

CHAPTER FIVE

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. In addition, because of 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

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- The climate of Ethiopia is therefore mainly 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.

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- Weather parameters are measured using various instruments. In general, the weather that impacts the surface of the Earth and those that live on the surface takes place in the troposphere.
- ***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. Climate also takes into account the extremes or variations that may occur beyond the average conditions.

5.2 Elements and Controls of Weather and Climate

- All weather conditions may be traced to the effect of the Sun on the Earth. Most changes in weather involve large scale horizontal motion of air which is called wind. Weather is expressed by a combination of several elements. Here are lists of major elements and controls of weather and climate. The climate of a region is ultimately determined by the radiation, its distribution and temporal fluctuations. The long-term state of the atmosphere is a function of a variety of interacting elements.

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Elements	Controls
Temperature	Latitude
Precipitation and humidity	Altitude/Mountain barriers
Wind and air pressure	Distance from the sea/Land and water distribution
	Winds and air pressure
	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. Moreover, the global climate system and any changes that occur within it also influence local climate

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- Hotness or coldness, rainy or cloudiness, sunniness, windiness or calmness, of air you are feeling on the daily base in your current location are expressions of weather. Now the question one should inquire here is what determines the variations in weather and climate between places and seasons. Hence, these determining factors are called *controls of weather and climate or climatic controls*. Some of the major controls are discussed below.

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- 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. Ethiopia's latitudinal location has bearings on its temperature.

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- 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.*

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- **b) Inclination of the Earth's Axis**
- The earth's rotation axis makes an angle of about $66\frac{1}{2}^{\circ}$ with the plane of its orbit around the sun, or about $23\frac{1}{2}^{\circ}$ from the perpendicular to the ecliptic plane. This inclination determines the location of the Tropics of Cancer, Capricorn and the Arctic and 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 directness of the sun and differences in length of day and seasons.

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- ***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. Moreover, 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';

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- ***The Vernal (spring) equinox:*** is the day when the point of verticality of sun's rays crosses the equator northwards. This equinox experiences in Northern 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

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- ***The Autumn equinox:*** appears to 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.

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- ***Solstice*** is an event when the overhead sun appears to cross northern or southern points relative to the celestial equator 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.

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- ***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 $23\frac{1}{2}$ in the Tropic of Cancer

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- ***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 $23\frac{1}{2}^{\circ}$ south of the equator

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- 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 lapse 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, but rather are the consequence of internal processes of expansion and contraction. This 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.

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- 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. Thus, if a mass of dry air at sea level rises to an altitude of about 18,000ft (5486.22 meters), the pressure upon it is reduced by nearly half and consequently its volume is doubled. As long as the air in the parcel is unsaturated (the relative humidity is less than 100 percent), the rate of adiabatic cooling or warming remains constant.

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- More precisely, 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 lapse rate*.

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- ***ii. Wet Adiabatic lapse rate***
- Due to the fact that the heat added during condensation starts cooling following the expansion, the air will no longer cool at the dry adiabatic rate. This is 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.

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- Hence, the rate at which rising or sinking saturated air changes its temperature is less than the dry adiabatic rate. 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 ***5°C per 1000 meters ascend.***

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- iii. ***Environmental lapse rate or Atmospheric lapse rate***
- This 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 clearly indicates that most of the atmospheric heat is received directly from the earth's surface and only indirectly from the sun.

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- But the lower layer is warmer, not only because it is closest to the direct source of heat but also of its high density. It contains more water vapor and dust, which causes it to be a more efficient absorber of earth radiation than is the thinner, drier, cleaner air aloft.
- 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 ***6.5°C/1000 meters.***

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

- 5.3.1Spatio -temporal 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.

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- 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. However, in Ethiopia, as it is a highland country, tropical temperature conditions have no full spatial coverage. They are limited to the lowlands in the peripheries.

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- Away from the peripheries the land begins to rise gradually and considerably, culminating in peaks in various parts of the country. Thus temperature, as it is affected by altitude, decreases towards the interior highlands. Mean annual temperature varies from over 30 °C in the tropical lowlands to less than 10°C at very high altitudes.

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- The Bale Mountains are among highlands where lowest mean annual temperatures are recorded. The highest mean maximum temperature in the country is recorded in the Afar Depression. Moreover, lowlands of north-western, western and south-eastern Ethiopian experiences mean maximum temperatures of more than 30°C.
- Environmental influences have their own traditional expressions in Ethiopia and there are local terms denoting temperature zones as shown in the table below:

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- distribution of Ethiopian temperature is characterized by extremes. The major controls determining its distributions are latitude and cloud cover. However, some parts of the country enjoy a temperate climate. 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

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- 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 northeast and southeast to a low of about 10°C-15°C over the northwestern and southwestern highlands. The variation in the amount of solar radiation received daily is small throughout the year. As already explained, temperature is high during the daytime in some places, and is considerably reduced at night resulting maximum difference in the daily range.

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- But in the case of monthly averages, variation is minimal and the annual range of temperature is small. This holds true in both the highlands and lowlands. In Ethiopia and elsewhere in the Horn, temperature shows seasonal variations. For example, months from March to June in Ethiopia have records of highest temperatures. Conversely, low temperatures are recorded from November to February.

