure obtained when the sum of the mean monthly temperatures in a year is divided by 12 months

  Mean Annual Temperature = $\frac{\text{Sum of Mean Monthly Temperature}}{12}$

- **Annual Temperature Range**

  It is the difference between the highest and lowest mean monthly temperature in a year

  OR It is the difference between the hottest month and the coolest month of the year

Qn. Differentiate between diurnal temperature range and annual temperature range

FACTORS WHICH INFLUENCE THE TEMPERATURE OF AN AREA:

Different areas in E.Africa experience varying temperatures. Some areas experience extremely hot temperatures of over 30^{o}c. They include North eastern Uganda, Northern Kenya, the rift valley areas and the coastal areas.

Other areas experience very low / cool temperatures especially the mountainous or highland areas such as the Kenya highlands, Kigezi highlands, Mt Kilimanjaro, Mt Rwenzori, Mt Meru and Mt Elgon among others.

Several factors influence temperature or contribute to the variations in the temperature in E.Africa and they include:

a. Altitude

It refers to the height of the land above sea level. Temperatures tend to drop as altitude increases by approximately 6.5^{o}c for every 1000 metres of ascent / rise. Due to this lapse rate effect, highland areas like Mt Rwenzori, Kenya and Kilimanjaro experience low temperatures while low altitude areas like the rift valley region experience hot temperatures

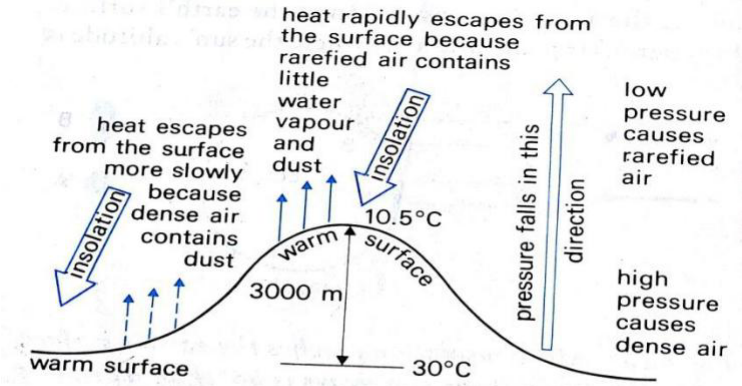


Fig. 14.3 A diagram to show the effect of altitude on temperature. What would the temperature be at the top of Mount Cameroon (4070 m) if the temperature at sea level were 30°C?

b. Latitude

It refers to the angular distance of an area from the equator. Temperatures tend to reduce as one moves away from the tropics towards the Polar regions. Given that E.Africa lies astride the equator, temperatures are uniformly hot with no big variations

c. Prevailing winds

They have a modifying effect on the temperature of the places where they blow depending on their origin. The North east trade winds which blow from the Arabian desert bring hot temperatures in North eastern Uganda (Karamoja) and Turkanaland while the Southeast trade winds and the Westerlies cause moderate temperatures around the Central plateau of E.Africa because they originate from the Indian ocean and the Atlantic ocean respectively

d. Continentality

It refers to the distance of a place from the sea. It is responsible for the variations in the temperatures between places near the coast and those in the interior. The South east trade winds transfer warm conditions to the coastal areas of E.Africa and this explains why Mombasa is relatively warmer than the interior of Kenya and E.Africa in general. Water bodies also have a modifying effect on temperature through the land and sea breezes

e. Vegetation cover

Thick vegetation cover has a modifying effect on the temperature of the surrounding areas through evapotranspiration. Forested areas have high humidity and relatively low temperatures for instance Mabira and Budongo forest. On the other hand, areas with limited vegetation cover tend to experience hot temperatures e.g North eastern Uganda and Turkana land in North western Kenya

f. Ocean currents

They are defined as streams of surface sea water moving on a large scale towards a defined direction. They are sub divided into two (2) categories i.e warm and cold ocean currents. They have a modifying effect on the temperature of the adjacent areas. Warm ocean

currents such as the Warm Mozambique currents raise the temperatures of the winds blowing around hence causing warm and/or hot temperatures to the adjacent lands such as Mombasa and Dar es Salaam

g. Cloud cover

It also determines the temperature of a place. Thick clouds control the amount of solar insolation reaching the earth's surface and at the same time trap the escaping radiation from the earth's surface. For this reason, areas with thick cloud cover like the Lake Victoria basin experience a small diurnal range of temperature than areas like Turkana land with limited cloud cover

h. Apparent movement of the overhead sun

The position of the sun influences seasonal variations in temperature. Temperatures are higher in regions where the sun is overhead. When the sun is overhead in the northern hemisphere between June and July, hot temperatures are experienced in the northern hemisphere and low temperatures in the southern hemisphere. When the sun is overhead in the southern hemisphere in December and January, temperatures are high in the southern hemisphere and low in the northern hemisphere

i. Humidity

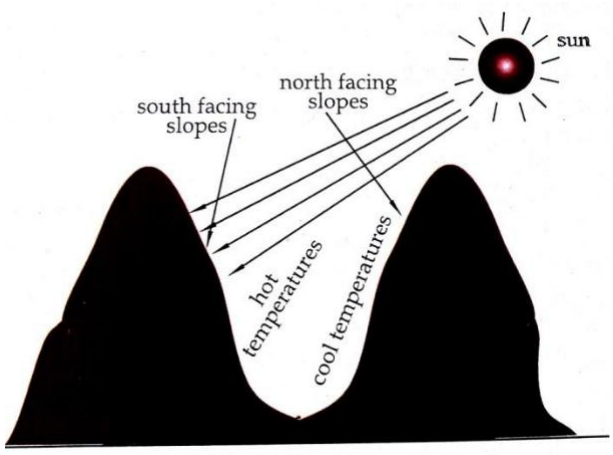
The amount of water vapour in the atmosphere determines the atmospheric temperature of a place. High amounts of humidity absorb heat and prevent heat loss from the earth's surface. This explains why areas with high humidity e.g equatorial regions experience hot temperatures during the day and at night than areas with low humidity which experience cool temperatures during the night due to excessive heat loss

j. Nature of the earth's surface (Albedo)

Surfaces covered by water or ice are bright so they reflect much of the heat (solar radiation) back into the atmosphere leading to low (cool) temperatures over the water surface during the day while solid dark coloured land surfaces absorb heat faster during the day leading to warm / hot temperatures

k. Aspect

It refers to the direction of a hill slope in relation to the position of the sun. It influences temperature in the temperate / polar regions where the south facing slopes in the northern hemisphere experience warm temperatures than the north facing slopes. In the southern hemisphere on the other hand, the north facing slopes are warmer than the south facing slopes. In the tropics however, the influence of aspect is not experienced due to the effect of the overhead sun



I. Human activities

The various activities of man such as deforestation, bush burning, overgrazing, mining and industrialization result into hot temperatures due to the destruction of natural vegetation, depletion of the ozone layer and the subsequent increase in carbonic emissions (gases) into the atmosphere which absorb solar radiation thereby causing hot temperatures. On the other hand, afforestation reduces carbon concentrations in the atmosphere since plants absorb carbondioxide leading to moderate temperatures.

Qn. Account for the variations in the temperature experienced in the different areas of E.Africa

ATMOSPHERIC TEMPERATURE DISTRIBUTION

Temperature is distributed in the atmosphere in such a way that an increase in altitude leads to a fall in temperature i.e temperatures are warmer near the earth's surface (lower atmosphere) and lower in the upper atmosphere. As air rises, its temperature changes. This is referred to as adiabatic temperature change. The rate of decrease in temperature with increase in altitude is known as adiabatic lapse rate. The average rate of fall in temperature is 1^{o}c per 150metres of ascent or 6.5^{o}c per 1000metres of ascent. Temperatures fall with increase in altitude because of the following:

- The air above the earth's surface expands over a wide space which leads to cooling hence low temperatures while air molecules near the earth's surface are compressed leading to high pressure and warm temperatures
- The air above the earth's surface contains less impurities to absorb heat hence it is cooler than the air near the earth's surface with impurities such as dust particles which absorb heat

- The amount of carbondioxide in the air is greater near the earth's surface than in the atmosphere and this causes temperature differences with variations in altitude
- The air above the earth's surface is far from the effect of terrestrial radiation hence it is cooler than the air near the earth's surface.

LAPSE RATE

It refers to the natural fall in temperatures with an increase in altitude **OR** a rise in temperatures with a decrease in altitude. As warm air rises, it expands and cools leading to a fall in temperatures. The increase in temperature or heat is caused by the compression of the air as altitude falls.

Types of Lapse Rate:

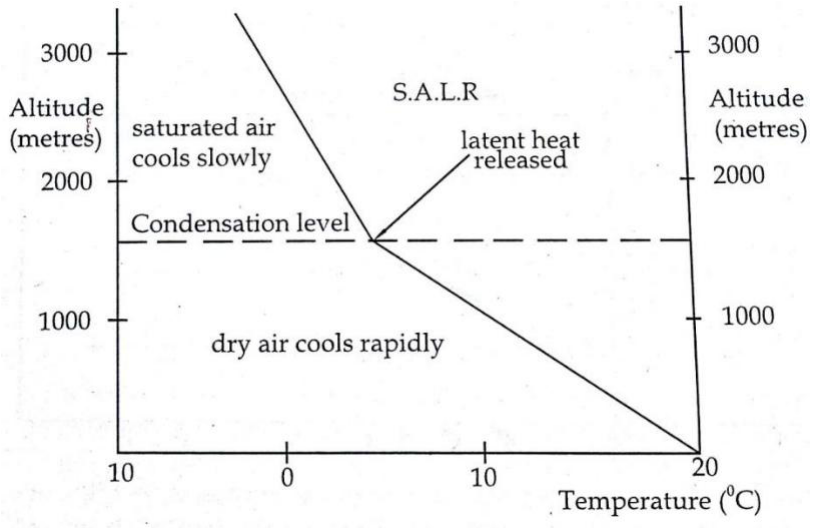
Lapse rate is described in three (3) ways:

a) **Environmental lapse rate**
It is the rate at which temperatures change with an increase or a decrease in altitude. It is the vertical distribution of the temperature of a given geographical location at a particular period

b) **Dry adiabatic lapse rate**

It is the rate at which dry air cools as it rises without affecting the temperature of the surrounding atmosphere. Dry air cools at a faster rate of 1^{o}c per 100 metres of ascent

c) **Saturated (Wet) adiabatic lapse rate**
It refers to the rate at which air saturated with water vapour cools as it rises to greater heights (higher levels) of the atmosphere. Saturated (humid) air cools at a rate which is slightly lower than that of dry air i.e between 0.3^{o}c – 0.9^{o}c per 100metres of ascent.



Qn. Distinguish between **stability** and **instability** in the atmosphere

Stability in the atmosphere refers to a state of equilibrium reached in the atmosphere when a mass of dry air which is rising in form of a wind has a lapse rate that is greater than that of the surrounding air i.e the environmental lapse rate of an air mass is less than the dry adiabatic lapse rate.

The rising air mass loses its temperature ultimately becoming cooler and denser than the surrounding air mass. It then sinks back to the ground level unless when some external force is at work.

While;

Instability is a state of unstable equilibrium of the atmosphere where the environmental lapse rate of an air mass is greater than the dry adiabatic lapse rate. A surface pocket of un saturated air when heated, will rise and cool at the dry adiabatic lapse rate and because it is warmer than the surrounding air mass, it will continue to rise. Due to the fact that the surrounding air is denser than the rising air mass, it will force it up to greater heights where it cools from.

High instability leads to the formation of cumulo-nimbus clouds, stratus and cirrus clouds. The strato-cumulus and cumulo-nimbus clouds are associated with intense rainfall and thunderstorms.

The cirrus and stratus clouds give rise to clear skies / sunny weather conditions

The alto-cumulus and alto-stratus clouds give rise to light drizzles and unstable windy conditions

High humidity is formed with in the atmosphere

ATMOSPHERIC STABILITY

Atmospheric stability refers to the state of the atmosphere in which vertical/upward motion of air is discouraged/resisted. It is a state of equilibrium reached in the atmosphere when a mass of dry air which is rising has a lapse rate greater than that of the surrounding air. An air parcel (mass) finds itself cooler than the air surrounding it at the same height hence it spontaneously sinks. For example when a parcel of air is lifted or forced to rise over a mountain that parcel will tend to settle back to its original level because it's heavier than the air around it. Also as the earth loses its heat through radiation at night, the air in contact with the ground also cools creating a condition of cool heavier air below warmer air. Warmer air just above a cool air layer creates a very stable air

condition.

ATMOSPHERIC INSTABILITY

This is an atmospheric condition in which vertical air movements is encouraged. It is the state in which an air mass finds itself warmer than the air surrounding it at the same pressure and height. The air mass will spontaneously rise and continue to rise until it reaches a level in which its new temperature equals that of the surrounding air.

This can occur when a mass of air is forced to rise from the lower ground level and up a mountain and it cools because the vertically moving air mass expands as it moves upwards. It can also occur during day. As the earth's surface is heated by solar radiations, it warms the air in contact with it and above it by conduction and convection. The stable air at lower levels warms until it is no longer colder than the air above and the temperature lapse rate approaches the dry adiabatic rate.

Instability of the atmosphere is therefore the state of unstable equilibrium of the atmosphere where the environmental lapse rate of the air mass is greater than the dry adiabatic lapse rate.

CAUSES OF ATMOSPHERIC INSTABILITY

The following processes cause instability

Mechanical lifting of the surface air as it is forced to rise over mountain ranges.

Convection caused by heating of the surface air which is in contact with the ground. The air becomes lighter, expands and rises.

Lifting of surface air i.e. warm surface air is forced to rise over the cold dense air.

Dense air pushing its way beneath a layer of warmer lighter air leads to atmospheric instability as air is forced to rise.

Friction between the air and the surface over which it is flowing leads to turbulence (instability). Once air blows over a surface which is uneven, the lowest layers of air continuously strike against the irregularities in the surface so that it goes up in a series of small scale saturates called eddies which are carried along with the wind.

EFFECTS OF ATMOSPHERIC INSTABILITY ON WEATHER CONDITIONS OF A PLACE

1. It influences formation of heavy rainfall as a result of condensation due to continued upward movement of air, it is usually accompanied by thunderstorms.

2. It affects temperature. With instability the rising (ascending) air loses its temperature at an average rate of 1^0C for every 150 metres of ascent (rise in altitude) in the upper troposphere.

However, in the lower troposphere, the air mass is warmer than the surrounding troposphere which makes it less dense and able to rise.

3. It leads to formation of fog and mist as a result of cooling process taking place in the lower levels of the atmosphere.

4. It leads to formation of clouds when cooling processes take place in the upper levels atmosphere. The vertical extension of the clouds depends on the intensity of the atmospheric instability.

5. Higher instability leads to formation of cumulonimbus clouds, nimbostratus clouds.

-Low instability leads to formation of cumulus, stratus, cirrus clouds

Strato cumulus and cumulo-nimbus clouds are associated with intense rainfall and thunder storms.

Cirrus and stratus clouds give rise to clear skies/sunny weather conditions.

The alto-cumulus, alto-stratus clouds give rise to light drizzles.

High instability leads to increased humidity.

Questions

1(a) Distinguish between stability and instability in the atmosphere.

(b) Explain the effects of atmospheric instability on the weather conditions of a place.

2 Describe how any 2 elements of weather are measured at a weather station.

3 Differentiate between diurnal range of temperature and mean monthly temperature.

4a) Differentiate between Mean Annual Temperature and Annual Range of Temperature.

b) Account for the variations in mean annual temperature over the African continent.

a)Mean annual temperature is the final figure obtained when the sum of mean monthly temperature (MMT) in one year is divided by 12 months

Whereas Annual Range of temperature is the difference between the highest and the lowest mean monthly temperature in a year.

b)

Approach:

- Show the existing variations in mean annual temperatures over the African continent
- Bring out reasons responsible for these variations

VARIATIONS (Mean Annual temperature).

- There is high mean annual temperature in the Sahara, Kalahari deserts and Northern

  Kenya
- There is low mean annual temperature in the highland areas e.g. Rwenzori, mountain

  Kenya etc.
- There is high mean annual temperature along the East African coast near Mombasa,

  Malindi, Dar-es -Salaam.
- There is fairly low mean annual temperature in Southern Africa along cape town,

  Johannesburg.

REASONS FOR VARIATIONS IN MEAN ANNUAL TEMPERATURE OVER THE AFRICAN CONTINENT

1. Apparent movement of the sun north and south of the equator.

An overhead sun in the Northern hemisphere causes high mean annual temperatures in July around northern Kenya, Kotido, Sudan, Somalia while at the same time causing low mean annual temperatures southwards over the Capricorn or southern Tanzania around Mbeya. On the other hands an overhead sun over the southern hemisphere in January causes higher mean annual temperature in the south over the Capricorn for example around Mozambique, southern Tanzania, south Africa while at the same time low mean annual temperature over cancer e.g. Ethiopia, Egypt among others.

2. Prevailing winds

North East Trade winds which originate from Arabian Desert bring desiccating effects which cause arid conditions characterized by high mean annual

temperature in Somalia, Ethiopia and Northern Kenya (Turkana). On the other hand the warm and moist westerlies from Congo bring relatively low temperatures south of mountain Rwenzori along Nyabirongo causing low mean annual temperature.

The South East Trade Winds pick moisture from Lake Victoria and bring low temperatures to Jinja, Mukono and Kayunga districts hence low mean annual temperature.

3. Ocean currents

Ocean currents such as the warm Mozambique, Guinea and Aghulas have a warming effect which raises mean annual temperatures of adjacent landmasses e.g. Mombasa, Dar-es-salaam. On the other hand cold ocean currents e.g. Banguela current in Angola South Africa and canaries along Morocco lead to low mean annual temperature in the adjacent land masses.

