Unit 2

THE PHYSICAL ENVIRONMENT OF THE WORLD AND ETHIOPIA

Unit Outcomes

After completing this unit, you will be able to:

- understand the origin of the earth and its tectonic movements.
- describe the movement, composition of the earth and components of its physical environment.
- discuss climate classification, change and climate of Ethiopia.
- Explain factors that affect the diversity of Fauna and Flora and soil in the ecosystem.

Main Contents

2.1 THE EARTH IN THE UNIVERSE

At the end of this section, you will be able to:

- discuss the concept of universe
- identify the position of the earth in the solar system
- explain the origin of the earth
- demonstrate the structure of the earth
- describe the geological time scale and major geological events
- realize the major geological events of Ethiopia
- describe the concept of continental drift theory.
- describe the characteristics of each type of rocks.
- demonstrate major rock distribution in Ethiopia
- state causes and impacts of soil degradation in Ethiopia.

Key Terms

- Universe
- Solar system
- Era
- Galaxy
- Geological time scale
- Plate tectonics
- Period
- Lithosphere
- Plate boundary
- Continental drift
- Plate

Start-up Activity

Discuss the following questions.

1. What do you understand about the universe and solar system?
2. What is the solar system?
3. In which galaxy is the earth located?

The universe is the totality of space and cosmos, in which everything is found. All heavenly bodies, including all stars, together with the sun, comets, meteors, planets and their satellites are found in the very vast space called the **universe**.

A **galaxy** is a large group of stars. The universe contains many galaxies. The Milky Way is our galaxy. Within the Milky Way is our solar system. A **solar system,** is a smaller group of heavenly bodies, which includes the sun at the center and the nine planets and their satellites and asteroids.

Activity 2.1

Fill in the blank spaces with the appropriate words or phrases.

1 The star from which we get light and heat is the _____.

2 The galaxy, of which our solar system is part, is _____.

2.1.1 The Origin and Structure of the Earth

The Origin of the Earth

Why is earth special?

The earth's origin is related to the process of formation of the solar system. Some scientists believe that the solar system, of which the earth is part, formed from a large flammable of hot whirling gases. The flammable was loosely packed gases, largely hydrogen and helium, and dust particles about 4.6 billion years before the present. The gases and dust particles gradually drew together because of gravitational pull and formed a thin disc. The disc, in due course, split into rings and kept spinning. The spinning rings at the center formed the sun, while the outer rings resulted in the formation of the nine planets, including the earth.

The earth is one of the nine planets that, along with the others, revolves around the sun. The orderly nature of our solar systems leads most researchers to conclude that the earth and the other planets formed at the same time and from the same material as the sun.

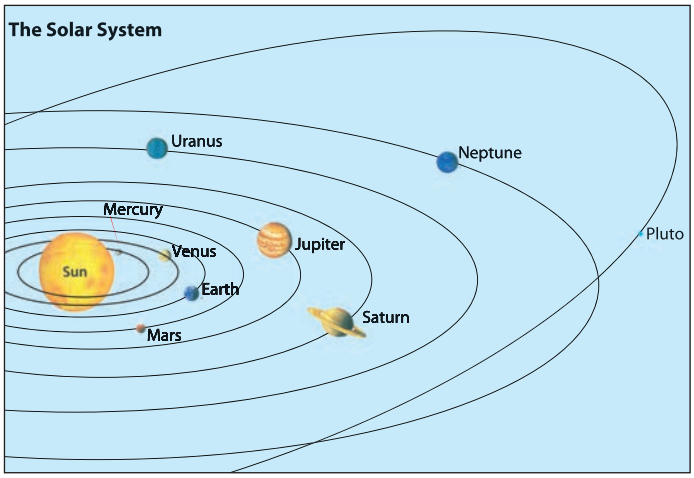


Figure 2.1: **The Solar System**

The solar system is the sun and the objects that are traveling around it. The objects around the sun include nine planets. Planets are objects that travel around a star in a path. That path is called an orbit.

The Structure of the Earth

Is the Earth a solid planet? Liquid? Gas?

Human lives on the surface of a globe that has a radius of nearly 6500 km, yet no one has ever penetrated more than a few kilometers below the solid earth. Geophysicists have inferred that the earth is composed of a great central core and a series of surrounding layers, known collectively as the mantle, and the crust (Figure 2.2).

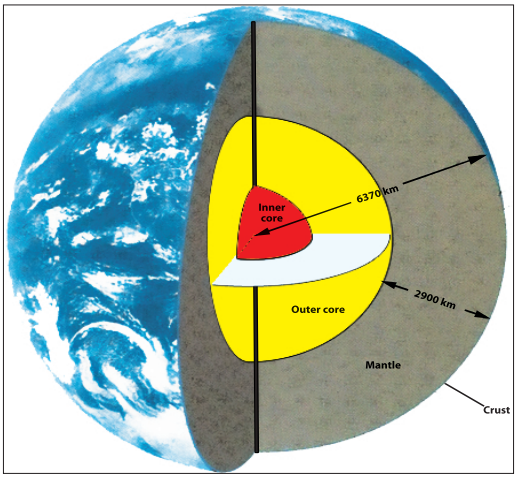


Figure 2.2: **Different layers of the earth's interior (***after Tarbuck Lutgens, 2005***)**

The Earth's Crust

The crust is the outermost and thinnest layer. Because it is relatively cool, the crust consists of hard, strong rock. Crust beneath the oceans differs from that of continents. Oceanic crust is between 4 and 7 kilometers thick and is composed mostly of dark, dense basalt. In contrast, the average thickness of continental crust is about 20 to 40 kilometers, although under mountain ranges it can be as much as 70 kilometers thick. Continents are composed primarily of light-colored, less dense granite. Relative to its size, Earth's crust is about as thin as an apples skin about 0.01 percent in volume.

The Mantle

The mantle lies directly below the crust. It is almost 2900 kilometers thick and makes up 80 - 84 percent of the earth's volume. Although the chemical composition is similar throughout the mantle, the earth's temperature and pressure increase with depth. These changes cause the strength of mantle rock to vary with depth, and thus they create layering within the mantle.

The Core

The core is the innermost layer of the earth. It is a sphere with a radius of about 3470 kilometers, and is composed largely of *iron and nickel*. The outer core is molten because of the high temperature at the center of the core. The core's temperature is about 6000°C, which is as hot as the sun's surface. The pressure is more than 1 million times that of the earth's atmosphere at sea level. The extreme pressure compresses the inner core into a solid, despite the fact that it is even hotter than the molten outer core. About 15 percent of Earth's volume is an iron - nickel core the size of Mars.

Activity 2.2

I Match the items in column A with items in column B.

	A		B
1	Crust	a	Continental crust
2	Mantle	b	2900 kilometers
3	Molten	c	Largely iron and nickel
4	Basalt	d	Magma
5	Core	e	the thinnest layer
6	Granite	f	Oceanic crust

II Answer the following questions:

7 Which layer constitutes about 80 percent of the volume of the earth?
8 In which part of the earth are you living?
9 Which layer of the earth account about 15% of the earth's volume?
10 What makes the mantel develop different layers?
11 What is the solar system?
12 How many degree Celsius the core temperature measured?

2.1.2 The Geological Time Scale and Major Geological Events

What is the geological time scale? How old is the earth? When did life first evolve?

The geological time scale is a record of earth's history, starting with earth's formation about 4.5 billion years before the present. Numbers on the time scale represent time in millions of years before the present.

Geologists have divided the earth's history into four major **eras** and each era into a number of **periods,** to which specific names have been assigned. The periods are further divided into **epochs**. The scheme of subdivisions is based upon various aspects and events of the earth's history, such as widespread occurrences of strong tectonic activity, the appearance or disappearance of particular forms of life, or extensive changes in environmental conditions. The eras are major divisions of the geological time scale. They are defined based on differences in the life forms that existed.

There are four eras:

- *The Precambrian*
- *The Paleozoic, whose name means ancient life*
- *The Mesozoic, or middle life*
- *The Cenozoic, or recent life*

The *periods*, which are subdivisions of eras, are defined in the same manner, based on differences in the life forms that existed. The periods of the Cenozoic are divided into *epochs*.

The Precambrian Era

When did the Precambrian era take place?

The Precambrian era is the longest geological time unit of Earth's history. It comprises 88% of the geological time scale. It lasted from 4.5 billion to about 600 million years before the present.

Little is known about the earth and the organisms that lived during this era. Rocks have been buried deeply and changed by heat and pressure. The Precambrian rocks formed foundation rocks in many parts of the world. Because of great pressure and heat, they transformed from either sedimentary deposits or volcanic origin rock types to metamorphic type rock, which is crystalline in nature.

The Paleozoic Era

What is the major event of the paleozoic era?

The beginning of the Paleozoic era is marked by the presence of the first organisms, ancient life with hard parts. This era began about 600 million years ago. Warm shallow seas covered much of earth's surface during the early Paleozoic era. Because of this, most of the life forms were of marine origin (lived in oceans).

The Mesozoic Era

Which animal species was dominant in the Mesozoic era?

The Mesozoic era, the era of "middle" life, began about 250 million years before the present. At the beginning, all continents were joined as a single land mass that we call **Pangaea**. It separated into two large land masses during the Triassic period. The northern mass and southern mass, respectively, were **Laurasia** and **Gondwanaland**. Reptiles were the dominant animal life form in the Jurassic period.

Figure 2.3: **The breakup of Pangaea over 200 million years (***After Tarbuck and Lutgens, 2005***)**

The Cenozoic Era

What is unique about the Cenozoic era?

The Cenozoic era is the era of recent life, which began about 70 million years ago, when dinosaurs and many other life forms became extinct. Many of the mountain ranges began to form. The climate became cooler, and ice ages occurred.

The present-day period is the Quaternary. We live in the Holocene epoch, which began after the last ice age. Our species, *Homo Sapiens*, probably appeared about 500,000 years ago, but became a dominant animal only about 10,000 years ago.

2.1.3 Geological events in Ethiopia

What do you know about geological events in Ethiopia? What happened during the cenozoic era in Ethiopia?

The whole of Africa essentially consists of a basement of ancient crystalline rock. During the Precambrian era, Ethiopia was made up of huge mountains which were folded and faulted. During the Paleozoic era, the land was greatly affected by persistent denudation (erosion) and peneplanation. In many parts of Ethiopia, there was no significant rock formation in this era.

At the beginning of the Mesozoic era, the land surface sank, very slowly. As a result, the sea invaded the land from the southeast towards the northwest. In this process, layers of sandstone and limestone were deposited, one over the other. The layers of sandstone, referred to as **Adigrat sandstone,** were formed first, followed by deposition of layers of limestone called **Hintalo limestone**. Gradually, the landmass which was under the sea started uplifting, and the land emerged out of the sea toward the end of Mesozoic era. Following this, the sea started to retreat in the southeast direction, and it deposited other layers of sandstone called **Upper sandstone.** Hence, by the end of the Mesozoic era, many parts of Ethiopia were covered by the three layers of Mesozoic marine sediment.

During the *Cenozoic era*, Ethiopia experienced two major geological events:

i The uplift of the Ethiopian landmass, followed by crustal deformations and the emission of an immense lava flow, Trapean (old) lava series, to the surface. This process produced the Ethiopian highlands.

ii During the middle tertiary, the land was subjected to major vertical displacements, which produced the formation of the Ethiopian Rift Valley. This divided the Ethiopian highlands into the Western Highlands and the Southeastern Highlands.

In the quaternary period, the earth experienced a marked climatic change resulting in rains known as the Pluvian Rains in Africa. During this period the Ethiopian plateaus were affected by heavy erosion.

Later on, the heavy rains were replaced by a dry climate which increased the rate of evaporation. As a result the rift valley lakes were reduced in size.

Within the Afar depression, there was believed to be a large lake. Due to absence of rivers flowing into the lake and a continuous rate of evaporation, it disappeared. Finally, salt, potash and pockets of saline water were left behind.

Activity 2.3

I Give short answers.

1 In which era and period did layers of sandstone form in Ethiopia? What are these layers called?

2 In which era was Ethiopia subjected to continuous erosion?

II Match the words in column B with the phrases in column A.

	A		B
3	Record of events in Earth history.	A	Cenozoic era
4	Geologic time with poorest fossil record.	B	Precambrian time
5	The geological era in which we live.	C	Mesozoic
6	Dinosaurs rose and became extinct during this era.	D	Geological time scale
7	Most of the life forms were marine origin.	E	Paleozoic era

III Critical Thinking

8 Why do we say that the Rift Valley region of Ethiopia is the most geologically unstable area in the country?

9 Identify some existing geological processes occurring along and in the Ethiopian Rift Valley System, and identify manifestations which indicate the unstable situation of the region.

10 Prepare a geographic newsletter on current developments of the Ethiopian Rift System.

2.1.4 The Movement of Continents

Continental Drift

What is continental drift? What is plates tectonics? What makes the lithosphere plate move?

The idea that continents, particularly South America and Africa, fit together like pieces of a jigsaw puzzle originated with the development of reasonably accurate world maps (Figure 2.4). Little attention was given to this idea until 1915, when Alfred Wegener, a German meteorologist, polar explorer and visionary, who lived between 1880 and 1930, published a book titled *The Origin of Continents and Oceans*. In his book, Wegener set forth the basic outline of his radical hypothesis of **continental drift**.

Figure 2.4:
The West African coastlines and eastern coastlines of South America appear to fit together like adjacent pieces of a jigsaw puzzle. The pink areas show locations of distinctive rock types in South America and Africa. (After Tarbuck and Lutgens, 2005)

Wegener suggested that once there was a single supercontinent, a huge landmass, that he called **Pangaea (***pan = all, gaea = Earth***)**. Wegener further postulated that during the Mesozoic era, about 200 million years ago, the supercontinent (Pangaea), which centered upon Africa, began to break apart into two. He called them ***Gondwanaland*** (which consisted of South America, Africa, the Arabian Peninsula, the Indian subcontinent, Australia and Antarctica) and ***Laurasia*** which included the North America and Eurasia. At a later stage, the two broke farther apart into smaller continents, which then 'drifted' to their present positions. This idea was common and remained popular until very recently.