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- It is not easy to observe distinct variation in temperature between seasons as the sun is always high in the tropics. However, there is a slight temperature increase in summer. Southern part of Ethiopia receives highest records of temperature in *autumn* and *spring* following the relative shift of the sun; whereas in the northern part of the country, summer season is characterized by higher temperature.

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- It has to be noted that certain seasons should have special considerations. For instance, unlike other parts of Ethiopia, the *southern and southwestern highlands* experience reduced temperature. This is because the temperature and the amount of energy reaching the surface is directly related with the directness of the sun. The direction of rain bearing winds (leeward or windward side) also determines the temperature variations in mountainous regions.

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. Thus, the rainfall system in Ethiopia is characterized by spatial and temporal variabilities.

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- 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*. The inter-annual oscillation of the surface position of the ITCZ causes a variation in the Wind flow patterns over Ethiopia and the Horn. 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.

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- However, these winds decrease the length of rainy seasons and magnitudes on the line of the shift. The shift takes place when the trade winds from the north retreat giving the space for equatorial westerlies. This development mainly happens in July in Ethiopia and the Horn causing variability and seasonality.

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- The ITCZ shifts towards south of equator (Tropic of Capricorn) in January. During this period, the Northeast Trade Winds carrying non-moisture-laden dominates the region. Afar and parts of Eritrean coastal areas experience rainfall in this period. 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 seasonal and annual rainfall variations are results of the macro-scale pressure systems and monsoon flows which are related to the changes in the pressure systems discussed in the previous sections of this chapter. The temporal variabilities of rainfall are characterized by:

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- ***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. Although, the Atlantic contributes a lot, the *Indian Oceans* is also sources of rainfall. During this season, Ethiopia and the Horn come under the influence of the Equatorial Westerlies (Guinea monsoon) and Easterlies. Hence, the *Guinea monsoon* and the *South easterly* winds are responsible for the rain in this season.

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- ***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.

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- ***iii. Winter (December, January and February)***
- In winter, the overhead sun is far south of equator. During this season, Northeasterly winds originating from the landmass of Asia dominantly prevail Ethiopian landmass. However, it has no significant coverage compared to other seasons. 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.

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- ***iv. Spring (March, April and May)***
- In this season, the noonday sun is shining directly on the equator while shifting north from south. The shift of the ITCZ, results in longer days and more direct solar radiation providing warmer weather for the northern world. In this season, the effect of the northeast trade wind is very much reduced. Conversely, the southeasterlies 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

- 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. The region is divided into dry and wet summer rainfall regions. Hence, 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.

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- ***ii.All year-round rainfall region***
- It has many rainy days than any part of the country. It is a rainfall region in the southwestern part of the country. The wetness of this region is particularly due to the prepotency of moist air currents of equatorial Westerlies called the *Guinea Monsoons*. Both duration and amount of rainfall decreases as we move from southwest to north and eastwards. Months in summer gain highest rainfall whereas the winter months receive the reduced amount. The average rainfall in the region varies from *1,400* to over *2,200 mm/year*.

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- ***iii. Autumn and Spring rainfall regions***
- The region comprises areas receiving rain following the influence of *southeasterly* winds. *South eastern lowlands* of Ethiopia receive rain during autumn and spring seasons when both the north easterlies and equatorial westerlies are weak. The south-easterlies bring rainfall from the Indian Ocean. About *60 percent* of the rain is in autumn and *40 percent* in spring. The average rainfall varies from less than 500 to 1,000 mm.
- ***iv. rainfall region***
- This rainfall region receives rain from the northeasterly winds. During the winter season, the Red sea escarpments and some parts of the Afar region receive their main rain.

5. 4. Agro-ecological Zones of Ethiopia

- As a result of the diversified altitude and climatic conditions, Ethiopia possesses diverse agro-climatic zones. These zones have traditionally been defined in terms of temperature. This system divides the nation into five major climatic zones namely *Bereha*, *Kolla*, *Woina Dega*, *Dega* and *Wurch*. A description of each of the zones is presented as follows.
- ***The Wurch Zone***
- The Wurch-zone is an area having altitude higher than 3,200 meters above sea level and mean annual temperature of less than 10°C. Mountains having typical characteristics of this zone include mountain systems of Ras Dashen, Guna, Megezez in North Shoa, Batu, Choke, Abune Yoseph etc. (see Table 5.2)

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- ***Dega Zone***
- This is a zone of highlands having relatively higher temperature and lower altitude compared to the *wurch* Zones. In Ethiopia, the Dega-zone is long inhabited and has dense human settlement due to reliable rainfall for agriculture and absence of vector-borne diseases such as malaria.
- ***Weyna Dega Zone***
- This zone has warmer temperature and moderate rainfall. It lies between 1500-2,300 meters above sea level. It is the second largest zone covering more than 26% of the landmass of Ethiopia. The temperature and rainfall of this category is highly suitable for majority of crops grown in Ethiopia. Hence, the zone includes most of the agricultural land. The *Weyna Dega* zone has also two growing seasons.