4. Large water bodies

Large water bodies e.g. oceans (Indian ocean, and Atlantic ocean), Mediterranean sea and lakes e.g. lake Victoria, Tanganyika etc. have cooling effect on adjacent landmasses through land and sea breezes and on-shore winds. This leads to low mean annual temperature in areas like Entebbe, Alexandria which are near large water bodies.

5. Absence of or presence of cloud cover:

Areas with thick cloud cover such as the equatorial basin like the Congo basin, Jinja have relatively high annual mean temperature because clouds tend to trap outgoing radiation leading to high temperatures.

On the other hand areas with less cloud cover e.g. the Sahara and Kalahari deserts have very high mean annual temperature because they receive maximum solar insolation during day.

6. Latitudinal location.

Areas along the equator receive maximum solar insolation because the sun's rays strike the earth at right angles and so the rays are more concentrated over a small area and travel a relatively shorter distance. This results into high mean annual temperature in areas along the equator e.g. Nairobi, Nanyuki in Kenya and Kayabwe in Masaka district.

On the other hand areas far from the equator e.g. South Africa receive solar

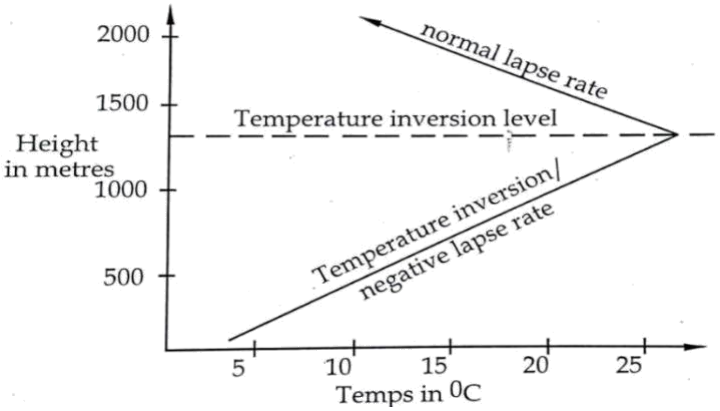
insolation of relatively lower intensity simply because the sun's rays strike the region at an oblique angle and so the rays are highly scattered resulting into relatively low mean annual temperature

7. Altitude (altitudinal factors).

Within the first layer of the atmosphere i.e. troposphere, temperature falls with a rise in altitude. For this reason areas on higher altitude e.g. mountain Rwenzori, Ethiopian highlands, mountain Kilimanjaro have low mean annual temperatures.

TEMPERATURE INVERSION

It is an atmospheric condition in which temperatures increase with an increase in altitude. In other words, the air at a higher altitude is warmer than the one in the valleys.
It is the opposite of the environmental or normal lapse rate where temperatures decrease with an increase in altitude.
Within the troposphere, an increase in temperature with altitude is up to a certain level referred to as the Temperature inversion level. Beyond this level, the normal lapse rate applies.
It is a temporary atmospheric condition which usually lasts for only a few hours especially in the morning time.
It normally occurs in highland areas due to temperature differences between the hill slopes and the valleys e.g In the Kigezi highlands, Kenya highlands as well as areas of limited cloud cover marked by air stability or calm weather. It also occurs in the semi arid areas.
It happens when surface air is cooled by the descending cold dense air while the warm light air is displaced upwards as illustrated below:



Causes of Temperature Inversion

1. Rapid radiation of the earth's surface during the night

When there's limited or no cloud cover, the earth's surface cools faster at night due to the rapid loss of heat. At night, the earth is cooled as a result of the following:

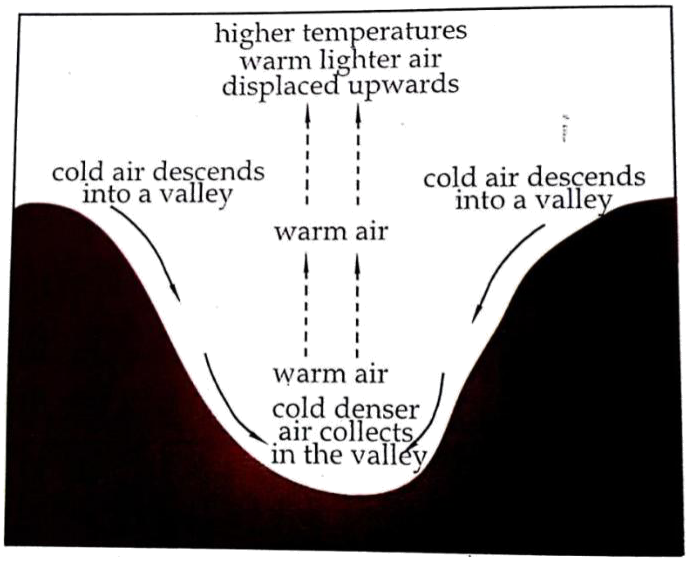
- The sky must be clear with no clouds to allow rapid loss of heat
- The air must be static to ensure effective cooling
- Longer nights to enable adequate time for cooling to take place

This causes cooling of the air near the earth's surface hence causing low temperatures near the ground surface as compared to the air which is far above the ground surface.

2. Subsidence or sinking of cold dense air from the highlands to the valleys at night i.e the effect of the Katabatic winds

Due to the rapid cooling of the upper slopes of highlands at night, air cools and becomes dense causing high pressure while the air in the valleys remains warm leading to low pressure. The cold dense air from the upper slopes therefore sinks downwards into the valleys displacing the warm air upwards hence causing temperature inversion e.g In the Kigezi highlands.

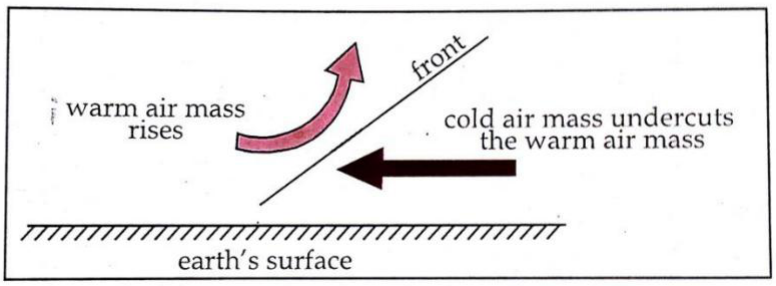
N.B: Katabatic winds are defined as winds which blow from the hill slopes downwards into the valleys at night



3. Frontal convergence of warm and cold air masses

When two air masses with different temperature characteristics meet, the cold air mass which is dense sinks downwards and undercuts the warm light air mass. The cold air mass ultimately lies below the warm air mass leading to temperature inversion called frontal / cyclonic temperature inversion. This occurs in the tropics where air fronts are common i.e the Inter tropical frontal zones in E.Africa. It is also referred to as Frontal or cyclonic temperature inversion

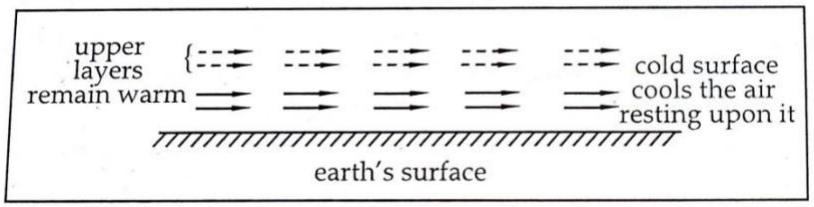
Illustration: Frontal temperature inversion



4. Advection

This is the horizontal movement and cooling of warm air blowing over a cold surface. This occurs when a mass of warm air horizontally blows over a cold surface. The cold surface cools down the lower layers of the air above it while the air far above remains warm. Temperatures will therefore become cold near the earth's surface and warm far above the ground surface. This is referred to as Advective temperature inversion. It eventually leads to the formation of advection fog

Illustration: formation of fog due to advection.



5. Movement of warm air into a cold region

Temperature inversion will occur when a warm air mass suddenly moves into a cold region where it is forced to rise upwards due to its lightness. As the warm air over rides the cold air, warm temperatures are transferred further to the cold region. This often occurs when warm trade winds blow into cold regions usually at a high altitude.

Effects of Temperature Inversion:

- It limits or retards the vertical movement of air currents leading to the creation of a stale atmospheric condition associated with limited rainfall
- It leads to premature surface condensation hence the formation of fog i.e tiny light water

droplets which form over the earth's surface

- It leads to the formation of cold frosty conditions especially in the hilly areas due to the subsidence of cold dense air
- It promotes atmospheric pollution at higher levels especially in the industrial areas since the industrial carbons are easily spread by the warm air above the earth's surface
- The fog formed due to temperature inversion reduces visibility which affects the aviation and the transport industry in general thereby causing accidents
- The cold frosty conditions caused by temperature inversion discourage the growth of some crops such as tomatoes
- The cold frosty conditions which occur in the valleys due to temperature inversion favour the growth of some crops like pyrethrum, tea and sorghum as well as temperate crops like grapes and apples
- It leads to cold related diseases like asthma and pneumonia due to the cold conditions associated with it
- The fog experienced in the morning hours in areas such as Kigezi highlands due to temperature inversion reduces the morning working hours

Qn. Examine the causes and effects of temperature inversion in E.Africa.

TERRESTRIAL RADIATION

It is also known as **Thermal radiation**. It is defined as the energy transmitted or transferred from the earth's surface to the atmosphere. Radioactive decay of isotopes at the earth's surface contributes to the occurrence of terrestrial radiation

Terrestrial radiation is transferred in form of long waves(electro-magnetic radiation) and it occurs all the time both during day and night time in form of infra red energy i.e both light and heat energy

The amount of terrestrial radiation varies with the nature of the surface area and its size e.g water surfaces emit less radiation than land surfaces. Equally, mountain tops emit less radiation than the lowlands

The air, water vapour and clouds take up a great deal of this energy emitted by the earth thus resulting into the rising of temperature in the atmosphere which is measured and recorded at a weather station

Terrestrial radiation therefore results into **a rise in the temperature** of the atmosphere

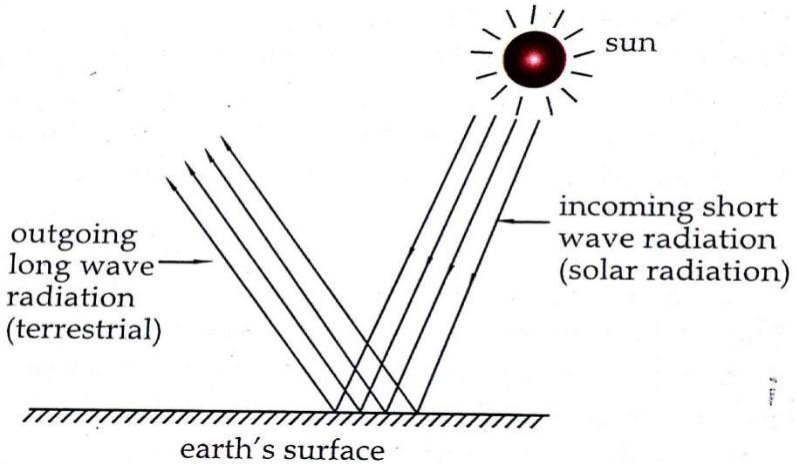
SOLAR RADIATION

It refers to the energy transmitted from the sun to the earth through the atmosphere.

It passes in the atmosphere in form of a beam of short wave rays (solar short wave radiation)

Solar radiation is received in a place during the day in form of light and it is converted into heat at the earth's surface
The amount of solar radiation received in a place also varies from time to time. The air, clouds and the ozone in the atmosphere absorb some of this energy while dust particles and clouds reflect and scatter the energy into the space

The earth therefore absorbs only a fraction of the energy emitted by the sun. The nature of the earth's surface (Albedo) is used to express the ability of a surface to reflect insolation



Conditions Influencing the In-coming Solar Radiation In an area:

- Latitude

The angular distance of a place from the equator partly determines the distance from the sun to the earth's surface. This further determines the angle of incidence at which the sun's rays fall upon the earth's surface
Hence, there's always maximum insolation in the low latitudes because the sun's rays strike the earth's surface at right angles and have a short distance to travel through the atmosphere.
There's intensive heating since there's a smaller surface area per ray. The sun's rays are however less intensive towards the mid latitudes and polar regions (high latitudes) because of the long distance they travel through the atmosphere and the oblique angle at which they strike the earth's surface

- Rotation of the earth

The rotation of the earth on its axis causes changes in solar radiation received in a place. Within the tropics when the sun is overhead, high amounts of solar radiation are received. Absence of the overhead sun at the poles, arctic and sub-arctic regions reduces the insolation rates

- Revolution of the earth

This causes seasonal variation in the amount of insolation received in the different places of the earth. More solar radiation is experienced during the summer season compared to the winter season

- Cloud cover

Clouds in the atmosphere absorb, reflect and refract insolation. This reduces the amount of solar

radiation reaching the earth's surface hence implying that areas with thick cloud cover experience less solar radiation as compared to areas with clear skies

- Aspect

Areas in the direct path of the sun's rays especially in the mid and high latitudes receive more solar radiation as compared to those areas sheltered from the sun's rays.
For instance, in the mid latitudes of the Northern hemisphere, the south facing slopes receive more solar radiation than the north facing slopes. This is because the south facing slopes are in the direct path of the sun's rays. The reverse is also true

- Humidity

The amount of water vapour in the atmosphere may absorb or reflect solar radiation. It prevents some percentage of the solar radiation from reaching the earth's surface. Areas with a low humid content such as arid and semi arid regions on the other hand experience more insolation on their surfaces because direct heat from the sun is received

- Impurities in the atmosphere

Impurities such as smoke and dust particles tend to absorb part of the solar radiation reaching the earth's surface. This means that areas with a lot of atmospheric impurities receive less solar radiation as compared to areas with clear atmospheric conditions

- The sun's hot spots

The surface of the sun has certain sections which are hotter and emit more radiation.
Therefore, sections on the earth's surface that receive heat directly from these hot spots experience greater solar radiation. The reverse is also true.

- Green house effect

The increase in the amount of green house gases like carbondioxide, methane, nitrous oxide, and carbon monoxide in the atmosphere affects the ozone layer hence triggering off the occurrence of global warming which ultimately increases the amount of solar radiation.
On the other hand, areas with limited atmospheric green house gases have an intact ozone layer hence they experience less solar radiation reaching the earth's surface

Qn a) Distinguish between terrestrial radiation and solar radiation
b) Describe the conditions that influence the in-coming solar radiation in an area

Qn. Define the term sunshine
Describe how sunshine is measured and recorded at a weather station

HUMIDITY

It is the amount of water vapour held in a given volume of air at a given time. Atmospheric water vapour is as a result of evaporation and transpiration.

Humidity varies from place to place usually ranging between 48% to 80%. Water vapour is significant in the atmosphere because:

- It influences the formation of rainfall through condensation
- It regulates the temperature of the atmosphere through absorbing radiation i.e solar and terrestrial radiation

- It stores energy in the atmosphere

The humidity of a place can be described as follows:

- **Absolute humidity**

  It is the actual amount of water vapour held by a given volume of air at a given temperature and time. Absolute humidity varies according to temperature and pressure. When air temperature reduces, water vapour condenses consequently lowering the humidity and when temperature rises, air is capable of holding more water vapour leading to high humidity

- **Relative humidity**

  It is the actual amount of water vapour held by a given volume of air at a given temperature expressed as a percentage ratio of water vapour it is capable of holding **OR** It is the ratio of the actual amount of water vapour present in a given volume of air at a particular temperature to the amount of water vapour which the air can hold.

$$\text{Relative humidity} = \frac{\text{Actual amount of water vapour in a given volume of air}}{\text{Saturated water vapour content}} \times 100$$

OR

$$RH = \frac{\text{Absolute Humidity}}{\text{Saturated water vapour content}} \times 100$$

Example:

If saturated air at $40^{o}c$ contains $40g/m^3$ of water vapour per $1m^3$, at a time of measurement the volume of air contains $20g/m^3$. Calculate the relative humidity.

$$\text{Relative humidity} = \frac{\text{Absolute humidity}}{\text{Saturated water vapour content}} \times 100$$

$$= \frac{20}{40} \times 100$$

Relative humidity = 50%

$$RH = \frac{\text{Absolute humidity}}{\text{Saturated water vapour content}} \times 100$$

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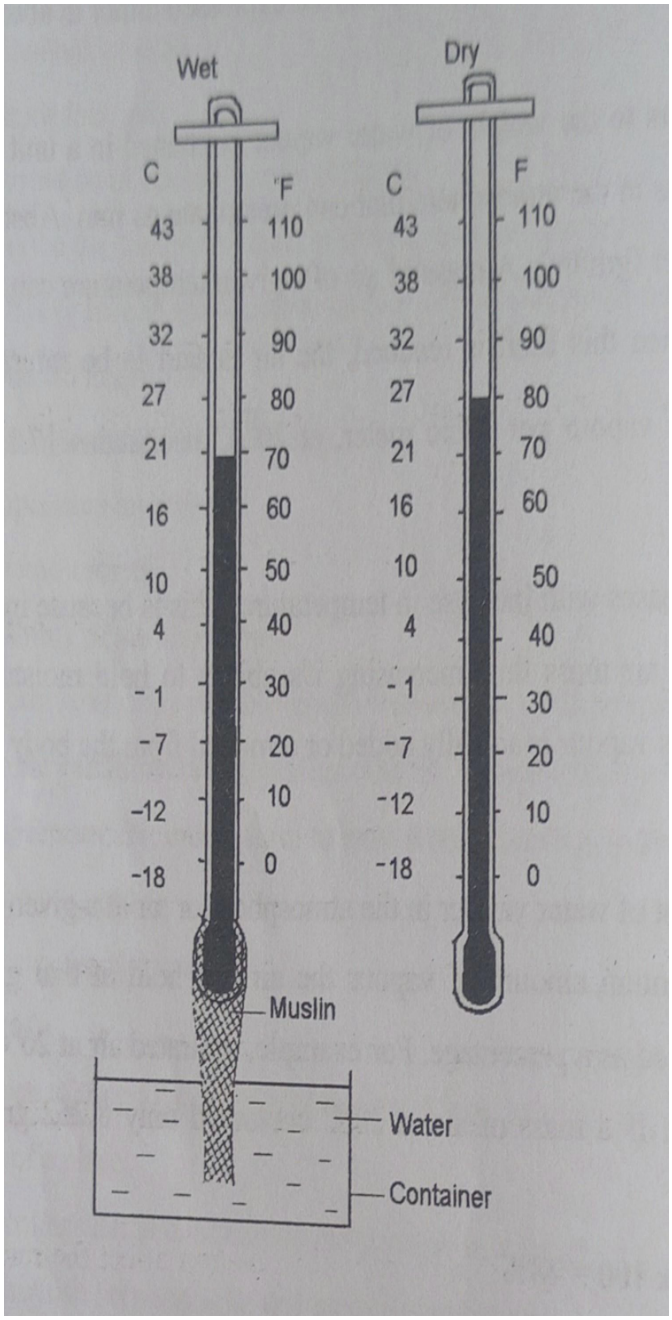
Relative humidity = 50%

MEASUREMENT OF HUMIDITY

- Humidity is measured using an instrument called hygrometer which consists of 2 ordinary thermometer. The bulb of one of the thermometers is covered in muslin (piece of linen cloth) which dips into a container of water.
- This is called wet bulb thermometer.
- The second thermometer is left free in the atmosphere to measure the temperature of the atmosphere.
- This is called the dry bulb thermometer.
- When the atmosphere is dry (i.e. air not saturated) a lot of evaporation takes place from the muslin /cloth.
- This process cools the wet bulb causing the mercury to contact. The temperature reading from the wet bulb thermometer will therefore be low.
- The dry bulb thermometer is not affected because it reads the actual temperature of the atmosphere and so it will give a different reading (usually higher reading). Humidity is then obtained from the difference in the readings of the 2 thermometers.