2.1.5 Components of the Earths Physical Environment

Basically the physical environment of the earth can be divided into four major parts: the water portion of the planet, (the **hydrosphere)**, Earth's gaseous envelope, (the **atmosphere)**, and the solid Earth, (the **lithosphere)**. But it should be noted that our physical environment is highly integrated and not dominated by rocks, water, or air alone. Rather, it is characterized by continuous interactions as air comes in contact with rocks, rocks with water, and water with air.

Furthermore, the **biosphere**, which is the totality of all plant and animal life on our planet, interacts with each of the three physical realms and is an equally integral part of the planet. Thus, the earth can be thought of as consisting of four major spheres: the *hydrosphere*, the *atmosphere*, the *lithosphere* and the *biosphere*.

A *The Hydrosphere*

What percentage of the hydrosphere forms streams and lakes?

The hydrosphere includes all of the earth's water, which circulates among oceans,

continents and the atmosphere. The oceans are the most prominent features of the hydrosphere, covering nearly 71 percent of the globe, to an average depth of about 3.8 kilometers. They account for about 97 percent of Earth's water. About 1.8 percent of the earth's water is frozen in glaciers. The hydrosphere also includes the 0.63 percent of the earth's water that is found underground, saturating the rock and soil of the upper few kilometers of the geosphere. Only 0.01 percent of the hydrosphere forms streams and lakes.

B *The Atmosphere*

What do you know about the atmosphere?

What percentage of the atmosphere is concentrated within 6 km altitude?

The earth is surrounded by a life-giving gaseous envelope called the **atmosphere**. It is a mixture of gases, mostly nitrogen and oxygen, with smaller amounts of argon, carbon dioxide and other gases. One-half of the mass of the atmosphere lies below an altitude of 5.6 kilometers, and 90 percent occurs within just 16 kilometers. About 99 percent is concentrated in the first 30 kilometers above the surface of the earth.

C *Biosphere*

What are the life forms that exist in the biosphere?

The biosphere is the zone inhabited by life. It is concentrated near the surface in a zone that extends from the ocean floor upward for several kilometers into the atmosphere. It includes the uppermost lithosphere, the hydrosphere, and the lower parts of the atmosphere.

D *Lithosphere*

What makes the top of the lithosphere?

Lying beneath the atmosphere and the oceans is the *solid earth*, referred to as the **lithosphere.** The ***lithosphere*** consists of three major layers: the crust, mantle and core (see Figure 2.5). The outermost layer is a thin layer called the ***crust***. Below a layer of soil and beneath the ocean water, the crust is composed almost entirely of solid rock.

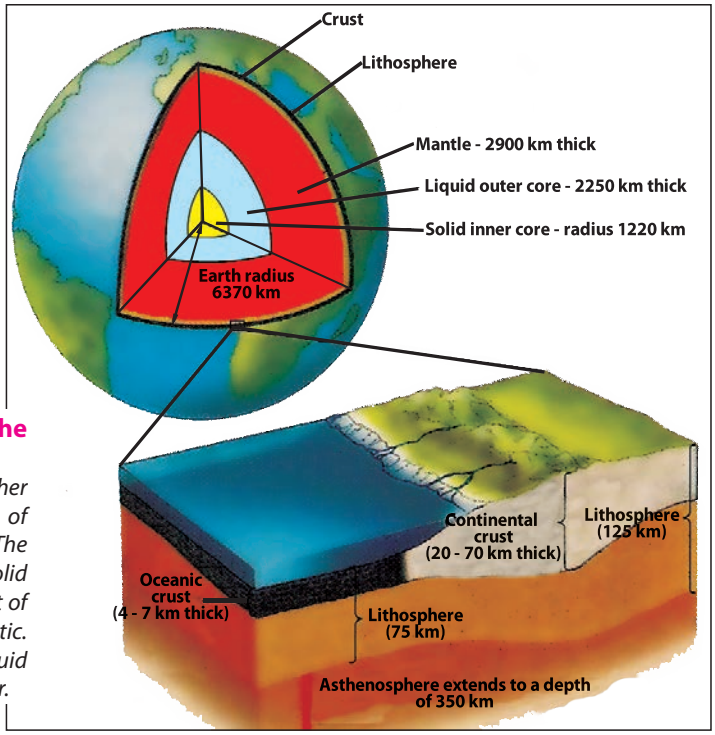


Figure 2.5: **The layers of the lithosphere**

Each of these layers is further subdivided. The crust consists of continental and oceanic crust. The uppermost mantle is hard solid rock, like the crust, while the rest of the mantle is hot, weak and plastic. The core consists of an outer liquid region surrounding a solid center.

The *mantle* lies beneath the crust. Although the mantle is mostly solid rock, it is so hot that it contains small pools of liquid rock called *magma*. The third and innermost layer is a dense, hot, partly molten *core* composed mainly of iron and nickel.

Focus

Note that the earth, which is part of the solar system, consists of four subsystems: *atmosphere*, *lithosphere*, *hydrosphere*, and *biosphere*. To these may be added the *anthroposphere*, which is that part of the earth on which humans have made their cultural imprint.

Components of the Lithosphere

Rocks

What are rocks? How are they formed?

Rocks are a naturally formed solid aggregate of one or more minerals.

Types, Formation and Characteristics

Geologists group rocks into three main categories called *igneous*, *sedimentary*, and *metamorphic rocks.*

1 *Igneous Rocks*

What is the origin of igneous rocks?

Igneous rocks (*ignis* = fire) form when the molten rock cools and solidifies, either in the crust or on the surface of the earth.

Igneous rocks come from melted rock deep in the earth, where it is very hot. The melted rock is called *magma*. The hot rock moves up through cracks in the earth's crust. Sometimes the magma cools and hardens before it gets to earth's surface. Sometimes the hot rock breaks out, or erupts, on the surface. Magma that gets to the surface is called *lava.*

Types of Igneous Rocks

There are two main groups of igneous rocks: *intrusive* and *extrusive* igneous rocks.

i **Extrusive igneous rocks:** Sometimes, when magma breaks through and erupts onto the relatively cool surface of the earth, it solidifies rapidly. Because it cools quickly when it reaches the earth's surface the molten rock, called *lava*, solidifies rapidly, and there is insufficient time for large crystals to form. As a result, many extrusive rocks have fine-grained textures, consisting of crystals too small to be seen with our eyes. An abundant and important example is *basalt* and *obsidian* (see Figure 2.6).

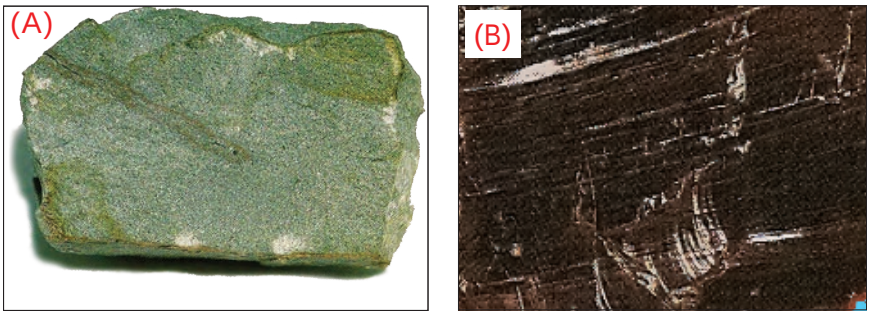


Figure 2.6: **Extrusive igneous Rocks** (A) *Basalt is a fine-grained volcanic rock and* (B) *Obsidian is natural volcanic glass. containg in no crystals.*

ii **Intrusive (plutonic) igneous rocks:** When magma solidifies within the crust, the magma cools slowly, and the crystals form over hundreds of thousands to millions of years. As a result, most plutonic rocks are coarse-grained. Granite is the most abundant rock in continental crusts. It is coarse-grained, and the crystals are clearly visible.

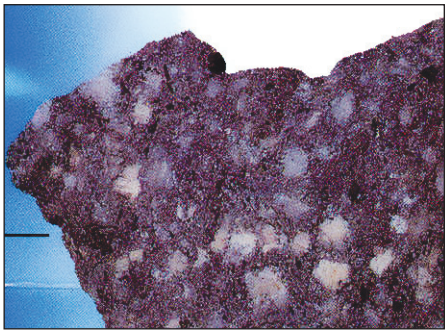


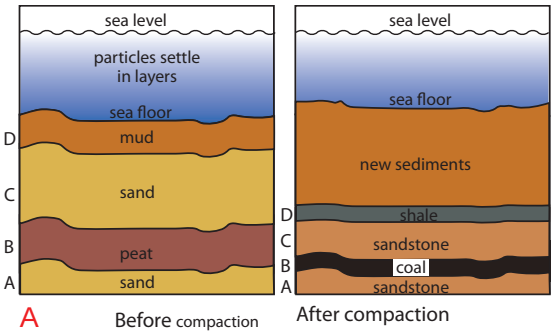
Figure 2.7: **Granite** *Granite is the most common coarse-grained igneous rock.*

2 *Sedimentary Rocks*

What is unique about sedimentary rocks?

Sedimentary rocks are made of small particles of matter, or sediments, of weathered rocks. They may be shells or other remains of living things. Water, wind and ice picked up sediment and transported it. Eventually they dropped the sediment in places where it collected into layers.

Most common sedimentary rocks are formed when sediment is compacted or cemented together. The weight of layer upon layer of sediment on top of each other compacts or squeezes sediment together to form sedimentary rocks.



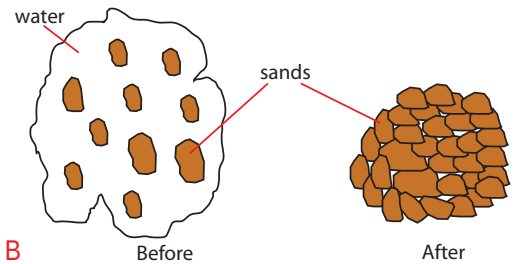


Figure 2.8: **How sediments become solid rock** *Sediments become solid rock by compaction and cementation.*

Types of Sedimentary Rocks

Which type of sedimentary rocks constitute 85 percent of all sedimentary rocks?

About 5 percent of the earth's crust is made up of sedimentary rocks. They are broadly grouped into four categories: *clastic, chemical, bioclastic* and *organic sedimentary rocks.*

i **Clastic sedimentary rocks:** They are composed of fragments of weathered rocks called *clasts*, which were transported and deposited, and then cemented. Clastic rocks make up about 85 percent of all sedimentary rock (Figure 2.9). This category includes sandstone, siltstone and shale.

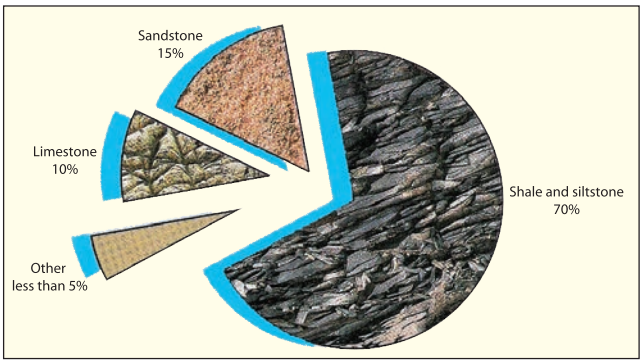


Figure 2.9: **Sandstone, siltstone and shale** *Sandstone, siltstone, and shale are clastic rocks that make up more than 85 percent of all sedimentary rock. Limestone and others make up less than 15 percent.*

ii **Chemical sedimentary rocks:** They are formed by direct precipitation from minerals in water. The water dries up, leaving layers of these minerals that turn into rock. *Gypsum* and *halite* (example: rock/table salt) are formed in this way. *Potash* is another type of chemical sedimentary rock. It is formed from solutions of certain salts.

iii **Bioclastic sedimentary rocks:** They are composed of broken shell fragments and similar remains of living organisms. The fragments are clastic, but they are, of course, of a biological origin. Limestone is a sedimentary rock which was formed from the shells of snails. A good example of limestone is chalk.

iv **Organic sedimentary rocks:** They consist of the solidified remains of plants or animals. *Coal* is an organic sedimentary rock made up of decomposed and compacted plants that died millions of years ago. When plants die, their remains usually decompose by reacting with oxygen.

3 Metamorphic Rocks

What makes metamorphic rocks hard and strong?

Metamorphic rock results from changes in other kinds of rock. Metamorphic rocks are produced from pre-existing igneous, sedimentary, and even other metamorphic rocks through heat and pressure inside the earth's crust.

Under the influence of heat, *limestone* and *sandstone* change, respectively, to *marble* and *meta-quartzite*. *Mudstone* and *shale* change to *schist* or *quartzite*, respectively, under the influence of both heat and pressure. They change to *slate* when subjected only to pressure. See Figure 2.10.

Figure 2.10: **Metamorphic rock** *Often have a banded appearance.*

Focus

Rocks are chunks of solid minerals. They are the most common and abundant materials on Earth. They consist of smaller crystals or grains called *minerals*. Basically one can identify three broad classes of rocks: igneous rocks, which are volcanic in origin, sedimentary rocks, which form by compaction and cementation of accumulated sediments under pressure, and metamorphic rocks that are transformed from volcanic or sedimentary rock, or even other metamorphic rock, under high pressure and heat.

Activity 2.4

1. In your geography work group, walk around your school compound and its surroundings. Collect samples of several types of rocks and bring them back to the classroom.
2. Work with your group to write a report about the collection of rock samples. Let the report consider each type of rock sample and present answers to the following questions. You can format some or all of the report as a chart.
   - a. What color is it?
   - b. Is it shiny?
   - c. Does it break or scratch easily? Use a coin, knife, or other hard object to test the sample for this characteristic. Is the rock hard or soft?
   - d. Is it permeable? To test for this characteristic, place the rock in water and see whether it absorbs liquid.
   - e. Is it crystalline? To test for this characteristic, examine the rock closely, looking for crystals. If you find crystals, are they large or small?