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- *Kolla Zone*

- In Ethiopia, the geographic peripheries in south, southeast, west and northeastern part are mainly in this category. Kollais the climate of the hot lowlands with an altitudinal range of 500 to 1500 meters above sea level. Average annual temperature ranges between 20°C and 30°C. Although mean annual rainfall is erratic, it can be as high as 1500 mm in the wet western lowlands of Gambella. Rainfall is highly variable from year to year. The region is boundary between the hot arid (Bereha) and the humid climates (Woina Dega).
- ***Bereha Zone***
- Bereha is the hot arid climate of the desert lowlands. The Bereha agro-climatic zone is largely confined to lowland areas with altitude of lower than 500 meters. Around Danakil depression, the elevation goes below the sea level. *Its* average annual rainfall is less than 200 mm, and average annual temperature is over 27.5°C. Strong wind, high temperature, low relative humidity, and little cloud cover usually characterize Bereha. Evapotranspiration is always in excess of rainfall. Djibouti, majority of Somalia, and coastal areas of Eritrea are categorized under Kolla and Bereha zones.

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

- Climate change refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, due to either natural variability or human activities.

- **5.5.1. Current Trends of Climate in Ethiopia**
- Current Trends of Climate in Ethiopia ***Trends in Temperature Variability***
- Over the last decades, Ethiopia has experienced climatic changes. Mean annual *temperature* has shown 0.2°C to 0.28°C rise per decade over the last 40-50 years. *A rise in average temperature of about 1.3°C has been observed between 1960 and 2006.* The rise has spatial and temporal variation. Higher rise in temperature was noted in drier areas in northeast and southeast part of the country. Notably the variability is higher in July-September. The number of 'hot days' and 'hot nights' has also shown increment. Consequently, the country's minimum temperature has increased with 0.37°C to 0.4°C per decade.

Trends in Rainfall Variability

- Precipitation has remained fairly stable over the last 50 years when averaged over the country. However, these averages do not reflect local conditions which are extremely divergent and the natural variability in rainfall in the country makes it difficult to detect long-term trends.

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- Rainfall variability is increasing (and predictability is decreasing) in many parts of the country. In some regions, total average rainfall is showing decline. For instance, parts of southern, south-western and south-eastern regions receiving Spring and Summer rainfall have shown decline by 15-20% between 1975 and 2010. This has strong implications for crop production, which becomes clear when assessing the change in areas that receive sufficient rain to support crop production.
- Changes in temperature and rainfall increase the frequency and severity of extreme events. Major floods have been a common occurrence, leading to loss of life and property in numerous parts of the country. Warming has exacerbated droughts, and desertification in the lowlands of the country is expanding.

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- 5. 5.2. **Causes of Climate Change**
- The causes of climate change are generally categorized as anthropogenic/manmade and natural causes.
- ***A. Natural Causes***
- Climate change has many natural causes, such as variations in the energy budget, the position of Earth relative to Sun, the position of continents relative to the equator, and even whether the continents are together or apart. Here are some of the major natural causes:
- ***Earth orbital changes***: The earth is tilted at an angle of 23.5° to the perpendicular plane of its orbital path. Changes in the tilt of the earth can lead to small but climatically important changes in the strength of the seasons. More tilt means warmer summers and colder winters.

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- **Energy Budget:** Although the Sun's energy output appears constant, small changes over an extended period of time can lead to climate changes. Since the Sun was born, 4.55 billion years ago, the star has been very gradually increasing its amount of radiation so that it is now 20% to 30% more intense than it was once.
- **Volcanic eruptions:** volcanic eruption releases large volumes of sulphur dioxide, carbon dioxide, water vapor, dust, and ash into the atmosphere. The release of large volume of gases and ash can increase planetary reflectivity causing atmospheric cooling.
- **A. Anthropogenic Causes**
- The growing influence of human activities on the environment is being increasingly recognized, and concern over the potential for global warming caused by such anthropogenic effects is growing. The warming of earth planet in the past 50 years is majorly driven by human

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- The industrial activities that our modern civilization depends upon have raised atmospheric carbon dioxide levels from 280 parts per million to 400 parts per million in the last 150 years. Human induced greenhouse gases such as carbon dioxide, methane and nitrous oxide have caused much of the observed increase in Earth's temperatures over the past 50 years.
- The decomposition of wastes in landfills, agriculture, ruminant digestion and manure management, synthetic compounds manufacturing, clearing of land for agriculture, industrial activities, and other human activities have increased concentrations of greenhouse gases. The major gases that contribute to the greenhouse effect include *Water vapor, Carbon dioxide (CO₂), Methane, Nitrous oxide, Chlorofluorocarbons (CFCs)*. Although, methane is less abundant in atmosphere, it is by far more active greenhouse gas than carbon dioxide.

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- 5.5.3. Consequences of Climate Change

- In many parts of the world, climate change has already caused loss of life, damaging property and affecting livelihoods. The impact of climate change is higher in low income countries, since they have limited capacity to cope with the changes. Some of the consequences of the changing climate include:
- **Impacts on human health:** The change can cause increased heat related mortality and morbidity, greater frequency of infectious disease epidemics following floods and storms, and substantial health effects following population displacement to escape extreme weather events. Climate change also raises the incidence malaria.
- **Impact on water resources:** Climate change is leading to melting of snow and glaciers that increases rise in sea level, increase drought and floods, distorts wind flow pattern, decreases water table. More frequent and longer droughts reduce the amount of run-off into rivers, streams and lakes.
- **Impact on Agriculture:** changes in temperature and rainfall patterns as well as significantly affect agricultural production. Climate change increases physiological stress and fodder quality and availability.

