

5. THE CLIMATE OF ETHIOPIA AND THE HORN

5.1. Introduction

What is the difference between climate and weather?

Weather- is the *daily condition of atmosphere:-* like *Temperature, Atmospheric pressure, Humidity, wind speed & direction, cloudiness and precipitation.*

*Hotness or coldness, rainy or cloudiness, sunniness, windiness or calmness of air you are **expressions of weather.***

Climate - is the *average condition of the atmosphere* over a long period of time, decades and more.

5.2. Elements and Controls of Weather and Climate

Elements:

1. Temperature
2. Precipitation and Humidity
3. Wind and Air Pressure

Controls:

1. Latitude/angle of the Sun
2. Land & water distribution
3. Winds and air pressure
4. Altitude & mountain barriers
5. Ocean currents

5.2.1. Controls of Weather and Climate

The determining factors for the ***variations of weather & climate b/n places*** are called ***controls of weather and climate***.

This is determined by ***a combination of many interacting factors*** which include ***latitude, elevation, nearby water, ocean currents, topography, vegetation, and prevailing winds***.

Some of the major controls are discussed below.

A. Latitude

Latitude is the ***distance*** of a location from the equator.

The ***sun shines directly on equator for more hours*** during the year than anywhere else.

As we move ***further away from the equator towards the poles***, ***less solar insolation and the temperature become colder***.

Ethiopia's latitudinal location (***proximity to equator***) has bearings on its temperature.

Ethiopia found around the equator that has:

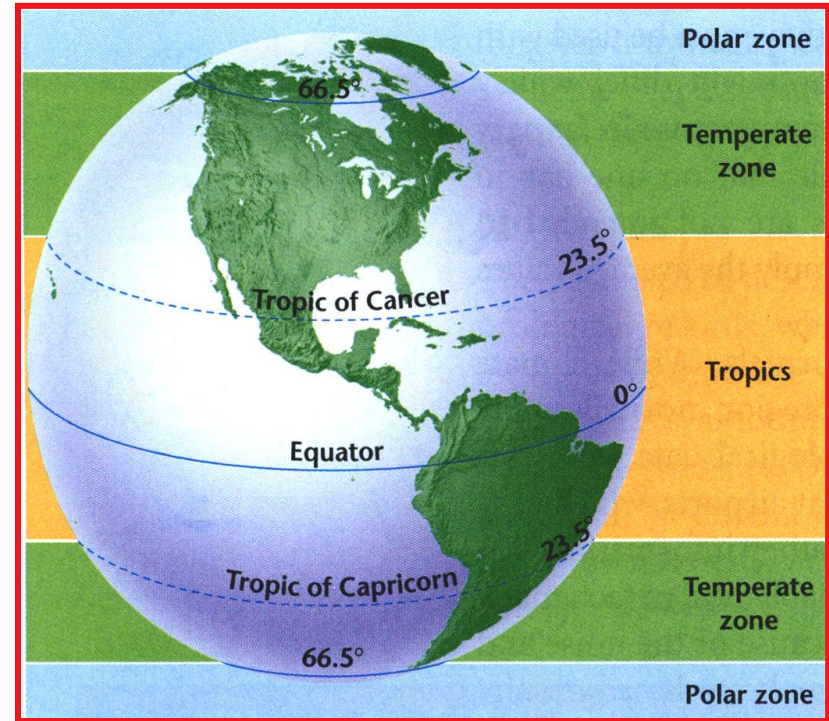
- ***High average*** temperatures and ***sun shines***
- ***High daily and small annual ranges*** of temperature
- No significant variation in ***length of day and night b/n summer and winter***.

2. Inclination of the Earth's Axis

The Earth's rotation makes an angle of (inclined) **$23\frac{1}{2}^{\circ}$** from *their axis* and also **$66\frac{1}{2}^{\circ}$** from *their orbit*. This bring the difference in **solar distance b/n polar & equatorial areas**.

Inclination determines the location of the **Tropics of Cancer, Capricorn and the Arctic & Antarctic Circles**.

As the earth **revolves around the sun**, this inclination produces a **change in the directness of the sun's rays**; which in turn **causes the differences in length of day and seasons**.



Equinox & Solstices:

A. Equinox:

It is an instant of time when overhead sun appears around the equator (when the sun seen crossing/passing the equator).