Distribution of Major Rocks in Ethiopia

Major rocks in Ethiopia include igneous, sedimentary and metamorphic rocks. These rocks are found exposed at the surface in different parts of the country. There are many other rocks underlying surface rocks.

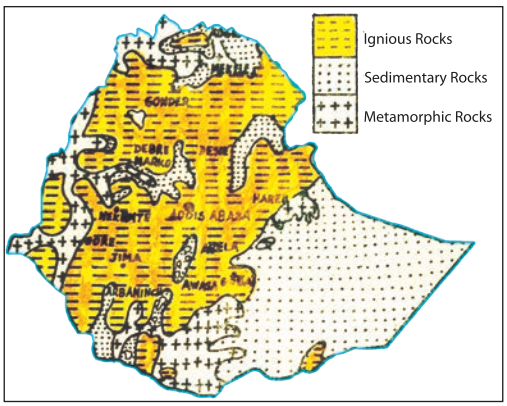


Figure 2.11: **Distribution of the major outcropping rocks in Ethiopia**

As you can see from the map igneous rocks cover large areas in the central part of the country. Eastern Ethiopia is mainly covered with sedimentary rocks. Metamorphic rocks are found in the northern, western and southern edges of the country.

Soil

Have you ever run barefoot through grass? Have you ever looked at a field of corn? Have you ever planted a flower seed in a garden?

Soil is a unique and vitally important part of the terrestrial ecosystems. It is fundamental to continue human existence; without soil we can not grow the food we need. *Soil is a complex mixture of inorganic minerals, decaying organic matter, water, air and living organisms*. The earth's thin layer of soil, utmost only a metre or two thick, provides nutrients for plants, which directly or indirectly provide the food all animals need to stay alive and healthy.

Soil Composition

What is soil made of?

Although soils vary considerably in composition, they all contain the same basic components: inorganic materials (minerals), air, water and organic material. The inorganic materials in soil are tiny particles. They come from rock fragments that have been broken down very slowly over many years. They account for about 45% of the composition of good-quality soil. Water and air often complement each other, and each accounts for 25% . The organic material consists of humus, roots, and other living organisms. It represents about 5% of the total.

Focus

What kinds of things live in soil?

Soil is the loose material of the earth's surface in which terrestrial plants grow. Soil is usually formed from weathered rocks or regolith changed by chemical, physical and biological processes. Look closely at and through a large quantity of soil. It is full of living creatures. You may see earthworms, mites, millipedes, centipedes, grubs, termites, and other large and small creatures. Soil is also full of things you can only see under a microscope.

In the small world of soil, a lot is going on. Worms and other fairly large creatures eat decaying parts of plants. Bigger animals eat smaller ones. They expel waste into the soil. Microscopic life forms, called bacteria and fungi, feed on the bodies of dead animals and reduce them to simpler materials that plants can use for food. Decayed plant and animal parts create a rich, dark-colored soil called *humus*.

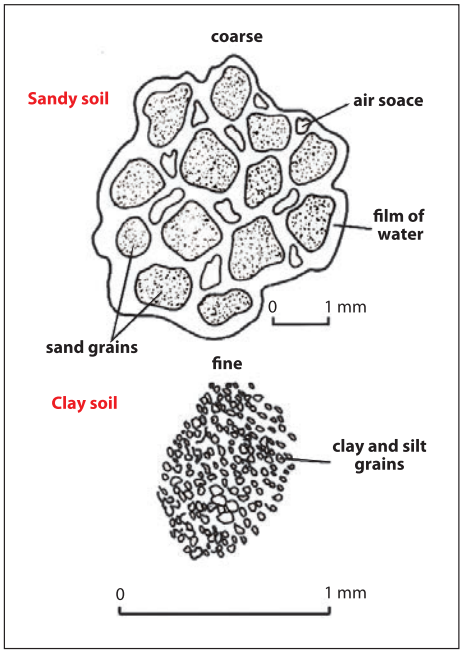


Figure 2.12: **Soil texture**
Look at these two microscopic views of sand and clay soils. Notice how much bigger the soil grains are in the sand. Large grains, as in sand, give a coarse texture. Clay and silt soils have a fine texture. A coarse, sandy soil allows water to drain through it quickly. Very little water is stored by the soil, so it quickly dries out. Clay soil is so fine that water has difficulty of passing between the grains, so these soils easily become waterlogged.

Formation of Soil

Soil formation takes a long time, which is why it is such a disaster when soil is washed away in floods: it will take hundreds or thousands of years to replace. The basic components of soil are:

- *the inorganic components: rock particles, air, water and mineral salts.*
- *the organic components: humus and living organisms*

Types of Soil

Which soil type is poorly drained and areated?

There are many different types of soil, which vary in their content of:

- *Clay - very fine, microscopic particles*
- *Silt - fine particles*
- *Sand - coarse particles*

Soils are classified according to the proportion of these different types of particles. Porosity is the major factor controlling the amount of water and air the soil can hold and the rate at which water moves through it.

Sandy soils have relatively large pores and the particles have little tendency to clump together.

Sandy soils have good aeration and are easy to work. However, sandy soils retain little water, they dry up quickly in hot weather and useful minerals are easily washed out of them. This means they are poor in plant nutrients. They are useful for growing crops which do not require large amounts of water, such as groundnuts.

Clay soils are made of very small particles, which are easily packed together. Clay soils have low porosity, retain water and rich in nutrients. They are poorly drained, poorly aerated and difficult to cultivate. Waterlogging, when all the pores fill with water, is a common problem. Poor aeration causes the death of roots due to lack of oxygen.

Silt soils: If the particles are smaller than sand, they are called silt. Soil with silt is less gritty to the touch and some what sticky when wet. When it is dry, however, soil with much silt is usually loose and cruby. Soil with silt accepts water more slowly than sandy soil, but more quickly than clay. It also retains water longer than sandy soil, but it dries faster than clay.

The ideal soil is a ***loam***, which is a mixture of sand, clay and silt and contains a mixture of particle sizes, and plenty of humus. Such a soil is fertile, it is properly aerated and contains adequate supply of mineral and water.

Major Soil Types of Ethiopia

Which soil type has the largest coverage in Ethiopia?

FAO, on the basis of predominant chemical and physical properties derived from parent materials, has identified about *18 major soil* associations in the country. Ten of the 18 soil associations are considered in this section, which together cover more than 87.4 % of the land area of the country.

Liptosols alone cover about 29.8% of the total land area of Ethiopia. But together with ***Regosol*** cover about 30% of the area of the country. These soil groups developed on recent lava and young quaternary sediments. They are mostly found in a rugged topography and steep slopes.

Nitosols cover about 12.5% of the area of Ethiopia. The ***Nitosols*** develop on gently sloping ground. They are basically associated with high rainfall and were, probably, formed originally on forest covered areas. But they are now widely found on cultivated areas and on mountain grasslands.

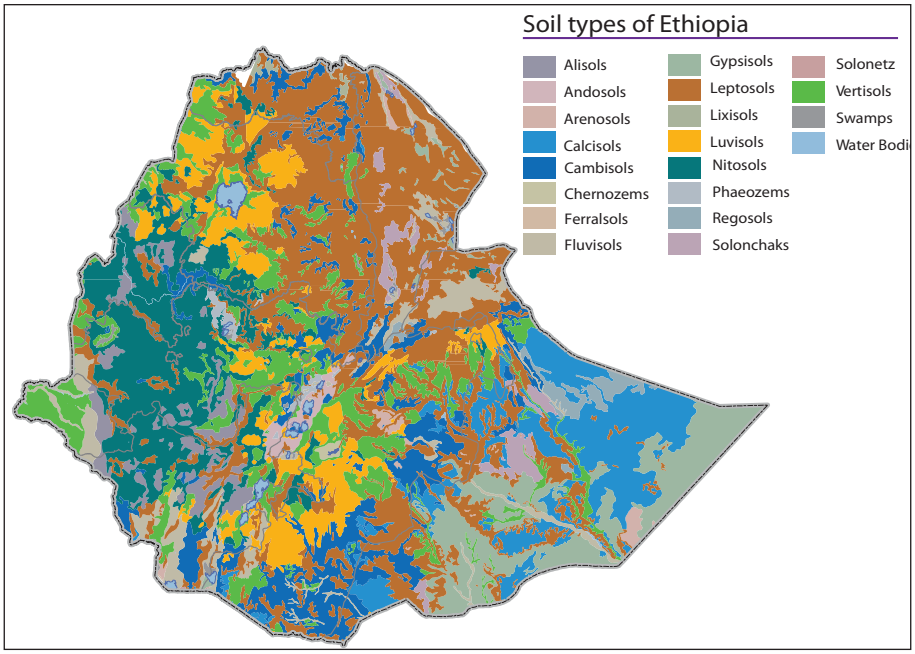


Figure 2.13: **Major Soils of Ethiopia**

Vertisols: These soils cover about 10 % of the land area of Ethiopia. They mostly develop on volcanic plateau. They also develop on sedimentary rocks, and alluvial plains. Unlike the ***Nitosols***, which are found in humid areas, Vertisols mostly occur in moderate climatic regions and gently slopping grounds.

Luvisols: They cover about 7.8% of Ethiopia and developed mainly in areas where pronounced wet and dry seasons occur. Where leaching is not very high, they are found in association with ***Nitosols***.

Fluvisols formed through erosion from the lava plateau of Ethiopia and deposited in depressions, lower valleys and lowlands of the country. They are associated with *fluvial* (river), *marine* (sea) and *lacustrine* (lake) deposits. ***Fluvisols*** are unique because their origin depends on the deposition of alluvium (being transported from many areas) than on weathering processes.

Other soils including ***Cambisols*** and ***Calcisols*** which, respectively, cover 9.4 and 9.3 of the area of Ethiopia have relatively good physical and chemical properties for agricultural production. ***Gypsisols*** which cover about 7.6% of Ethiopia occurs in the eastern lowlands have limited agricultural potential. ***Solanchaks*** are saline soils, which develop in areas of high evaporation and capillary action.

Focus

The soils of Ethiopia were basically derived from the rocks of the basement complex, Mesozoic old sediments and rocks of Trapean and Aden volcanic-series lavas, including Quaternary sediments. Diversity in topography and climate, including biological diversity, heightened the highly fragmented (mosaic) nature of soil types in Ethiopia. On the other hand, although about 18 different soil groups have been identified in the country, 87% of the combined areas of Ethiopia is covered by 10 of them. Further, more than half of Ethiopia is covered by vertisols, nitosols, acrisols, lithosols, regosols and cambisols.

Activity 2.5

i Answer the following questions

1 Which soil is an extremely leached version of nitosols?

2 Which soil group most commonly cover sides of major river gorges, escarpments and other very steeply sloped areas?

3 Where are lacustrine deposits found most commonly?

4 If you want run a modern farm, which soil type is your choice?

5 Which soil types formed from already existing rocks?

6 How many percent of the hydrosphere water found underground?

ii Fill in the blanks with appropriate word or phrase

7 Rocks make up about 85 percent of all sedimentary rock _____.

8 Rocks are dominant in the central part of Ethiopia _____.

9 Eastern Ethiopia is largely covered by _____ rocks.

Soil Degradation and Conservation in Ethiopia

What is soil degradation? What causes soil degradation? Can you list different forms of soil erosion? What causes soil erosion and what is the impact of soil erosion in Ethiopia? List possible soil-conservation measures for Ethiopia.

A *Soil Degradation*

Degradation, in geological terms, means the wearing down of rocks by disintegration. It refers to the general lowering of the surface of land by erosive processes.

In connection with soil, *soil degradation* refers to a change in the state of soil due to increased erosion, leaching and both processes.

Erosion

Erosion is the term given to the process of the wearing away of soil by natural agents (running water, wind, ice, wave action and corrosion) and the transport of the rock debris that results. Wind, water and other agents of erosion move the eroded particles to some other location, where it is deposited as sediment. Soil erosion is a natural process that removes soil from the land. However, human activities frequently aggravate this process.

Causes of Soil Erosion in Ethiopia

The causes of soil erosion can be divided into two: physical and human.

i ***Physical causes*** involve a combination of the following physical factors: steepness of slope, the intensity, duration and seasonality of rainfall, soil type (example, texture) and vegetation cover.

ii ***Human causes*** have to do with human interference with natural processes, including *deforestation*, *overgrazing* and bad farming practices which deplete plant cover, leaving the land exposed and vulnerable to erosion. Activities that lead to deforestation include the burning of forests and the cutting down of trees faster than the forests can regenerate.

In Ethiopia, about 1.9 billion tons of topsoil is washed away from the highlands every year. The loss of topsoil has been estimated to cost billions of Ethiopian birr per year. Since topsoil production rates are so slow, the lost topsoil is essentially irreplaceable.

Badly eroded soil has lost all of its topsoil and some of its subsoil, and it is no longer productive as farmland. In Ethiopia, soil erosion has reached critical levels for farmers.

Water erosion is the main cause of soil erosion in Ethiopia. People left the soil unprotected when they removed protective plant cover by farming, burning crop residues, overgrazing and cutting trees (see Figure 2.14). Additional damage has occurred through over cultivation and by disturbing the soil, using heavy machines in road and building construction and mining activities.

In Ethiopia, soil loss occurs at a rate of between 1.5 billion and 2 billion cubic meters per year. About four million hectares of highlands is now considered irreversibly degraded.

Figure 2.14: **Soil erosion** *This badly degraded area in Kembata and Timbaro Zone in SNNPR has lost its potential for cultivation.*

Types of Soil Erosion

Soil erosion by running water are of three types: *sheet, rill, and gully erosion.*

i ***Sheet erosion*** occurs when the soil scattered by rain drops is removed more or less uniformly from every part of a slope.

ii ***Rill erosion*** occurs when the smooth surfaces of the slope develop small depressions in which water concentrates and later overflows to create many shallow channels called ***rills***.

iii ***Gully erosion*** develops when the water flowing along *rills* converges in channels that become enlarged, causing deep cuts in the ground. This process often causes considerable damage to both the topsoil and the subsoil. Running water, when concentrated, is able to pick up soil particles and move them downslope. In cases of prolonged (continuous) erosion, ***gullies*** (such as the one shown in Figure 2.15) are likely to form.