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- ***Impact on Ecosystem:*** climate change affects the success of species, population, and community adaptation. The rate of climatic warming may exceed the rate of shifts in certain range species, these species could be seriously affected or even disappear because they are unable to resist.
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- **5.5.4. Climate Response Mechanisms**
- *How do our forefathers react to the changing climate? Do we have any traditional (indigenous) mechanism?*
- Climate change is one of the most complex issues facing us today. So even if we stopped emitting

Mitigation and its Strategies

- Mitigation measures are those actions that are taken to reduce and control greenhouse gas emissions changing the climate. Moreover, it implies reducing the flow of heat trapping greenhouse gases into the atmosphere, either by reducing sources of these gases or enhancing the “sinks” that accumulate and store these gases (such as the oceans, forests and soil). The goal of mitigations is to avoid significant human interference with the climate system. There are some mitigation measures that can be taken to avoid the increase of pollutant emissions.
- Practice Energy efficiency
- Increase the use of renewable energy such as solar
- Efficient means of transport implementation: electric public transport, bicycle, shared cars etc.

Adaptation and its Strategies

- Throughout history, people and societies have adjusted to and coped with changes in climate and extremes with varying degrees of success. Adaptation is simply defined as adapting to life in a changing climate. It involves adjusting to actual or expected future climate. The goal is to reduce our vulnerability to the harmful effects of climate change such as extreme weather events or food insecurity. It also encompasses making the most of any potential beneficial opportunities associated with climate change (for example, longer growing seasons or increased yields in some regions).

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- Some of the major adaptation strategies include:
- building flood defenses,
- plan for heatwaves and higher temperatures,
- installing water-permeable pavements to better deal with floods and storm water
- improve water storage and use are some of measures taken by cities and towns.
- landscape restoration and reforestation,
- flexible and diverse cultivation to be prepared for natural catastrophes
- preventive and precautionary measures (evacuation plans, health issues, etc.)

CHAPTER SIX

SOILS, NATURAL VEGETATION AND WILDLIFE RESOURCES OF ETHIOPIA AND THE HORN

- **6.1. Introduction**

- The past geological process and varied climatic events ensued Ethiopia to have varied soil and biological diversity. The formation and spatial variabilities of soils in Ethiopia is largely related to topographic and climatic factors, parent material (rocks) and land use. Different parts of Ethiopian regions experiences. Likewise, the distribution of wildlife and natural vegetation in Ethiopia and the Horn is controlled by many factors important among which are *climate, soil types, drainage*, etc. Natural vegetations are vital for human beings in many ways. Plants can provide shelter, food, source of fuel, pasture and grazing, raw material for industries. Ethiopia possess unique and characteristic fauna and flora with a high level of endemicity. However, manmade as well as natural problems are threatening their availability and distribution.

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- **6.2. Ethiopian Soils: Types, Degradation and Conservation**
 - **Introduction**
- Soil is a delicate but highly varied composition of mineral particles, organic matter and living organisms in dynamic equilibrium. This variability reflects primarily the parent material from which the soil was formed over very long periods of time and the environment in which the soil has developed. *It consists of* weathered mineral materials (45%), organic matter (5%), air (20-30%) and water (20-30%).

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- Soil formation is a long-term process. It could take several thousands of years to form a single stratum of soil. As it is a complex mixture of several constituents, its formation is also more complex. The formation of a particular type of soil depends on parent material, climate, topography, living organism and time.
- Weathering disintegrates the inorganic substances (rocks) of soils. It is the breakdown of rocks at the Earth's surface, by the action of rainwater, extremes of temperature, and biological activity. There are three types of weathering involving in soil formation. These are:

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- **A .mechanical (physical) weathering**
- Physical disintegration causes decrease in size without appreciably altering composition. Differential stresses due to heating and cooling or expansion of ice break the rock. Abrasion (erosion by friction) due to water containing sediment or wind carrying debris is another type of physical weathering.
- **B.Biological weathering**
- The process of biological weathering involves the weakening and subsequent disintegration of rock by plants, animals and microbes. Roots of plant can exert pressure on rock. Although the process is physical, the pressure is exerted by a biological process (*i.e.*, growing roots). Microbial activity breaks down rock minerals by altering the rock's chemical composition, thus making it more susceptible to weathering

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- **C.Chemical weathering**
- Chemical weathering involves the modification of the chemical and mineralogical composition of the weathered material. A number of different processes can result in chemical weathering. The most common chemical weathering processes are hydrolysis, oxidation, reduction, hydration, carbonation, and solution.
- In most cases, the minerals in the parent materials are also found in the soils, which are formed from the disintegration and decomposition of the rock. However, this is not true of alluvial soils, which are transported from one place to the other by agents like running water.
- Soils have two basic properties:

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- ***Physical properties***
- Soil physical properties are influenced by composition and proportion of major soil components. Properties such as texture, structure, porosity etc. are categorized under physical soil properties. These properties affect air and water movement in the soil, and thus the soil's ability to function.
- ***Chemical Properties***
- Soil chemistry is the interaction of various chemical constituents that takes place among soil particles and in the water retained by soil. Soil properties like availability of minerals, electrical conductivity, soil pH, etc. Soil chemical properties affect soil biological activity and indirectly the nutrient dynamics.