During this passage:

- ***sunlight shines equally*** on the **N^{rn} and S^{rn}** hemispheres.
 - *Half of each hemisphere is light, and half is dark.*
- ***Length of day and night are equal.***

The ***earth rotate on its axis determines day and night***(cause seasonal changes in the ***daylight and darkness periods***), and ***revolves on its orbit around the sun determine the seasons.***

Equinox appears twice a year:

- ***The Vernal (spring) equinox***
- ***The Autumn equinox***

I. The vernal(spring) equinox: March 21st

Is the day when the point of verticality of sun's rays crosses the ***equator northwards***.

This equinox experiences in **N^{rn} Hemisphere** when the sun is exactly above the equator.

During this period, the ***length of day and night are equal***.

Vernal (spring) equinox marks the ***beginning of spring season***.

March 21 marks the offset of the vernal equinox.

II. The Autumn Equinox: 23rd September

➤ It appears when the ***sun moves southward across the equator*** on **23rd of September**.

➤ It gives ***equal length b/n day and night***.

➤ **Autumn Equinox** marks ***the beginning of Autumn season***.

➤ **23rd of September** marks the ***offset of the Autumn equinox***.

B. Solstice:

Overhead sun appears *either N^{rn} or S^{rn} Hemisphere.*

During solstice both hemispheres has *either the most or least sunlight of the year.*

In other words, sunlight is at *maximum in one hemisphere & at a minimum in the other hemisphere.*

Resulting in *unequal length of days & nights in the hemispheres.*

I. The Summer Solstice: June 21st.

Sun is directly overhead on **tropic of cancer** at $23\frac{1}{2}^{\circ}\text{N}$ of equator.

The **N^{rn} hemisphere** has maximum tilt towards the sun, *experiencing longest daylight of the year.*

II. The Winter Solstice: December 22nd : the day when *maximum southward inclination* is attained in the **S^{rn} Hemisphere.**

In the **S^{rn} Hemisphere**, it occurs when overhead sun is directly over the **Tropic of Capricorn at $23\frac{1}{2}^{\circ}\text{S}$** of equator.

3. Altitude

It is the **height of location** above the sea level.

In general, **temperature decreases with increasing elevation.**

The **average rate** at which **temperature changes per unit of change in altitude** is known as **lapse rate.**

The lapse rate is limited to the **lower layer of the atmosphere(that is troposphere).**

The normal lapse rate is **6.5°C/1000 m** rise in altitude.

There are three types of lapse rates:

- i. *Dry Adiabatic Lapse Rate*
- ii. *Wet Adiabatic lapse rate*
- iii. *Environmental lapse rate or Atmospheric lapse rate*

I. Dry Adiabatic Laps Rate

Temperature changes occur not only as a result of heat addition or withdrawal from outside sources, but also by the ***consequence of expansion and contraction of air parcel***. This is known as ***adiabatic temperature change***.

Adiabatic lapse is the rate of change of the temperature of a rising/sinking air parcel with altitude as a result of ***expansion/compression***.

The major causes of ***adiabatic*** temperature changes is ***vertical displacement of air (sinking/ rising air)***.

Ascending motion: the parcel of air ***expands***, and it ***cools down***.

Descending motion: the air parcel ***compresses***, and it ***warms up***.

Dry Adiabatic Laps Rate is the rate at which temperature of rising dry air (unsaturated air - ***air with relative humidity < 100%***)) changes.

When air rises, it **expands**(cover large volume) because it has **less weight** up on it.

If a **mass of dry air** at sea level **rises** to an altitude of about **18,000ft (5,486.22 meters)**, the **pressure upon it is reduced** by nearly half & consequently its **volume is doubled**.

More precisely, if the upward movement of air **does not produce condensation**, then the expansion of air will cause the temperature to fall at the constant **dry adiabatic lapse rate**.

The rate of **heating or cooling** is about **10°C/1000 m** of change in elevation/altitude.

II. Wet Adiabatic lapse rate

*The rate at which temperature of **Saturated or precipitated** rising or sinking air changes with altitude.*

It is the adiabatic lapse rate for saturated air.

It is the result of two competing effects:

- Cooling due to **expansion**
- Heating due to **condensation**- that cause a release of latent heat.

The condensation of water vapor will release **latent heat** and this will **heat the air parcel**.

