CHAPTER THREE
THE TOPOGRAPHY OF ETHIOPIA AND THE HORN

- Brainstorming questions
- What is ….geology
- What is the environmental and socio-economic, and political implications of Ethiopian topography?
- What expression of '*Ethiopia is a roof of East Africa*' implies?



General Characteristics of the Ethiopian Physiography

- The Ethiopian landform is characterized by great diversity: plateaus, high and rugged mountains, deep river gorges and vast plains.
- Altitude ranges from 125 meters below sea level (i.e. Kobar Sink) to - 4,620 m. above sea level (i.e. Mount Ras Dashen).
- Ethiopia has the largest proportion of elevated landmass in Africa(Roof of East Africa).
- >50% of the Ethiopian landmass is above 1,000 meters of elevation
- >44% of Ethiopian landmass is above 1,500 meters of elevation(22% of this is at 2000 meters a.s.l).

Cont'd…

- The diversity in topography brought about differences in natural features (soil, climate, vegetation and wild life) and socio-cultural and economic phenomena.

❖ 1000 meters contour line is used as the demarcation line between Ethiopian highlands and lowlands.

- *Highlands (>1000 meters): characteristics*

☞ Moderate and high amount of rainfall (>600 mm per year)

☞ Lower mean annual temperature (<200C)

☞ favourable climate for biotic life (fauna and flora)

☞ Possibility of Rain-fed agriculture

Cont'd…

- Free from tropical diseases
- Conducive for human habitation (densely settled)

- These highlands makeup nearly 56% of the area of the country and has two subdivisions: lower highland higher highland .

1) lower highland (1,000 - 2,000 m.a.s.l), which make up 35%
2) higher highland (>2,000 m.a.s.l) constitute nearly 22%.

Cont'd…

- ❖ *Ethiopian lowlands: descriptions* &characteristics
- ☞ Constitute 44% of the area of the country
- ☞ Receive Fewer amounts of rainfall and higher temperature
- ☞ High prevalence of tropical diseases
- ☞ Lower population densities
- ☞ Nomadic and semi-nomadic economic life
- ☞ Vast plain lands favourable for irrigation agriculture along the lower river basins

The physiographic division of Ethiopia

- Which geological era and forces were responsible for the formation of Ethiopian physiography?
- What are the major physiographic divisions of Ethiopia?
- What biophysical characteristics can be mentioned about areas under rift in Ethiopia?



Cont'd…

- The 3 major categories of physiographic division in Ethiopia:

1) The Western highlands and lowlands
2) The South-eastern (Eastern) highlands and lowlands
3) The Rift Valley

❖ *The Western Highlands and Lowlands*:

- includes all the area west of the Rift Valley
- Makeup 44% of the area of the country
- Comprised of 4 groups of highlands (76.3%) and 4groups of lowlands (23.7%)

The Western Highlands

- This category, consists the following main categories:

1) The Tigray Plateau
2) North Central Massifs
3) The Shewa Plateau/central highlands
4) The Southwestern Highlands

The Western Highlands

- *The Tigray Plateau*:

☞ It constitutes about 13% of the area of the region.

☞ It is an elongated highland with most of the land being in between 1,000 and 2,000 meters above sea level.

☞ However; there are some high mountains with elevations of over 3000 meters in this plateau.

➢ E.g. Mount Tsibet → 3988 meters .a.s.l

➢ Mount Ambalage → 3291 meters .a.s.l,

➢ Mount Assimba 3248 meters .a.s.l.

☞ It constitutes about 13% of the area of the region

North Central Massifs

- Is the largest Physiographic in the western highlands
- 58% of the region is at an altitude of more than >2,000 meters.
- It follows the Abay and Tekeze gorges
- much of these plateau and tablelands are still capped by the Trappean lava.
- In its central part, it accommodates the Lake Tana basin.
- Is the second highest physiographic division next to the Shewan Plateau
- It consists of the Gonder, Wello and Gojjam Massifs.

Cont'd…

- Out of the 26 mountain peaks with altitude of more than 4,000m.a.s.l in Ethiopia, 19 mountain peaks are found in this physiographic region. Example

☞ Mount Ras Dashen → 4,620 m.a.s.l

☞ Mount Weynobar/Ancua → 4462 m.a.s.l

☞ Mount KidisYared → 4453 m.a.s.l

☞ Mount Bwahit → 4437 m.a.s.l

The Shewa Plateau/central highlands

- is the smallest of the Western highlands covering only 11% of the area of the whole physiographic region.
- Nearly three-fourth of its area is located at an altitude of more than 2,000 meters above sea level an hence; has the largest proportion of elevated ground
- Some of the highest mountain in the Shewan plateau is Mount Abuye-Meda (4,000 m.a.s.l) in Northern Shewa, Mount Guraghe in the south is 3,721 meters high.

The Southwestern Highlands

- Is the second largest in the Western highlands accounting for 22.7% of the area of the region.
- About 70% of its area is lies within 1,000-2,000 meters altitude.
- It extends from the north (Abay gorge) to the south(Chew Bahir).
- This physiographic division consists the highlands of Wellega, Illuababora, Jimma, Kaffa, Gamo and Gofa.
- This plateau is the wettest in Ethiopia and drained by Dabus, Deddessa (tributaries of Abay), Baro, Akobo and the Ghibe/Omo rivers.

Cont'd…

- Guge Mountain is the highest peak in this physiographic subdivision with the height of 4,200 meters above sea level.

The Western Lowlands

- Make 11% of the area of the physiographic region an elevation ranging between 500 and 1000 meters above sea level
- *Consists of four subdivisions*: these are

☞ Tekeze lowland

☞ Abay-Dinder lowland

☞ Baro lowland, and

☞ Ghibe lowland

❖ except '*Baro lowland*', climatically the region is characterized by arid or semi-arid conditions accompanied by Pastoral or semi-pastoral economic activities.

3.2.2. The Southeastern Highlands and Lowlands

- This physiographic region is the second largest in terms of area covering 37% of Ethiopia.
- This highlands make up 46% of the physiographic division while the rest (54%) is lowland.
- These are further subdivided into two units of highlands and two units of extensive lowlands.

❖ *The Southeastern Highlands*: this category consists

A. The Arsi-Bale-Sidama Highlands
B. The Hararghe Plateau

Cont'd…

❖ *The Southeastern Lowlands*:

- make up 54% of the area of the physiographic region and one-fifth of the country.
- This region consists two plains: namely Wabishebelle plain (60%) and Ghenale Plain(40%).They include the plains of Ogaden, Elkere, and Borena.
- Due to harsh climatic conditions, this region support few populations(sparsely populated) by pastoral and semi-pastoral communities .
- Animal husbandry, irrigation, agriculture, exploitation of petroleum and natural gas are the economic potential the region.