When the air is saturated i.e. humidity is 100% there will be no evaporation from the muslin (wet bulb thermometer) and so the readings on the two thermometers will be the same (without any difference).

Thus:

- Where there is no difference in the readings, it means the air is saturated i.e. humidity is 100%

- Where the difference is small, it means humidity is high.
- Where the difference is big e.g. high temperature on dry bulb thermometry and very low temperature on the wet bulb, thermometer it means the humidity is low.

Factors which influence the Humidity of a place:

- Temperature

  Temperature controls or determines the rate of evaporation and transpiration. Hot temperatures lead to high rates of evaporation hence increasing the amount of water vapour in the atmosphere while cool temperatures reduce evaporation rates resulting into minimum condensation hence lowering the humidity of a place
- Altitude

  Since temperatures decrease with increase in altitude, high altitude areas like mountain tops experience low humidity as water vapour condenses while areas of low altitude like the coastal areas of E.Africa and the rift valley region experience hot temperatures which encourage high evaporation rates leading to high humidity
- Water bodies

  Such as lakes and the Indian ocean act as sources of water vapour through evaporation. Areas near water bodies therefore experience high amounts of water vapour and hence high humidity e.g around the lake Victoria basin and the coastal areas compared to areas far away from water bodies e.g North eastern Uganda (Karamoja region) and North western Kenya (Turkana land)
- Vegetation cover

  Areas with thick vegetation cover such as forests experience high rates of evapotranspiration leading to high humidity than areas with scattered vegetation such as scrub, thickets and steppe savannah which experience minimum evapotranspiration and therefore low humidity
- Inter Tropical Convergence Zone (I.T.C.Z)

  The apparent movement of the sun leads to variations in humidity between the northern and southern hemisphere. When the sun is overhead in the north, hot temperatures are experienced leading to high humidity in the north and low humidity over the south while the south experiences high humidity than the north when the sun is overhead in the south. The equatorial region however experiences uniformly hot temperatures throughout the year thereby leading to high humidity
- Continentality or Distance from the sea

  Areas near the coast experience high humidity because of the effect of the land and sea breezes while the areas far away from the coast experience low humidity due to the absence of land and sea breezes. Coastal areas also experience low humidity due to the effect of warm ocean currents which transfer warm temperatures towards the land masses leading to high evaporation
- Influence of ocean currents

  Warm ocean currents raise the temperature of the winds blowing over them hence resulting into high humidity while cold ocean currents have a cooling effect on the winds blowing over them leading to low humidity. The high humidity experienced along the E.African coast is therefore as a result of the influence of the warm Mozambique currents

- **Prevailing winds**
  Moist winds such as the South east trade winds cause high humidity in the areas over which they blow e.g the E.African coastal areas and the Lake Victoria basin. However, dry winds with less moisture cause low humidity in the areas over which they blow e.g the North east trade winds are responsible for the low humidity in Karamoja in North eastern Uganda and in the Turkana land in North western Kenya
- **Relief**
  Highland areas tend to have high humidity on the wind ward side because of the ascending moist winds e.g on the wind ward side of Mt Rwenzori, there's high humidity than on the lee ward side
- **Human activities such afforestation, re afforestation and agro forestry encourage** high rates of evapotranspiration resulting into high amounts of water vapour in the atmosphere hence high humidity while activities like bush burning, overgrazing, deforestation and swamp reclamation lead to reduced evapotranspiration and hence low humidity

Qn a) Distinguish between absolute humidity and relative humidity
b) Account for the variations in the humidity experienced in E.Africa

EFFECTS OF HUMIDITY ON WEATHER

Humidity influences weather of a place in number of ways:

1. Condensation of humidity near the ground produces fog or mist e.g. in Ankole and Kigezi Highland.
2. Humidity facilitates rainfall formation. When humidity/water vapour rises to condensation level, clouds form which eventually result into rainfall.
3. High condensation of humidity in the atmosphere leads to formation of cumulo-nimbus clouds which reduce atmospheric temperatures by blocking the sun's insolation from reaching the earth's surface.
4. Difference in concentration of humidity leads to formation of different types of clouds e.g. high humidity leads to cumuilo-nimbus clouds, while low humidity leads to fog/mist.
5. Difference in atmospheric humidity leads to formation of different pressure zones (i.e. high or low pressure) which result into motion of wind. Wind moves from a region of low humidity to a region of high humidity.

EVAPORATION

Evaporation is the process by which water is changed from liquid state to gaseous state.

FACTORS THAT INLFUENCE/DETERMINE THE RATE OF EVAPORATION

1. **Temperature:**

Under natural conditions evaporation occurs steadily under any temperature. Therefore the higher the temperature, the greater the rate of evaporation.

2. **Relative humidity**

Low relative humidity in the atmosphere encourages more evaporation. However, higher humidity e.g. when air is saturated, the rate of evaporation reduces.

3. **Air movements:**

The stronger the wind the greater will be the rate of evaporation.

4. **Nature of the surface:**

Evaporation is more rapid on bare soil compared to where the surface is covered with vegetation.

5. **Water surface (e.g. oceans/lakes etc.)**

Evaporation is higher on large water surfaces than in areas without water bodies.

CONDENSATION

Condensation is the process of formation of water droplets from water vapour when air has been cooled to and beyond its dew point i.e. it is the process where water vapor turns into liquid. Dew point is the temperature at which saturation of air occurs.

CAUSES OF CONDENSATION/FACTORS THAT INFLUENCE CONDENSATION OF WATER VAPOUR IN THE ATMOSPHERE

1. **Adiabatic cooling**

When air rises to the upper levels of the atmosphere, it expands and cools. The cooling of air reaches dew point at approximately 0^0C and therefore condenses into either fog, mist, sleet, hail or rain.

2. **Contact with cold surface**

This is when air comes into contact with a cold surface whose temperature is below dew point. This leads to cooling of the warm moist air leading to condensation to form water droplets on the earth's surface inform of mist, fog,

dew.

3. Meeting of air masses

When two air masses (nearly saturated) which have different temperatures meet i.e. a warm air mass and a cold air mass, condensation will take place in the warmer air mass when it touches the cold air mass.

4. Radiation from the earth during night:

During cloudless clear skies, the earth loses most of its heat acquired during the day. Towards the morning, temperatures on the earth's surface reaches dew point (very cold), and warm moist air in contact with it condenses into fog.

5. Presence of aerosols (condensation nuclei)

For condensation to take place, it is necessary for some nuclei to be present in the atmosphere on which the droplets can form. These nuclei can be in form of particles of dust, smoke, gases, volcanic ash etc. These particles tend to attract tiny droplets of water around them causing condensation.

When the droplets join up in the air to a certain size, they may fall to the earth in form of rain, snow, hail, sleet.

6. Presence of humidity

For condensation to occur, the rising air must have some moisture, water vapor/humidity. It is the moisture in the air that condenses into water droplets after being cooled.

MIST AND FOG

Mist and fog are surface forms of condensation which reduce visibility (i.e. the distance an observer can see).

MIST

Mist is a layer of water droplets close to the ground forming a low cloud due to cooling of air beyond its dew point limiting visibility to between 1-2 kilometers

FOG

Fog is a dense layer of condensed water droplets close to the ground forming a low cloud due to cooling of air beyond its dew points and limiting visibility to less than 1 kilometre.

TYPES OF FOG

1. Advection fog.

This is the type of fog which results from the horizontal movements of warm moist air over a cold surface i.e. cold land or sea surface.

When moist warm air moves, over a cold surface (sea or land), it is cooled and condensed into fog i.e. advection fog.

Advection fog is common near the sea coasts where warm air blows over the cold water of the sea.

It also occurs in winter when warm air is forced to move over a cold surface (ice-covered ground).

N.B: Advection refers to horizontal transfer (movement) of air while convection refers to vertical transfer of air.

2. Radiation Fog

This is the type of fog formed during a period of calm, clear weather when the surface of the earth is rapidly cooled by radiation.

The layers of air resting upon the earth's surface cool leading to condensation and formation of water droplets.

In hill areas e.g. Kigezi Highlands, the cooled dense air from the hill slopes flows down the valley by force of gravity into the hollows/depressions and as it comes into contact with the cold earth's surface, condensation occurs producing a layer of fog called radiation fog. It is common in Kigezi, Kabale town.

3 Steam fog

This is the type of fog formed when cold air passes over a much warmer water surface.

When the cool air moves over warm water, its lower portion is warmed leading to condensation near the ground level in form of steam hence steam fog. This type of fog is not common.

4 Frontal Fog

This is the type of fog which occurs when warm nearly saturated air is mixed with colder air resulting in an over-saturated mixture. It is associated with the meeting of warm moist air mass with cool dry air mass.

The cold air mass cools the warm air mass and causes moisture contained to condense near the ground to form fog (frontal fog). This is associated with quick

drizzles.

5 Hill Fog

This is a low sheet of clouds covering hill tops. It is formed when rising humid air undergoes expansional cooling and eventually becomes saturated. When the saturated air rises higher it produces fog that often appears as a low sheet of clouds on hill tops.

FACTORS/CONDITIONS NECESSARY FOR THE FORMATION FOG:

1. Clear skies at night.

The absence of cloud allows the surface of the earth to lose much of the insolation which it received during the day leading to radiation fog.

2. High relative humidity

The air should have high relative humidity for rapid condensation to occur.

3. Light breeze:

This allows air in contact with the ground surface to be cooled and this cooling is not easily transmitted to overlying air hence leading to fog near the surface of the earth.

EFFECTS OF FOG

1. Fog reduces visibility to a distance of 1 kilometer hence disrupting transport.
2. It leads to health problems e.g. colds and asthma.
3. It slows down the growth and ripening of crops e.g. grapes, mangoes, tomatoes etc. in Kigezi, Germany etc.
4. It discourages settlement due to cold temperatures in the valleys e.g. in the valleys of Ntungamo, Kabale, Kenya Highlands etc.

HAZE

This is a form of obstruction resulting from the concentration of dust particles in the air that reduces visibility. It is experienced in the tropics during the dry season e.g. the Harmattan haze in West Africa.

DEW

This refers to water droplets normally formed on plants or in the air during the night due to rapid terrestrial radiation at night. As the air cools by conduction

and moisture (vapour) in the air or transpired from plants, condenses, water droplets called dew form.

AIR PRESSURE

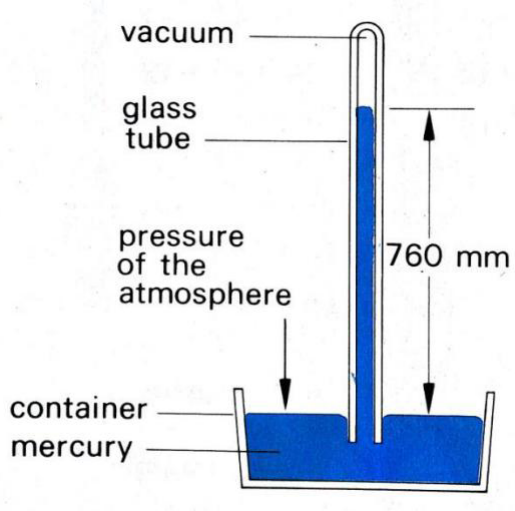
It is the weight (force) of the air exerted per unit area on the earth's surface. It is mathematically expressed as:

Pressure = $\frac{\text{Force}}{\text{Area}}$

The weight of air is the vertical column exerted from the upper limit of the atmosphere to the earth's surface which is approximately 1.034kg/cm^3 over the sea level.

It is measured and recorded in units known as **Millibars**. However, the average pressure or weight of the air on the earth's surface is measured in **Millibars per unit area**.

Atmospheric pressure is measured using a mercury barometer or an aneroid barometer. A **mercury barometer** consists of a glass tube which is inverted over a bowl of mercury. The glass tube is marked in mm as illustrated below:



Air has weight and therefore exerts pressure on the earth's surface. A rise in atmospheric pressure caused by air pressure over the surface forces the mercury to rise in a glass tube.

When atmospheric pressure falls, mercury is forced to flow out of the glass tube and the mercury column in the glass tube falls

Atmospheric pressure is measured by looking at the column of mercury supported in the glass tube

It is expressed in Millibars e.g 750mm of mercury corresponds to 1000millibars (mbs) **N.B**:

When air pressure changes, the weight of the mercury column changes accordingly i.e when air pressure increases, the mercury column in the glass tube rises and vice versa.

The recorded mean pressure values are used in tables, maps and charts.

An **aneroid barometer** comprises of a small metal container with most of the air driven out to form a vaccum.
Since there's practically no pressure at all inside the box, any increase in pressure on the outside of the box will cause the lid to move inwards hence registering high pressure by the indicator on the revolving dial.
When there's a decrease in pressure, the lid springs outwards registering or recording (indicating) low pressure by the indicator on the revolving dial.

Pressure varies from one place to another and from time to time.

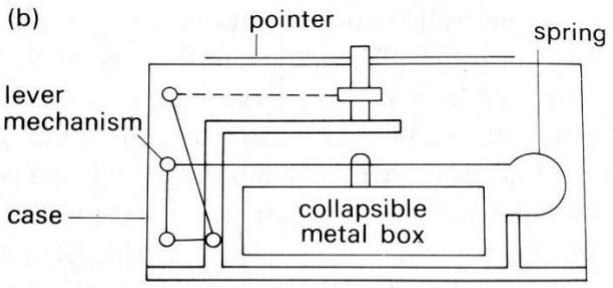


Fig. 13.11 (b) section through aneroid barometer

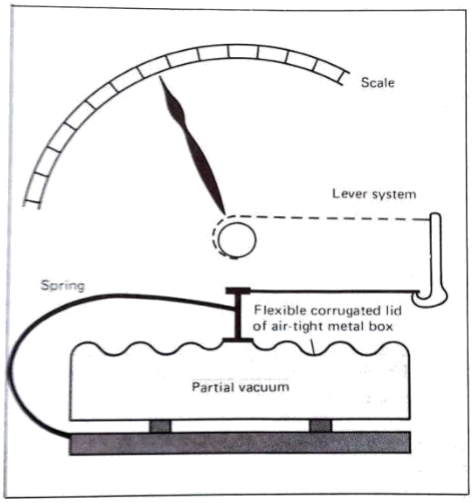


Fig. 11.3 *Aneroid barometer which measures air pressure*

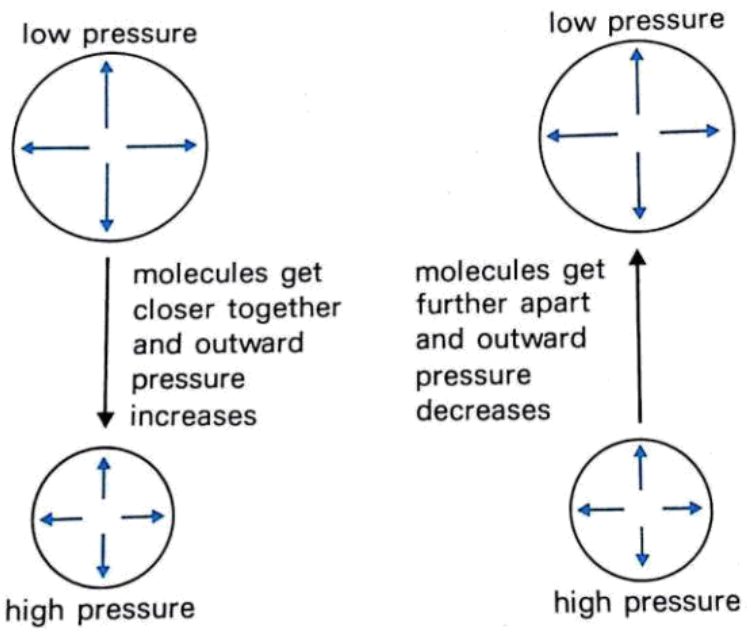
Factors influencing atmospheric pressure:

- Temperature

  There's an inverse relationship between the temperature and atmospheric pressure of a place.
  Hot temperatures lead to low pressure while cold temperatures lead to high atmospheric pressure.
  When air is heated, the air molecules expand and spread over a wide area resulting into low pressure while low or cold temperatures result into contraction and condensation of air molecules thereby exerting high pressure on the earth's surface. For that matter, Polar regions are high pressure zones while equatorial areas are low pressure belts.