The heat is released in the process of ascent, therefore affecting or lowering the rate of temperature change of the rising air.

If a saturated air containing water droplets were to sink, it would compress and warm.

The rate at which rising or sinking saturated air changes its temperature is less than the dry adiabatic rate.

Therefore, rising and saturated or precipitating air cools at a slower rate than air that is unsaturated.

This process is called ***wet adiabatic temperature change***.

The rate of cooling of wet air is approximately **5°C/1000 m ascend**.

III. Environmental lapse rate or Atmospheric lapse rate

This is the ***actual, observed change of temperature with altitude increase or decrease.***

The fact that ***air temperature is normally highest at low elevations and decreases with altitude.***

The rate of change is ***6.5⁰c/1000m.***

5.3. Spatio-temporal Patterns and Distribution of Temperature and Rainfall in Ethiopia

5.3.1. Spatio-Temporal Distribution of Temperature

***Altitude and latitude** are the two most important elements in determining **spatial distribution of temperature** in Ethiopia.*

*Mean annual temperature varies from **> 30^{0c} in the tropical lowlands** to **< 10^{0c} at very high altitudes** (e.g. Bale Mountains).*

The ***highest mean maximum temperature*** in the country is recorded in the:

➤ ***Afar Depression***

➤ ***lowlands of western, north-western and south-eastern Ethiopia-***

*Which experiences mean maximum temperatures of **> 30^{0c}**.*

Table below shows Temperature zones based on ***Temperature vs. Altitude:***

<i>Altitude (meter)</i>	<i>Mean annual Temp (0C)</i>	<i>Description of Temperature Zone</i>	<i>Local Equivalent</i>
<i>3,300 and above</i>	<i>10 or less</i>	Cool	<i>Wurch</i>
<i>2,300 - 3,300</i>	<i>10 – 15</i>	Cool Temperate	<i>Dega</i>
<i>1,500 - 2,300</i>	<i>15 – 20</i>	Temperate	<i>Woina Dega</i>
<i>500 - 1,500</i>	<i>20 – 25</i>	Warm Temperate	<i>Kola</i>
<i>below 500</i>	<i>25 and above</i>	Hot	<i>Bereha</i>

Latitude and cloud cover are the major controls determining ***temporal distribution of temperature*** in Ethiopian.

In the ***tropics***, the ***daily range of temperature is higher*** and the ***annual range is small***, whereas the reverse is true in the ***temperate latitudes***.

The reason for high daily range of temperature is that- ***high temperature during the daytime*** in some places & is considerably ***reduced at night*** resulting- ***maximum difference in the daily range***.

In Ethiopia ***daily maximum temperature*** varies from ***> 37°C*** in ***lowlands of northeast & southeast*** to about ***10°C - 15°C*** in the ***northwestern and southwestern highlands***.

In Ethiopia and elsewhere in the horn, temperature shows ***seasonal variations.***

For example:

Months from ***March to June*** in Ethiopia have records of ***highest temperature.***

Where as from ***November to February*** - have records of ***low temperature.***

Southern part of Ethiopia receives ***highest records of temperature*** in:

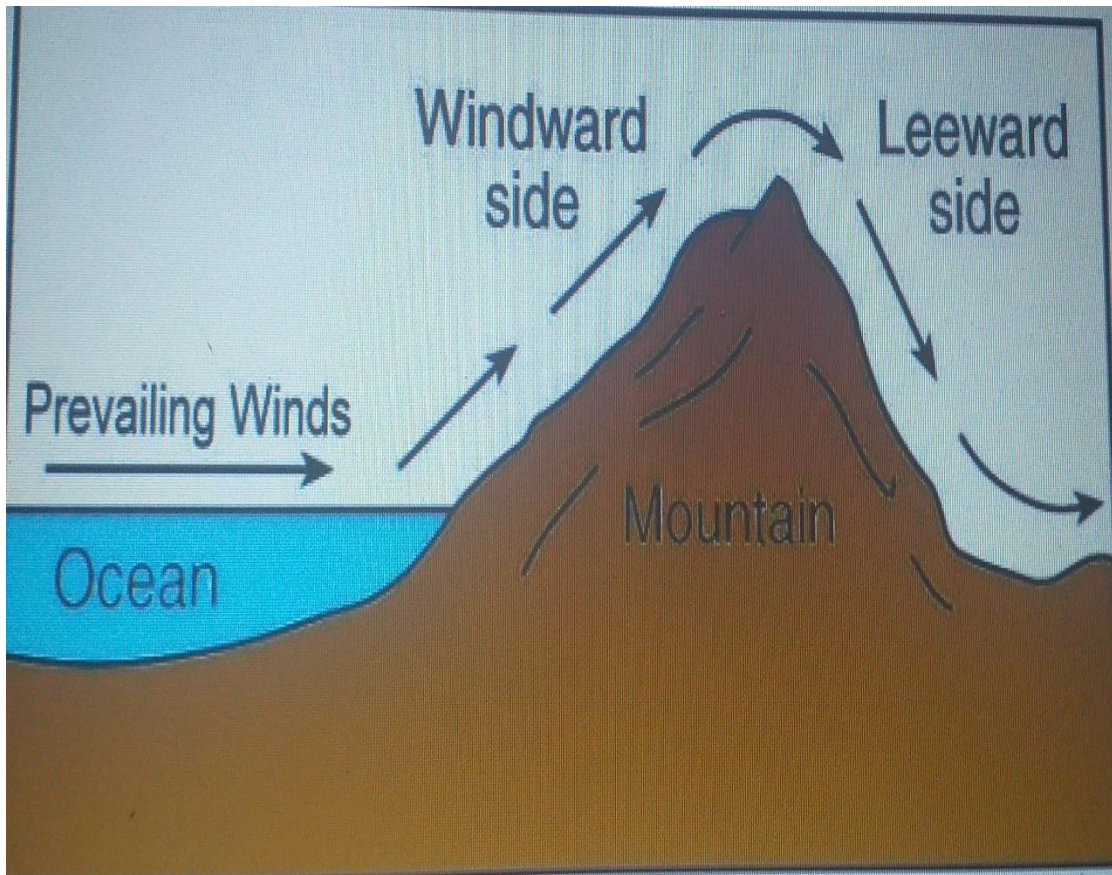
➤ ***Autumn*** (September, October and November) and

➤ ***Spring*** (March, April and May);

Whereas in the ***northern part of the country*** receives ***highest records of temperature in summer season*** (June, July, August).

The ***direction of rain bearing winds*** also determines the ***temperature variation in either side of a mountain(that is Windward &Leeward)***.

As wet ***air rises*** over a mountain, ***it cools, and then it condenses,*** and ***releases moisture (rain)***. This is called the ***windward side***. ***The opposite side*** called the ***leeward*** side.



Windward – is the side of the mountain that receives ***most of the precipitation***.

Leeward- is the side of the mountain that receives ***less amount of precipitation***.

5.3.2. Spatio-Temporal Distribution of Rainfall

Rainfall system in Ethiopia is characterized by ***spatial and temporal variabilities***.

Rainfall system in Ethiopia needs understanding of the position of ***Inter Tropical Convergence Zone(ITCZ)***).

Inter Tropical Convergence Zone(ITCZ)

✓ It is the convergence of ***Northeast Trade winds & Equatorial Westerlies***.

✓ It is a low pressure zone

Oscillation of ***ITCZ*** position is a ***cause for variation in the wind flow patterns***, which in turn ***cause variation of rainfall distribution*** over Ethiopia and the Horn.

Seasonal or Temporal Variabilities

I. Summer(June, July & August):

Majority of Ethiopian regions, *except lowlands in Afar and Southeast*, receive rainfall during the *summer season*.

Sun overheads *north of the equator*(Tropic of cancer $23\frac{1}{2}^{\circ}$ N).

During this season, Ethiopia and the Horn come under the influence of the *Equatorial Westerlies (Guinea monsoon) and Easterlies* - Are winds responsible for the *rain in summer season*.

Equatorial Westerlies (Guinea monsoon)- winds from *Atlantic ocean*.

South Easterlies – winds from *Indian ocean*.

High pressure cells develop on the *Atlantic & Indian oceans*.

II. Autumn(Tsedey) (September, October and November):

Autumn is the season between ***summer and winter***.

ITCZ shifts towards the equator weakening the equatorial ***westerlies***.

During this season ***south easterlies*** from ***Indian Ocean*** showers the ***lowlands in southeastern part of Ethiopia***.