The Rift Valley

- The Rift Valley is a structural depression formed y the tectonic force
- The formation of the Rift Valley has separated the Ethiopian Highlands and Lowlands in to two
- It extends from the Afar triangle in the north to Chew Bahir for about 1,700 km2.
- It covers 18% of the area of Ethiopia
- It is elongated with a NE-SW orientation

Cont'd…

- The Rift Valley is further subdivided into three physiographic sub-regions

❖ *the Afar Triangle: characteristics*

- ➢ is the largest and widest part of the Rift Valley
- ➢ 54% of the Rift Valley area
- ➢ Morphologically, it has triangular-shape lowland (1,000 meters to 125 meters below sea level)
- ➢ one of the most hostile environments on Earth ((maximum temperatures can exceed 50°C during the summer wet season;
- ➢ Located at low altitude between (300-700 meters) and characterized by:

Cont'd…

- faulted depressions (grabens), volcanic hills, active volcanoes, volcanic ridges, lava fields and low lava platforms.
- Have Lakes like Abe, Asale, and Afrera and Denakil Depression (Kobar Sink).
- generally hot and dry
- ***The economic importance of the region***: salt extraction, irrigation along the Awash River and electric potential from geothermal energy

The Main Ethiopian Rift/ Central Rift

- It refers to the narrow belt of the Rift Valley that extends from Awash River in the north to Lake Chamo in the south.
- This part of the Rift Valley is the narrowest and the highest.
- It has an average width of 50-80 kilometers and general elevation of 1,000-2,000 meters above sea level.
- ***The presence of cinder cones and volcanic mountains*** like: Mount Fentale, Boseti-guda (near Adama), Aletu (north of Lake Ziway) and Chebi (north of Lake Hawasa).
- ***Other resource base of the region***: recreational value of the lakes, the agriculture and the geothermal energy potential
- The lakes of the region is generally milder and watery.

The Chew Bahir Rift

- is the smallest part of the Rift Valley that includes the Gneissic highlands of Konso
- is the broad and shallow depression.
- It includes the streams of Segen and Woito.

The Impacts of Relief on Biophysical and Socioeconomic Conditions

- Relief influence the various socioeconomic aspects of Ethiopia as presented hereunder;
- *Relief influences Agricultural practices*: Choice of farming techniques (e.g. in rugged terrain mechanized farming techniques are difficult to practice).
- *Relief influences crop production* (e.g. corps like barley, wheat are well adapted to higher altitudes whereas crops like sorghum, maize are well adapted to *lower altitude*.

Cont'd…

- *Relief influences the practices of animal husbandry* (e.g. equines and sheep are reared in the higher altitudes and camels and goat are well adapted to lower altitudes).
- *Influences on Settlement pattern: Highlands* of Ethiopia that experience a temperate type of climatic condition that are mainly free from most of the tropical diseases are densely settled.
- The highlands are characterized by sedentary life and permanent settlements whereas, lowlands are inhabited by pastoralists with temporary settlements.

Cont’d…

- Influences on Transportation and communication
- Hydroelectric power potential
- Socio-cultural feeling
- Impacts on climate
- Impacts on soil
- Impacts on natural vegetation

CHAPTER FOUR
DRAINAGE SYSTEMS AND WATER RESOURCE OF ETHIOPIA AND THE HORN?

- *Brain storming activity*
- What is drainage and drainage system?
- What is mean by Ethiopia is ‘Water Tower of Eastern Africa’?
- What are the Major Drainage Systems of Etiopia?



4.1 Introduction

- 71% of the earth's total surface is covered by water bodies (i.e. seas and oceans). Of the earth's total water surface, nearly 97.5% is *alkaline* accumulated in seas and oceans. The remaining 2.5% is fresh water, of which nearly 68.7% is deposited in glaciers, 30.1% in ground water, 0.8% in permafrost and 0.4% in surface waters.
- *Surface waters* are water in lakes, rivers, atmosphere, soils and wetlands.

Cont'd…

- Surface and ground waters are the most abundant and easily available fresh waters. However, fresh water is distributed unevenly throughout the world due to *latitudinal*, *climatic*, *topographic* factors.

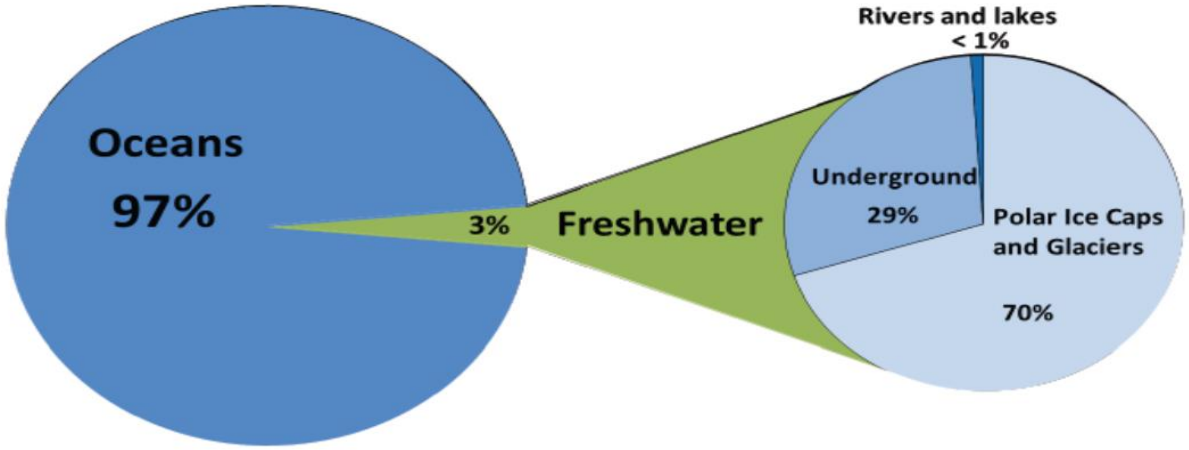


Figure Source: Getting the picture: our changing climate http://gettingthepicture.info/3/;http://www.unwater.org/downloads/Water_facts_and_trends.pdf

Cont'd…

- The topographic setup of Ethiopia is characterized by complex blend of massive highlands, rugged terrain, and low plains.
- This diverse topographical setup, relatively higher rainfall and its nearness to equator made the country to have larger volume of ground and surface water. Consequently, around 0.7 % of the total land mass of Ethiopia is covered by water bodies.

Cont'd…

- Although it requires further and detailed investigation, the country's surface water potential is estimated to be 124.4 *billion cubic meters* (BCM) as an integrated river basin master plans studies shows. Consequently, many call Ethiopia, the 'water tower of Eastern Africa'.

Cont'd…

- *Drainage*:-is the flow of water through well-defined channel.
- drainage system is made up of a principal river and its tributaries (the rivers that flow into it).
- A *river system* begins at a place called the source or headwater and ends at a point called mouth.
- Therefore, a drainage system is branched network of stream channels together with the adjacent land slopes they drain.

Cont'd…

- The *drainage pattern* of an area is the outcome of the geological processes, nature and structure of rocks, topography, slope, amount and the periodicity of the flow.
- A drainage basin is the topographic region from which a river and its tributaries collect both the surface runoff and subsurface flow.
- The general patterns of major river basins in Ethiopia are determined by topographical structures described below.

Cont'd…

a) The topography of the outward sloping of the Western and South eastern plateaus
b) The structural formation of the Rift Valley with its in-ward-sloping escarpments resulting mainly in an inland drainage system.
c) Faults and joints that structurally influence part of the courses of many rivers.