- Altitude

  Atmospheric pressure decreases with an increase in altitude. This is because air at a high altitude spreads over a wide area which reduces its weight thereby causing low pressure. So, high altitude areas like highlands / mountain tops have low pressure due to the gravitational force towards the low altitudes.
  Low altitude areas such as foot hills and sea level on the other hand experience high pressure because the air near the ground supports the weight of air above it hence, the underlying or bottom air molecules constantly push downwards onto the earth's surface. This is also due to the high concentration of air impurities like dust particles and carbondioxide at the low altitudes.



- Rotation of the earth

  As the earth rotates, air at the poles (North and South poles) is blown away towards the equator. It crosses parallels which are getting longer. The cold dense air at the poles crosses from the high latitudes towards the equator spreading over a wide area leading to low pressure. This accounts for the low pressure at the equator.
  Air rising at the equator spreads out as it moves towards the poles. It crosses parallels which are getting shorter and contracts to occupy a small space. Its pressure therefore rises. This accounts for the high pressure at the horse latitudes.

- Latitudinal location

  Air pressure tends to increase away from the equator towards the Polar Regions. The equatorial region experiences low air pressure because of the intense or high insolation (heat) from the overhead sun while Polar Regions which experience a low intensity of insolation experience high pressure

- ❖ Nature of the earth's surface

  Land and water surfaces experience varying air pressure because of differences in the rate of heating and heat loss. This however affects atmospheric pressure at a local scale. During the day, land surfaces absorb heat faster than water surfaces leading to low pressure over the land and high pressure over the sea. Conversely at night, low pressure develops over the sea and high pressure over the land because the land surface cools faster than the water surface Amount of water vapour in the atmosphereplace

- ❖ Moist air is cold and dense hence it exerts high pressure on the earth's surface while dry air with little or no moisture is warm and light (less dense) hence exerting low pressure on the earth's surface
- ❖ Apparent movement of the sun (Influence of the I.T.C.Z)

  Low pressure belts shift with the apparent movement of the overhead sun. When the sun is overhead the northern hemisphere (Tropic of Cancer) in June – July, high temperatures are experienced in the north leading to low pressure and high pressure over the southern hemisphere. In December – January when the sun is overhead in the southern hemisphere (Tropic of Capricorn), temperatures rise and low pressure develops over the south while the north develops high pressure.

Qn a) Describe how atmospheric pressure is measured and recorded at a weather station

b) Explain the factors that influence the atmospheric pressure of a place

EFFECTS OF ATMOSPHERIC PRESSURE ON WEATHER AND CLIMATE

- ★ Abrupt change of atmospheric pressure resulting into steep pressure gradient results into formation of most violent cyclones called typhoons and hurricanes.
- ★ A gentle change of atmospheric pressure over a wide area results into soft winds asscoauted with dry conditions.
- ★ Differences in atmospheric pressure results into movement of air from regions of high pressure to regions of low pressure.
- ★ Movement of air masses (air of different characteristics) leads to convergence of such air masses resulting into formation of cyclonic rainfall.
- ★ Uniformity of atmospheric pressure over a wide area results into calm conditions.

Question

Describe the effects of atmospheric pressure on weather and climate

Examine the causes and effects of atmospheric pressure.

GLOBAL ATMOSPHERIC PRESSURE BELTS (ZONES):

1. **Equatorial low pressure belt**

This belt exists between 5^0N and 5^0S of the equator. Due to the effect of overhead sun there is intense heating throughout the year leading to low pressure zone. North east and south east trade winds converge here. This region is called the inter-tropical convergence zone (ITCZ).

2. **Sub-tropical high pressure belts;**

This belt exists between 30^0N and 30^0S of the equator. It is also known as the horse latitudes. This is a

zone of descending air currents that cause high pressure.

3. Temperate low pressure belts;

This belt is found approximately 60^0N and 60^0N of the equator. It is a region of low atmospheric pressure because air masses tend to rise/expand after converging near the earth's surface.

4. Polar high pressure belt.

This is a zone found at the North and South Pole that's 90^0N and 90^0S of the equator. There is extremely low temperature at the poles. This causes high pressure since air molecules over the earth's surface are dense.

NB: The distribution of pressure zones over the earth's surface influences the formation of winds.

CLOUDS (CLOUD COVER)

- Clouds are masses of water droplets or tiny ice crystals that float in the air formed by condensation of water vapour.
- The amount of cloud cover and the nature of cover are recorded at meteorological stations and appear on weather maps.
- The amount of cloud cover in terms of the proportion of the sky which is covered is expressed in Oktas (that's in eights) for example 4/8 means the sky is half covered with clouds.
- On weather maps places with equal amount of cloud cover are joined with lines called isonephs.

TYPES OF CLOUDS

Clouds are classified according to the height where they occur or according to their form and appearance. According to their form and appearance there are 3 major types of clouds that's; stratus, cumulus and cirrus clouds.

1. STRATUS CLOUDS

- These clouds appear as flat white blankets at low altitude of less than 2100 meters above sea level.
- They occur in layers and are generally formed by the mixing of two nearly saturated air masses with different temperatures and characteristics.
- They may also be formed by air moving over a damp, undulating surface. As the air moves across the ground surface, moisture is picked up and at the same time the friction between the air current and the ground surface produces eddies which lift the basal air upwards away from the damp surface and bring new bodies of unsaturated air into the surface. If the air is lifted to heights where dew point temperature occurs, stratus cloud forms.

CHARACTERISTICS OF STRATUS CLOUDS.

- They are found at low altitudes usually less than 2100 meters above sea level.
- They are layered or blanket-like
- They are thin and sheet-like with shallow vertical extension.
- They cover wide areas that's they are large

- They are grey in color

WEATHER CONDITIONS ASSOCIATED WITH STRATUS CLOUDS

- Create dull weather
- Cause heavy rain (nimbo-stratus)
- Have high relative humidity
- Stratus clouds can be subdivided into:

a) Strato-cumulus clouds: These are low rolls of clouds which are soft and grey and frequently cover the entire sky. Because the cloud mass is usually not very thick, blue sky often appears between the breaks in the cloud.

b) Nimbo-stratus clouds. These are thick and shapeless clouds. They produce precipitation for example rainfall or snowfalls.

2. CUMULUS CLOUDS

- These are clouds with great vertical extent. Cumulus cloud has a rounded top and horizontal base. It looks like cotton wool. They occur majorly in humid tropical regions.
- They are formed by a diabatic cooling. The convectional currents produced by the heating of the base layers of the atmosphere in contact with the earth lead to formation of bubbles of air which rise upwards gradually detaching themselves from the base layers to form cumulus clouds.
- The commonest and major type of cumulus clouds is cumulo-nimbus.
- Cumulo-nimbus clouds are dark-heavy-looking clouds rising like mountains high into atmosphere.
- They are commonly known as thunder clouds, as they bring convectional rainfall accompanied by thunder and lighting.

CHARACTERISTICS OF CUMULUS CLOUDS

- They have a bubble- like or lumpy cotton wool appearance.
- They are dark/grey
- They occur between altitudes of 500-9000 meters

WEATHER CONDITIONS ASSOCIATED WITH CUMULUS CLOUDS

- Lightning and thunder
- Heavy rain (cumulo-nimbus)
- During day dense cumulo-nimbus clouds lead to reduction of atmospheric temperatures.
- Dense cumulo-nimbus clouds block terrestrial radiation leading to high temperatures during the night.
- They lead to increase in humidity in the atmosphere.
- They are associated with strong winds which may destroy crops and settlements.

3. CIRRUS CLOUDS

- These are very high clouds. They appear fibrous and wispy.
- They are formed where air is relatively stable and condensation is taking place by the forced

ascent (uplift) of air over the warm front of a depression or over a mountain range.

CHARACTERISTICS OF CIRRUS CLOUDS

- They are fibrous and wispy in appearance
- They are white or milky in appearance
- They are found at high altitude that's between 6000-12000 metres.
- They are detached in nature
- They are associated with fair weather.

ROLE OF CLOUDS/INFLUENCE OF CLOUDS ON CLIMATE AND WEATHER

1. Clouds prevent the sun's rays from directly striking the earth's surface hence reducing the amount of solar radiation received by the earth during the day, leading to low temperatures.
2. Clouds lead to formation of rainfall when tiny water droplets become too heavy to be held up in the atmosphere.
3. Clouds such as low clouds like mist and fog reduce visibility.
4. Surface clouds/low clouds like fog and mist lead to low temperatures on the earth's surface.
5. The nature of clouds helps meteorologists to predict the types of weather condition likely to occur in an area.
6. Clouds emit electric charges that may lead to occurrence of static electricity like lighting experienced during thunderstorms.

PRECIPITATION

It refers to all forms of moisture which fall on the earth's surface from the atmosphere. Precipitation occurs as a result of the condensation of water vapour in the atmosphere to form rainfall, hail, fog and dew.

Precipitation forms under the following conditions:

- ✓ Adiabatic cooling of air which occurs when moist air rises and cools until when the temperatures reach the dew point at the condensation level. The water vapour condenses to form clouds or precipitation
- ✓ Air contact with a cold surface
  When warm moist air moves over a cold surface, the water vapour is cooled and it condenses into precipitation. This commonly occurs over the sea leading to the formation of fog
- ✓ Mixing of air in the atmosphere
  When two (2) air masses or wind systems meet in the atmosphere, the warm air is cooled down and it condenses leading to the formation of water droplets
- ✓ Terrestrial radiation at night
  Rapid loss of heat by the land surface causes rapid cooling which also in turn causes the condensation of water vapour near the earth's surface. This is responsible for the formation of dew especially in the semi arid areas
- ✓ The degree of relative humidity
  When air is fully saturated i.e with a relative humidity of 100%, any increase in water vapour results into condensation to take place hence forming water droplets
- ✓ Existance of condensation nuclei
  The amount of tiny particles in the atmosphere such as dust and smoke facilitate the occurrence of condensation. Water molecules often form or cling onto these tiny particles suspended in the atmosphere

acting as condensation nuclei

N.B: Condensation in the atmosphere results into the formation of clouds. Clouds are defined as thick water droplets suspended in the atmosphere as a result of the condensation of water vapour when temperatures drop to the dew point.

Clouds in the atmosphere affect the weather conditions of a given place in the following ways:

- Clouds lead to low surface temperatures by absorbing radiation from the sun during the day. This reduces the amount of insolation received on the earth's surface
- Clouds regulate warm temperatures during the night by acting as a blanket that prevents heat loss from the earth's surface. Areas with thick cloud cover e.g the equatorial region experience a low diurnal range of temperature due to the reduced amount of heat loss at night
- Dense cloud cover results into dark un clear conditions during day time. Thin cloud cover results into clear sunny day conditions
- Thick cloud cover is associated with heavy rainfall while thin clouds lead to little or no rainfall at all
- Low altitude clouds like mist and fog reduce visibility that hinders human activities such as transport thereby causing accidents.

RAINFALL

It is defined as coalesced water droplets that fall under the influence of gravity. It occurs as a result of condensation of water vapour in the atmosphere. The water droplets become heavy to be held up in the atmosphere and hence, they later on fall down to the ground under the influence of gravity.

Types of Rainfall:

- **Convectional Rainfall**

It is a type of rainfall which occurs as a result of evaporation induced by heat. Evaporation releases water vapour into the atmosphere which condenses to form clouds and later rainfall. It is common in the equatorial areas which experience intense heating almost throughout the year while in the mid latitudes, it is received during summer. The heat from the sun causes evaporation from the land and water surfaces as well as evapotranspiration from vegetation. The water vapour rises until when it reaches the condensation level where it cools and condenses into water droplets or clouds which result into rainfall.

Characteristics of Convectional rainfall:

- It is experienced in areas with intense heating
- It is associated with prolonged rains covering a wide area
- It is mainly received in the afternoons
- Lightning and thunderstorms are so common
- It involves heavy showers
- It occurs during summer in the mid latitudes

- **Orographic Rainfall**

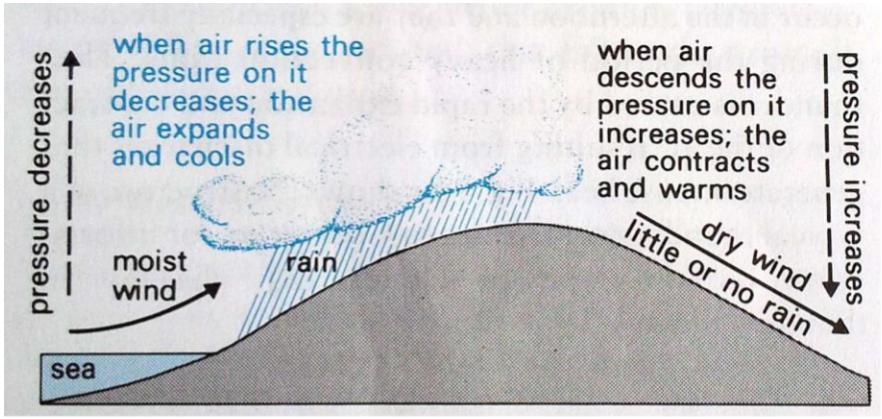
  It is also known as relief rainfall.

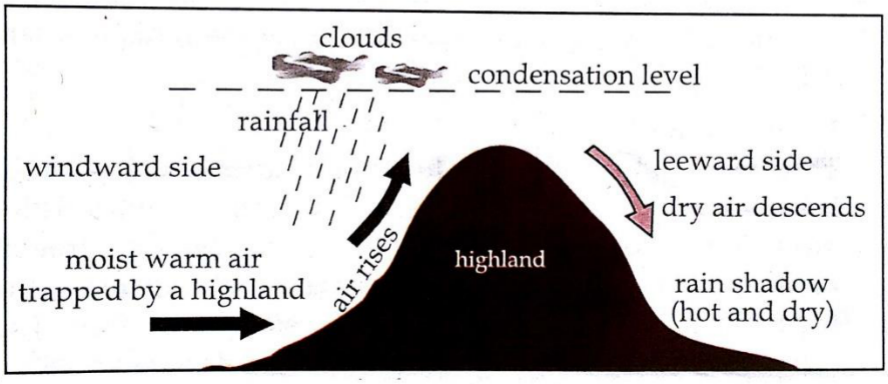
  This is a type of rainfall experienced in the highland areas. It occurs when moist air is forced to rise upwards by a relief barrier such as a mountain (highland) or hill. The onshore moist air rises until when it reaches the condensation level to form clouds which consequently release rainfall on the wind ward side. Air rises up the mountain cooling at an adiabatic lapse at the condensation point at an average rate of 1^{o}c per 100metres to form cumulo nimbus clouds. As the clouds become dense, water droplets are released as rainfall on the wind ward slopes. Air descends on the lee ward side when it is cool and dry hence resulting into little or no rainfall. This region is called the rain shadow.

  This type of rainfall is common in the mountainous areas / highlands of Kilimanjaro, Rwenzori, Elgon, Muhavura and Mt Kenya

Characteristics of Relief rainfall:

- It is often heavy on the wind ward side of the highlands
- It occurs as a result of the ascent of moisture laden air over a highland
- It involves prolonged periods of rain or precipitation
- It occurs in proximity to highlands Occasional thunderstorms and hail are common





- **Frontal (Cyclonic) Rainfall**

  It is a type of rainfall which occurs when two air masses of different characteristics meet at a front. The warm air mass is forced to rise over the cold dense air mass which descends at front. Warm moist air rises and cools at an adiabatic lapse rate until when the condensation level is reached. Condensation occurs to form clouds which eventually release water droplets called frontal rainfall.