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- 6.2.2. Major Soil Types in Ethiopia

- Soils of Ethiopia are basically derived from *crystalline, volcanic and Mesozoic* sedimentary rocks. One can therefore, say that some of the soil divisions in the country are based on the geologic structure. However, it should be born in mind that, there are soils formed due to long waited deposition of sediments.
- FAO has identified 18 soil associations in Ethiopia at scale of 1:2,000,000. Out of the major soils, 11 soil associations cover about 87.4 percent of the land area. The *six major groups of soils* in Ethiopia are discussed under the following points:
 - *A Environmental condition* i.e. parent material, climatic conditions, topography, the way they were formed.
 - *B Characteristic* i.e. significant chemical and physical properties.
 - *C Agricultural suitability* in relation to texture, structure, topography, moisture-storage capacity, etc.
 - *D Occurrence*: general location of the soil types.
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- **Nitosols and Acrisols**
- ***Nitosols*** develop on gently sloping ground. Their parent materials *include trap series volcanics, volcanic ash, and even metamorphic rocks*. They are strongly weathered soils but far more productive than most other tropical soils. They are basically associated with highlands with high rainfall and they were, probably, formed on forest covered areas originally.

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- Due to the high rainfall, there is considerable soil leaching which makes the ***nitosols*** to be poor in soluble minerals like potassium, calcium etc.; and rich in non-soluble minerals like iron and aluminum. The reddish-brown color of these soils is because of high concentration of *iron (ferric) oxides* due to leaching. But they are now widely found on cultivated areas and on mountain grasslands. ***Nitosols*** are dominantly found in western highlands (*Wellega*), southwestern highlands (*Kaffa, Illuababora*), Southern highlands, Central highlands, and Eastern highlands.

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- ***Acrisols*** are one of the most inherently infertile soils of the tropics, becoming degraded chemically and organically very quickly when utilized. Acrisols have very low resilience to degradation and moderate sensitivity to yield decline. In Ethiopia, it has lost most of the base nutrients and are characterized by low productive capacity. ***Acrisols*** are found along with *nitosols* mostly in some pockets of southwestern highlands of Ethiopia where there is high rainfall.

- **2 Vertisols**

- Vertisols are heavy clay soils with a high proportion of swelling clays when wet, and cracks when dry. These soils are extremely difficult to manage (hence easily degraded), but has very high natural chemical fertility. Vertisols mostly develop on *volcanic plateau basalt, trachyte and pyroclastic materials, sedimentary rocks, colluvial slopes and alluvial plains*. The vertisols are also soils of highlands and moderate climates. In Ethiopia, they are commonly found in parts of *Northwestern, Central and Southeastern highlands* (especially in *Gojjam, Shewa, Arsi, Bale and central Hararghe*).

- **3 *Lithosols, Cambisols and Regosol***

- These soils are mostly found in rugged topography and steep slopes. There is little evidence of *pedogenic processes* (soil forming processes). As a result, they are young, shallow and coarse textured and so have low water holding capacity. In addition, they are found in areas of low rainfall. So, most of the areas covered by these soils have limited agricultural use. They are, in most cases, left under the natural plant cover and used for grazing.
- By and large, these soils are found in different parts of rugged and steep slopes of Central Highlands, on the *Rift Valley Escarpments* and *highlands in of western Hararghe*. Regosol and Lithosols are also found in the Danakil and eastern Ogaden.

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- **4 .Xerosols, Yermosols and Solanchaks**
- These are soils of desert or dry steppe soils majorly available in arid and semiarid areas. Though the degree may vary, desert soils are characterized by high salt content and low organic content, because of the scanty vegetation. Generally speaking, these soils have poor humus content and nitrogen, but are rich in phosphorus and potash and can be very fertile if irrigated.
- Xerosols are soils of the deserts, has low organic content. These soils are extremely subjected to wind erosion and concentration of soluble salts. Yermosols are even drier and more problematic than Xerosols. Solanchaks are saline soils which develop in areas of high evaporation and capillary action. Badly managed irrigation schemes may turn soils into solonchaks.

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- In Ethiopia, Xerosols are found in Ogaden and northeastern escarpments, whereas the Yermosols and Solonchaks cover the Ogaden and Afar plains. The Solonchaks are majorly located in salty plains of Afar.
- **5 .Fluvisols**
- Fluvisols develop on flat or nearly flat ground, on recent alluvial deposits. These soils are associated with *fluvial (river)*, *marine (sea)* and *lacustine (lake)* deposits.
- These are soils formed due to deposition of eroded materials from highlands. The deposition takes place in depressions, lower valleys and lowlands. Lower regions of rivers like Omo.

- Fluvisols are highly variable, but much prized for intensive agriculture because:
- they develop on flat ground, deposition sites,
- they are associated with rivers and ground water, making them important for large-scale irrigation and
- they are fertile and their fertility is always renewed as a result of deposition of new soil materials.