4.2 The Major Drainage Systems

- Why do rivers rise from higher slope and flow towards the lower?
- Ethiopian drainage systems are broadly classified in to three main categories, namely:

i. Western

ii. Southeastern and

iii. Rift Valley Drainage Systems

4.2.1 The Western Drainage Systems(WDS): A brief descriptions

- are the largest of all drainage systems draining 40 percent of the total area of the country
- carry 60 percent of the annual water flow.
- Comprised of four major river basins: Tekeze, Abay, Baro-Akobo and Ghibe (Omo). Unlike Tekeze, Abay, and Baro-Akobo, which flow westward, the Ghibe (Omo) flows southward.
- For the general characteristics of these and other rivers, see table 4.1 on the next slide.

Cont'd…

- Table 4.1: Data on major Ethiopian rivers

River	Catchment Area(km^2)	Annual Volume BMC	Terminus/Mouth	Major tributaries
Abay	199,812	4.5	Mediterranean	Dabus, Dedessa, Fincha, Guder, Muger, Jema, Beshilo
Wabishebelle	202,697	3.4	Coast of Indian Ocean	Ramis Erer, Daketa Fafan
Genale Dawa	171,042	6	Indian-Ocean	Dawa, Weyb, Welmel, Mena
Awash	114,123	4.9	Inland (within Ethiopia)	Akaki, Kesem, Borkena, Mile
Tekeze	87,733	8.2	Mediterranean	Goang, Angereb
Gibe (Omo)	79,000	16.6	Lake Turkana	Gojeb
Baro Akobo	75,912	23.23	Mediterranean	Akobo

Source: Compiled from different basin development master plans

4.2.2 The Southeastern Drainage Systems (SEDS)

- Nearly the entire physiographic region of southeastern part of Ethiopia is drained by the southeastern drainage systems.
- Slopes: south-eastwards
- Major highlands of this basin include plateaus of *Arsi*, *Bale*, Sidama and Harerghe.
- Wabeshebelle and Ghenale rivers carry 25 percent of the annual water flow of Ethiopia.
- *Wabeshebelle* is the largest (in terms of its catchment area in the region) and the longest river in Ethiopia.

Cont'd…

- Despite its size, it fails to reach the Indian Ocean and disappears in the sands, just near the Juba River in Somali.
- *Ghenale (Juba) river* has fewer tributaries but carries more water than Wabeshebelle, reaches the Indian Ocean.

Cont'd…



Figure 4.1: Drainage Basins of Ethiopia; Source: CSA shape file, 2012

4.2.3 The Rift Valley Drainage System (RVDS): A brief description

- The RVDS is an area characterized by small amount of rainfall, high evaporation and small catchment area.
- Awash river basin (the most utilized river in the Ethiopia) is the only major river of the RVDS with the catchment area of 114,123 km2 and 4.9 billion cubic meters average annual discharge.
- The Awash River originates from Shewan plateau (central Ethiopia) covering some parts of the Amhara, Oromia, Afar, Somali, Dire Dawa, and Addis Ababa City Administration.

Cont'd…

- In this system, there is no one general flow direction as the streams flow in all directions (the Awash flows in a northeast direction) and finally ends up in Lake Abe along the Ethio-Djibouti border.
- *The Afar drainage sub-basin* has practically no stream flow and the only main surface waters in the basin are Lake Afrera and Asale, which were formed through tectonic activities.
- The *Southern part of the Rift Valley sub-basin* is characterized by a number of lakes and small streams and hence, described as 'lakes region'.

Cont'd…

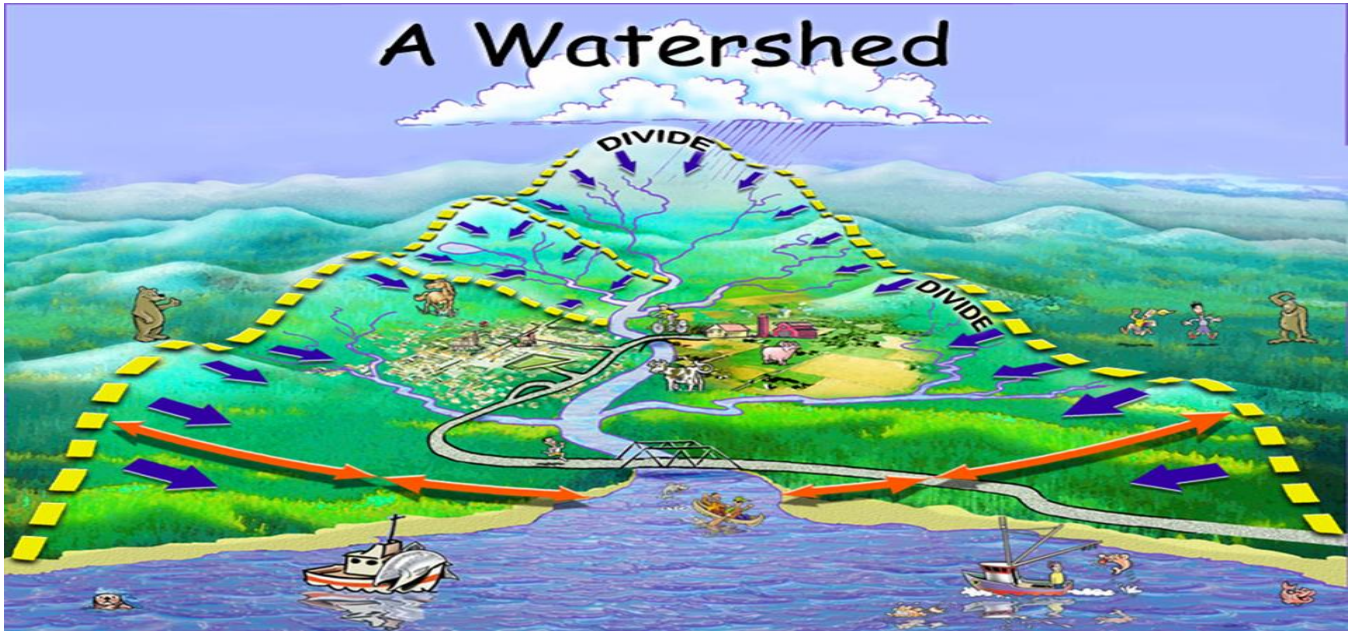
- There are *small streams* that supply water to the lakes (e.g. Meki and Katar Rivers flow into Ziway; Bilate into Abaya; and Segen into Chew Bahir).
- Some of these lake are also interconnected (e.g. Lakes Ziway and Langano drain into Lake Abijiata through the small streams of Bulbula and Horocolo respectively).

4.3. Water Resources: Rivers, Lakes and Sub-Surface Water

- Why do majority of Ethiopian rivers end at seas and oceans?
- 4.3.1. The Ethiopian Rivers
- Unlike many other African countries, Ethiopia is endowed with many rivers originating from highland areas and crossing the Ethiopian boundary.
- Altogether, Ethiopian rivers form *12 major watersheds* (see fig. 4.1) separating the Mediterranean Sea from the Indian Ocean drainage systems.

Cont'd…

- *Water shade*: Land area from which all water drains flow to a destination such as a river pond area from which all water drains, flow to a destination such as a river, pond, stream, lake, or estuary. It is a catchment basin that is bound by topographic features(fig below).