Characteristics of Frontal Rainfall

- It is experienced along fronts such as the Inter tropical convergence zone (I.T.C.Z) where trade winds meet
- It involves heavy showers covering small local areas
    - It lasts for only a few hours It involves violent thunderstorms

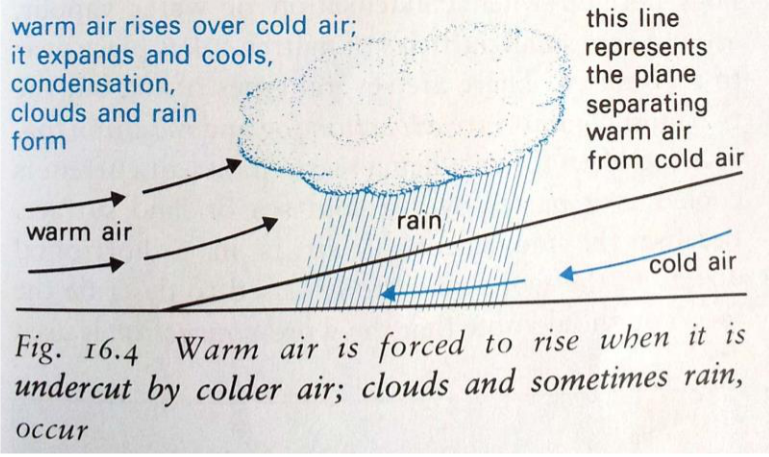
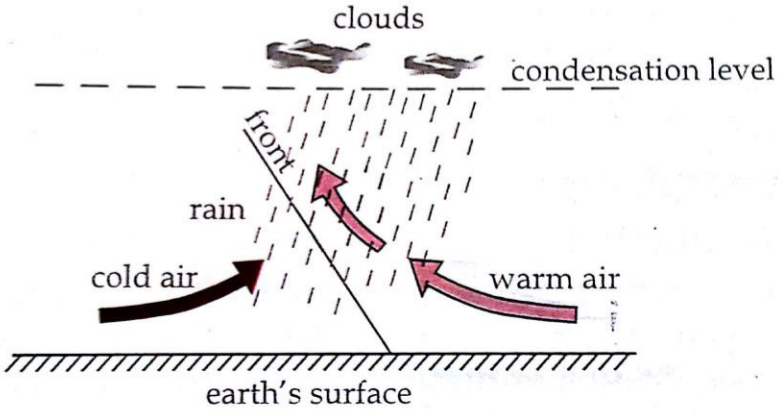
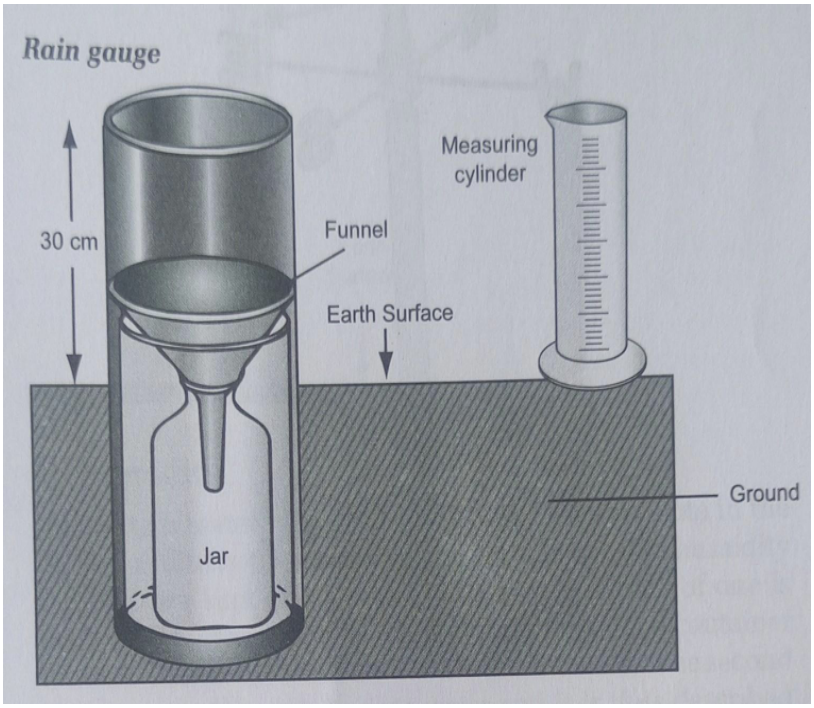


Fig. 16.4 Warm air is forced to rise when it is undercut by colder air; clouds and sometimes rain, occur



MEASUREMENT OF RAINFALL

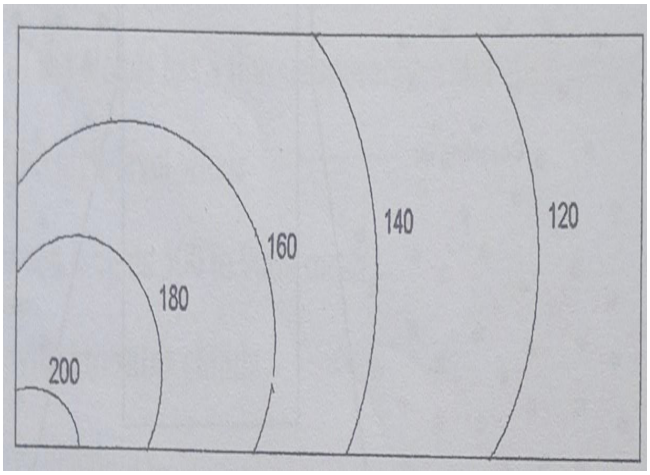
- Rainfall is measured using a rain gauge.
- Rain gauge consists of a cylindrical copper container, a funnel, a jar and a measuring cylinder. When it rains, rain water is led by the funnel into the jar placed inside the metallic container. After 24 hours, the water in the jar is removed and poured into a measuring cylinder which has a scale graduated (marked) in millimeters. Reading for that day is taken (usually at 9:00 a.m.).
  N.B Rain gauge should be placed about 30 centimeters above the ground level in order to prevent any rain from splashing up and from the ground into the funnel.
- The lower part of the gauge is fitted into the ground to guard against evaporation of rain water that has collected.
- The gauge is placed in the open jar away from trees, buildings among others.



RECORDING OF RAINFALL

1. Daily rainfall amount: This is the amount of rainfall received in a day. Each day, rain water collecting in the jar is poured into the cylinder graduated in millimeters and the total rainfall for the day is obtained.
2. Total monthly rainfall: This is the amount of rainfall received in a month. It is obtained by adding up the amount of rainfall recorded each day for a whole month.
3. Mean monthly rainfall: This is obtained by dividing the total monthly rainfall by the number of days in the month for that month.
4. Mean Annual rainfall. This is obtained by adding up the mean monthly rainfall for several years usually between 15- 30 years and then dividing the result by the number of years. Recording of rainfall on weather maps is done using lines called isohyets. These lines join places with the same amount of rainfall.

ISOHYETS



Rainfall amounts can also be recorded on bar graphs.

Qn (1)

Describe how mean monthly rainfall is obtained at a weather station

Qn (2)

Describe how any 2 elements of weather are measured and recorded at a weather station.

FACTORS INFLUENCING RAINFALL DISTRIBUTION IN E.AFRICA:

Rainfall distribution refers to the pattern in which rainfall is spread over a given area in a specific period of time.

Rainfall in E.Africa varies mainly in terms of amount and seasonality. Heavy rainfall of over 1000mm per annum is experienced in areas around the Lake Victoria basin, coastal areas and the highland areas of Mt Kenya, Elgon and around the Kigezi highlands among others.

Moderate rainfall ranging between 760-1000mm per annum is experienced in South western Tanzania, Central and Northern Uganda]as well as Southern Kenya

Low rainfall of less than 760mm per annum is received in areas like Karamoja region, Ankole Masaka corridor, Turkana land, Masai land and

the Albert flats

The variations in the amount of rainfall received in E.Africa are influenced by the following factors:

- **Apparent movement of the sun (I.T.C.Z)**

  In June – July when the sun is overhead in the north, intense heating occurs creating a low pressure belt and the convergence of moist winds which result into heavy rainfall in the north. The same condition is experienced in the south in December – January.

  The north and south therefore experience a single rainfall maximum due to the movement of the sun. Because the sun is overhead at the equator twice in a year, a double rainfall maxima is experienced in the equatorial areas such around the Lake Victoria basin

- **Prevailing winds**

  They have a rainfall effect on the areas over which they blow because they transfer weather characteristics to the areas where they move. The South east trade winds emerge from the Indian ocean when they are moist so they are responsible for the heavy rainfall experienced along the E.African coast as well as the northern shores of lake Victoria while the North east trade winds from the Arabian desert are responsible for the low and un reliable rainfall in North eastern Uganda and North western Kenya

- **Vegetation cover**

  Areas with thick vegetation cover like tropical rain forests experience heavy rainfall due to the high rates of evapotranspiration e.g around Mabira, Budongo and the coastal areas with mangrove forests. On the other hand, semi arid areas with scattered vegetation cover experience low and un reliable rainfall e.g Karamoja region and Turkana land

- **Influence of water bodies**

  Such lakes and the Indian ocean recharge the atmosphere with water vapour through evaporation as well as through land and sea breezes. Therefore, areas near water bodies experience heavy convectional rainfall e.g the lake Victoria basin and the coastal areas while areas far away from water bodies experience low and un reliable rainfall e.g In North eastern Uganda

- **Relief**

  Highland areas in E.Africa experience heavy rainfall on the wind ward slopes since they act as barriers towards the movement of the moist winds hence forcing them to rise upwards towards the condensation level thereby forming orographic rainfall. On the other hand, lowland areas like the Albert flats experience low rainfall due to the absence of relief barriers to trap them

- **Altitude**

  High altitude areas like mountainous regions experience heavy rainfall due to cool temperatures which induce condensation of moisture bearing winds while

areas of low altitude experience low to moderate rainfall due to the limited cooling effect for instance Mt Elgon areas receive heavy rainfall than the rift valley region

- **Latitudinal location**
  Areas located at or near the equator experience heavy rainfall which is evenly distributed throughout the year with a double rainfall maxima in March and September because the sun is overhead at the equator twice in a year while areas far away from the equator experience moderate to low rainfall with a single rainfall maximum because the sun is overhead at the tropic of cancer in the north and tropic of Capricorn in the south once in a year
- **Ocean currents**
  Warm ocean currents like the warm Mozambique currents increase the temperature of the ocean water and cause an increase in the rate of evaporation. The water vapour is therefore picked up by the onshore winds resulting into heavy rainfall in the coastal areas of E.Africa between Mombasa and Dar es Salaam
- **Corriolis force effect**
  According to Ferrel's law, the South east trade winds are deflected to the right of their path as they cross the equator due to the rotation of the earth. This is responsible for the heavy rainfall received around the northern and north eastern shores of lake Victoria while low and un reliable rainfall experienced in the Ankole Masaka corridor
- **Perturbation**
  It refers to the development of low pressure belts over the Indian ocean due to intense insolation. This forces winds from the interior of E.Africa to blow offshore (seaward) resulting into heavy rainfall over the Indian ocean and dry conditions in North eastern Kenya
- **Coastal configuration**
  The North east and South west alignment of the coast forces winds to blow parallel to the coast instead of blowing onshore. This is responsible for the low rainfall received in North eastern Kenya
- **Human activities**
  Such as deforestation, overgrazing, sinking of bore holes and swamp reclamation among others reduce the rate of evaporation and evapotranspiration resulting into low rainfall e.g in the Karamoja region and Turkana land. On the other hand, afforestation and re-afforestation result into increase in the rate of evaporation and evapotranspiration hence increasing the amount of rainfall in the areas where the trees are planted

Qn a) Distinguish between convectional rainfall and orographic rainfall b) Account for the variations in rainfall distribution in E.Africa

FOG

It refers to tiny and light water droplets which form close to the earth's surface. It is a meteorological condition where condensation occurs at a low altitude or near the ground surface resulting into poor visibility over a given area to about 1 kilometre (0.62 miles).

Fog develops by condensation of water vapour in the atmosphere near a cold surface. For condensation to occur, condensation nuclei such as smoke and dust particles must be suspended in the atmosphere near the earth's surface.

Types of Fog:

There are different types of fog which occur depending on the conditions of formation

- ✓ **Radiation fog**

  It is a type of fog which is formed due to rapid terrestrial radiation and cooling of the earth's surface. It mainly occurs at night. The air near the earth's surface therefore cools and condenses to form a layer of fog called radiation fog

- ✓ **Advection fog**

  It is a type of fog formed when warm moist air passes over a cold surface. This causes rapid cooling and condensation of the lower layers of air to form fog

- ✓ **Frontal Fog**

  It is a type of fog formed when a warm air mass meets with a cold air mass. The cold air mass cools down the warm air mass above it resulting into condensation near the earth's surface. This is so common around the coastal areas and the Inter tropical convergence zone

- ✓ **Hill fog**

  It refers to a low sheet of cloud that covers the lower slopes of hills. It is common in the hilly and mountainous areas which experience cool / low temperatures at high altitude. The rising air is cooled down along the hill slopes leading to pre mature condensation that results into the formation of hill fog

- ✓ **Steam fog**

  Is a type of fog formed when a cold air mass passes over a warm water surface. The water vapour from the water surface condenses easily upon mixing with the overlying cold air. Steam fog forms rapidly and disappears quickly.

HAIL

It refers to frozen rain droplets which usually range between 5 – 50 mm in diameter. The frozen rain droplets usually have a concentric layer of ice as well as being white and opaque in character.

Hail is a form of precipitation which falls on the earth's surface in form of small ice pellets or hail stones.

It is associated with extreme instability in the atmosphere resulting from uplift of air by convective currents

Hail forms due to the condensation of moisture in the lower atmosphere followed by strong rising air currents. The water droplets are therefore pushed up to the freezing point to form ice pellets which are thick and dense enough to overcome the uprising air currents. Consequently, ice falls on the earth's surface in form of hail stones.

It usually occurs in unstable cumulo nimbus clouds where vertical uplift or rise of air is strong enough to carry condensed droplets above to great heights of the freezing level where they are turned into ice crystals at a very high altitude.

The initial droplets freeze above the freezing point hence condensation nuclei is ice. After being carried upwards to greater heights by the uprising air currents, an additional layer of ice is formed on the original ice nucleus by collision and coalescence with super cooled water vapour / droplets around.

The pellets fall and rise many times until when the weight of the enlarged ice crystals is sufficiently great to overcome any uprising current. Finally, the crystals fall as hailstone due to gravity

Qn. Describe the processes leading to the formation of the following:

a) Fog
b) Hail
c) Orographic rainfall

WIND

- It is defined as moving air or air in motion. Air usually moves in a definite direction and is therefore referred to as a wind system.
- Winds often blow from regions of high pressure to regions of low pressure determined by temperature differences.
- Winds are either local or global. Global winds are generally referred to as Air masses and they have great influence on the climate of extensive areas while local winds have micro climatic influence.
- Winds may also be referred to as breezes when they are light.

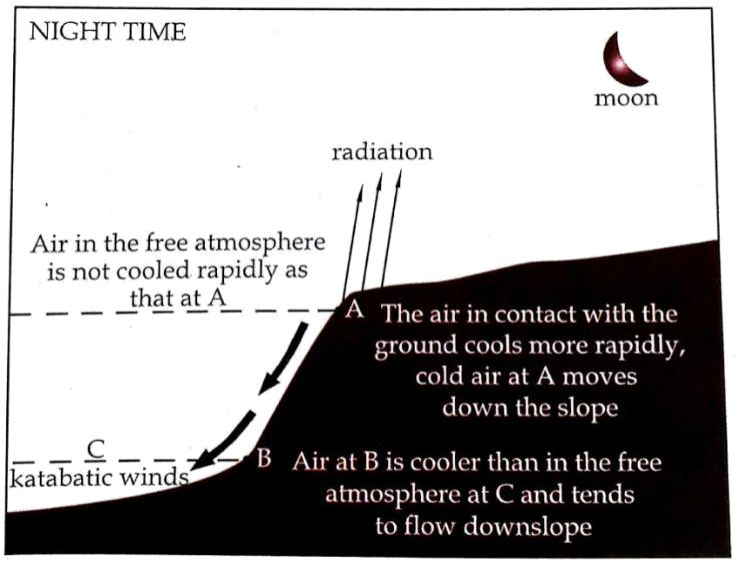
LOCAL WINDS

They are winds which blow over localized areas i.e they are less extensive wind systems. They result from differences in pressure in particular areas leading to air masses from areas of high pressure to blow towards areas of low pressure.

TYPES OF LOCAL WINDS:

A. KATABATIC WINDS

They are local winds which move down slope under the influence of gravity at night. They occur in highland areas at night when cold dense air moves down slope. Katabatic winds form due to rapid cooling of the highland slopes at night due to their exposure leading to high pressure over the slopes. The slopes lose a lot of heat through radiation hence they cool down much faster than the valleys ultimately becoming areas of high pressure. The air on the slopes becomes denser than the air in the valleys. The cold dense air from the highland slopes therefore blows down slope (descends) to the valleys i.e from a high pressure zone to a low pressure zone forming a Katabatic wind as illustrated below;



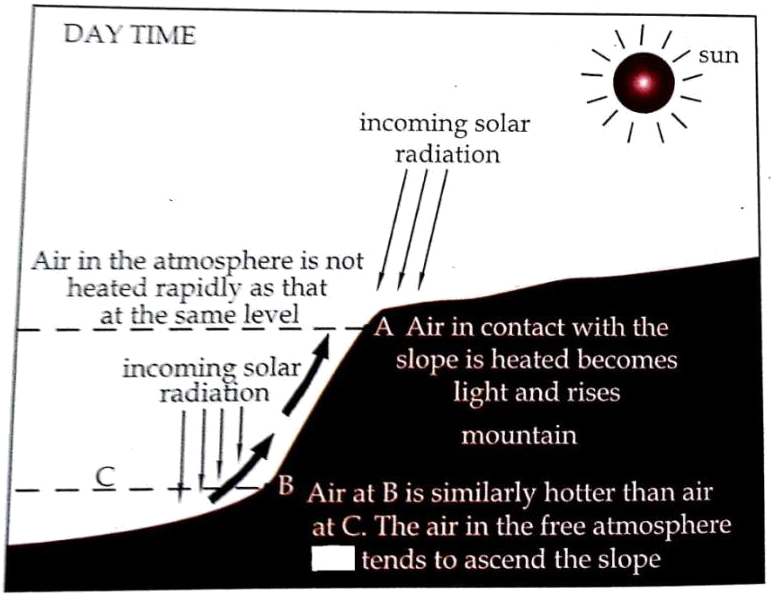
Katabatic winds normally result into the following weather conditions:

- There's formation of mist and fog in the valleys especially in the morning hours because of the meeting of descending cold air and the warm air in the valley
- Cold conditions are created in the valleys during the night usually extending to the morning hours
- Temperature inversion is experienced in the valleys as the cold descending air displaces the warm air upwards thus the air in the valley is colder than the air above it
- Frost conditions are experienced in the valleys due to rapid cooling caused by the descending cold air

B. ANABATIC WINDS

They are local winds which flow from the valleys upwards the highland slopes during the day. They occur as a result of the differences in the rate of heating between the valley and the upper slopes in highland areas.