Figure 2.15: **Gully erosion** *This very deep gully developed because of the construction of the main road at Kurfa, past Nazareth (Adama), on the way to the town of Wolenchiti, Oromia Region.*

Stream Erosion

Rivers can form large concentrations of runoff that run downslope. Such river runoffs can cut the surface of the earth laterally and vertically, and transport eroded materials in the form of a solution full of mud downslope along their course (Figure 2.16). In this process, they form gorges and valleys. Ethiopian rivers are essential agents of erosion in the country. Soil erosion by runoff is serious in the highlands of Ethiopia. It occurs wherever grass, bushes, and trees are disappearing. Deforestation and desertification leave land more liable to erode.

Figure 2.16: **Stream erosion** *Amassa River is used as a border between Woliyta and Gamo zones. It carries a lot of mud in the form of a solution brought down from upslope areas of Wolyita Zone. It drains into Lake Abaya.*

Wind erosion

Wind erosion is the most common form of erosion in dry and treeless areas where the soil is exposed. The dry and unprotected topsoil from fields is blown away. Wind forces are capable of removing all of an area's topsoil and transporting it several thousand kilometers away.

Soil Conservation in Ethiopia

What is conservation?

Simply the term *conservation* means *the protection of resources from destructive influences*. The term applies to the positive work of maintenance, enhancement and wise management, of resources and to restoration by reducing and reversing rates of damage and destruction of resources. For example, conservation efforts might reduce the consumption rate of a valuable resource to prevent its irreversible depletion.

Soil Conservation Measures Needed in Ethiopia

There are several measures we can institute to reduce, minimize or eliminate soil erosion by wind and running water. They include:

- ***contour ploughing*** *– ploughing across slopes, rather than up and down them, to create barriers to runoff.*
- ***terracing*** *– installing ledges for cultivation at right angles to slopes to reduce runoff.*
- ***strip cultivation*** *– planting different crops in alternating strips to retain water and soil.*
- ***installing hedges*** *and* ***other windbreaks*** *– creating borders of closely growing bushes, shrubs or trees beside or around areas to protect them from winds, predation by animals, and so forth.*
- ***afforestation*** *and* ***reforestation*** *– planting trees, for example, on bare land that is vulnerable to erosion.*
- ***avoiding cultivation*** *– leaving land that is unsuitable for cultivation untilled.*
- ***plugging gullies*** *– for example, with brush and wood barriers.*
- ***limiting grazing*** *– keep livestock according to the carrying capacity of the land.*
- ***fallowing*** *– initiating multi-year periods of non-cultivation for the land, allowing it to regenerate its fertility.*

Here are more-detailed descriptions of some of these methods.

i **Contour ploughing:** It is ploughing across slopes rather than up and down them in order to reduce runoff. It is one of the simplest ways to prevent soil erosion. This soil-conservation practice is useful on gentle slopes. As the plough tills, it creates ridges across the slopes. They act as barriers to down-running water, preventing runoff from eroding the slope's soil.

Contour ploughing can reduce soil erosion by as much as 50 percent in drier regions, and it increases crop yields and conserves water.

Figure 2.17: **Contour plowing**
Tilling land at right angles on slopes creates a series of ridges (narrow raised areas) that slow runoff and prevent soil erosion.

ii **Strip cultivation:** It refers to the planting of different crops in alternating strips. Typically, the farmer alternates closely grown crops (such as wheat, teff, barley, and other small grains) and open-growing crops (such as corn and cotton). The closely grown crops minimize the flow of water, which reduces soil erosion and allows more water to be absorbed into the ground.

Figure 2.18: **Strip cultivation**
The strips are planted with alternating crop types.

iii **Windbreaks:** They are plantings of trees or other plants that protect bare soil from the full force of the wind (Figure 2.19 (A) and (B)). Windbreaks reduce the velocity of wind, and decrease the amount of soil that it can move away.

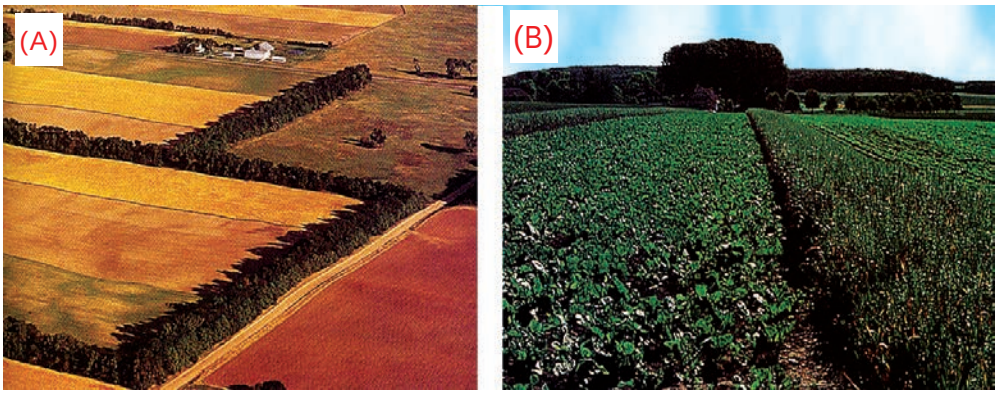


Figure 2.19: **Windbreaks** *In large plain areas, trees provide protection from wind erosion. The trees along the road protect the land from oncoming winds (A). In the other field, temporary strips of vegetation serve as windbreaks (B).*

iv **Terracing:** It involves building level surfaces at right angles to the slope to retain water and reduce the amount of erosion. It is an expensive method of controlling erosion since it requires moving of soil and stones to construct the level areas. This method of soil and water conservation has been commonly practiced by the Konso people of Ethiopia. It is also used in other steep-slope areas of Ethiopia.

Figure 2.20: **Terraces** *Terraces are installed at right angles to the slopes in (A). They are extremely important for people who live on steep slopes, especially in countries with little available land. They require much energy and hand labor. The type of terracing shown in (B) is appropriate for gentler slopes. It is more widely spaced, and it allows the use of farm machines.*

v **Reforestation and afforestation:** Reforestation is the planting of trees on land previously forested but from which the trees have been removed by natural causes or by cutting, burning or other means (Figure 2.21). *Afforestation* refers to the planting of land, not formerly so covered, with trees to make a forest for commercial or other purposes.

Figure 2.21: **Reforestation** *The photograph shows* ***reforestation****, planting trees on hills that were once badly denuded and devoid of trees. The area in this photograph is close to Negash town (which is the site of what is probably the first and oldest mosque in Ethiopia, Negashi, Tigray).*

Focus

Soil is a renewable resource that can be replenished indefinitely by applying appropriate measures of conservation, although some of these measures are enormously expensive. *Conservation* is wise use of resources in the best possible way, so that the greatest long-term benefit is realized by society.

Activity 2.6

Part I

Give answers to the following questions.

1 What is soil/land degradation?
2 What causes soil degradation?
3 Which forces of soil erosion are most damaging in (a) the highlands and (b) the lowlands of Ethiopia?
4 What are renewable and non-renewable resources?
5 What measures of soil conservation are commonly practiced in Ethiopia?

Part II

In your group, discuss these issues.

1 The difference between reforestation and afforestation.
2 Which measure of soil conservation is the cheapest and most effective?

2.2 CLIMATE

At the end of this section, you will be able to:

- Realize the criteria used for classifying climate;
- Compare the climate classifications of the Greeks' and that of Koppen;
- Express causes of climate change;
- Explain major consequences of climate change

Key Terms

- greenhouse effect
- greenhouse gases
- ozone layer
- permafrost
- desertification

How does climate differ from weather? What are the elements of climate? What are climate controls? Why is climate classification needed? What are the major types of climate and climatic regions of the world? In which climatic region do you live?

2.2.1 Classification of the Climates of the World

How is climate classified?

There are many ways to classify climate, each with its own advantages and disadvantages, depending on the purposes for which it is used. In the following sections, we consider two systems of climate classification with their climatic regions:

- *the system of the ancient Greeks – based on temperature and sunshine within latitudinal boundaries*
- *the Koppen system – based on temperature and precipitation as reflected in vegetation zones*

Classification by Ancient Greeks

Which zone is warm year - round?

After considering worldwide temperature and sunshine distribution, the ancient

Greeks divided the world into three climatic regions. Note that they are bounded by specific latitudes:

1. ***The low-latitude tropical (or torrid) zone*:** a winterless tropical region. It is bounded by the northern and southern limit of the sun's vertical rays (23½°N and 23½°S). In this climatic region, the noon sun is always high, day and night are of nearly equal length, and it is warm year-round.
2. ***A middle-latitude temperate zone*:** sandwiched between the other two zones i.e., (23½° – 66½°N), and 23½° – 66½°S this climatic region has distinct summer and winter seasons and exhibits characteristics of both extremes, in terms of seasonal temperatures.
3. ***The high-latitude polar (or frigid) zone*:** bounded by (1) the Arctic Circle, at 66½N-90°N, and (2) the Antarctic Circle, at 66½°S-90°S. Places with this climate are considered summerless, because they are cold all year round due to long periods of winter darkness and a low summer sun.

The ancient Greeks' system is some what simplistic method of climatic classification because it does not consider precipitation, and therefore it does not differentiate between wet and dry regions.

The Kõppen System of Climate Classification

What makes Koppen classification more acceptable than the others?

This widely used classification of world climates is based on seasonal variations in the annual and monthly averages of temperature and precipitation. It was devised by the famous German scientist Waldmir Kõppen (1846 – 1940). Faced with the lack of adequate observing stations throughout the world, Kõppen related the various climates to the distributions and types of native vegetation in the world. In this way, where no climatological data were available, climatic boundaries could be approximated with vegetation zones.

The Kõppen climate classification, is now used by climatologists throughout the world. It defines five principal climatic groups. Each type is designated by a capital letter. Note that a single climatic region can exist in multiple locations on the earth. A Koppen *climatic region* is not a spatial or areal region.

A. ***Tropical moist climate:*** All months have an average temperature above 18°C (64°F). There is enough moisture to support abundant plant communities. Since all months are warm, there is no real winter season.

B ***Dry climates:*** precipitation is deficient most of the year. Potential evaporation and transpiration exceeds precipitation.

C ***Moist mid-latitude climates with mild winters:*** C climates have warm-to-hot summers with mild winters. The average temperature of the coldest month is below 18°C (64°F) and above -3°C (27°F).

D ***Moist mid-latitude climates with severe winters:*** D climates are similar to C climates, but have distinct summer and winter seasons. They have enough moisture to support abundant plant communities. The average temperature of the warmest month exceeds 10°C (50°F), and the coldest month average drops below -3°C (27°F).

E ***Polar climates:*** They have extremely cold winters and summers. The average temperature of the warmest month is below 10°C (50°F). Winters are extremely cold, and even the summers are cool. Since all months are cold, there is no real summer season.

H ***Highland climate:*** At low latitudes the effect of altitude can produce tundra and polar conditions. Glaciers on tropical mountain sum its attest to the cooling effects of altitude highland climates follow the pattern of Earth's mountain ranges.

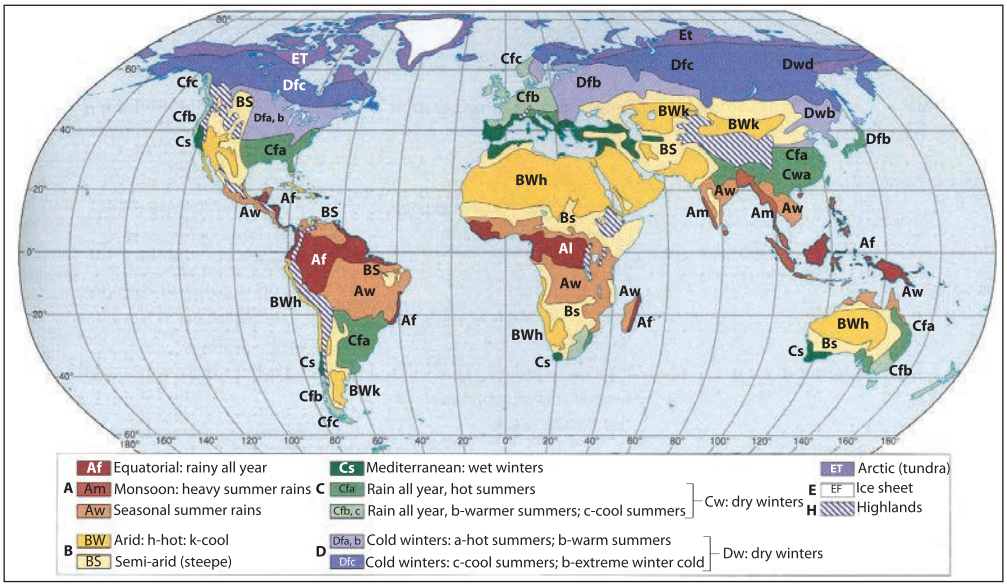


Figure 2.22: **General climate classfication**

Activity 2.7

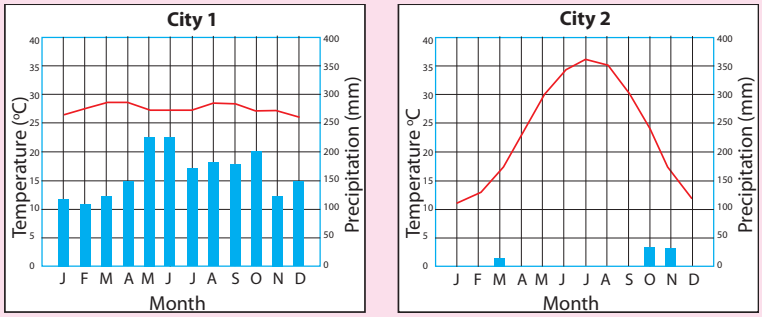


Figure 2.23: **Seasonal patterns of temperature and precipitation for meteorological stations in two different cities**

1 Study the monthly temperatures of City 1 and City 2.

2 Compare and contrast. Next study the seasonal patterns, in each city, for each of the two climate elements – temperature and precipitation. Then perform the following activities and answer the following questions:

- a Describe the pattern of rainfall and temperature distribution for each city.
- b Which city has the warmest climate?
- c Which city has the driest climate?
- d Which city is probably situated in a desert?
- e Which city is probably located in a tropical zone?
- f Which city has uniform annual precipitation distribution?