4.3.2 The General Characteristics of Ethiopian Rivers

- *Ethiopian rivers have the following characteristics:*

☞ Almost all major rivers originate from the highlands with an elevation of >1500 meters a.s.l.

☞ trans-boundary

☞ extreme seasonal fluctuation(i.e. high volume during wet season and low volume during the dry season)

☞ Have rapids and waterfalls along their course as they flow from highland to low land.

☞ Have steep profiles as they flow on steep slopes.

☞ Some of them serve as boundaries (both international and domestic administrative units).

4.3.2. The Ethiopian Lakes

- Ethiopia is rich in lakes and majority of lakes are located within the Rift Valley System. All Ethiopian lakes are result of tectonic process that took place during Quaternary period of Cenozoic era.
- Lake Tana, is the largest lake in Ethiopia and shallow depression formed through slower sinking and reservoir by lava flow between Gojjam and Gonder massifs.
- Ethiopia also has 'crater lakes' at and around *Bishoftu*, *Wonchi* (near Ambo), *Hayk* (near Dessie) and the Crater Lake on top of *Mount Zikwala*.

Cont'd…

- *Lake Ashenge* (Tigray) is formed on a *tectonic basin*.
- *man-made lakes*: Ethiopia also has anthropogenic lakes such as Lakes Koka, Fincha and Melka Wakena, and many other lakes dammed following hydroelectric power generation projects.
- within main Ethiopian rift, Lake Abaya is the largest of all the lakes in the system. A the southern tip of the Rift Valley, Chew Bahir is drained by Segan and Woito.
- Shala and Ziway are the shallowest and the deepest lakes in the central Ethiopian Rift respectively (see Table 4.2).

Cont'd…

- Table 4.2: Area and depth of some of Ethiopian Lakes

Lake	Area (km^2)	Max. Depth(m)	Lake	Area (km^2)	Max. Depth(m)
Tana	3600	9	Abijata	205	14
Abaya	1162	13.1	Awassa	129	10
Chamo	551	13	Ashenge	20	25
Ziway	442	8.95	Hayk	5	23
Shala	409	266*	Beseka	48.5	11
Koka	205	9			

Source: compiled from various sources

Cont'd…

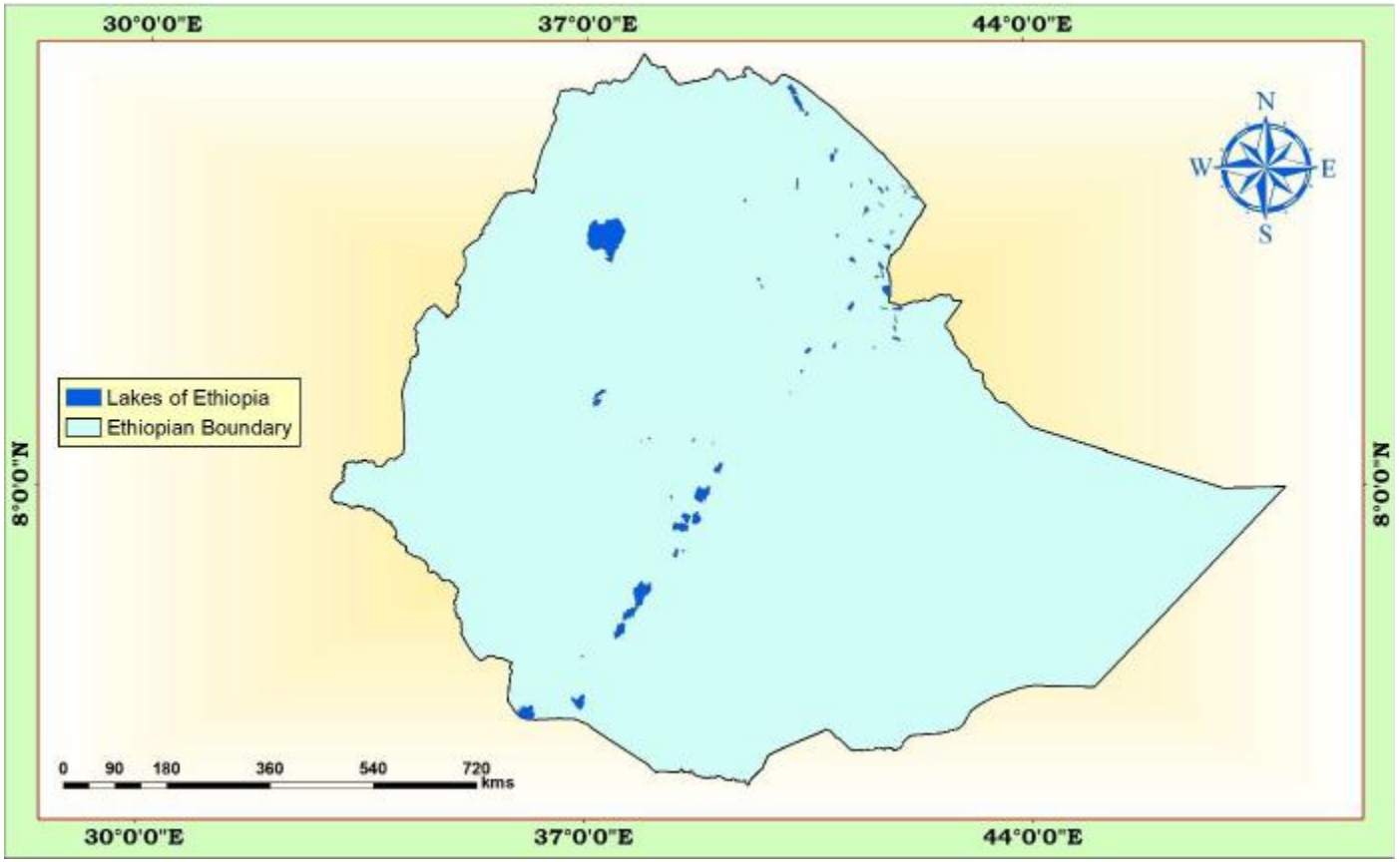


Figure 4.2. Lakes of Ethiopia Source: CSA shape file, 2012

4.3.3. Subsurface (Ground) Water Resource of Ethiopia

- Brainstorming questions:

1. What factors can determine the availability of ground water resources?
2. The potential of exploitable water in Ethiopia is huge, so why our agriculture is still rain fed?
3. What do you think that Ethiopian rivers are not conducive for navigation?
4. What factors made Ethiopia's water resources being underutilized?



- Ethiopia has lower ground water potential as compared to surface water resources. However, there exists higher total exploitable groundwater potential.
- Based on existing scanty knowledge, the groundwater potential of Ethiopia is estimated to be 2.6 - 6.5 BMC (underestimated).However; various studies shows that, Ethiopian potential of groundwater is believed to be between 12-30 BMC.

4.4. Water Resources Potentials and Dev't in Ethiopia

- Though Ethiopia benefited less from her water resources, there are plenteous of opportunities that can transform the resource into societies collective social and economic needs.