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- **6 .Luvisols**

- Luvisols develop mainly in areas where pronounced wet and dry seasons occur in alternation. Where leaching is not very high, they are found in association with nitosols. Luvisols have good chemical nutrients and they are among the best agricultural soils in the tropics. So, they are intensively cultivated. However, when luvisols are found on steep slopes (stony) and on flat areas (waterlogged) they are avoided and left for grazing.

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- In Ethiopia, places with luvisols include *Lake Tana* area, parts of Northern, Central and Eastern Highlands and Southern lowlands.
- **6.2.2. Soil Degradation**
- Soil degradation is defined as a change in any or all of soil status resulting in a diminished capacity of the ecosystem to provide goods and services. It could also be the deterioration of the physical, chemical and biological properties of soil. It is a critical and growing global problem. It is a major concern for at least two reasons. First, soil degradation undermines the productive capacity of an ecosystem. Second, it affects global climate through alterations in water and energy balances and disruptions in cycles of carbon, nitrogen, sulfur, and other elements.

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- There are three major types of soil degradation. These are:
- **i .Physical Degradation:** refers to the deterioration of the physical properties of soil. This includes:
 - **A .Compaction:** densification of soil is caused by the elimination or reduction of structural pores. Soils prone to compaction are susceptible to accelerated runoff and erosion.
 - **B .Soil erosion:** is a three-phase process consisting of the *detachment of individual soil particles*, transportation and *deposition*. The continuous strike of soil surface by rain droplets considerably weakens the soil and makes it susceptible to erosion. When sufficient amount of water accumulates, the soil will begin to move towards lower slope until the erosive agent loses its energy. Erosion of topsoil by wind and water exceeds soil formation at an alarming rate. Obviously for countries like Ethiopia where agriculture plays the dominant role in the economy and livelihood of the people, the causes, consequences and possible ways of minimizing soil erosion require serious consideration. In Ethiopia, an estimated average of 42 tons per hectare of soils is eroded annually.

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- **ii. Biological Degradation**

- Reduction in soil organic matter content, decline in biomass carbon, and decrease in activity and diversity of soil fauna are ramifications of biological degradation. Because of prevailing high soil and air temperatures, biological degradation of soil is more severe in the tropics than in the temperate zone. It can also be caused by indiscriminate and excessive use of chemicals and soil pollutants.

- **iii .Chemical Degradation**

- Nutrient depletion is a major cause of chemical degradation. In addition, excessive leaching of cat-ions in soils with low-activity clays causes a decline in soil pH and a reduction in base saturation. Chemical degradation is also caused by the buildup of some toxic chemicals and an elemental imbalance that is injurious to plant growth.

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- **Causes of soil degradation**
- Soil degradation may result from natural and human-induced causes. Topographic and climatic factors such as steep slopes, frequent floods and tornadoes, storms and high-velocity wind, high-intensity rains and drought in dry regions are among the natural causes. Deforestation and overexploitation of vegetation, overgrazing, indiscriminate use of agrochemicals and lack of soil conservation practices, and over extraction of ground water are some anthropogenic causes of soil degradation.

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- **6.2.4. Soil Erosion Control Measures**
- The aim of soil conservation is to reduce erosion to a level at which the maximum sustainable level of agricultural production, grazing or recreational activity can be obtained from an area of land without unacceptable environmental damage. Since erosion is a natural process, it cannot be prevented. But it can be reduced to a maximum acceptable level or soil loss tolerance.
- We have two major soil erosion control mechanisms. These are:
 - **A. Biological Control measures**
 - These types of soil erosion control mechanisms include vegetative strips, plantation, and reforestation. Biological controls can prevent splash erosion, reduces the velocity of surface runoff, increases surface roughness which reduces runoff and increases infiltration, and etc.

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- **B .Physical control measures**
- Physical measures are used to control the movement of water and wind over the soil surface. The major types of physical erosion control measures commonly applied in Ethiopia includes terracing, check dams, gabion, trenches, contour ploughing, soil bunds etc.

6.3. Natural Vegetation of Ethiopia

- **6.3.1.Introduction**

- *Natural vegetation* refers to a plant cover that develops with little or no human interference. It can also be seen as any original plant cover grown in an area. Its distribution on the surface of the earth is uneven majorly controlled by factors such as *climate, soil types, drainage*, etc. However, to a large extent, temperature and precipitation affect the spatial distribution and the original plant cover of a region. That is why, more than any other single element, the natural vegetation of an area becomes a very good indicator of the climatic conditions.

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- Natural vegetations are vital for human beings in many ways. Plants can provide shelter, food, source of fuel, pasture and grazing, raw material for industries, source of timber and non-timber products. The other uses include moderating effect on local climate, as home of wild life, medicinal values, minimizing soil erosion etc.
- The characteristics of Ethiopia's natural vegetation are to a large extent determined by elevation (and temperature) and rainfall. In Ethiopia, since temperature is mostly controlled by elevation, the spatial distribution of natural vegetation in the country is strongly correlated to it.

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- Lowlands due to their low rainfall and high temperature have harsh environment and are characterized by *xeromorphic* plants (plants which are adapted to drought and high temperatures). Highlands (up to about 3000 m) are cooler than the lowlands and where there is adequate moisture a variety of forests can be seen. Plants whose growth is limited by the low temperature characterize high altitude areas (mostly above 3000 m). Ethiopia possesses an estimated number of 6000 species of higher plants of which 10% are endemic.