During the day, the highland slopes are heated more than the valleys hence, the air over the hill slopes is heated, it expands, becomes light and rises upwards thereby creating a low pressure zone hence convectional rising of air on the upper slopes. The cold dense air in the valleys under high pressure rises up the slopes to replace the vacuum created by the warm rising air finally resulting into Anabatic winds as illustrated below:



Anabatic winds result into the following weather conditions:

- Formation of mist and fog on the upper slopes of the mountains as the ascending cold air moves over a warm surface
- Orographic rainfall is experienced in the mountainous areas as warm air rises from the upper slopes
- Low clouds are formed in highland areas due to the cooling effect of the ascending cold air at and beyond its condensation level or dew point
- Cold temperatures are transferred from the valleys to the upper slopes of the highlands

Qn a) Distinguish between Anabatic winds and Katabatic winds

b) Describe the weather conditions associated with:

I. Anabatic winds
II. Katabatic winds

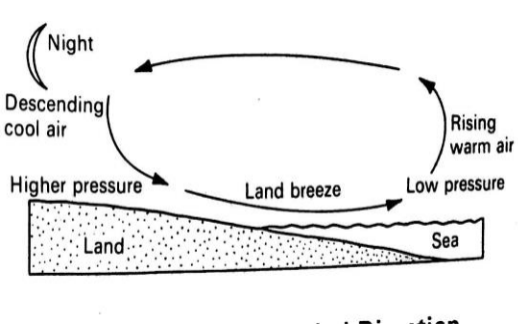
C. LAND BREEZE

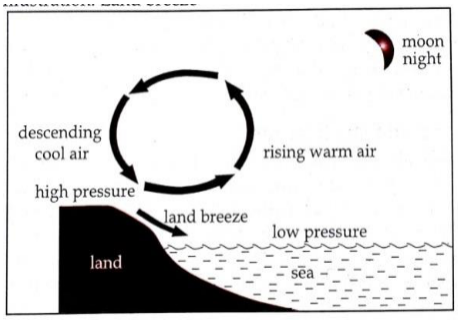
In general, land and sea breezes are local winds which occur in areas where land lies in close proximity to a water body such as around the L.Victoria shores and the coastal areas of E.Africa.

Factors for the occurrence of Land and Sea breezes:

- Differences in specific heat capacities of the land and sea
- Mobility of water compared to the solid land
- Heat transmission through the transparent water as opposed to the opaque land
- Differences in the reflecting capacity of the land and water

A land breeze is the movement of cold dense air from the land towards the sea. It occurs at night. It is as a result of differences in the air pressure between the land and water surface. Rapid terrestrial radiation over the land leads to rapid cooling hence creating a high pressure belt while low pressure is created over the warm sea surface. Wind therefore blows from the land towards the sea as a Land breeze.





Causes of a Land breeze:

- Loss of radiation at the coastal lands at night. Land therefore cools faster than the sea / water hence temperatures are cooler over the land than the sea which retains much of its heat
- Water loses heat more slowly such that the air above it remains relatively warm
- Low pressure is created over the warm sea and high pressure over the cold land. Cool air from the land under high pressure blows towards the sea to replace the rising air hence forming a land breeze

Effects of a Land breeze:

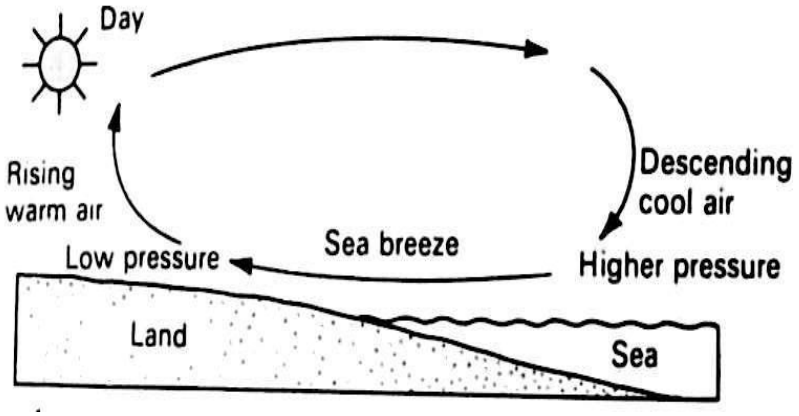
- It results into lowering of temperature over the sea as cold air from the land blows towards the sea

- Formation of fog / misty conditions occurs over the sea as cold air from the land cools down the warm air over the sea leading to premature condensation as well as poor visibility
- Temperature inversion occurs over the sea as cold air from the land displaces warm air upwards over the sea
- Dense clouds and heavy offshore rainfall are experienced over the sea as warm air is displaced upwards to the condensation level
- It results into dry conditions on the land because little or no rainfall is received

- It results into violent thunderstorms
- It also causes high humidity over the sea / lake

D. SEA BREEZE

It is the movement of cool moist air from the sea towards the land. It occurs during the day. Rapid heating of the land surface during the day creates a low pressure belt over the land while high pressure develops over the sea which is less heated. So land warms faster than the sea hence temperatures are high over the land and cold over the sea. Convective currents of warm air rise over the land and create low pressure at the sea surface. This forces cool moist wind (air) to blow from the sea towards the land to replace the rising air hence forming a sea breeze as illustrated below;



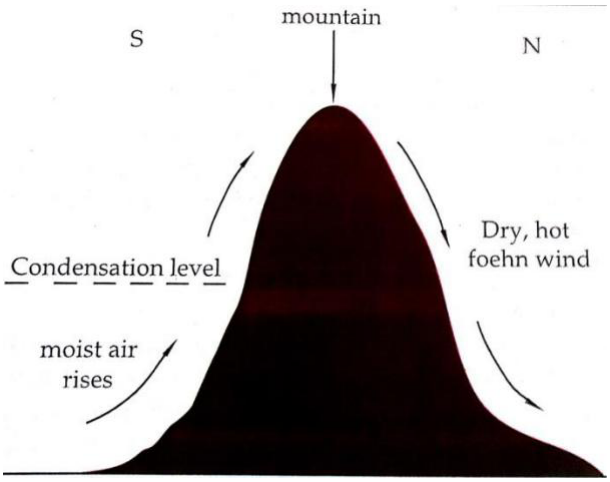
Effects of a Sea breeze:

- It lowers temperature on the land especially in the afternoons as cool air from the sea replaces the rising warm air
    - It is associated with onshore convectional rainfall which is normally received in the early morning and afternoon hours
    - It causes violent thunderstorms
    - It results into high humidity over the land
    - Thick cloud cover is formed over the land
    - It leads to the formation of fog / misty conditions on the land which results into poor visibility

Qn. Examine the causes and effects of land and sea breezes in East Africa

F. FOEHN WIND

- It is a dry wind experienced on the lee ward side of mountains when descending air becomes compressed with increased pressure.
- It is experienced in the valleys of the northern Alps particularly in Switzerland during spring
- Air is forced to move upwards the southern slopes of the Alps, where it later expands and cools. Condensation takes place when the air is saturated. Rain and even snow falls on the higher slopes.
- On the lee ward slopes, the air descends and gains heat due to an increase in temperature. The air is compressed and warmed. Most of its moisture is lost and wind reaches the valley bottom as a dry hot wind known as a Foehn wind
- The wind incidentally causes a sudden rise in temperature. Being hot and dry, sometimes it triggers off wild fires in the Alpine valley as well as causing low relative humidity



G. CHINOOK WIND

The term “Chinook wind” is derived from the Indian word “Chinook” which means “Snow eater.”

It is called so because it is hot and it causes melting of snow. Chinook winds are experienced on the eastern slopes of the Rocky mountains in the United States of America and Canada during the winter season.

Chinook winds are similar to Foehn winds in terms of development and effects. They only differ in areas of occurrence (operation)

Chinook winds are so hot that they can raise the temperature of an area by 19^{o}c within 25minutes.

PROCESS OF FORMATION

- Warm moist prevailing winds are forced to rise higher upon meeting a highland (mountain).
- As it rises, it expands and therefore cools adiabatically first at the dry adiabatic lapse rate and then at a saturated adiabatic rate.
- It condenses to form clouds and eventually rainfall on the wind ward side of the mountain/highland.
- When the wind begins to descend on the leeward side, it undergoes adiabatic compression and therefore warms up at a rate of 10^{0}C for every 1000 meters of descent. It at this moment that chinook wind forms.
- Chinook winds cause aridity/dry conditions on the leeward side of mountains for example Karamoja is dry because it is within the leeward side of Ethiopian highlands and therefore washed by chinook winds. Similarly, Kasese, Fort portal and Ankole -Masaka corridor are dry because they lie in the leeward side of mountain Rwenzori and so washed by chinook winds.

EFFECTS OF CHINOOK WINDS

- Since they are warm and dry, chinook winds from the mountain Rwenzori have caused aridity in Karamoja and Turkanaland of Northern Kenya.

- In temperate regions chinook winds from the Rocky and Appalachian Mountains have led to melting of snow.
- The melting of snow has led to flooding of lowlands especially in temperate regions.
- Chinook winds boost tourism in mountainous regions for example Switzerland by limiting snow coverage.
- Chinook winds stabilize weather by creating an increase in atmospheric temperature.

GLOBAL WINDS (PLANATEARY WINDS)

These are winds that blow fairly consistently from high to low global pressure belts. They divided into 3 major types that's:

1.Trade winds

2. Westerlies

3. Polar winds

a) TRADE WINDS

These are winds that blow towards the equatorial low pressure areas in both the Northern and southern hemispheres. Because these winds used to help traders sail from one part to another in the early days, they are called trade winds.

CHARACTERISTICS OF TRADE WINDS

1. They blow from the North East in the Northern hemisphere and South East in the southern hemisphere towards the equator (equatorial low-pressure belt).
2. They follow a regular path (route).
3. As a consequence of the earth's rotation on its axis, a drag force deflects these winds that's as winds from the southern hemisphere cross the equator they are deflected to the south

east to become south east trade winds. While winds from the northern hemisphere as they cross the
equator, are deflected to the north east to become Northeast trade winds. This is due to coriollis force.

4. They are less regular over land areas than they are over the oceans. They are very constant in strength and direction especially over the oceans.
5. They sometimes contain intense depressions.
6. They blow from high pressure belt near 30^0 latitude in each of the hemisphere (Northern and southern hemisphere).

b) WESTERLIES

These are winds that blow from the sub-tropical high pressure zones (belts) towards the mid-latitudes low pressure zones.

These winds are also deflected by the drag force (coriollis force) as a result of the earth's rotation on its axis. The winds that blow north wards in the northern hemisphere become North westerlies while the winds that blow south wards in the southern hemisphere become south westerlies after deflection.

CHARACTERISTICS OF WESTERLIES

1 They blow from the horse latitudes (sub-tropical high pressure belt) to the sub-polar or temperate low pressure belts.

2. They are extremely variable both in direction and velocity.
3. They contain anti-cyclones and cyclones.
4. They are deflected to the right to become south westerlies in the Northern hemisphere and to the left to become North westerlies in the Southern hemisphere.

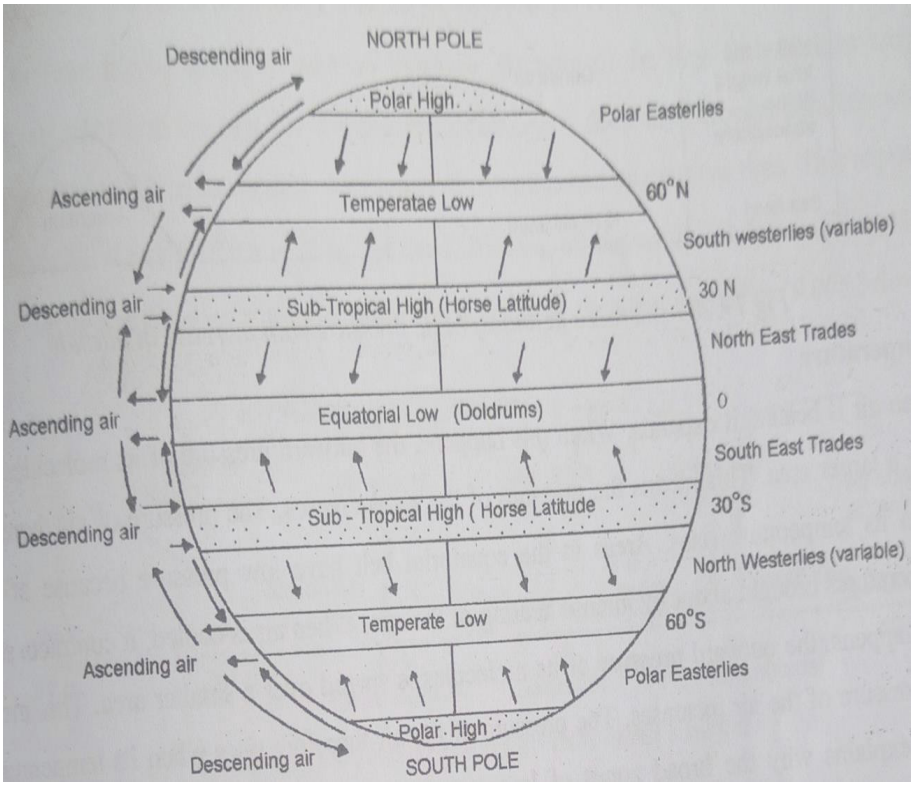
c) POLAR WINDS

These are winds that blow from the polar high pressure regions to the lower latitudes that's temperate low pressure regions.

These winds are cold and dense due to their origin.

CHARACTERISTICS OF POLAR WINDS

1. They blow from polar high pressure to temperate low pressure zones.
2. They are better developed in the southern hemisphere than the northern hemisphere.
3. They are deflected to the right to become the North east and to the left to become the south east polar winds in the southern hemisphere.
4. They are irregular in the northern hemisphere because they blow over land.
5. They are regular in the southern hemisphere because they blow over the water surface.



MONSOON WINDS

- Monsoon winds are seasonal winds which move to the northern hemisphere that's Asiatic landmasses during one season and reverse to move to the southern hemisphere that's along the eastern African coast during another season. These winds occur at intervals of 6 months. The word monsoon comes from Arabic world "Mausin" which means season.
- These winds are common in Asian countries for example India (Indian sub-continent) Pakistan, Bangladesh, Thailand among others.
- They are prominent within the tropics on the eastern sides of landmasses particularly in the Indian Ocean.

CHARACTERISTICS OF MONSOON WINDS

- They are seasonal winds occurring at interval of 6 months that's reverses direction after 6 months. In the tropics they are dominant on the eastern side of the land masses particularly in the Indian Ocean.
- They are classified under trade winds.

CAUSES OF MONSOON WINDS (FORMATION OF MONSOON WINDS).

- Monsoon winds are caused by differences in specific heating capacities between land and water which create pressure differences and subsequent wind movement.
- During December-January, the northern hemisphere experiences winter. These low temperatures in the northern hemisphere lead to creation of high pressure zone within the Asian land masses. In the same period, the sun is in the southern hemisphere where its insolation (heat) leads to high temperatures and therefore low pressure in the southern hemisphere. The difference in pressure compels the winds from the cold (high pressure zone) in the northern hemisphere to blow towards the hot (low pressure zone) in the Southern hemisphere. This takes place in January hence it is

called January monsoon.

- During summer in the northern hemisphere and winter in the southern hemisphere, high pressure builds in the southern hemisphere because of extreme cold conditions while low pressure builds in the northern hemisphere because of high temperature (summer). Wind is compelled to move from the southern hemisphere towards the equator. It is then deflected to the right and converges towards the Asian land mass across the Indian Ocean.
- This occurs in July and is therefore called the July monsoon or southwest monsoon
- The difference in temperatures is brought about by the apparent movement of the overhead sun that triggers the movement of trade winds across the Indian Ocean.

EFFECTS OF MONSOON WINDS

a) EFFECTS ON WEATHER (WEATHER CONDITIONS ASSOCIATED WITH MONSOON WINDS).

1. Monsoon winds bring hot conditions having originated from the tropical latitudes and blown over a warm ocean.
2. They bring humid conditions, having blown over a warm ocean from which they pick moisture that's they raise humidity in Mombasa, Malindi among others.
3. They bring heavy torrential rainfall with thunder and lightning to many areas for example East African coast around Mombasa, Malindi, Kilwa, Dar-es-salaam.
4. During the inter-monsoon periods, winds are high and variable causing often clear moving skies and thunder storms later in the afternoon hours of the days.

b) EFFECTS ON HUMAN ACTIVITIES

1. Heavy rains associated with monsoon winds cause flooding along the coast of India leading to displacement of people,

destruction of property and crops in the gardens hence famine results.

2. Monsoon winds are important to sailors and navigators because they propel (drive) the boats facilitating navigation.

3. Monsoon winds support farming because they bring rainfall. When they arrive late, crops tend to fail leading to famine for example in In India.

Questions

a) Explain the causes of monsoon winds over the Indian ocean.

Approach

- Define monsoon winds
- Explain the causes

b) Describe the weather conditions associated with monsoon winds.

OCEAN CURRENTS

Ocean currents are general movements or drifts of the surface water of the ocean in a fairly defined direction. They are continuous general movement of masses of surface ocean waters horizontally and in a fairly defined direction. They tend to be persistent. Most ocean currents drift very slowly and that is why they are commonly referred to as drifts.
Ocean currents may be either warm or cold i.e., there are warm ocean currents and cold ocean currents.

Causes of ocean currents

The prevailing winds; winds influence oceanic circulation, this is because as winds blow friction is generated between the wind and water surface causing the water to move in the general direction of the wind. Some winds such as trade winds which almost continuously blow in the same direction cause surface waters over which they blow to move in the direction to which they blow e.g. across the Atlantic ocean westerlies produce the North Atlantic drift and Kuro Siwo currents (in thePacific).