❖ Some of the '*potential development uses*' of water resource are:

☞ Hydro-electric Potential

☞ Irrigation and Transportation

☞ Fishing and Recreation

Hydro-electric Potential

- Ethiopian rivers have a very high potential for generating electricity. The exploitable potential of hydroelectric power is estimated at about 45000 megawatts.
- Currently many hydroelectric power dams are operating and many others are under construction to realize Ethiopia's ambitious energy goals.
- *Grand Ethiopian Renaissance Dam (GERD)* is the country's largest dam under construction aiming to generate 6400 megawatts.

Cont'd…

- *Gilgel Gibe III* hydropower project has gone operational generating 1870 megawatts.
- Currently Ethiopia is administering 14 hydroelectric power plants constructed on Lake *Aba Samuel* (the first hydroelectric power generation plant installed in 1932), Koka, Tis Abay, Awash, Melka Wakena, Sor, Fincha, Gibe/Omo, Tana Beles and Tekeze, generating close to 4000 megawatts of energy.

Irrigation and Transportation

- The uses of Ethiopian rivers both for irrigation and transportation is constrained by the country's physiographic setups characterized by steep slopes, rapids, waterfalls, narrow and deep valleys and gorges in the high land areas.
- However, on the lowlands, the demand for irrigation is high and country's potential for this irrigation is estimated to be 5.3 million hectares.
- The Baro-Akobo and Genale Dawa river systems have large irrigation potential compared to other basins.

- Despite the untapped irrigation practice, more than 60% of the area under irrigation so far is located in Rift Valley Drainage System.
- Most of Ethiopian rivers are not suitable for transportation and *Baro river* is the only navigable river at its lower course.
- Comparatively, Ethiopian lakes are much suitable for transportation than rivers(e.g. Lake Tana and Abaya are relatively the most used for transportation).

Fishing and Recreation

- Ethiopian lakes are rich in fish and The present annual production of fish is estimated to be 31.5 thousand tons.
- The exploitable potential is however, by far greater than the current production. Exploitable fish potential is vary from lake to lake.
- Currently, Lake Tana has the leading potential of fish exploitation estimated to be between 8,000-10,000 tons per year and followed by Lake Chamo having Fish production estimated at 4,500 tons per year.
- However, more than 60% of fish supplies are coming from Ethiopian main Rift Valley lakes.

- However, some of the lakes are currently threatened by sedimentation, invasive species (water hyacinth), over exploitation and expansion of investments around lakes.
- Apart from being the source of fish, many Ethiopian lakes also serve other purposes of recreational and tourist attractions site due to:
  - ☞The presence of variety of fish, birds and other aquatic life forms in the lakes
  - ☞the scenic beauty of the lakes
  - ☞the hot springs around the lakes
  - ☞the spectacular river gorges and the most impressive waterfalls, etc.

CHAPTER FIVE

5. THE CLIMATE OF ETHIOPIA AND THE HORN

5.1 Introduction

- Ethiopia as a large country in the Horn of Africa, is characterized by a wide variety of altitudinal ranges and diverse climatic conditions.
- its closeness to the equator and the Indian Ocean, the country is subjected to large temporal and spatial variations in elements of weather and climate.
- **The climate** controlled by the seasonal migration of the ***Intertropical Convergence Zone*** (ITCZ) and associated atmospheric circulations as well as by the complex topography of the country.

- ***Weather*** is the instantaneous or current state of the atmosphere composing temperature,atmospheric pressure, humidity, wind speed and direction, cloudiness and precipitation.
- ***Climate*** refers the state of the atmosphere over long time periods, decades and more. It is the composite of daily weather conditions recorded for long periods of time.

5.2. Elements and Controls of Weather and Climate

- Weather is expressed by a combination of several elements.
- major elements and controls of weather and climate.

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

5.2.1. Controls of Weather and Climate

- The climate of any particular location on earth is determined by a combination of many interacting factors.
- These include latitude, elevation, nearby water, ocean currents, topography, vegetation, and prevailing winds.
- these determining factors are called *controls of weather and climate or climatic controls.* 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 you move further away from the equator towards the poles, less solar insolation is received during the year and the temperature become colder.
- Latitudinal location of Ethiopia and the Horn resulted in;
  - *high average temperatures*,
  - *high daily and small annual ranges of temperature*,
  - *no significant variation in length of day and night between summer and winter.*

b. Inclination of the Earth's Axis

- The earth's rotation axis makes an angle of about 66 ½ ° with the plane of its orbit around the sun, or about 23 ½ ° from the perpendicular to the ecliptic plane.
- This inclination determines the location of the Tropics of Cancer, Capricorn and the Arctic and Antarctic Circles

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

Equinoxes and Solstices

- An ***equinox*** is the instant of time when the sun strikes the plane of the Earth's equator.
- During this passage the length of day and night are equal.
- revolution of the earth along its orbit, the inclination of its axis from the plane of that orbit, and the constant position (parallelism) of the axis causes seasonal changes in the daylight and darkness periods
- Equinox appears twice a year.
- Let’s see two major equinoxes’;

- Let's see two major equinoxes';

➢ ***The Vernal (spring) equinox*:**

- is the day when the point of verticality of sun's rays crosses the equator northwards.
- experiences in Northern Hemisphere when the sun is exactly above the equator.
- 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.

- **The Autumn equinox,**

❖happen when the sun crosses equator giving approximately equal length between day and night.

- It appears to happen when the visible sun moves south across the celestial equator on 23rd of September.
- It marks the beginning of Autumn season.