Part 2

With your teacher, visit the meteorological station found nearest to your school. Ask the experts there to give you the most recent available 12 months of data for your locality's monthly temperature and precipitation.

3 When you return to your classroom, use the data to perform these activities,

4 Draw two graphs, similar to those in Figure 2.24, that show seasonal distributions of

- a temperature
- b rainfall;

5 Identify

- a the warmest three months
- b the coldest three months
- c the driest three months
- d the wettest three months

Part 3

Work with your group to choose a group representative to present your ideas to the class.

2.2.2 Climate Change

What is climate change? Is climate change a reality? What are some of the manifestations and consequences of climate change?

Climate change is a long-term change in the statistical distribution of weather patterns over periods of time that range from decades to millions of years. It may be a change in the average weather conditions or a change in the distribution of weather events with respect to an average, for example, greater or fewer extreme weather events. Climate change may be limited to a specific region, or may occur across the whole Earth.

Causes of Climate Change

What causes climate change?

The earth's climate is dynamic. It is always changing through a natural cycle. What the world is more worried about is that the changes that are occurring today have been speeded up because of man's activities. These changes are being studied by scientists all over the world and tried to identify the causes. The causes of climate change can be divided into two categories - those that are due to natural causes and those that are caused by human factors.

A *Natural causes*

There are a number of natural factors responsible for climate change. Some of the more prominent ones are continental drift, volcanoes, ocean currents etc. Let's look at them in a little detail.

Continental drift

The continents that we are familiar with today were formed when the landmass began gradually drifting apart, millions of years back. This drift also had an impact on the climate because it changed the physical features of the landmass, their position and the position of water bodies. The separation of the landmasses changed the flow of ocean currents and winds, which affected the climate. This drift of the continents continues even today; the Himalayan range is rising by about 1 mm (millimeter) every year because the Indian land mass is moving towards the Asian land mass, slowly but steadily.

Volcanoes

When a volcano erupts it throws out large volumes of sulphur dioxide (SO_2), water vapour, dust, and ash into the atmosphere. Although the volcanic activity may last only a few days, the large volumes of gases and ash can influence climatic patterns for years. Millions of tones of sulphur dioxide gas can reach the upper levels of the atmosphere (called the stratosphere) from a major eruption. The gases and dust particles partially block the incoming rays of the sun, leading to cooling.

Ocean currents

What causes ocean currents?

The oceans are a major component of the climate system. Ocean currents move vast amounts of heat across the planet - roughly the same amount as the atmosphere does. But the oceans are surrounded by land masses, so heat transport through the water is in channels.

Ocean currents have known to change direction or slow down. Much of the heat that escapes from the oceans is in the form of water vapour, the most abundant greenhouse gas on earth. Yet, water vapour also contributes to the formation of clouds, which shade the surface and have a net cooling effect.

B *Human Causes*

How do human activities affect climate?

The industrial revolution in the 19th century saw the large - scale use of fossil fuels for industrial activities. These industries created jobs and over the years, people moved from rural areas to the cities. This trend is continuing even today. More and more land that was covered with vegetation has been cleared to make way for houses. Natural resources are being used extensively for construction, industries, transport, and consumption. Consumerism (our increasing want for material things) has increased by leaps and bounds, creating mountains of waste. Also, population growth has increased to an incredible extent. All this has contributed to a rise in greenhouse gases in the atmosphere.

Greenhouse gases and their sources

What are the sources of green house gases?

Carbon dioxide is undoubtedly, the most important greenhouse gas in the atmosphere. Changes in land use pattern, deforestation, land clearing, agriculture, and other activities have all led to a rise in the emission of carbon dioxide.

Methane is another important greenhouse gas in the atmosphere. About 1/4 of all methane emissions are said to come from domesticated animals. These animals produce methane during the cud - chewing process. Methane is also released from rice or paddy fields that are flooded during the sowing and maturing periods.

A large amount of nitrous oxide emission has been attributed to fertilizer application.

Greenhouse effect

What aggravates green house effect?

The greenhouse effect is a process by which thermal radiation from a planetary surface is absorbed by atmospheric greenhouse gases, and is re-radiated in all directions. Since part of this re-radiation is back towards the surface, energy is transferred to the surface and the lower atmosphere. As a result, the temperature there is higher than it would be if direct heating by solar radiation were the only warming mechanism.

This mechanism is fundamentally different from that of an actual greenhouse, which works by isolating warm air inside the structure so that heat is not lost by convection.

Global warming, a recent warming of the earth's surface and lower atmosphere, is believed to be the result of a strengthening of the greenhouse effect mostly due to human - produced increases in concentration of atmospheric greenhouse gases, CO_2 in particular.

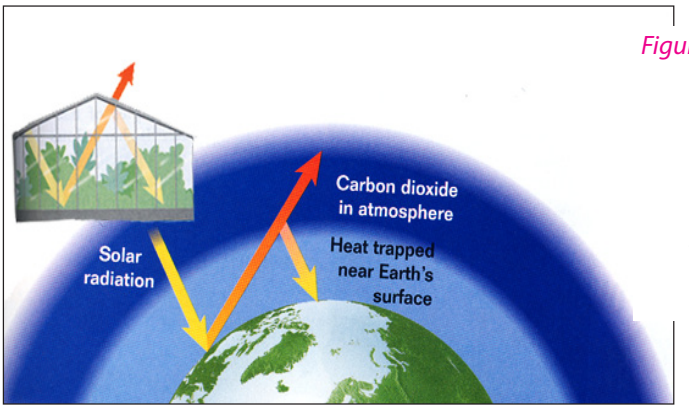


Figure 2.24: **The greenhouse effect** *The moment you step into a greenhouse, you feel the greenhouse effect. Heat trapped by the glass walls warms the air inside. Similarly, atmospheric greenhouse gases, particularly CO_2, trap heat close to Earth's surface.*

Since the beginning of the industrial revolution, the burning of fossil fuels has increased the levels of carbon dioxide in the atmosphere from 280 ppm to 390 ppm (parts per million). The emissions of carbon are directly proportional to energy consumption.

Consequences of climate change

What are the possible consequences of climate change resulting from global warming?

Global warming

Global warming is the increase in the average temperature of earth's near - surface air and oceans since the mid - 20th century and its projected continuation. According to the 2007 fourth assessment report by the Intergovernmetnal Panel on Climate Change (IPCC), global surface temperature increased by about 0.74 ± 0.18°C (1.33 ± 0.32°F) during the 20th century. Most of the observed temperature increase since the middle of the 20th century has been caused by increasing concentrations of greenhouse gases, which result to human activity such as the burning of fossil fuel and deforestation. Global dimming, a result of increasing concentrations of atmospheric aerosols that block sunlight from reaching the surface, has partially countered the effects of warming induced by greenhouse gases.

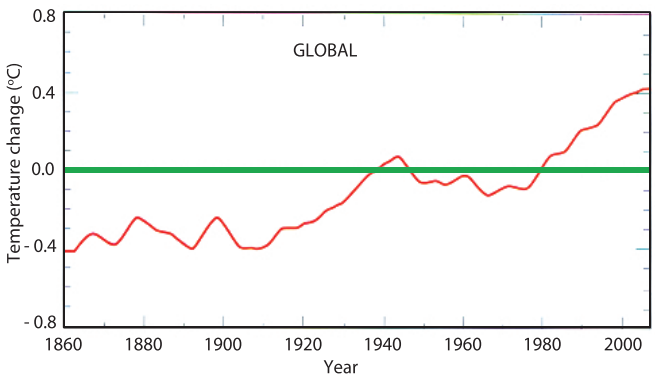


Figure 2.25: **Average global temperature variations from 1860 through 2000** *The zero line represents the average surface temperature from 1961 to 1990 (Source: P. D. Jones, et al., and Climate Change 2001: the Scientific Basis, 2001, by J.T. Houghton, et al.)*

Desertification

Desert - like condition's may spread over human habitats, crop lands and wet lands. Grass land and forest areas might turn into desertified environments as a result of global warming and hence climate change.

Drought

Because of climate change which results in extensive damage to plants, crops and animals, droughts are likely to occur more frequently. Up to three billion people could suffer from increased water shortages by 2080. In Ethiopia, for example,

drought started to reoccur more frequently, at an interval of 3 to 8 years in the most drought prone regions.

A rise in the sea - level

Globally, the average sea - level could rise by 18 to 59 cm, or more, by the end of the century. Rising sea levels could swamp some small, low - lying island states and put millions of people living in low - lying areas at greater risk of flooding.

It is also possible that salt from rising sea levels may contaminate underground fresh water supplies in coastal areas. The sea expected to encroach coastal areas and cover land surfaces.

Shift of the direction of global winds

If the average global temperature increases the jet stream will weaken and global winds will shift from their “normal’ position. This in turn may disturb the “normal” amount of seasonal pattern and distribution of precipitation.

Shift of Tropical Zone

The tropical zone expected to extend north and southwards by not less than one degree in the northern and southern hemisphere respectively.

Expansion of Tropical Diseases

It is widely recognized that zone of mosquitos breeding and hence malaria spread farther into upper grounds, lower Woina Dega agroclimatic zones in case of Ethiopia.

Loss of Biodiversity

A global temperature rise could make some species extinct. There are already changes to the way plants and animals live.

Further changes in rainfall and temperature will affect many animal and plant species around the world. Some species might be unable to adapt quickly enough and habitats might not be available for them to move into. If global temperatures rise by two degrees celsius, 30 percent of all land-living species could be threatened by an increased risk of extinction.

Focus

The atmospheric greenhouse effect blocks the escape of some radiation to upper space. Therefore it heats the earth's atmosphere and surface. This process is due to the presence of blanketing "greenhouse gases" such as CO_2, CH_4, N_2O, CFC, and water vapor in the atmosphere. Their presence acts as a barrier to radiation and heat that would normally escape through the atmosphere. The atmosphere warms as it absorbs and then emits infrared radiation downwards, while allowing shortwave radiation to pass out, away from the earth. The most noticeable result of the greenhouse effect is global warming, which is characterized by global temperature rises ranging between 0.5°C and 0.6°C.

Activity 2.8

In your geography work group, perform the following activities.

1 Discuss climate change: what it is and how it differs from climate variability. List some of its most noticeable effects.

2 What changes do you observe in your locality in relation to climate change? Do you think any of Ethiopia's endangered plant and animal species still exist in your wereda and region? Have patterns of temperature and rainfall changed during your lifetime or that of your parents or of the elders in your family?

Ask your parents and elderly relatives about temperature and rainfall changes in your locality? Have such changes been significant within their lifetimes? Within your lifetime, so far? Have such changes affected any of your lives? If so, how?

3 Consider any other changes in your locality that you think have resulted from climate change.

Create a report of all of your findings and opinions in your science journal.

4 Have you heard about any rivers, lakes or swampy areas in your locality that have shrunk in volume or even disappeared due to climate change? If so, write about it and report your ideas in class.

5 Travel, either with the group or alone, to nearby rural area and talk with the peasants about climate change. Have they encountered the term climate change? Are they aware of climate changes in their area? If so, what are the changes, and how have they affected their work and earning capacity? For example, have climate changes led them to change their farming activities, and have those changes affected their ability to earn a living?

6 Work with your group to prepare a report on your activities findings and opinions that you developed during in Tasks 1–5 of this Activity. Then work together to choose a group representative to present the report to the class.

2.3 CLIMATE OF ETHIOPIA

At the end of this section, you will be able to:

- describe the spatio-temporal variation of temperature in Ethiopia;
- compare rainfall distribution of Ethiopia by place and time;
- discuss factors why Ethiopia experiences climate different from other tropical countries;
- differentiate climate zones of Ethiopia;
- explain the reasons that drought may not necessarily followed by famine;
- identify drought prone areas of Ethiopia;
- state drought coping mechanism in agriculture.

Key Terms

- altitude
- traditional climate zone
- insolation
- Inter tropical convergence zone
- drought prone areas
- drought
- desertification
- rainfall regime
- range

2.3.1 Distribution of Major Elements of Climate in Ethiopia

What are the two most important elements of climate? Is the distribution of rainfall and temperature uniform in Ethiopia?

Temperature Distribution

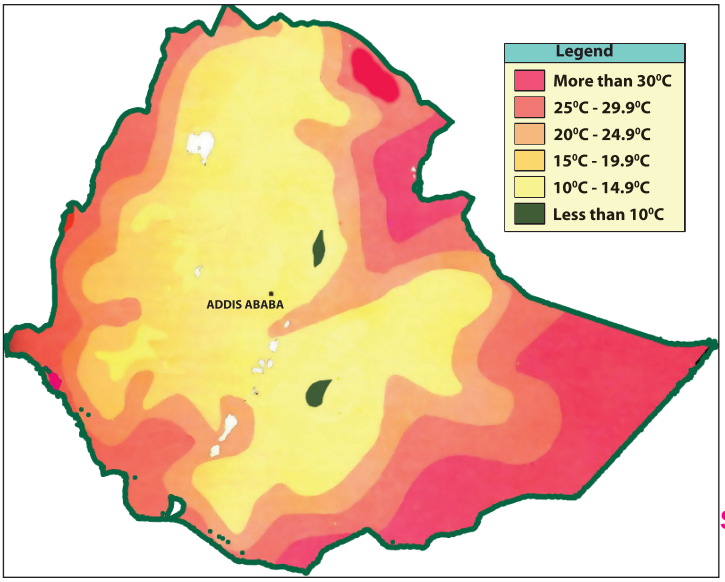
Temperature in Ethiopia is determined primarily by altitude and latitude. Ethiopia lies within the tropics, a zone of maximum insolation, where every place has overhead sun twice a year. However, considerable portions of Ethiopia are highland areas, and their altitudes give them non-tropical temperatures. Ethiopia's tropical climate occur in lowlands at the country's peripheries.