III. Winter (December, January and February):

ITCZ shifts towards farther to ***Capricorn 23 ½°S***.

High pressure cells develop on ***Arabian land***.

During this season, ***northeasterly winds*** originating from the ***landmass of Asia crossing the Red Sea*** carry ***very little moisture*** and supplies rain only to ***Afar lowlands*** and the ***Red Sea coastal areas*** but ***most parts of Ethiopia is stay drying***.

IV. Spring(Belg) (March, April and May):

ITCZ again shift to ***north of the equator from South.***

In this season, the ***effect of the northeast trade wind*** is very much reduced.

Conversely, ***Southeasterlies from the Indian Ocean*** provide ***rain to:***

- ***highlands of Somalia;***
- ***central and southeastern lowlands and highlands of Ethiopia.***

Rainfall Regions of Ethiopia

Based on rainfall distribution, both in *space and time*, **four rainfall regions** can be identified in Ethiopia and the Horn. These are:

I. Summer Rainfall Region:

This region comprises *almost all parts of the country*, except the *southeastern and northeastern lowlands*.

The region experiences *most of its rain during summer (kiremt)*, while some places also receive *spring (Belg) rain*.

Having *rainfall of 1,000 mm or more per year*.

II. All year-Round Rainfall Region:

This region comprise the ***southwestern part of the country.***

This region receive rain from ***equatorial Westerlies winds (Guinea Monsoon).***

It has ***many rainy days*** than any part of the country.

Both ***duration and amount of rainfall*** decreases as we move from ***southwest to north and eastwards.***

Gain Maximum rainfall in summer months, whereas the winter months receive the reduced amount.

The average rainfall in the region varies from ***1,400 to over 2,200 mm/year.***

III. Autumn and Spring Rainfall Regions:

It comprises ***South eastern lowlands*** of Ethiopia that receive rain during ***autumn and spring seasons***.

This region receive rain from ***southeasterly winds***.

The ***average rainfall*** varies from ***less than 500 to 1,000 mm***.

IV. Winter Rainfall Region:

This rainfall region receives rain from the ***northeasterly winds***.

It comprise ***Red sea escarpments and some parts of the Afar region*** that receive their main rain during winter season.

5.4. Agro-ecological Zones of Ethiopia

Formerly in Ethiopia, ***agro-ecological zones*** were classified in ***traditional ways***- as ***Bereha, Kolla, Woina Dega, Dega and Wurch.***

These Agro-ecological Zones were grouped based on ***homogenous area having similar agricultural land uses.***

The ***elevation*** was the main ***parameter/base*** for ***traditional agro-ecological divisions.***

Agro-ecological Zones	Altitude (m)	Mean annual RF (mm)	Length of growing periods (days)	Mean annual temp(°C)	Area share (%)
<i>Wurch</i> (cold to moist)	>3,200	900-2,200	211–365	Below 10	0.98
<i>Dega</i> (cool to humid)	2,300 - 3,200	900-1,200	121–210	≥11.5–17.5	9.94
<i>Weyna Dega</i> (cool sub humid)	1,500 - 2300	800-1,200	91–120	>17.5 – 20.0	26.75
<i>Kola</i> (Warm semiarid)	500 - 1,500	200-800	46–90	>20.0 – 27.5	52.94
<i>Berha</i> (Hot arid)	<500	Below 200	0–45	>27.5	9.39

Length of crop growing period (LGP) – is defined as the number of days per year that sufficient water is available in the soil to support plant growth.

LGP captures multiple factors (*RF, potential evapo-transpiration, and soil moisture storage properties*).

5.5. Climate Change/Global Warming/: Causes, Consequences and Response Mechanisms

5.5.1. Introduction: What is Climate Change?

Climate change refers to a change in the *state of the climate*.

Climate Change is:-

- an **increases** in the **average temperature** of *Earth's atmosphere, oceans, & landmasses*
- Melting of snow and ice
- Rising global average sea level

5.5.2. Causes of Climate Change

The causes of climate change are generally categorized as:

I. Natural Causes

II. Anthropogenic/man-made causes

I. Natural Causes

The most important natural causes of climate change are:

- ***Earth orbital changes:*** The Earth's orbital inclination lead to small but climatically important changes through changes in the ***strength of the seasons.***
- ***Energy Budget:*** Sun's energy output small changes over an extended period of time can lead to climate changes. The gradually increasing in ***amount and intensity of solar radiation.***
- ***Volcanic Eruptions:*** volcanic eruption releases large volumes of ***Sulphur dioxide, carbon dioxide, water vapor, dust, and ash*** into the atmosphere- can lead to global warming.