Figure 5.1 Autumnal Equinox

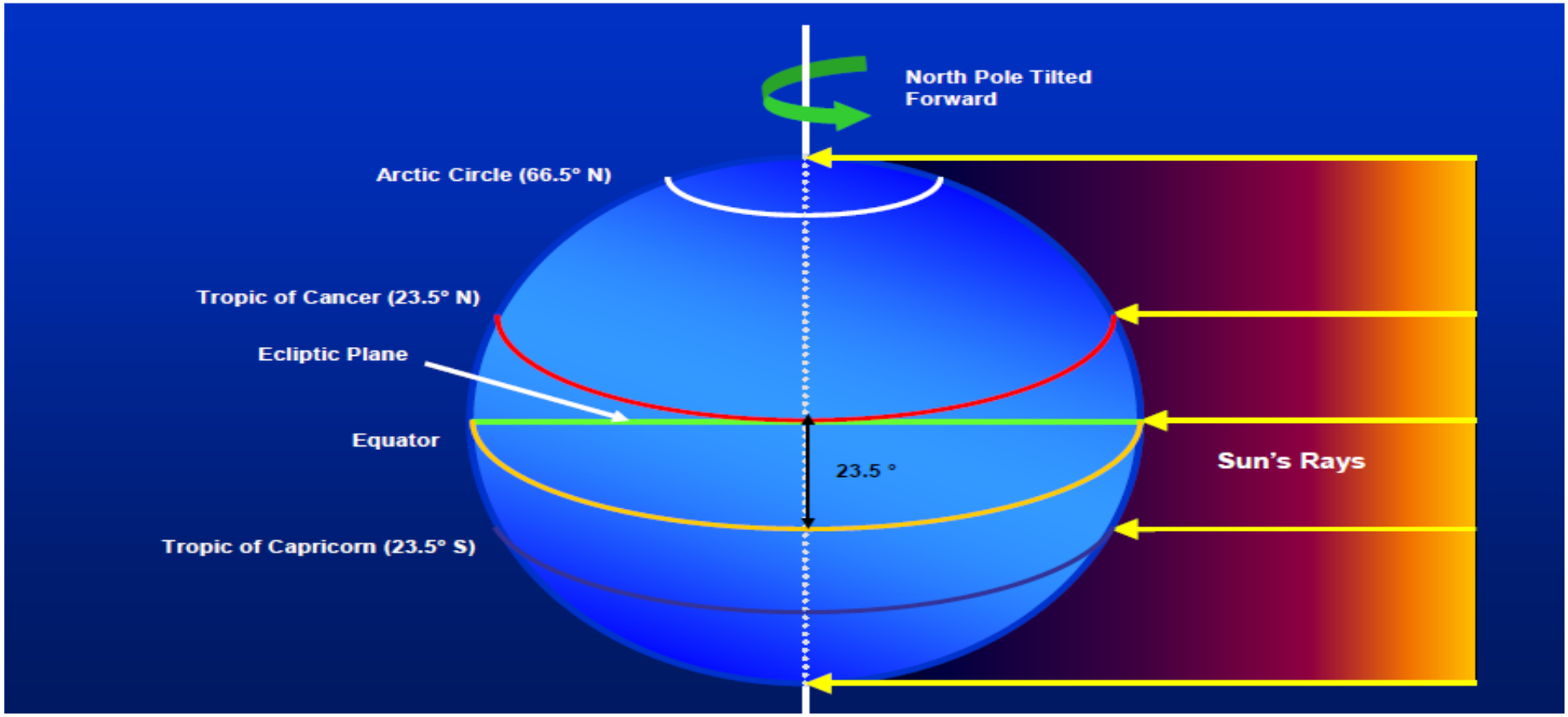
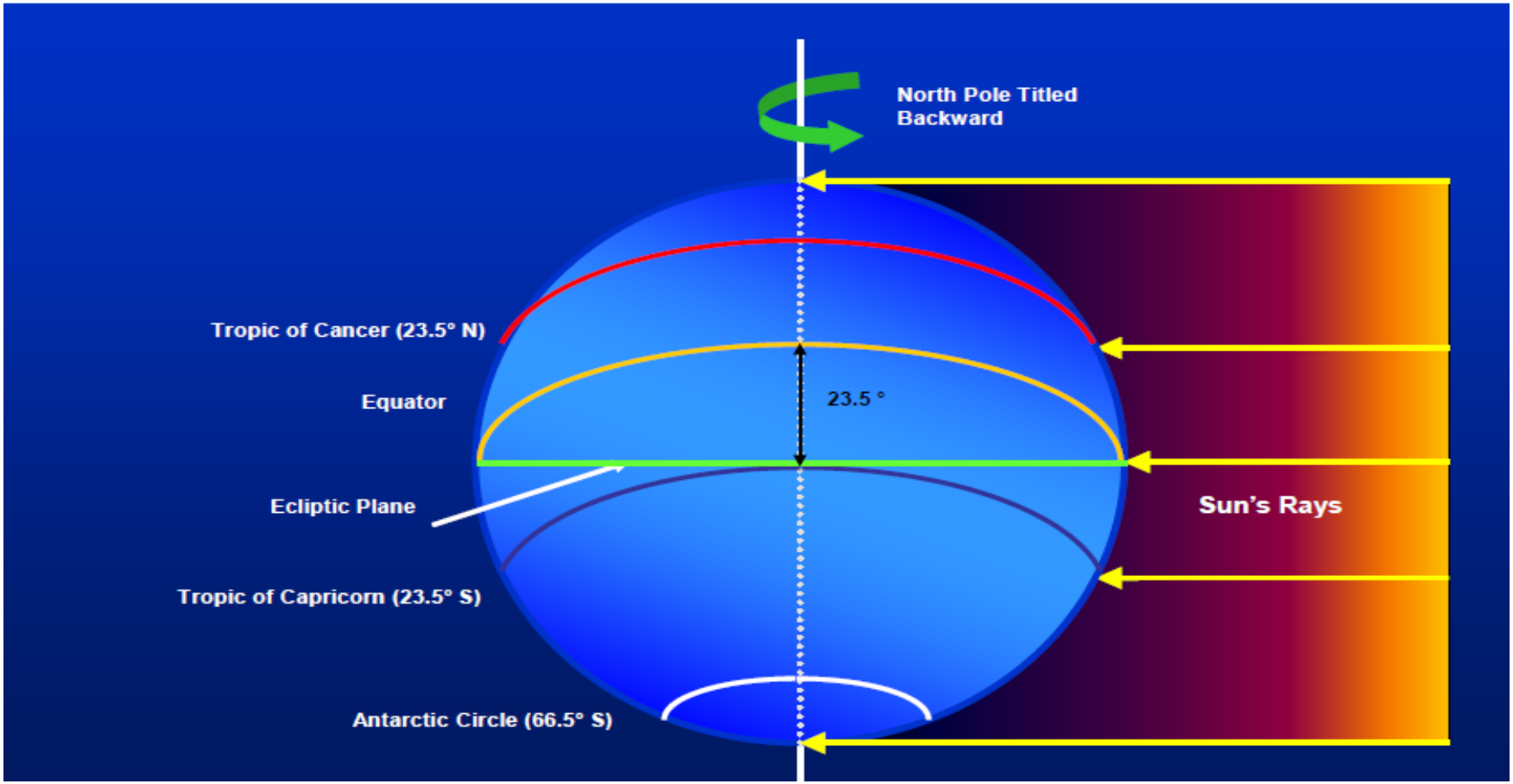


Fig 5.2 Vernal(spring) Equinox



- ***Solstice ;*** is an event when the overhead sun appears to cross northern or southern points
- resulting in unequal length of days and nights in the hemispheres.
- Both hemispheres during this event has either the most or least sunlight of the year.