Rotation of the earth; the earth's rotation influences the direction of movement of ocean currents. It causes the currents to be deflected to the right in the direction to which they flow in the northern hemisphere and in the southern hemisphere the currents tend to be deflected towards theleft.
It is generally because of the Coriolis force that the ocean currents are deflected.

Differences in temperature; ocean currents may be caused by differences in temperature. Such currents are generally referred to as convection currents.
Heating by the sun in the low altitudes makes the waters less dense and the waters therefore drift pole wards.
In the equatorial belt, temperatures are high and therefore waters are warm and tend to be less dense, unlike the polar region or highlatitude region waters. As a result, the warm waters of the equatorial region drift towards the higher latitudes.

Salinity of the waters; salinity may increase the density of the waters. Saline waters (these of high PH/basic waters) tend to be denser than waters of low salinity. It is generally noted that waters of high salinity tend to flow to areas of low salinity e.g. the surface water current from the Mediterranean Sea which enters the Atlantic Ocean is due to difference in salinity. The high rate of evaporation and limited rainfall may result into highsalinity.
This means that the Mediterranean Sea is made up of waters of high salinity and therefore flows into relatively less saline waters of the Atlantic Ocean while the under current flows in the opposite direction.

Coastal configuration; the alignment the coast and the existence of sub marine ridges is partly responsible for the direction of flow of ocean currents. The shape of the land helps in the direction of moving currents e.g. the North equatorial current tends to be deflected north wards because of the shape of the horn ofAfrica.

Ocean currents may be characterized by under currents. These are return or compensating currents that normally flow within the equatorial latitudes. They flow in the opposite direction from which the opposite currents are flowing. They are normally known as counter currents that replace the surface waters that may have moved to anotherregion.

WARM OCEAN CURRENTS

These are ocean currents with warm waters and may include, the warm Mozambique current or the warm Agulhas current or South equatorial current in Africa. Other warm currents include; the warm gulf stream, the North Atlantic drift, the North pacific current, the Kuro siwo current, the East Australia current, the Brazilian current and the North east monsoon drift.

Characteristics of warm ocean currents

They have higher temperatures i.e. tend to bewarm.
They generally tend to flow on the eastern side of the continental landmasses in

the low latitudes (except for Guineacurrent).

They generally tend to flow on the western side of the continental landmasses in the mid and high latitudes e.g. the Pacific current and the North Atlanticdrift.

They tend to flow from the lower latitudes to the higher latitudes i.e. flow pole ward away from theequator.

In the northern hemisphere, their circulation tends to be clockwise while in the southern, their circulation tends to beanti-clockwise.

They generally tend to be of lower density/highsalinity.

They flow on the surface but later lose temperatures and become under water currents.

COLD OCEAN CURRENTS

These are ocean currents with waters of low temperature, i.e. the waters are cold. In Africa the main cold ocean currents include; the cold Benguella current and the cold canary current. Elsewhere examples include the Californian current, cold Peruvian current, the North equatorial current, East Greenland current and the West Australian current.

Characteristics of cold ocean currents

They are characterized by low temperatures, i.e. they have lowwaters.

Theytendtoflowfromhighlatituderegionstoregionsoflowlatitude, i.e. they flow equator wards from regions of cold conditions.

They generally flow on the western side of the continental landmasses. This is true in the lower latituderegions.

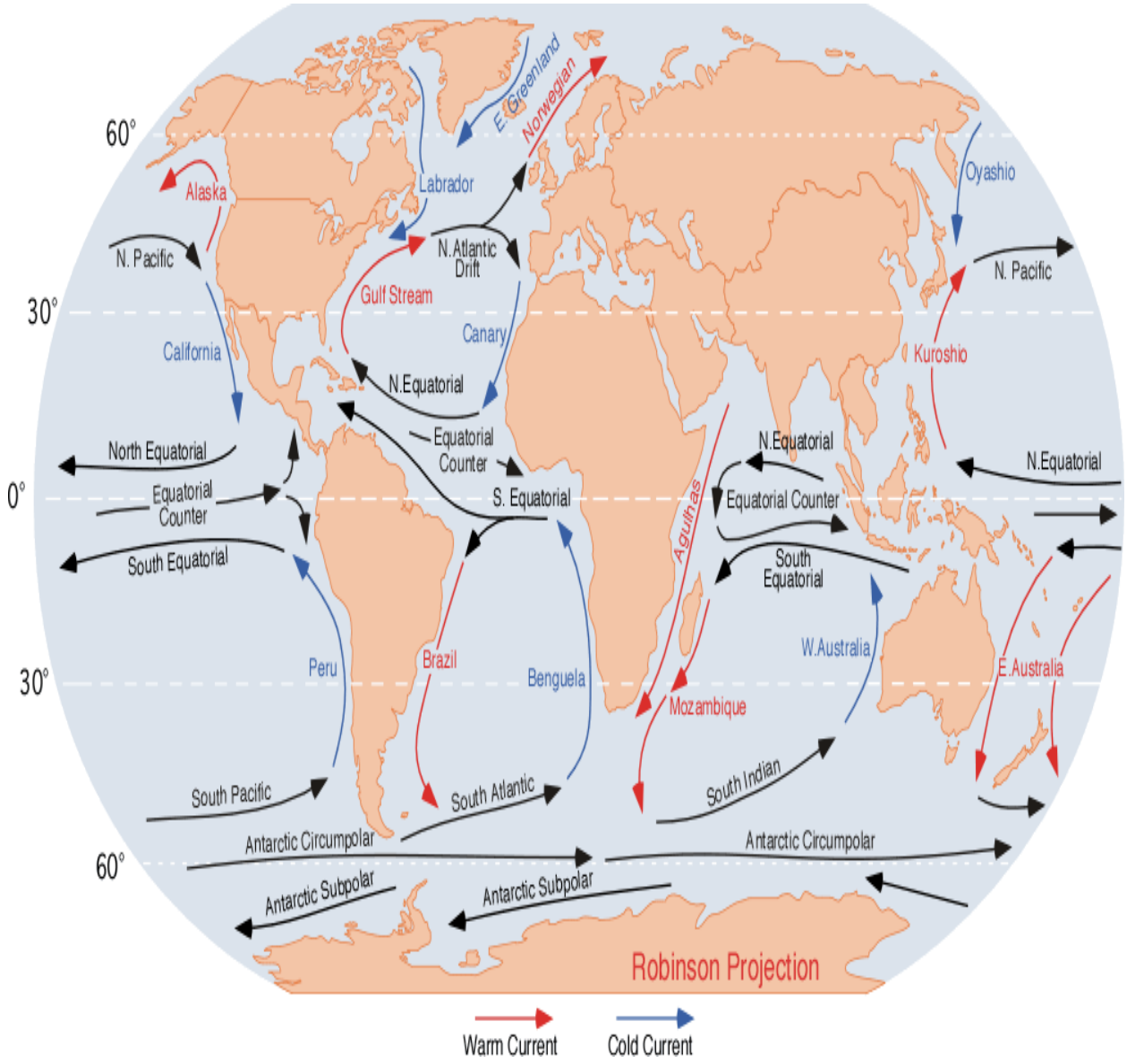
In the mid and high latitude regions, they tend to flow on the eastern sides of the continents e.g. the Labrador Current, the Oya siwo current.

They tend to characterized by high density/lowsalinity.

In the northern hemisphere their circulation tends to be anti- clockwise while in the southern hemisphere their circulation tends to beclockwise.

They are also characterized by up-welling of waters at thecoasts.

World map showing the various ocean currents



EFFECTS OF OCEAN CURRENTS

Ocean currents influence the climate and environmental conditions of adjacent lands.

Effects of warm ocean currents

Warm ocean currents have influenced the climate or environmental conditions of the areas adjacent to them in the following ways;

1. They lead to warm conditions, i.e. they tend to warm or raise the temperature of the adjacent area, this is because the winds which blow over them are warmed up and as they blow onshore they bring in warm conditions e.g. the North Atlantic drift raises the temperatures of the coasts of Portugal, France, Britain, the Netherlands etc. and the ocean ports remain ice free in winter. Durban on the eastern coast of South Africa is affected by the warm Mozambique current and has temperatures of 24.4^0C compared to Port Noloth on the west coast along the same latitude which has temperatures of 15.5^0C because of the cold Benguela current.

2. Warm ocean currents lead to heavy rainfall conditions on the adjacent coastal lands. This is because over warm ocean currents there is high rate of evaporation and the winds that blow over them pick the moisture which winds later rise, cool down and condense to form rainfall e.g. along the East Africa coast and along the west African coast there is heavy rainfall because of the warm Mozambique and warm Guinea currents respectively. For instance Beira receives 1,521 mm and Durban receives 1,008 mm of rainfall per annum.

3. They results into humid conditions, i.e. high humidity. This is because warm ocean currents are associated with high humidity due to the relatively high temperatures. All these tend to increase the humidity of the surrounding areas e.g. the Natal Province of South Africa and the coasts of Western Europe.

4. Warm ocean currents influence the temperatures of winds and result into warm winds. Winds that tend to originate from areas with warm currents are generally regarded as warm maritime winds.

5. They lead to increased cloud cover over the adjacent coastal lands. This is because of the high rate of evaporation. The water vapour rises, cools and condenses to form dense clouds (cumulonimbus clouds) which later result into heavy rainfall.

Effects of cold ocean currents

Cold ocean currents influence the climate and environmental conditions of the adjacent land masses in the following ways;

1. Cold ocean currents tend to control the temperatures of the surrounding land masses due to the influence of the land and sea breezes. E.g. the Benguela lowers the temperatures of surrounding areas in Namibia e.g. Walvis Bay has temperatures of 16^0C as compared to Durban's 25^0C and yet they lie at almost the same latitude.

2. Cold ocean currents lead to arid conditions or the formation of marine deserts on the adjacent coastal lands. This is because of limited evaporation and winds that blow over them hardly pick any moisture. The winds also generally tend to be off shore winds meaning that the level of condensation that will result into rainfall islow.
Examples of marine deserts include the Namib Desert which is due to the cold Benguela current. The Californian desert is due to the cold Californian current and the Atacama Desert due to the cold Peruvian current.

3. They tend to result into low humidity; this is because of the low rate of evaporation. This consequently leads to limited cloud cover because of the limited atmosphericmoisture.

4. Cold ocean currents lead to the formation of cold offshore fog or misty conditions as a result of rapid radiationcooling.
It may also be due to when slightly warm air blows over the cold ocean currents resulting into steam fog e.g. there are frequent foggy conditions in San Francisco in southern California and in the Labrador region in eastern Canada.

Effects of ocean currents on human activities along the coastal areas

The nature of ocean currents has influenced human activities in the coastal regions.

Effects of warm ocean currents

a. The resultant high rainfall experienced has encouraged crop cultivation or rainfed-agriculture.This is common along the east African coast and West African coast where a number of crops are grown, e.g. cloves, sisal, and sugarcane along the East African coast. Along the West African coast crops like cocoa are grown in Ghana.

b. The high rainfall experienced encourages the growth of forests and people may be involved in forestry activities, e.g. in Gabon, forestry activities such as lumbering are practiced. On the east African coast lumbering is also carried out in

the mangroveforests.

c. The high temperatures or warm conditions along the East African coast are conducive for the growth of coral polyps and the resultant rocks and land forms like coralreefs.

These coral rocks have been a potential for the manufacture of cement from the coral limestone e.g. the Bamburi cement.

In addition the coral reefs have been a tourist attraction and have promoted tourist activities along the coast of east Africa. Furthermore, the fringing reefs have tended to be a hindrance to deep sea fishing along the east African coast.

d. The heavy rainfall that may result may be associated with thunderstorms which tend to be destructive to the crops and property and also disrupts the economicactivities.

Effects of cold ocean currents

a. The arid conditions lead to the growth of pastures of short grass which has encouraged pastoralism. It is important to note that pastoralism is common in semi-arid areas such as the Namib Desert and Kalahari Desert.

b. The arid or desert conditions have promoted tourism. Such areas have been gazetted as wildlife conservation sites e.g. Namib Desert.

c. The arid or desert conditions have also provided a conducive environment for the film industry. Film making has been carried out in the arid areas such as the Namib Desert.

d. The ocean currents cause upwelling of ocean waters creating conducive conditions for the growth of planktons and this has encouraged fishing in these areas. The upwelling may be rich in phosphates and nitrates that promote plankton growth e.g. fishing has been an important activity in the coastal waters of Morocco, South Africa, Angola andMauritania.

e. Cold ocean currents lead to the formation of fog which tends to reduce on visibility over water and air thereby hindering navigation and aviation.

THE CLIMATE OF EAST AFRICA

East Africa lies within the tropical latitudes but due to a combination of factors the region experiences a variety of climatic types.The different parts experience different types of climate which include:

Equatorial climate

This type of climate is experienced in the region between 5°N and 5°S of the equator. For instance in places such as the Congo basin. In East Africa the equatorial climate is experienced around the L.Victoria basin and typical equatorial climate is experienced within the L.Victoria and specifically the Islands within L.Victoria.Typical equatorial climate is characterised by;

- Heavy rainfall of about 2000 mm evenly distributed throughoexperienced.
- Temperatures are high with an average of 27°C.
- High humidity of about 80% or more.This is because of evaporation and heavy rainfall which is received.
- Double maxima of rain i.e.there are two rainfall peaks received.The rainfall regime is characterized by a bimodal pattern.There is hardly any dry spell (dryseason).
- The type of rainfall received is mainly convectional rainfall commonly accompanied by lightning and thunderstorms.
- There is thick or dense cloud cover because of the humid conditions that result into rising air whose moisture condenses at higher levels to form clouds.
- It is characterised by low atmospheric pressure and this is mainly because of the high temperatures experienced.

In East Africa due to factors such as altitude, the equatorial climate has tended to be modified.The equatorial climate experienced in much of East Africa is not typical that of the rest in other tropical regions.That is why most of the areas fringing Lake Victoria are said to experience a modified equatorial type of climate rather than atypica lequatorial type of climate.This is because the characteristics do not reflect typical equatorial type of climate
e.g. heavy rainfall of about1500mm is experienced.Temperatures average 23°C.
In addition, humidity is less than 80% and there is some distinct or short dry spelle xperienced es pecially in January and June.

Moist Tropical Climate/Modified Equatorial climate

This is experienced in much of Central and Western Uganda and
parts of northern Uganda.This type of climate may not differ much from the equatorial type of climate however rainfall received is less and seasons tend to be distinct. It is characterized by the following;

- High rainfall fairly distributed throughout the year. Annual rainfall ranges from1000mm-1500mm.
- Moderate temperatures of between 25°C and 27°C.
- There are seasons of rainfall and aridity experienced i.e.there are dry and wet seasons. However in some parts, the rainfall seasons tend to merge to form one long rainfall season and one long dry season.This is common with regions further from the equator.Therefore some areas experience double maxima of rain while others experience a single maximum of rain.
- Rainfall varies with the position of the area e.g. in the northern hemisphere, most tropical regions receive rainfall in the second half of the year while in the Southern it is received in the firs thalf of the year. This is because of the influence of the ITCZ.
- Relative humidity is moderate i.e. from 50%–60%.
- The temperature range is moderate i.e about 5 -10°C.

DRY TROPICAL CLIMATE

This type of climate is experienced in several parts of East Africa mainly adjacent to the semi arid region e.g. the Western parts of Karamoja, the Southern Nyika plateau, parts of Western Tanzania, etc.
This type of climate is characterised by the following;

- Rainfall received ranges between 760mm–1000mm.
- Rainfall is seasonal though the dry seasons tend to belong.
- There are high temperatures experienced, average temperatures tend to be above 30°C.
- The temperature ranges are high approximately10 -15°C.
- There is limited cloud cover.
- There is low atmospheric humidity i.e. less than 40%.

SEMI ARID AND ARID CLIMATE /SEMI DESERT & DESERT CLIMATE

This type of climate is experienced in Northern Kenya e.g. the Chalbi desert, North Eastern Uganda i.e. Karamoja, semidesert in Southern Kenya i.e. Nyiri desert, North Eastern parts of Tanzania e.g. Masai steppe semidesert. In central Tanzania, in the Eastern parts of Ankole i.e. the Ankole–Masaka corridor.
In addition, Semidesert climate is also experienced in the Western Rift valley region around Lake George and Lake Edward. Semiarid conditions are also experienced in the rift valley as well. This type of climate is characterised by the following:

- Low rainfall of less than 760mm. Other areas experience even much less e.g. in the Chalbi desert annual rainfall is 250mm.
- There is very low humidity of about 20% or less.
- There is limited cloud cover i.e. there are generally clear skies partly due to the

limited atmospheric moisture required for cloud formation.

- Temperatures tend to be high, average temperatures range from 35°C – 38°C.
- There is a high diurnal range of temperature approximately 20°C.
- Unreliable rainfall i.e. periods of extended drought may be experienced and rain fall periods may not be predicted.

MONTANE CLIMATE/ ALPINE CLIMATE

This climate may also be referred to as Alpine climate and is experienced on the mountain peaks of E.Africa e.g. high levels of Mt. Rwenzori, Mt.Kenya, Mt.Elgon, Mt.Meru, Mt.Kilimanjaro, Mt.Muhavura, Mt.Mgahinga, Mt.Sabinyo, etc.
The distinguishing factor is that

- there are low temperatures experienced.
- Snowfall may also be experienced in altitudes of more than 4800m.
- The type of rainfall received is relief and is heavier on the wind ward sides of the mountains
- the lee ward side experience lower rainfall because of the shadow effect.
- Atmospheric pressure in the montane climate conditions tends to be low as a result of ratified air.
- Inaddition, the gravitationa leffect at higher altitudes is lower resulting into the low pressure.