Away from the peripheral lowlands, the land begins to rise gradually and considerably, culminating in peaks in various parts of the country. The highlands form the heartland of the country. Thus temperature in most of the center of the country is affected by altitude, and temperature essentially decreases from Ethiopia's peripheries towards the interior. Ethiopia experiences both hot and cold extremes of temperature (see Figure 2.26).

Daily Temperatures: Ethiopia's daily temperatures are more extreme than its annual averages. In terms of spatial distribution, Ethiopia's daily maximum temperature varies from a high of more than 37°C over the lowlands of the northeast and of the southeast to a low of about 10°C-15°C over the highlands of Ethiopia. In terms of temporal distribution, the months of March, April and May are generally the hottest throughout the country.

Monthly Temperatures: Ethiopia's monthly temperatures also exhibit extremes. The lowest monthly minimum temperatures mostly occur over the highlands of the country. Most of the highlands experience mean minimum temperatures as low as 0°C between November and January (Bega season). The highest mean monthly minimum temperature (20°C - 30°C) is observed in the Dallol Depression. The lowest mean monthly minimum temperature (0°C or less) occurs in January in the highlands in the northwest (Gonder and Gojam), central (Shewa) and southeast (Arsi-Bale), and the highest (30°C) occurs in the lowlands of the western, southeastern and northeastern areas.

Annual temperatures: Mean annual temperature varies from a low of about 10°C, in the northwest, central and southeast highlands, to a high of about 35°C at the country's northeastern edges, which contain the Dallol (Denakil) Depression. As you can again infer, altitude is the most important temperature-controlling factor in Ethiopia.



Source: *EMA, 1988.*

Figure 2.26: **Mean annual temperature distribution Ethiopia**

Temperature Ranges

Daily (diurnal) temperature range: In the northern hemisphere, during the winter months of December, January and February, the sun apparently shifts to the southern hemisphere and Ethiopia experiences its *bega* season. During this period, the sky is clear, without blanketing cloud cover to retain heat or cold on earth. Therefore, during the day the heat from the sun is intense. But at night, because of the clear sky and relatively longer nights, temperature drops very low. Reflecting such clear-sky conditions, Ethiopia's daily temperature range is greatest during bega in most parts of the country.

Annual temperature range: Ethiopia's annual temperature range is the highest in the lowlands, and it decreases with increasing altitude.

Distribution of Rainfall

Which part of Ethiopia is the driest and wettest?

Overall, mean annual rainfall ranges from over 2200 mm in pockets of areas in the southwestern high lands to less than 400 mm over the northeast and southeastern lowlands of the country (Figure 2.27). However, the low end of the range is much less in the southeast lowlands, the Ogaden area, standing at 200 mm. In the northeast lowlands, the Afar region, it is even less than 100 mm.

The map shows that southwestern Ethiopia is the region of heaviest rainfall. It is the wettest part of the country, with only two to four dry months in a year. The mean annual rainfall for southwestern Ethiopia is about 1500 mm, but in some areas it is much higher – reaching up to 2800 mm in Mocha, southwestern parts of Gore and Arjo. Also well over the national average, mean annual rainfall can exceed 2000 mm in parts of Gimira and Kafa, Limu, Gore, Buno Bedele, Sore and Geba and the southern extreme of Gimbi. The adjoining western lowlands of Gambella and Assossa and Benishangul, which are found on the windward sides of the western highlands, receive over 1000 mm of annual rainfall.

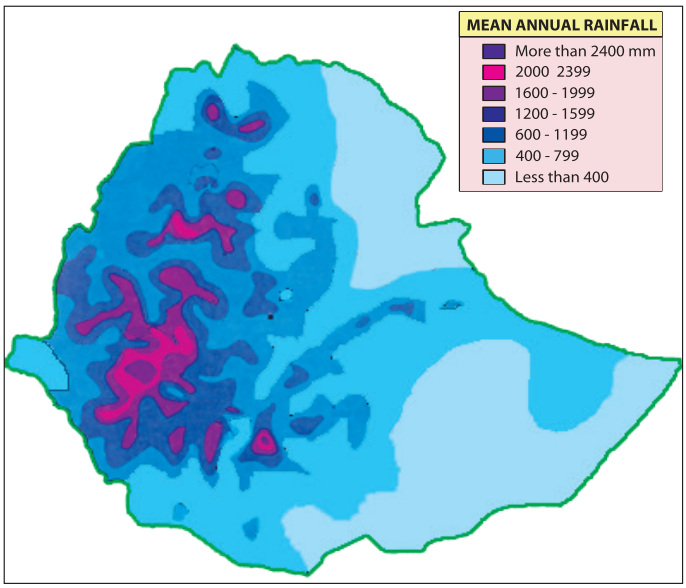


Figure 2.27: **Mean annual rainfall distribution in Ethiopia (***Adapted from the National Atlas of Ethiopia, EMA, 1988***)**

From the southwest, mean annual rainfall gradually decreases towards the northeast and east. In central and north-central Ethiopia, the annual amount is moderate, about 1100 mm. But, there are some pockets where annual rainfall reaches over 2000 mm. These include the western parts of Awi zone, and parts of Metekel and Kola Dega Damot. In parts of northern Gonder and central Wegera and central Semien, the mean annual exceeds 1600 mm.

In southeastern Ethiopia, the mean annual rainfall is about 700 mm. However, this amount varies from over 2000 mm in Jemjem, and over 1200 mm in parts of Genale and Dolo in the Bale zone and parts of Webera in Harerge, to less than 400 mm in most of the Ogaden area. In northern Ethiopia, including Tigray and Wollo, the mean annual rainfall is about 500 mm, but in some areas it rises to over 1200 mm.

Seasonal Pattern of Rainfall

Which part of Ethiopia is all - year rainfall region?

Summer Rainfall

As the ITCZ (Inter - Tropiacal convergence zone, zone of convergence of north east and south east trade winds) drifts towards the north in northern hemisphere summer (Keremt), the equatorial westerly winds from the South Atlantic Ocean invade most parts of Ethiopia, while the trade winds from the north retreat from the country. The ITCZ's southward drift marks the onset of the trade winds from the north, which causes the retreat of the equatorial monsoons. Such periodical shifts in the flow pattern of winds causes rainfall to be variable and seasonal in Ethiopia.

Rainfall in Ethiopia is seasonal, varying in amount over space and time. There is the long and heavy summer rain, which is normally referred to as "the big rain" or *keremt*. There are also short and moderate rains in autumn *(Tebi)*, winter *(Bega)* and spring *(Belg)*. They are collectively called "the little rains".

In contrast to the rest of Ethiopia, southwestern Ethiopia gets rain for a long period that stretches usually for more than eight to ten months.

Other regions, for instance the southeastern lowlands, receive rain twice a year. These rainy seasons do not correspond with *keremt* or *bega*.

In most of highland Ethiopia, the main rainy season is in summer (June to September), when the ITCZ is to the north of Ethiopia. During this season, the whole country with the exception of a few places is under the influence of the southwest equatorial westerly winds from the South Atlantic Ocean or of the south easterly winds from the Indian Ocean.

Effects of the southwest equatorial westerly winds: The southwest equatorial westerly winds originate from the South Atlantic Ocean, and they blow over the humid regions of the Gulf of Guinea, the Congo basin and Central Africa on their way to Ethiopia. When these winds approach Ethiopia they encounter highlands. When they start ascending over the highlands, they cause heavy rain in southwestern Ethiopia because they are moisture - laden. However, the amount of rainfall gradually decreases as the winds move north and northeastwards.

Highland Ethiopia receives the widest coverage of these *keremt* rains, though the amount that falls in different areas varies. The southwest experiences the longest *Keremt* rain. *Keremt* lasts for only two to three months in the extreme northeast highlands.

The eastern escarpments of the northeastern highlands and associated lowlands (the Afar region) remain dry, because they are in what is called a rain shadow.

Effects of the southeasterly winds: The southeasterly winds that originate from the Indian Ocean blow over Ethiopia's southeastern highlands and associated lowlands. However, these winds lose their moisture over the East African highlands before they reach Ethiopia. Therefore, the country's southeastern highlands and associated lowlands that receive the winds remain relatively dry.

Winter Rainfall

In winter the ITCZ shifts farthest south. Most of Ethiopia comes under the influence of North East Trade winds, which originate from west Asian high pressure centers.

These winds are cold and dry, and they carry little or no moisture, giving most of the country a dry winter. Only the Red Sea coastal plains, including parts of the Afar region, receive rain. This rain is little in amount, and is due to the area's proximity to the Red Sea.

Another exception to this lack of rain is southwestern Ethiopia. In winter this region is still under the influence of the equatorial westerly winds, although they are now weak. The moderate rain they supply to the region at this time is the area's smallest annual amount.

Spring and Autumn Rainfall

In spring the ITCZ drifts to the north and lies across Ethiopia. At this time, a strong low-pressure cell develops over the Sudan. This center attracts.

- *Winds from the Gulf of Aden*
- *Indian Ocean highs*

These moist south easterly winds blow across central and southern Ethiopia, and they produce the big rains in southeastern Ethiopia.

The same winds produce the little rain of spring for the east central part of the northwestern highlands. These rains are often called *Belg* rain.

Spring is the major rainfall season in the southeastern highlands and associated lowlands (Ogaden, Borena of Oromia and the South Omo zone). The area's second rainfall season is in autumn.

In the southeast peripheral lowlands, the towns of Moyale and Kelafo also receive their rainfall in spring and autumn. Moyale's annual rain is about 1000 mm. Kelafo's is about 500 mm. For Moyale, about 50% occurs in spring, and about 37% occurs in autumn. For Kelafo, the percentage distribution are approximately 60% and 33% respectively.

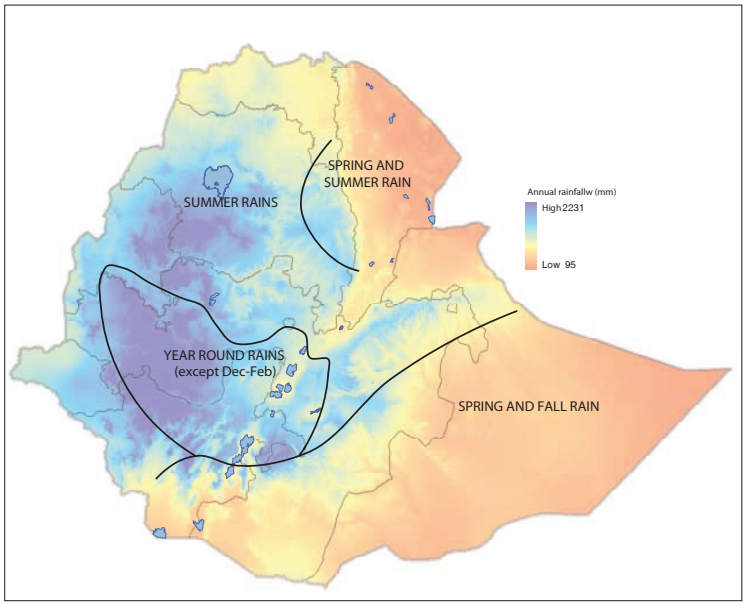


Figure 2.28: **Rainfall Regimes and Climates of Ethiopia**
(*Adapted from the National Atlas of Ethiopia, EMA, 1988*)

2.3.2 Major Climate Controls in Ethiopia

Which geographical factor is more important to the climate of Ethiopia?

Many physical factors influence Ethiopia's climates and their distribution. They are collectively called controls of climate.

Ethiopia's most important climate controls are

- *latitude*
- *altitude*
- *cloud cover*

The above noted factors, together with other less important ones, determine the distribution of climate in Ethiopia. As noted earlier, Ethiopia is located within the Tropics. Therefore, in principle, it is a tropical country and might be expected to

have tropical climate throughout. However, since Ethiopia is a highland country, much of its climate is affected by *altitude*. It is only in lowland areas that a tropical climate (*Kolla*) prevails. Altitude is the most important climate control in the highland parts of the country. For instance, rainfall amount tends to increase with altitude, while, in contrast temperature decreases with increasing elevation. Next to altitude in importance is latitude. See Table 2.1.

Table 2.1: **Relationships between temperature, latitude and altitude**

Town	Latitude	Altitude (m)	Mean annual temperature (°C)
Addis Ababa	9°	2400	17
Awash	9°	916	25
Ambo	9°	2130	18
Nekemte	9°	2005	18.3
Dire Dawa	9.6°	1160	25

In Ethiopia's highlands, cloud cover is another important climate control during the long rainy season – June to September. Although this period has high sun, comparatively low temperatures prevail due to the season's cloud cover, which absorbs and reflects away much of the incoming rays of the sun. The other period of high sun in Ethiopia is March to May. In the highlands, this season is not characterized by cloud cover and its temperatures are relatively high. The northeast and southeast lowlands have both low altitude and clear skies, and therefore their temperature is high.

Focus

Climate controls are factors that act on climate elements and produce different climate types. On a global level, important climate controls include latitude, altitude, distance from the sea, ocean currents, wind and air pressure, major and local relief, and sky conditions. In the Ethiopian context, altitude and latitude are the most important determinants of climate. Although two places might lie on nearly the same latitude, if their altitudes vary, they probably have large temperature differences.

Activity 2.9

Give short answers:

1 Identify the absolute location of Ethiopia.
2 What are the two water bodies that separate northeast Africa from Asia?
3 Which landform divides the Ethiopian highlands in to two?
4 What sort of climate would Ethiopia have if it had no highlands?
5 Is the climate of Ethiopia uniform throughout the country? Is the climate of Ethiopia shaped more by its latitudinal location or its variation in relief?
6 Which season is the warmest, coldest, wettest and driest in your area? Are there relationships between the major wind systems and the distribution of rainfall in Ethiopia?