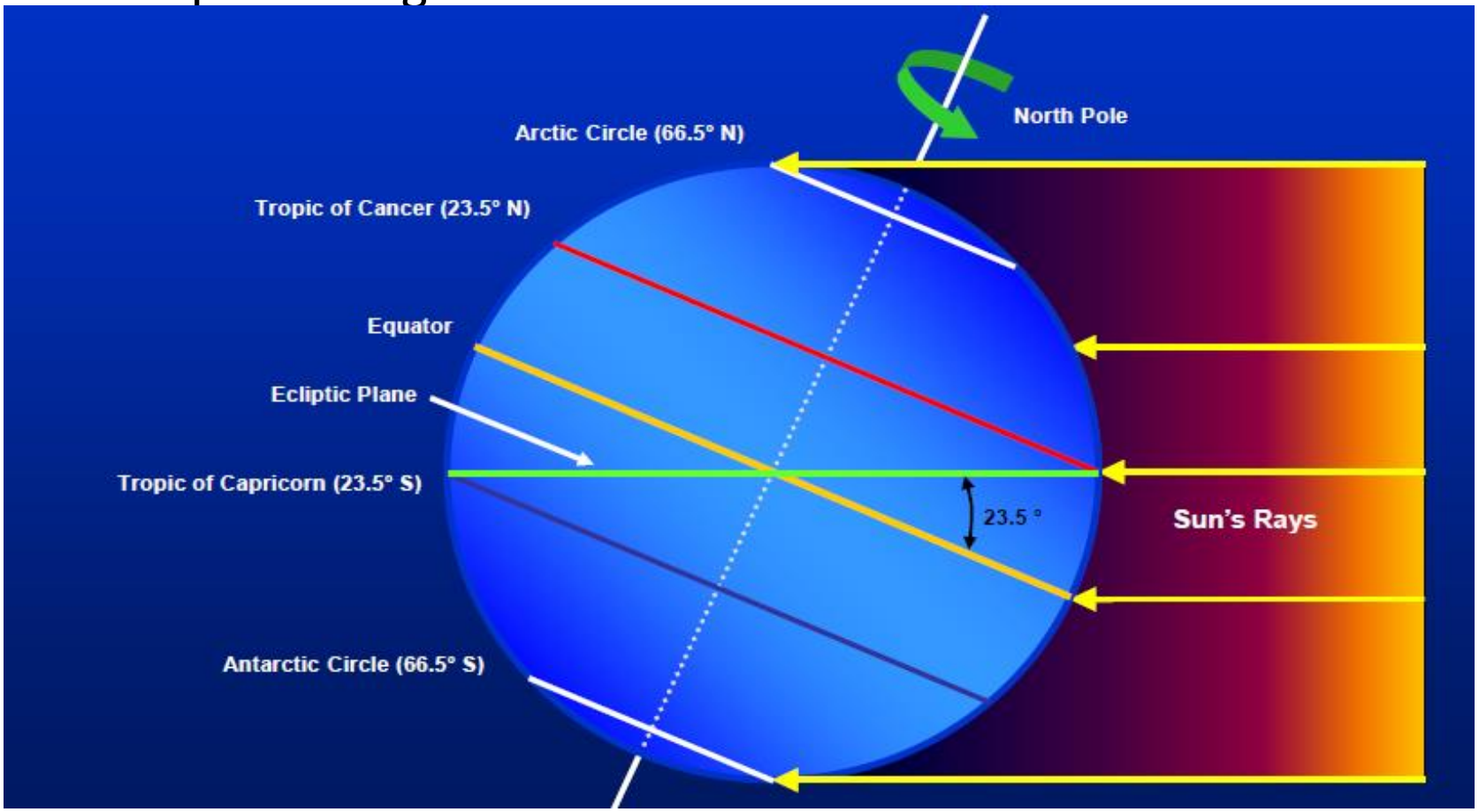
❑ **The summer Solstice:** on June 21st, the northern hemisphere has maximum tilt towards the sun experiencing longest daylight of the year.

✓ It is the astronomical first day of summer in the Northern Hemisphere.

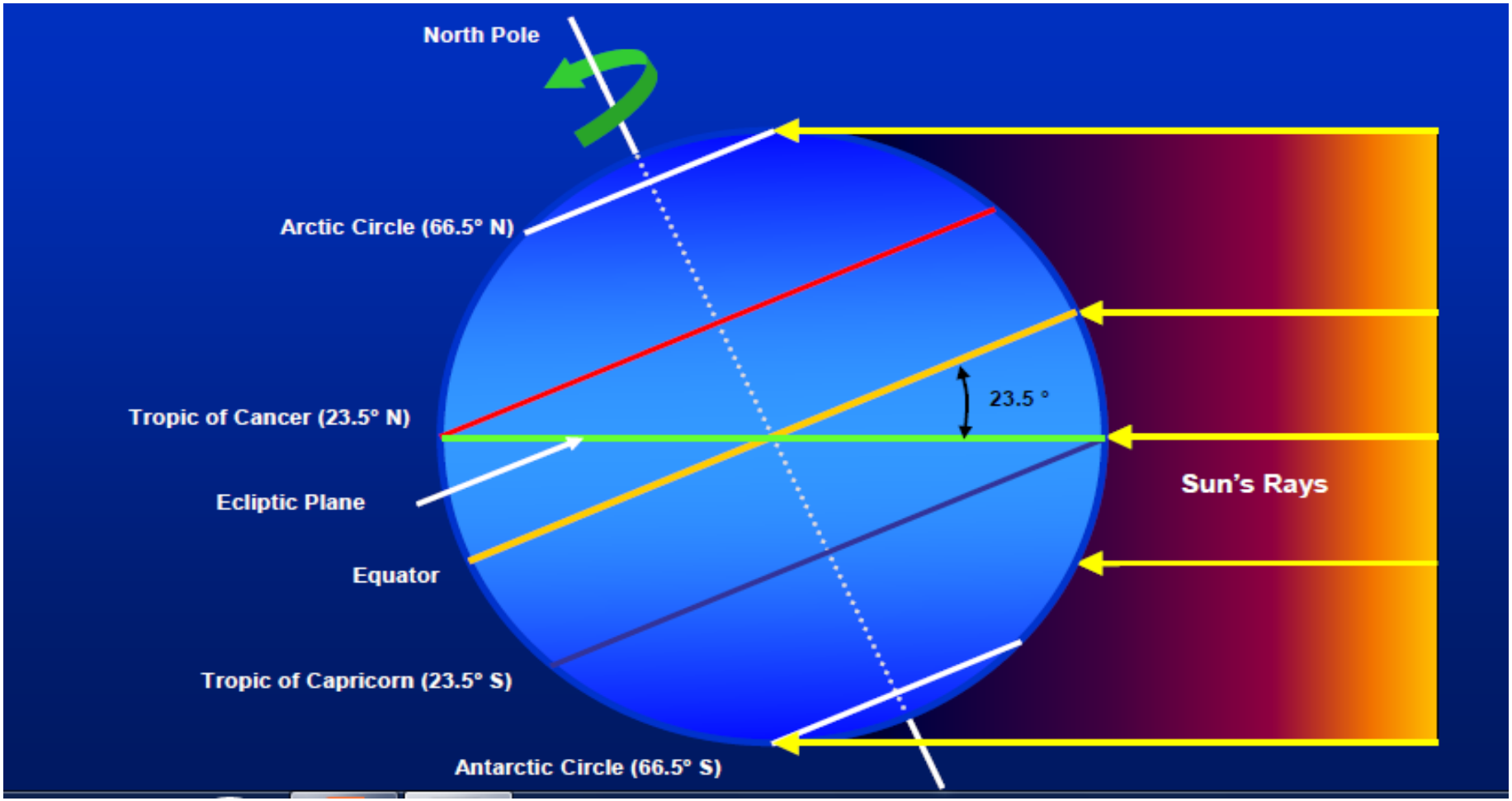
✓ The sun is at its highest position in the noonday sky, directly above 23 ½ in the Tropic of Cancer.