TROPICAL MONSOON CLIMATE

This is experienced in the coastal region of E.Africa. The climate is basically influencedbytheseasonal winds known as the monsoon winds.These seasonal winds affect the coastal areas of E.Africa i.e. the N.E & S.E monsoons tend to bring in heavy rainfall.

- The rainfall is high and ranges between 1000mm and 1800mm.
- Since the coastal regions are at a lower altitude, high temperatures are experienced.

Areas that experiencebtropical monsoon climate include areas along the coastal belt e.g. around Malindi, Mombasa,Tanga, DaresSalaam, Kilwa, etc

ARIDITY IN EAST AFRICA

Aridity is a climatic phenomenon characterised by high temperatures and insufficient rainfall or very low rainfall. In the USA areas of less than 250mm of rainfall are regarded as arid areas. However in some parts of the world, the aridity may be measured differently e.g. in East Africa areas of less than 500mm maybe regarded as arid. Areas of aridity are generally referred to as deserts or semi deserts and are characterised by dryness.

In East Africa areas that experience aridity include Northern Kenya, parts of Eastern Kenya, North Eastern Uganda, the Ankole-Masaka corridor, parts of North Eastern Tanzania, Central Tanzania, parts of southern Kenya and parts of the western and the Eastern rift valley e.g. along Lake Albert, Lake Edward and Lake George.
Desert areas are those that may receive less than 250mm of rainfall and these may include areas in Northern Kenya e.g. around Ladwor in North Eastern Kenya and the Chalbi desert.
In addition to this there is also the Nyiri desert in Southern Kenya and the Masai steppe in North eastern Tanzania.
On the other hand semi desert areas experience relatively higher rainfall though less than 500mm.

CHARACTERISTICS OF ARID AREAS

Low and seasonal rainfall is experienced. Drought is a common phenomenon in such areas.
High temperatures are experienced i.e. temperatures of 30°C and above.
High diurnal range of temperature normally more than15°C i.e. during the day it is very hot and during the night is cold.
There is generally low humidity. Relative humidity tends to be less than 20%.
There is a limited cloud cover. Much of the year is characterised by clear skies.
There are high transpiration rates and evaporation rates.
There is unreliable or unpredictable rainfall.
There is occurrence of strong winds and occasionally dust storms are experienced.
There is limited plant cover, this is because of the low rainfall such that the vegetation tends to be adapted to low rainfall conditions e.g. there are generally drought resistant species such as steppe savannah grasslands, thicket, thorn bush, cactus, scrub, as well as patches of bare land.

CAUSES OF ARIDITY

Arid conditions in East Africa have been brought about by a number of factors.
The basic causes of aridity have been physical while human factors have increased or contributed to further aridity in east africa.

Physical causes of aridity

Prevalence of dry/desiccatedwinds.Some areas in East Africa have been

influenced by dry winds forinstance the N.E trade winds which emanate from the Arabian Desert.Those winds pick some moisture as they blow Southwards towards Africa, however these winds tend to loose their moisture in the Ethiopian highlands. Since they are dry they do not bring in rain.They even absorb the little moisture that exists in the regions in which they blow and even warmup such areas.This explains why the dry conditions are experienced in northern Kenya.

Limited water masses: Several areas in East Africa that experience aridity such as Northern Kenya and central Tanzania lack large water bodies that could otherwise contribute to atmospheric moisture through evaporation.This therefore results into limited atmospheric moisture in such areas and therefore dry conditions result.

Highland relief causing the rain shadow effect on the leeward side of the highland. Relief has contributed to aridity in East Africa because of the rainshadow effect produced on the leeward side of mountains.
The prevailing winds that continue onto the leeward side from the Windward side are desiccated or dry and do not bring in rainfall but instead may even absorb the little moisture that may exist in the leeward areas. Arid areas in East Africa that are due to the rain shadow effect include Northern Kenya, the Masai steppe on the leeward side of the Pare and Usambara mountain ranges in N.EastTanzania.The western rift valley zone area on the leeward side of the Rwenzori mountains. Inaddition, the absence of highlands or mountains to trap high-level winds bearing moisture may also contribute to aridity, this is because winds gather momentum and blow away to other areas.

Continentality: This refers to the remoteness from the sea. Areas far from the Indian Ocean and whose climate is continental or affected by land conditions have tended to suffer from aridity. Coastal areas are influenced by maritime conditions such as land and sea breeze that contribute to high rainfall. However, continental areas such as central and N.Eastern Tanzania tend to be dry because of the long distance from the sea.

Coastal configuration: This refers to the shape or alignment of the E. African coast.The coast is aligned in a N.E or S.W direction. Due to this alignment winds from the N.E such as the N.E trades tend to blow parallel to the coast especially along the Kenyan coast in a south westerly direction and hardly blow inland. Therefore these moisture-laden winds which may not blow inland deprive much of northern, central and southern parts of Kenya of rainfall.This therefore partly explains the prevalence of arid conditions in these parts of kenya.

Corriolis force effect: this is a drag force as a result of the earth's rotation and has effect in that any object moving in the northern hemisphere from the southern hemisphere is deflected to the right. This force accounts for the prevalence of arid conditions in the Ankole- Masaka corridor and other parts to the N.West of Lake Victoria.This is because when the S.E trade winds blowing throughTanzania cross the Equator, they are deflected eastwards i.e. to the right leaving the north Western parts of lake Victoria without moist winds.This explains the semi-desert/arid conditionsexperienced in the Ankole-Masaka corridor and the neighbouring areas.

Perturbation: This is a situation where low pressure conditions due to high temperatures are created on the Indian Ocean and as a result air from the land or air that would have blown onshore is instead redirected into this low pressure belt. Air will therefore blow from the land to the Indian ocean thereby becoming offshore winds and as a result rain is formed in the Indian ocean while parts of the East African main land and including Northern Kenya are left dry.
Perturbation that may occur during certain seasons contributed to aridity and especially the extended drought in east Africa.

Human causes of aridity

These include mans' environmentally unfriendly activities such as the following:

Deforestation: The removal of vegetation by man is a cause of aridity.This has been due to mans' activities in the clearance of forests and other forms of natural vegetation.The main activities involved

include cultivation, lumbering, industrialisation etc which have led to the destruction of natural forests that contribute to atmospheric moisture. Destruction of this source of atmospheric moisture results into aridity. Deforestation also contributes to soil erosion, which inturn leads to poor plant growth consequently leading to poor rates of transpiration thereby compounding the problem of aridity.

Overstocking: The rearing of a big number of animals i.e. more than what the pasture land can accommodate can lead to aridity. In case the carrying capacity of the land is exceeded, the pasturesare depleted very fast and the large number of animals trample the ground to create bare patches ofland and loosening the soils thereby promoting erosion. This results into poor vegetation growthand low levels of transpiration and consequently leading to aridity.

Overgrazing: This may be as a result of continuous grazing by herbivorous animals without leaving the land to rest. Over grazing depletes the vegetation cover and may lead to low rainfall because of limited transpiration.

Bush burning: This may also be responsible for aridity because it leads to the degeneration of the grass and other plants and reduces transpiration.Traditional farmers normally burn grass with the aime of ensuring growth of fresh pastures for the animals but this may have adverse effects on the climate.

Reclamation of wetlands: Wetlands like swamps, swamp forests, grasss wamps, marshlands, dombos etc are major sources of atmospheric moisture through evapotranspiration and their reclamation greatly reduces the process. Inaddition, the water table is lowered. In the final analysis, humidity and rainfall are reduced and this leads to aridity. Reclamation in EastAfrica has been due to the search for land, for cultivation, settlement as well as industrialisation.

Borehole drilling: The sinking of boreholes to provide underground water resources for humans and animals may lead to the lowering of the water table. As the water table falls, plant roots may fail to access the soil moisture and as a result the plants wither.This therefore reduces the capacity of the natural vegetation to recharge the atmosphere with water vapour through evapotranspiration and this may increase on the problems of aridity.

Industrialisation:Industrial development has also been a cause of aridity or desertification in East Africa. Industrial plants or factories emit exhaust fumes or clouds of smoke containing pollutants such as carbon dioxide, carbonmonoxide, sulphurdioxide etc which tend to be green house gases. Such gases are good absorbers of solar radiation thereby contributing to increase in temperatures.
In addition, gases such as carbon dioxide and sulphurdioxide may dissolve in water leading to acid rains. Acid rains lead to forest damage in that the plants loose their leaves, their growth stagnantes and may finally die.This in turn will also reduce on the ability of the natural vegetation torecharge the atmosphere with moisture through transpiration and hence aridity.

Mining: The extraction of minerals and more so through opencast method leads to the destruction of surface vegetation meaning that the ability of the vegetation to contribute to the atmospheric moisture is greatly reduced and thereby compounding the problem of aridity.

Poor methods of cultivation: Primitive or non-scientific methods of cultivation that expose soils to erosion have also contributed to aridity. With erosion the ability of the soil to support plant growth is reduced meaning that there would be poor vegetation and consequently low levels of evapotranspiration. Such methods include shifting cultivation, cultivating up and down slope and other forms of subsistence cultivation. In addition, the use of machinery such as tractor ploughs that carry out deep cultivation tend to loosen soil particles making them prone to erosion.

Political conflicts/Wars: These may lead to destruction of vegetation through burning, cutting down of trees, demolition of vegetation by armoured vehicles as well as emission of dangerous chemicals and gases through explosives and bombs. Such explosives tend to harm the natural vegetation. Consequently, transpiration is reduced and rainfall also reduces.

All these human environmentally unfriendly activities may result in reduced atmospheric moisture and an increase in temperature. It is important to note that human causes of aridity increase desert conditions.They are also, the causes of desertification. Otherwise the naturally existing desert areas of East Africa are basically as a result of physical factors.

DESERTIFICATION

This refers to the development of desert like conditions in an area and more so in a region adjacent to a desert. It may be expressed as the advancement or extension of the desert. Desertification has been commonly experienced in the Sahel region of Africa. In East Africa desert like conditions have beene xperienced or developed in parts of Northern Kenya, Central and Northern Tanzania, N.Eastern Uganda and the Ankole-Masaka corridor and parts of Western Uganda adjacent to Lake Albert, Lake George, Albert Nile and within the east African rift valley.

Indicators of desertification

- Decreasing rainfall amounts.
- Rainfall becomes more unreliable i.e. more recurring cycles of drought start being experienced.
- Increasing temperatures i.e. temperatures tend to rise.
- Reducing relative humidity i.e. the amount of water vapour in the atmosphere reduces.
- Increasing diurnal range of temperature.
- Reducing thickness of cloud cover i.e. the skies tend to become clearer and clearer with each passing year.
- There is loss of water retention capacity of the vegetation and soils i.e. there are increasing evapotranspirationrates.
- Reduced bio-diversity i.e. there is degradation of the biological productivity of the land i.e. reduced plant and animal species.
- Increasing wind and run off erosion hence consequently resulting into reduced soil fertility.

Causes of desertification

Desertification is basically caused by environmentally unfriendly human activities. However to a small extent it maybe brought about by naturally existing conditions in the atmosphere that may lead to cycles of drought. Such atmospheric systems that result into cyclic changes or occurrences in the atmosphere have compounded the problem of desertification.

Human activities that have contributed to desertification in East Africa in general include the following:

Deforestation.
Overgrazing.
Overstocking.
Bush burning.
Reclamation of wetlands.
Borehole drilling.

Industrial activity.Mining/Quarrying.
Poor methods of cultivation.
Political conflicts/wars.

Problems of desertification

Desertification is associated with a number of negative effects and therefore it is undesirable.These include the following:

1. It may lead to crop failure or low crop yields hence leading to famine and human suffering. In sub–Saharan Africa it has been a major cause of famine.This is because of the prolonged dry seasons and recurring droughts which lead to crop failure and consequently food shortages resulting into human suffering and death due to hunger, starvation and diseases.

2. The resultant decreasing rains may prompt irrigation. Consequently this may lead to salinisation of the soils, which is also a form of soil degradation.

3. The high or increasing temperatures are in conducive for human settlement as well as human activities such as cultivation.

4. The degradation or deterioration of the natural vegetation may cause a decrease in forestry products and a reduction in the ability of the natural vegetation to protect the environment.

5. It encourages soil erosion and creates conducive conditions not only for runoff water erosion but also wind erosion.

6. It may lead to the encroachment of sand dunes due to wind erosion and such sand dunes are normally unsuitable for human activities such as cultivation.

7. It may result into the disappearance of some drainage features such as small streams and wetlands due to excessive evaporation and yet these drainage features play important roles i.e. both protective and productive roles.

8. Leads to the destruction of the natural habitat for wildlife and hence reduced biodiversity.This is because desertification leads to a change in the physical environment such as reduced vegetation cover, increased temperatures and reduced wetlands. It also destroys the natural habitat for a variety of wildlife.

Measures to combat desertification

In East Africa and other parts of Africa, a number of steps have been taken to combat desertification or reverse the trend of desertification. These include;

Legislation against environmental degradation. Laws have been passed against the destruction of the environment such as wetland reclamation. Most of such vulnerable areas have been gazetted as nature reserves or conservation sites.**Afforestation:**this has involved the campaign to plant trees in order to arrest the effects of desertification.Tree planting campaigns have been conducted by the government, NGO's, environmental/wildlife clubs as well as individuals.

Reafforestation: i.e. re-planting of trees where trees have been cut or where deforestation has taken place e.g. Mabira forest, Kibaale forest etc.

Introduction and practice of improved methods of cultivation i.e. methods that do not harm the environment.This has been mainly through protecting agricultural land by adopting practices that conserve soil e.g. mulching, croprotation, gully prevention measures, application of manure and fertilizers etc.

Rotational grazing: This has been facilitated by paddocking. Efforts have also been made to ensure that the carrying capacity of land is maintained in order to avoid overstocking. Rotational grazing also helps to check over grazing.

Re-settlement of people adjacent to forest reserves as well as eviction of forests encroachers. Re-settlement of the people is to prevent encroachment upon the forests especially when population is increasing and when land shortage problems are cropping up e.g. encroachers in Kibaale forest reserve were evicted and resettled.

Sensitization of the public about the role of forests or natural vegetation.This has been through the education of the masses on the dangers of deforestation and also how to utilize the enviroment sustainably. This has created awareness about environmental issues such as desertification-associated problems.This sensitization has been through a variety of mass media e.g. the press, electronic media, seminars/workshops, schools, Local council meetings, public rallies etc.

Introduction and encouragement of the use of fuel savingstoves or those that use saw dust such that less biomass is used as fuel. This reduces on the tendency of the destruction of forests for fuel.

Rural electrification and provision of other sources of energy such as solar energy, biogas etc as an alternative to wood fuel.

Creation or establishment of environmental organizations to champion or spearhead the fight against desertification through environmental protection and restoration of degraded lands. Some of these organizations are governmental or non-governmental.They may also be international, inter-state, national or local. Some are also voluntary organizations. Examples of these bodies include; NEMA in Uganda (a parastatal body charged with protecting the environment.) Uganda Wildlife Authority (UWA). In addition, there are wildlife clubs, tree planting clubs and anti-pollution clubs. International organizations include; the Kagera Basin Organisation, Inter Governmental Authority on Drought and Development (IGADD), interstate bodies like the East African Wildlife Society and others like Karamoja Development Agency (KDA) to combat desertification and aridity and ensure development of the area.

Encouragement and use of indigenous methods of protecting the environment and protecting it e.g. through traditional customs and taboos.

Population control measures through population re-distribution and family planning as well as encouraging late marriages, discouraging polygamy etc to avoid overpopulation, which would lead to land shortage and deforestation.

EFFECTS OF CLIMATE ON HUMAN ACTIVITIES

Climate has influenced landuse and human activities in several parts of East Africa. The different climatic conditions such as equatorial climate, modified equatorial climate, tropical, montane, semidesert and desert climates have had profound effect on human activities, or land use in areas where they are experienced. This is because the rainfall and temperatures may vary and create conditions for different land use or human activities.

The effects can be seen in the following ways;

1. In the equatorial or moist tropical type of climate, a variety of human land use activities have cropped up e.g. forestry, cultivation of annual and perennial crops, dairy farming such as in the Kenya highlands, areas around Lake Victoria etc.

2. In areas of tropical climate, there is cultivation of mainly annual crops as well as the rearing of livestock, wildlife conservation and tourism have been important.

3. Temperate climatic conditions as experienced in the highland areas such as the Kenya and Kigezi highlands, Rwenzori Mt. Ranges have cool conditions that have favoured dairy farming and growth of vegetables or temperate crops such as wheat, Irish potatoes etc.These highland areas have also favoured the growth of pyrethrum e.g. in Kabale and Bundibugyo.

4. Montane climatic conditions as experienced in the mountainous areas such as the Rwenzori, Elgon, Kenya, Kilimanjaro, Meru etc have encouraged forestry especially montane forests which may be temperate
e.g. the Coniferous forests or they may be Bamboo forests. Other economic activities in montane climatic regions include; Lumbering, Wildlife conservation and tourism such as mountaineering or sight seeing.

5. In the semi-desert climatic regions there has been the growth of drought- resistant crops e.g. Sorghum, Millet, Maize and Sisal have been encouraged. Nomadic pastoralism has also been practised in Semi-arid areassuch as Karamoja, the Masailand, Turkana land and the Boran region of northern Kenya.
Furthermore, tourism and wildlife conservation haved eveloped in these areas. Many of the semi-desert regions have been gazetted as wildlife conservation sites such as National parks and Game reserves thereby promoting tourism e.g. Tsavo National Park, Queen Elizabeth National Park, Serengeti National Park, Kidepo Valley National Park, and lake Mburo National Park etc.

CLIMATE CHANGE

- Meaning of climate change
- Causes of climate change
- Measures of mitigating climate change

END