2.3.3 Main Seasons and Climatic Zones of Ethiopia

Main Seasons of Ethiopia

Which season is the driest in most part of Ethiopia? In which season flowers blossom?

Ethiopia is a tropical country. It is located completely within the tropical zone. Because of its tropical location there is little variation in the length of days and nights. The maximum difference, about 30 minutes, occurs in December and June. Many people of the country are not aware of the differences. There are four main seasons per year: *Keremt*, *Tseday*, *Bega and Belg* (Table 2.2).

Table 2.2: **Temporal distribution of the main seasons in Ethiopia**

Months*	Name of season		Location of the sun
	English	Amharic	
June, July and August	Summer	*Keremt*	Northern hemisphere
September, October and November	Autumn	*Tseday*	Around the equator
December, January and February	Winter	*Bega*	Southern hemisphere
March, April and May	Spring	*Belg*	Around the equator

* *The months noted correspond only roughly to the traditional seasons.*

Traditional Climatic Zones of Ethiopia

The traditional Ethiopian classification of climatic zones is based on altitude and temperature. This system divides the nation into the following five major climatic zones: *Bereha, Kolla, Woina Dega, Dega and Wurch.*

Bereha: *Bereha* is the *hot arid climate*. *Bereha* is the climate of the desert lowlands that are found below 500 m above mean sea level where the average annual rainfall is less than 400 mm, and average annual temperature is over 30ºC. *Bereha* is usually characterized by strong wind, high temperature, low relative humidity, and little cloud cover. Evapotranspiration is always in excess of rainfall in some places.

Kolla: *Kolla* is a (*warm*-to-*hot semi-arid climate*). *Kolla* is the climate of the hot lowlands with an altitudinal range of 500 to 1500 m a.s.l. Average annual temperatures are between 20ºC and 30ºC. Although mean annual rainfall ranges between 410 mm and 820 mm, it can be as high as 1600 mm in the wet western lowlands of Gambella. Rainfall is highly variable from year to year.

This region is intermediate between the hot arid climate and the humid climates.

Woina Dega: This is subtropical warm-to-cool semi-humid zone which corresponds to roughly with what is commonly known as the warm temperate climate. *Woina Dega* has distinct dry and wet months in winter and summer respectively.

The average annual temperature is between 15ºC and 20ºC, and annual rainfall is generally around 1200 mm.

Woina Dega covers the temperate highlands that fall with altitudes between 1500 m and 2300 m amsl. In the southwest, rainfall reaches 2400 mm.

Dega: *Dega* corresponds *roughly with* the temperate *climate*. *Dega* is the climate of the cool temperate highlands. It covers a region with an altitude range of 2300 m to 3300 m amsl. The *coldest* month is less than 10ºC. The area experiences adequate rainfall. Rainfall ranges from about 1000 mm, in most areas, to 2000 mm in higher altitudes.

Wurch: *Wurch* is a type of Alpine climate. The annual average temperature is less than 10ºC. Annual rainfall is between 800 and 2000 mm. The zone exists at altitudes equal to or more than 3300 m amsl.

This zone exists as afro-alpine areas on the highest areas of Ethiopia's plateaus. It is found in small isolated high areas such as the Senate plateaus (Bale zone), Semen mountains (north Gonder), Mount Guna (south Gonder), Amara Saint (south Wollo), and the Choke mountains (Gojam).

Table 2.3: **Traditional Temperature and Altitude Zones in Ethiopia**

Traditional Zones	Global	Altitude (meters) Zones	Mean Annual Temperature (°C)
Wurch	Alpine	Above 3300	Below 10°C
Dega	Temperate	2300 - 3300	10°C - 15°C
Woina Dega	Sub - Tropical	1500 - 2300	15°C - 20°C
Kolla	Tropical	500 - 1500	20°C - 30°C
Bereha	Desert	Below 500	>30°C

Source: *Atlas for secondary schools of Ethiopia*

Activity 2.10

I Answer the followings.

1 What are the main traditional classification of seasons in Ethiopia? What are their corresponding names in your mother-tongue language?

2 Which traditional Ethiopian seasons correspond with summer, autumn, winter and spring?

3 Are there any cultural differences between the Kolla and Dega people? Do they cultivate the same crops, rear the same domestic animals, use the same staples and wear similar clothes?

4 Do you think Dega and Kolla crops ripen at the same time? Why do the Dega people send their cattle to Kolla for grazing during rainy seasons?

II Using the following 2008 temperature and rainfall data for Addis Ababa (Table 2.4), perform these tasks:

5 Determine the city mean monthly maximum and minimum temperatures.

6 Calculate the 2008 annual mean temperature.

7 Identify the three warmest and coldest months of that year.

8 Regarding temperature range, identify
   a the month with the greatest range
   b the city's annual range
9 Identify the city's total annual rainfall.
10 Identify the three driest and wettest months.

Table 2.4: **Temperature and rainfall data of Addis Ababa, 2008**

	Unit	J	F	M	A	M	J	J	A	S	O	N	D
Max. temp	°C	23.3	24.1	26.6	25.2	25.8	25.5	21.3	21.3	22.9	23.0	23.9	22.2
Min. temp	°C	9	10	11.9	12.0	12.1	12.3	11.5	11.6	11.9	10.5	8.7	10.7
Rainfall	mm	21.3	2.73	28.4	80.6	58.9	82.6	349.9	388.3	112.9	45.8	4.4	0

2.3.4 Drought in Ethiopia

What is drought? What is famine? Does drought necessarily lead to famine? What are the causes of drought? What are some of the consequences of drought? What is the average recurrence interval of major and minor drought in Ethiopia? Which part of Ethiopia is the most affected by recurring drought? What are some drought-mitigation and drought-adaptation measures? What is drought?

Drought is a condition that happens when much less rain is received than is normally expected. It is a period of abnormally dry weather that is sufficiently long enough to cause serious problems for agriculture and other activities in the affected area. This extended period usually involves months or years during which the region receives consistently below-average rainfall.

Drought is one of the world's major environmental hazards. It affects human and animal life catastrophically, and it can cause severe crop failure.

Consequences of drought

Unless drought-causing conditions are reversed by putting into practice measures of mitigation, drought can have adverse consequences both on the natural environment and on the socio-economic life of the people in drought-prone areas. Some of the general consequences include climate change, drying up of surface and subsurface water sources (ponds, streams, swamps, reservoirs, lakes, etc.),

decline in underground water tables, loss of soil moisture, crop failure, starvation and famine, death of animals and human beings, lack of seeds, livestock and labor, loss of biodiversity and environmental deterioration, desertification, rural out-migration, etc.

Although famine and starvation can result from drought, they are not its necessary consequences, even though this has generally been the case in Ethiopia and other less developed countries.

Drought can happen anywhere in the world. But a countries' ability to resist it is a function of their developmental stage. Less developed countries like Ethiopia are highly vulnerable, and affected by post-drought effects. In addition, their political, economic and social affairs are highly influenced by drought and its product, famine. However, economical well-to-do countries can manage drought and resist its after effects with their systems and wealth. A country under the influences of drought and famine for long periods of time may develop *dependency syndrome*. This may lead to loss of self esteem and national pride and end up in longing for foreign donations.

Drought-Prone Areas in Ethiopia

The three drought-probability zones of Ethiopia include:

i *High drought probability zone* (zone III) covered about 25% of Ethiopia in 1988. This zone includes the *Bereha* climatic zones of the largest part of the Somali and Afar regions, part of the Tigray region, the eastern portion of the Amhara region, and the southern part of the Oromia region.

ii *Medium drought probability zone* (Zone II) covers part of the Somali, Oromia and Afar regions, and small portions of the eastern Tigray and Amhara regions. It covers about 10% of the country.

iii *Low drought probability zone* (Zone I) also covers about 16% of Ethiopia's area, including most of the semi-arid (*Kolla*) climatic zones. It includes part of the eastern highlands of Tigray and Amhara regions, the eastern and southern parts of Harerge, a portion of the Bale, Borena and Guji zones, and the southern portion of the south Omo zone.

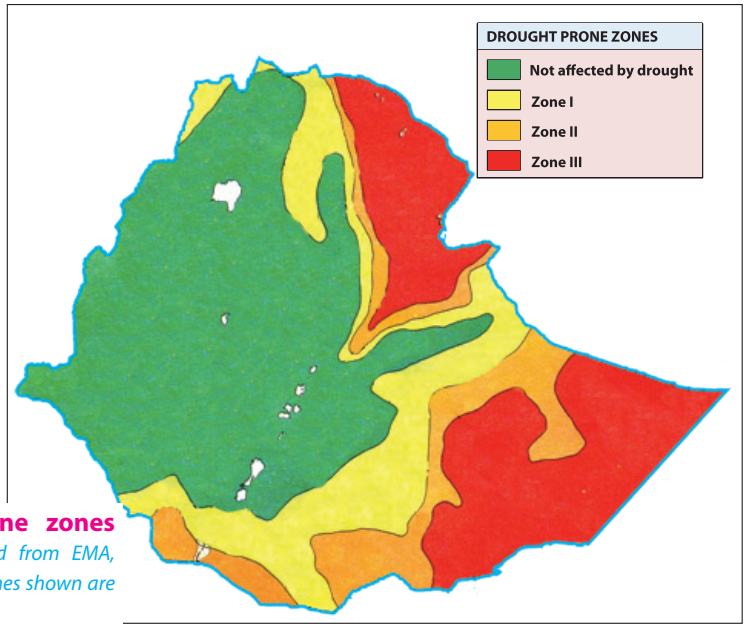


Figure 2.29: **Drought-prone zones in Ethiopia** (*Adapted from EMA, 1988. Internal boundary lines shown are no more in use.*)

Drought-Coping Mechanisms in Ethiopia

What should be done to mitigate and cope with drought and its adverse effects?

Geographers expect major droughts to reoccur in Ethiopia at about ten-year intervals and expect minor droughts at two-years intervals. Hence, the Federal and Regional Governments, the nation's farming community and other stake holders, should make themselves ready for the challenge of reoccurring drought and related problems by mobilizing the resources of rural farming and pastoralist communities and government facilities to avert the situation by implementing as many of these mitigation and adaptation measures as possible.

- *carefully planned land use to increase agricultural productivity and minimize erosion*
- *encouraging farmers in the drier areas to plant crops that have low water-dependencies*
- *drilling deep water wells, installing water pumps and building simple irrigation channels.*
- *rainwater harvesting collecting and storing rainwater on various scales*
- *recycling waste water for reuse after treatment and purifying*
- *building reservoirs and canals and redirecting rivers as massive attempts at irrigation in drought-prone areas*
- *instituting outdoor water-use restriction - regulating the water use of sprinklers or buckets for watering outdoor plants, for filling pools, and for water-intensive home maintenance tasks*

- *planting trees in degraded areas*
- *ensuring wise use of forest rangeland resources*
- *maintaining reserves of food (for example, grains) and other facilities*
- *limiting household size by regulating population growth*
- *instituting water and soil conservation programs.*
- *Other measures include resettlement and rehabilitation of drought victims, the distribution of seeds, oxen, fertilizers and livestock in pastoralist regions, and construction of roads.*

Activity 2.11

1. Why and how might famine affect "the national pride" of a country?
2. Identify the regions which have been most susceptible to frequently reoccurring drought and famine in Ethiopia.
3. Why are most of the western highlands and associated lowlands of the southwest not much prone to drought?
4. Which areas in Ethiopia are in a transitional zone or moderate drought-probability zone?
5. Identify the natural and human factors that result in drought.
6. What are the effects of drought on water resources?
7. What measures do you suggest to combat drought in your locality?
8. What measures are taken by people to fight drought in your local area?
9. What measure is the government taking in your locality to fight drought and famine?
10. Do you think we can solve the problem of famine with international aid only? Discuss.
11. What is the difference between aid and development aid?
12. Which one is important for the future of the country? Discuss this issue in your group.

2.4 ECOSYSTEMS

At the end of this section, you will be able to:

- review the concept of an ecosystem;
- discuss how climate affects the distribution of an ecosystem;
- realize the effect of latitude on the variation of an ecosystem;
- explain the role of altitude on the distribution of ecosystem;
- relate factors that affect the diversity of fauna and flora in the ecosystem;
- identify factors that affect soil in ecosystems.

Key Terms

- ecology
- ecosystem
- abiotic factor
- biotic factor
- habitat
- fauna
- flora
- deciduous
- savanna
- biome

Do you remember the discussion about ecosystem in grade 9? What is an ecosystem? What are the components of an ecosystem? How do organisms interact with each other in an ecosystem?

An ecosystem is all the living and non-living things in an area interacting with each other. Ecology is the study of how all these things interact in order to survive.

Ecosystems vary in size. Some are small and some are much larger like the ecosystem of the desert of Africa, and the rainforest of Brazil that cover large areas of a country or continent.

It doesn't matter where they are or what they look like all ecosystems have the same elements.

The non-living parts of an ecosystem are the ecosystem's abiotic (a'biot'ik) factors. All living things need certain non-living things in order to survive. Abiotic factors include water, minerals, sunlight, air, climate, and soil.

2.4.1 Factors that Affect the Distribution of Ecosystems

Two primary non-biological factors have major impacts on the kind of ecosystem that develops in any part of the world:

- *precipitation*
- *temperature*

In turn, elevation (altitude) affects these primary factors.

Precipitation and Temperature

How does temperature influence the distribution of vegetation?

Precipitation and *temperature* are major factors that determine the vegetation in an ecosystem, In turn, the types of vegetation that result affect everything else in the ecosystem eventually. Figure 2.30 shows the impact of precipitation and temperature on vegetation.

The types and degrees of impact that precipitation has on an environment depend on several aspects of precipitation, including the total amount of precipitation per year, the form in which it arrives (rain or hail or snow), and its seasonal distribution. Precipitation might be evenly spaced throughout the year or it might be concentrated at particular times, creating wet and dry seasons.