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- **6.3.2. Major Natural Vegetation Types of Ethiopia**
- Taking altitude into consideration it is possible to broadly classify the vegetation belts of Ethiopia into the following five groups.
- ***a) Afro-alpine and sub-afro alpine Region***
- ***b) Forest Region***
- ***c) Woodland Savannah Region***
- ***d) Steppe Region***
- ***e) Semi-desert Region***
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- **1 .Afro-alpine and Sub-afro alpine Region**
- Ethiopia has the largest extent of Afro-alpine and sub afro-alpine habitats in Africa. This vegetation type, also known as high mountain vegetation is similar to the Alpine vegetation in temperate regions. These ecosystems are found on mountains having an elevation ranging between 3,200 and 4,620 meters above sea level. The Afro-alpine habitat covers nearly 1.3% of the total landmass of Ethiopia.

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- **The Afro-alpine** region is found at very high altitudes (4,000 – 4,620 m). Like any other landform in Ethiopian, the climate of Afro-alpine ecosystems is controlled by latitude and altitude. The annual precipitation which ranges between 800 and 1,500 mm, is mostly in the form of sleet or snow. Temperature records of 0°C and below are widely experienced in these ecosystems. Soils in this ecosystem are mostly shallow and eroded. The Bale and Semein mountains are typical examples of afro-alpine vegetations.

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- Compared to the Afro-alpine, the **Sub-afro-alpine** region is found at a lower elevation, roughly between 3,300 and 4,000 meters. As a result, the plants in this region are adapted to somewhat less extreme environment than the **Afro-alpine**.
- Vegetation in the Afro-alpine region consists of tussock grasslands, scrub, scattered mosses and lichens while the Sub-afro alpine region is dominated by woodland, often degraded to scrub stages and also wet grasslands. *Lobelia rhynchopetalum* (gibbera) and *Erica arborea* (Asta) are some of the dominant species in the Afro-alpine and Sub-afro alpine regions respectively.

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- **2 .Forest Region**
- Forest is a complex ecosystem consisting predominantly of trees that shield earth and support numerous life forms. Not all forests are similar in terms of species composition, structure and physiognomy. In any geographical region, environmental factors such as climate, soil types, topography and elevation determine the types of forests.
- In Ethiopia, forests are found at different elevations, 450 to 3,500m in humid parts

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- These wide variations in rainfall and altitude result in two broad classification of forests: Highlands and Lowland forests. Highland forests include Hagenia Abyssinia (*Kosso*), Juniper procera (*tid*), Arundinaria Alpina(*kerkha*), Podocarpus falcatus (*zigba*), Aningeria adolfi-friedericicii (*keraro*) and Olea africana (*Weyra*) forests; while Baphia are classified as lowland forests. Moreover, there are also *Gallery (Riverine) Forests*. These are forests that stretch along the banks of the lower courses of rivers. Riverine forests are classified as lowland forests and are found in some places such as the banks of Awash, Wabishebelle, Ghenale etc. Dominant species include Ficus sur (*sholla*) and different kinds of acacia trees.

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- **3. Woodland Savannah Region**
- Like the forests, the woodland savannahs are also found in areas of wide altitudinal ranges (250 to 2,300 m). Although the mean annual rainfall ranges between 200 and 1,400 mm, the large part of this region is found at a lower elevation and in a drier environment. The plants in the woodland savannah are known for their xeromorphic characteristics like shading of leaves during the dry season. Vegetation types with intermediate characteristics between savannahs and woodlands are shrublands and bushlands. Woodland savannah region can be broadly classified into three divisions:

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- ***Juniper procera*** (*tid*) is dominant species for both the Junipers Forests and Junipers Woodlands. The difference is in height: 3 - 45 meters tall in the forests and 10 -15 meters in the woodlands.
- ***Acacia woodlands*** are dominated by both trees and shrubs, which belong to the same genus 'Acacia'. E.g. ***Acacia etbaica***(*grar*),***Acacia mellifera*** (*Konter*).
- ***Mixed deciduous woodlands***: As the name implies, most of the trees in ***mixed deciduous woodlands*** shed their leaves during the dry season.(see Table 6.2)

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- **4 .*Steppe and Semi Desert Regions***
- These are regions in the arid and semiarid parts of the country where the temperature is very high and the rainfall very low. Both are found at low elevations, the steppe at elevations of *100 to 1,400* m above sea level and the semi-deserts at *130 meters* below sea level to 600 meters above sea level.
- The steppe gets a mean annual rainfall of 100 to 550 mm as compared to 50 to 300 mm for the semi desert areas. Growing period lasts up to 2 months for the steppe and a maximum of one month for the semi-deserts. Even though there is a variation in the degree of alkalinity and salinity; soils in both regions are generally alkaline and saline.