II. Anthropogenic Causes:

*These are **human activities** that cause climate change.*

For instance:

- **Decomposition of wastes in landfills**
- **Clearing of land for agriculture**
- **Industrial/manufacturing activities, and other human activities that could increase **concentrations of greenhouse gases** such as **carbon dioxide, nitrous oxide in the atmosphere- that brings** global warming.**

Much of the waste that is disposed of in landfills decompose, resulting in the release of both **methane and carbon dioxide**.

The transportation sector and industries are the **major contributor to climate change by releasing much CO₂ emissions**.

5.5.3. Consequences/Impacts of Climate Change:

In many parts of the world, climate change has already caused ***loss of life, damaging property and affecting livelihoods.***

Some of the consequences of the changing climate include:

A. Impacts on human health:

- The change can cause increased heat that may lead to ***mortality and morbidity;***
- Infectious disease epidemics following floods
- Health effects following population displacement to escape extreme weather events.
- Climate change also raises the *incidence malaria.*

B. Impact on water resources: Climate change can:

- Lead to melting of snow and glaciers ***that increases rise in sea level and floods.***
- Increase drought that could reduce the amount of run-off into rivers, streams and lakes.

C. Impact on Agriculture:

- Changes in temperature & rainfall significantly affect agricultural production.
- Climate change increases physiological stress and fodder quality and availability.

D. Impact on Ecosystem:

Species could be seriously affected or even disappear because they are unable to resist the over hot temperature.

5.5.4. Climate Response Mechanisms:

This is how to react to the changing climate.

There are ***three major response mechanisms*** to climate change:

- ***Mitigation***
- ***Adaptation***
- ***Resilience***

I. Mitigation and its Strategies

Mitigation measures are those actions that are taken to **reduce and control greenhouse gas(GHG) emissions** changing the climate.

It implies **reducing the emission of GHGs into the atmosphere**, either by **reducing sources of these gases** or **enhancing the “sinks”** that accumulate and store these gases, like **afforestation**.

Forests/forestry can have significant absorbing atmospheric Carbon dioxide.

Some **mitigation measures** that can be taken to **avoid the increase of pollutant emissions** are:

➤ **Increase Practice Energy efficiency:**

- ✓ Use of energy-saving technology (like hybrid cars).
- ✓ Reducing energy consumption associated with processing/ manufacturing (by improving manufacturing processes), & in transportation.
- **Increase the use of renewable energy** such as solar, wind, thermal
- **Efficient means of transport implementation:** electric public transport, bicycle, shared cars etc.

II. Adaptation and its Strategies

It is adjusting / adapting to life in a changing climate and coping with changes in climate.

The goal is to **reduce our vulnerability** to the **harmful effects of climate change** such as extreme weather events or food insecurity.

Adaptation: coping with climatic change – by taking measures to **reduce the negative effects, or exploit the positive ones** (making of any **potential beneficial opportunities- Example** short growing seasons crops or increased yields in some regions).

Some of the ***major adaptation strategies*** include:

- Building flood defenses---***Flood management***
- Installing water-permeable pavements to better deal with floods and storm water --- ***Ditch construction***
- Plan for ***heatwaves and higher temperatures***,
- Improve water storage and use.
- Landscape restoration and reforestation,
- Diverse cultivation to be prepared for natural catastrophes--- ***Develop crop varieties adapted to drought, higher temperatures***
- ***Preventive & precautionary*** measures (Taking proactive measures- like evacuation plans, health issues, early-warning systems for climate change related diseases etc.)

III. Resilience and its strategies: *Recycle and carbon clean methods.*

Increasing recycling means that less waste ends up in landfills, decreasing landfill emissions.

On the other side, *recycling paper products* both saves *GHG emissions* that would have been generated as well as allows *trees to continue to act as carbon sinks.*

Resilience strategy also encompasses- *Carbon clean methods* - *'carbon-neutral growth/ activity/*Low-Carbon Development Strategies (LCDS).