❑ ***The winter solstice*:** 22nd of December is the day when the maximum southward inclination is attained in the Southern Hemisphere

- In this event the sun travels shortest length causing longest night and shortest daylight.
- In the Northern Hemisphere, it occurs when the sun is directly over the Tropic of Capricorn, which is located at 23 ½ ° south of the equator. Figure 5.3 Summer Solstice



- Figure 5.3 Winter Solstice



c. Altitude

- Altitude is the height of location above the sea level. Under normal conditions there is a general decrease in temperature with increasing elevation.
- The average rate at which temperature changes per unit of altitudinal change is known as ***lapse rate***.
- The lapse rate is limited to the lower layer of the atmosphere named as troposphere.
- The normal lapse rate is 6.5°C per kilometer rise in altitude.

Types of lapse rate

- Three types of lapse rates are identified;

i. Dry adiabatic laps rate

- The temperature changes occurring in the rising or subsiding air mass are not the result of additions of heat to, or withdrawals of heat from outside sources

- the consequence of internal processes of expansion and contraction is known as adiabatic temperature change.
- An adiabatic lapse rate is the rate at which the temperature of an air parcel changes in response to the expansion or compression process associated with a change in altitude.
- Vertical displacements of air are the major cause of adiabatic temperature changes.
- When air rises, it expands because there is less weight of air upon it.
- if the upward movement of air does not produce condensation, then the energy expended by expansion will cause the temperature of the mass to fall at the constant *dry adiabatic lapse rate.*
- The rate of heating or cooling is about 10°C for every 1000 m of change in elevation.
- This rate applies only to unsaturated air, and thus it is called the *dry adiabatic laps rate.*

ii. Wet Adiabatic laps rate

- due to the latent heat in the water vapor carried by the air.
- 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 at the moist adiabatic rate because evaporation of the liquid droplets would start the rate of compressional warming.
- Prolonged cooling of air invariably produces condensation, thereby liberating latent heat. 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 ***50c per 1000*** *meters ascend.*

iii. Environmental lapse rate or Atmospheric lapse late

- refers to the actual, observed change of temperature with altitude.
- The fact that air temperature is normally highest at low elevations next to the earth and decreases with altitude.
- indicates that most of the atmospheric heat is received directly from the earth's surface and only indirectly from the sun.
- This decrease in temperature upward from the earth's surface normally prevails throughout the lower atmosphere called troposphere.
- The principal exception to the rule is the cause of temperature inversions. The rate of change is ***6.50C/1000 meters.***

5.3. Spatiotemporal Patterns and Distribution of Temperature and Rainfall in Ethiopia

5.3.1. Spatiotemporal Distribution of Temperature

- Altitude is an important element in determining temperature of Ethiopia and the Horn.
- Latitude, humidity and winds, with varying magnitude have also significant impacts on temperature conditions in Ethiopia.
- The spatial distribution of temperature in Ethiopia is primarily determined by altitude and latitude.
- The location of Ethiopia at close proximity to equator, a zone of maximum insolation, resulted for every part of the country to experience overhead sun twice a year.
- But Ethiopia, as it is a highland country, tropical temperature conditions have no full spatial coverage.

- temperature, as it is affected by altitude, decreases towards the interior highlands.
- Mean annual temperature varies from over 30 0Cin the tropical lowlands to less than 100c at very high altitudes.
- The highest mean maximum temperature in the country is recorded in the Afar Depression.
- ***Table 1: Temperature versus Altitude***

Altitude (meter)	*Mean annual Temp (^{0}C)*	*Description*	*Local Equivalent*
3,300 and above	*10 or less*	Cool	*Wurch*
2,300 - 3,300	*10 – 15*	Cool Temperate	*Dega*
1,500 - 2,300	*15 – 20*	Temperate	*Woina Dega*
500 - 1,500	*20 – 25*	Warm Temperate	*Kola*
below 500	*25 and above*	Hot	*Bereha*

Source: MoA, 2000

- 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.
- In Ethiopia, as in all places in the tropics, the air is frost free and changes in solar angles are small making intense solar radiation.

- Ethiopia's daily temperatures are more extreme than its annual averages.
- Daily maximum temperature varies from a high of more than 37°C over the lowlands in NE and SE to a low of 10°C-15°C over the NW and SW highlands.
- In Ethiopia and elsewhere in the Horn, temperature shows seasonal variations. For EX., months from March to June in Ethiopia have records of highest temperatures.
- Conversely, low temperatures are recorded from November to February.

5.3.2. Spatiotemporal Distribution of Rainfall

- Rainfall system in Ethiopia is characterized by complexities.
- To encompass the system, it needs an understanding of the position of Inter Tropical Convergence Zone (ITC), pressure cells, and Trade Winds.
- the rainfall system in Ethiopia is characterized by spatial and temporal variabilities.
- Rainfall in Ethiopia is the result is influenced by the position of Intertropical Convergence Zone (ITCZ).
- The convergence of Northeast Trade winds and the Equatorial Westerlies forms the ITCZ, which is a low-pressure *zone.*
- Following the position of the overhead sun, the ITCZ shifts north and south of the equator.

- As the shift takes place, equatorial westerlies from the south and southwest invade most parts of Ethiopia bringing moist winds.
- Following the directness of the Sun in March and September around the equator, the ITCZ shifts towards equator.
- During this time, the central highlands, southeastern highlands and lowlands receives rainfall as the south easterlies bring moist winds.

Seasonal or Temporal Variabilities

- The rainfall is highly variable both in amount and distribution across regions and seasons.
- The temporal variabilities of rainfall are characterized by;

- The temporal variabilities of rainfall are characterized by;
- ***i. Summer (June, July, August)***

- From mid-June to mid-September, majority of Ethiopian regions, except lowlands in Afar and Southeast, receive rainfall during the summer season as the sun overheads north of the equator.
- High pressure cells develop on the Atlantic and Indian Oceans around the tropic of Capricorn, the *Indian Ocean* is also source of rainfall
- During this season, Ethiopia and the Horn come under the influence of the Equatorial Westerlies (Guinea monsoon) and Easterlies.

II. Autumn (September, October and November)

- **Autumn** is the season of the year between summer and winter.
- The exact position of the ITCZ changes over the course of the year, oscillating across the equator.
- In autumn the ITCZ shifts towards the equator weakening the equatorial westerlies.
- During this season, the south easterlies from Indian Ocean showers the lowlands in southeastern part of Ethiopia.

iii. Winter (December, January and February)

- During this season, northeasterly winds originating from the landmass of Asia dominantly prevail Ethiopian landmass.

- The northeasterly winds crossing the Red Sea carry very little moisture and supplies rain only to the Afar lowlands and the Red Sea coastal areas.

iv. Spring (March, April and May)

- The shift of the ITCZ, results in longer days and more direct solar radiation providing warmer weather for the northern world.
- the effect of the northeast trade wind is very much reduced.
- Conversely, the south easterlies from the Indian Ocean provide rain to the highlands of Somalia, and to the central and southeastern lowlands and highlands of Ethiopia.

Rainfall Regions of Ethiopia

- four rainfall regions can be identified in Ethiopia and the Horn. These are:

  ***i.* Summer rainfall region**

- comprises almost all parts of the country, except the southeastern and northeastern lowlands.
- most of its rain during summer (kiremt), while some places also receive spring (Belg) rain.
- The region is divided in to dry and wet summer rainfall regions.
- the wet corresponds to the area having rainfall of *1,000 mm* or more.
- The High altitudes and the windward side experience such rainfall amount.