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- In these regions xerophytic (i.e. drought-resisting plants) are the dominant vegetations. Xerophytic plants such as short shrubs, scattered tufts of grass species and a variety of acacias are some of the examples. Where there are moist soils, rich vegetation of acacia and palm trees may be observed. Trees are normally restricted to fringes along watercourses

- **6.3.3. Natural vegetation Degradation**

- Over the past century, a rapid growth of the already dense Ethiopian population has led to overexploitation of the land. In areas with settled agriculture, new land has been cleared at the expense of forests. Ethiopia's forest resources have been disappearing at an alarming rate. A century ago, forests covered about 40 percent of the total land area. For the last few decades, forests have been cleared for different reasons. Major causes for the gradual disappearance of the natural vegetation in Ethiopia are:
 - Clearing of forests for cultivation
 - Timber exploitation practices
 - Charcoal burning and cutting for fuel
 - Extensions of coffee and tea production areas
 - Overgrazing
 - Expansion of settlements both rural and urban, and clearing for construction

- **6.3.2. Natural Vegetation Conservation**

- Conservation of biodiversity is protection and management of biodiversity so as to maintain at least its current status and derive sustainable benefits for the present and future generation. There is an urgent need of conservation of the ever-degrading biodiversity. There are three main approaches of biodiversity conservation:
- **Protection:** through designation and management of some form of protected area. Protected areas include sanctuaries, national parks, and community conservation areas.
- **Sustainable forest management:** involving sustainable harvesting of forest products to provide a source of financial income
- **Restoration or rehabilitation:** is the process of assisting the recovery of a forest ecosystem that has been degraded, damaged, or destroyed. This may involve the re-establishment of the characteristics of a forest ecosystem, such as composition, structure, and function, which were prevalent before its degradation.
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- **6.4. Wild Life/wild animals in Ethiopia**

- 6.4.1. Introduction**

- Ethiopia is one of the few countries in the world, which possess unique and characteristic fauna with a high level of endemism. Existence of wide range of ecosystems endowed Ethiopia with great varieties of habitats contributing for the occurrence of high faunal diversity. However, data on faunal resource of the country is as a whole is limited to mammals, birds, reptiles, amphibians and a few groups of arthropods.

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- Ethiopia has about 860 avian species (16 endemic species and two endemic genera), 279 species of mammals (31 endemic species and six endemic genera), 201 species of reptiles (14 endemic species), 23 species of amphibians (23 endemic species), and 150 freshwater fish (6 endemic species).
- A total of 279 mammalian species of which 31 are endemic are known to occur in Ethiopia including those that require urgent conservation action i.e. Walia Ibex (*Capra walie*), Gelada Baboon (*Theropithecus gelada*), Mountain Nyala (*Tragelaphus buxtoni*), Ethiopian Wolf (*Canis simensis*), Starck's Hare (*Lepus starcki*).

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- Generally speaking, the main wild life concentrations in the country occur in the southern and western parts. The wild animals in Ethiopia can be classified into five major groups:
- 1 .Common wild animals (those animals that are found in many parts of the country (e.g. *hyenas, jackals*)
- 2. Game (lowland) animal, (which include many *herbivores like giraffes, wild asses, zebras etc. and carnivores like lions, leopards, and cheetahs*)
- 3 .Tree animals or arboreals (which include *monkeys, baboons*)
- 4 .A variety of *birds* in the Rift Valley lakes
- 5 .Rare animals (*gelada baboon and Semien fox*) scattered in highlands; *walia- ibex* in the Semien Massifs, *Nyala* in the Arsi Bale massifs).
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- **6.4.2. Wildlife Conservation**
- *What are the challenges of wildlife conservation in Ethiopia?*
- Wildlife plays an important role in several ways. The importance of wildlife can be categorized as ecological importance, economic importance, investigatory importance, conservation of biological diversities etc. Wild animals can be used for:
 - scientific and educational researches (valuable information for medical purposes and environmental studies)
 - physical and mental recreation (aesthetic value)
 - promotion of tourism (economic value)

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- To prevent the destruction of wildlife a total area of *nearly 100,000* square kilometers of national parks, sanctuaries, community conservation areas, botanical gardens, wildlife reserves etc. have been established in different part of the country. Hence in Ethiopia there are:
- 21 major national parks (see Table 6.2),
- 2 major wildlife sanctuaries,
- 3 wildlife reserves,
- 6 community conservation areas,
- 2 wildlife rescue centres,
- 22 controlled hunting areas,
- 2 botanical gardens, and 3 biosphere reserves

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- Even though the number and the predominant animals may vary, many of the national parks in Ethiopia have different turnovers of animals. These include buffaloes, zebras, lions, elephants, ostriches, giraffes, oryx, African wild asses, etc. (Table 6.2: National Parks of Ethiopia, page 80 module)

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- Some of the national parks are unique in their wild animals they have. E.g.
- ***Abiyatta-Shalla lakes National Park*** is predominantly bird sanctuary. Important bird species include the flamingos and pelicans.
- ***Omo, Mago, and Gambela National Parks*** have hippopotamus and crocodiles in rivers and lakes.
- ***Semien and Bale Mountains National Parks*** have rare animals like *Walia ibex*, *Semien fox*, *gelada baboon* and *Nyala*.
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- 6.4.3. Challenges of wildlife conservation in Ethiopia.
- Limited awareness on the importance of wild life
- Expansion of human settlement in protected areas.
- Conflict over resource
- Overgrazing (fodder and wood)
- Illegal wildlife trade
- Excessive hunting
- Tourism and recreational pressure
- Mining and construction material extraction
- Forest fire
-