Temperature patterns are also important. They vary considerably in different parts of the world. For example, **tropical areas** have warm, relatively unchanging temperatures throughout the year, whereas the **poles** have long winters, with extremely cold temperatures, and relatively short, cool summers. In other areas, temperature variation is between those extremes, creating different types of cold and warm seasons.

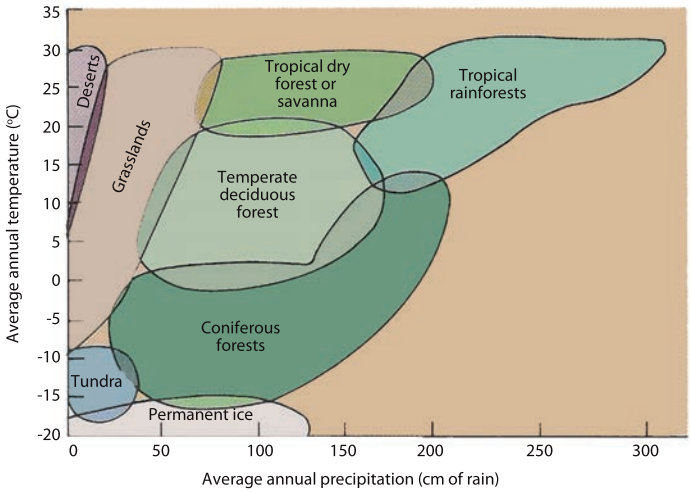


Figure 2.30: **Impact of temperature and precipitation on vegetation**

Figure 2.30 illustrates the way that temperature and moisture influence the kind of vegetation that occurs in an area. Areas with low moisture and low temperatures produce **tundra**. Areas with high moisture and freezing temperatures during part of the year produce **deciduous or coniferous forests**. Dry areas produce **deserts**. Moderate amounts of rainfall or seasonal rainfall support **grasslands or savannas**. Areas with high rainfall and high temperatures support **tropical rainforests**.

The Effect of Elevation on Climate and Vegetation

What makes higher altitudes cool?

As height above sea level increases, the average temperature decreases. As one proceeds from sea level to the tops of mountains, it is possible to pass through a

series of ecosystems that are similar to what would be encountered if one traveled from the equator to the north pole (see Figure 2.31).

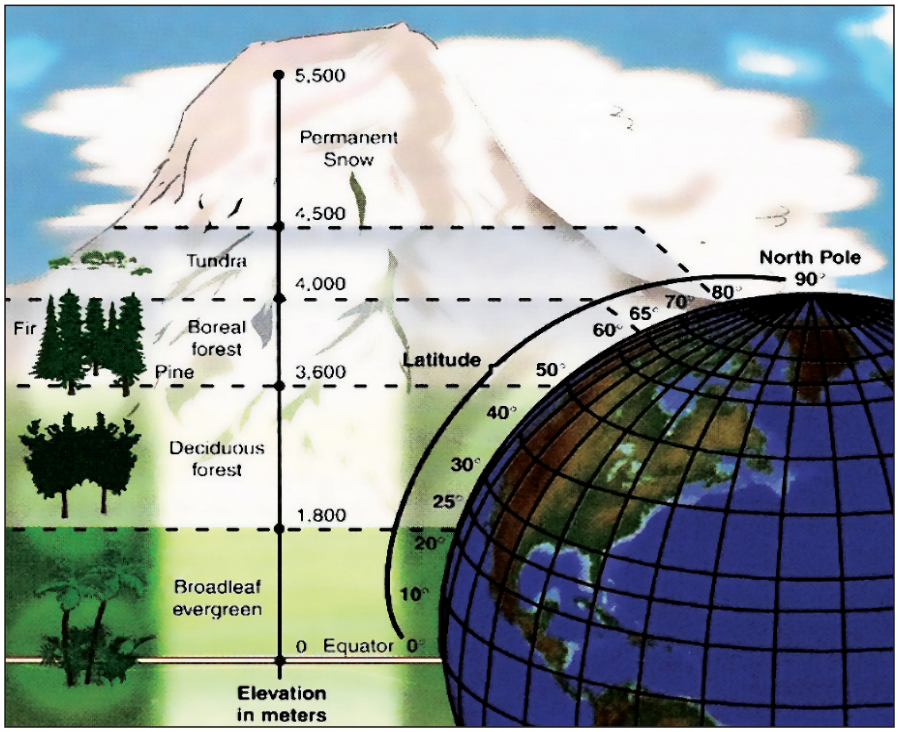


Figure 2.31: **Relationships between altitude latitude, and vegetation**

The higher the altitude, the cooler the climate becomes. For example, This happens when we travel from the peripheral lowlands of Ethiopia to the mountains found in the northwest and southeast of the country. Even in the Tropics, tall mountains can have snow on the top, for example, on Mt. Kilimanjaro (see Figure 2.32). Thus, it is possible to experience the same change in vegetation by traveling up a mountain as one would experience traveling from the Equator to the north pole.

Focus

An **ecological system** or, in short, an **ecosystem,** is a system formed by the interaction of all living organisms with each other in an area and with the chemical and physical factors of the environment in which they live. They are all linked by the transfers of energy and materials that constitutes the *food chain*. **Ecology**, on the other hand, is the scientific study of the inter-relationships between living organisms and the environment. An **ecological factor** is any environmental factor which affects a living organism.

Figure 2.32: **Mount Kilimanjaro**
It is the highest mountain (5895 m) in Africa. It is found in Tanzania along the border with Kenya. It rises to about 4000 m above the surrounding surface, rising through rainforest, moorland, alpine desert, snow fields and ice cliffs, and all of these phenomena are virtually on the equator (3°S latitude)!

2.4.2 Diversity of Fauna, Flora and Soil of Ecosystems

Among many factors that shape the type of fauna, flora and soil type of an ecosystem, climate plays a decisive role in their distribution and activities.

The land on earth is divided into six major kinds of large ecosystems called biomes. The six biomes are: desert, tundra, grass land, decidious forest, taiga and tropical rain forest. Each biome has its own kind of climate, soil, plants and animals. Each biome can be found in different parts of the world. For example a desert biome is found in North America, Africa, South America, Asia and Australia.

Desert

What is desert? What characterizes it?

A lack of water is the primary factor that determines that an area will be a desert. Deserts are areas that generally average less than 25 centimeters of precipitation per year. They are also likely to be windy.

Plants and animals are many species, but they typically have low numbers of individuals. However, those species that are present are specially adopted to survive in dry, often hot or cold environments. For example, water evaporates from the surfaces of leaves. As an adaptation to this condition many desert plants have very small leaves that allow them to conserve water. Some, such as *cactus*, have the ability to store water in their spongy bodies or their roots for use during drier periods.

Other plants are *ephemerals*, only bursting into life when rain falls, flowering and producing seeds which may then lie dormant for years until the next rain falls. The Rose of Jericho, a plant of the Middle East, is a good example of this type.

All of the animals that live in deserts are able to survive with a minimal amount of water. They generally have an outer skin that resists water loss, so they lose little water by evaporation.

Due to lack of moisture and vegetation in hot desert areas there has been little true development of soil, the surface simply consisting of drifted sand, pavements of bare rock, gravel or boulders.

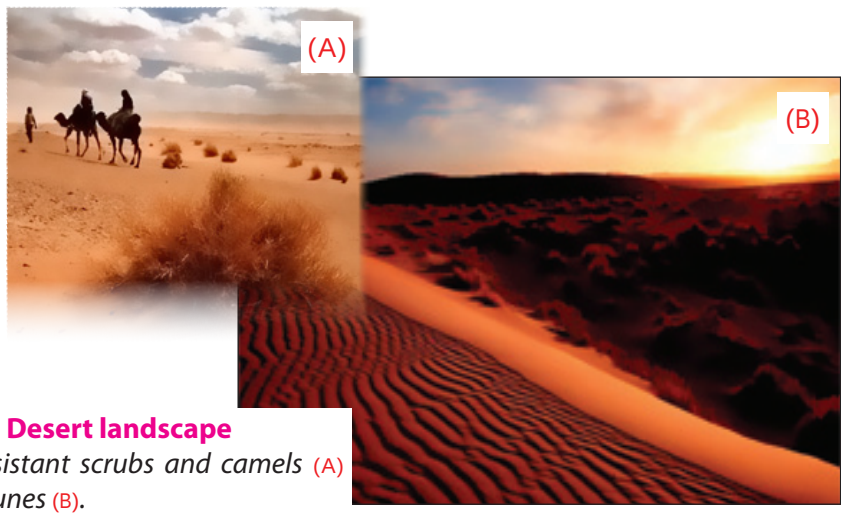


Figure 2.33: **Desert landscape**
Drought-resistant scrubs and camels (A) *and sand dunes* (B).

Figure 2.34: **A desert ecosystem, the Sahara Desert**

Tundra

Why is tundra called a treeless region?

The harsh climate of the high latitudes around the Poles prevents the growth of most plants. Indeed, the very word tundra means' a treeless plain.

Even in mid summer only the top few centimetres of ground thaws out and beneath this it is permanently frozen - Permafrost. In addition to lichens and mosses which are the basic 'building blocks' of the tundra ecosystem, a range of grasses and sedges with dwarf and creeping plants are to be found.

Under natural conditions, the tundra vegetation was grazed by large migratory herds of caribou and reindeer. Other grazing animals of the tundra include the *musk ox*, which survives the cold by means of extremely thick coat. Predators include *polar bears* and the *arctic fox*, which is largely dependant on the huge numbers of ground - nesting birds that migrate to the tundra to breed during the short summer. Among them are several species of *geese*, *wild fowl* and *wading birds*. One of the most remarkable of these is the *Emperor penguin*, adapted to withstand the Antarctic cold by a thick layer of blubber and a fine covering of feathers.

The sub soil remains permanently frozen and the surface layer is waterlogged since water cannot percolate through the impermeable permafrost.

The lack of oxygen in these water logged conditions restricts bacterial action so that the remains of the tundra vegetation only partly decompose and accumulate as a layer of peat, stained black by acid humus.

Grass Lands

Why do grasses become dominant in the region?

Temperate grasslands are also known as *prairies* or *steppes* and typically *savannas* are tropical grass lands (Figure 2.35). Grass lands generally receive between 25 and 75 centimeters of precipitation per year. Grasses make up 60 to 90 percent of the vegetation. Many other kinds of flowering plants are interspersed with grasses.

In areas where the human population is small, huge herbivore animals including *elephants*, *zebras*, *wildebeest*, *gazelles* and *antelopes*, roam across the African plains. Carnivores, such as *lions*, *cheetahs* and *leopards*, prey on the grazing herds, along with scavenging *jackals*, *hyenas* and *vultures*.

The soil of tropical grasslands are strongly influenced by the lengthy droughts that alternate with wet seasons.

Figure 2.35: **Typical East African grassland savanna, a region of wet-and-dry climate (Aw), after Ahrens, 2007**

Deciduous Forest

Why do trees shed their leaves during winter in deciduous forest?

This is a forest biome with many trees that lose their leaves each year. This is where broad-leaved trees grow. Each autumn the leaves turn yellow, orange and red painting the land with glorious colors. Then, the leaves fall to the ground which is what deciduous means and decay. The dead leaves help make the soil rich and fertile. Trees shade leaves to conserve water.

These areas generally receive 75 to 100 centimeters of relatively evenly distributed precipitation per year. In deciduous forests of North America and Europe, common tree species are *maples*, *birch*, *beech*, *elm*, *oaks*, and other hard woods. In addition many small flowering plants bloom in the spring.

These forests are home to a great variety of insects like beetles, moth larvae, wasps and ants. The birds that live in these forests are primary migrants that arrive in the spring of the year. A few kinds of birds including *woodpeckers*, *turkeys*, *geese* and some *finches*, are year-round residents. Amphibian and reptiles prey on insects and other small animals.

Several kinds of small and large mammals inhabit these areas *mice*, *squirrels*, *deer*, *shrews*, *moles*, and *opossums* are common examples. Major predators on these mammals are *foxes*, *badgers weasels*, *coyotes* and *birds of prey*.

Taiga, (Coniferous Forest)

How does coniferous forests differ from deciduous forests?

The climate is one of short, cool summers and long winters with abundant snowfall. Precipitation ranges between 25 and 100 centimeters per year.

Conifers such as *spruces*, *firs* and *larches* are the most common trees in these areas. These trees are specifically adapted to winter conditions. The needle - shaped leaves are adapted to prevent water loss.

The branches of these trees are flexible, allowing them to bend under a load of snow so that the snow slides off the pyramid - shaped trees without greatly damaging them.

Most birds are migratory and feed on the abundant summer insect population, which is not available during the long, cold winter. Typical mammals are *deer, caribou, moose, wolves, weasels, mice, snowshoe hares*, and *squirrels*.

In this cold climate, in which precipitation exceeds evaporation, the needles and litter from the coniferous trees are slow to decay.

When they do so, they form an acidic humus soil. This severely restricts the variety of plant species able to grow here. Those that do occur, such as conifers, are those species that require few nutrients.

Tropical Rainforest

In which biome do we find Earths tallest trees?

Tropical forests are located near the equator.

The temperature is normally warm and relatively constant. Most areas receive in excess of 200 centimeters of rain per year - some receive 500 centimetres or more. Because of the warm temperatures and abundant rainfall, most plants grow rapidly; however soils are usually poor in nutrients because water tends to carry away any nutrients not immediately taken up by plants. Many of the trees have extensive root networks, associated with fungi, near the surface of the soil that allow them to capture nutrients from decaying vegetation before the nutrients can be carried away.

They have a greater diversity of species than any others biome. More species are found in the tropical rainforests of the world than in the rest of the world combined. It is typical to have distances of a kilometer or more between two individuals of the same species. *Balsa, teakwood, ironwood, mahogany, ebony* and other ornamental woods are common.

Associated with this variety of plants is an equally large variety of animals. Insects, such as ants, termites, moths, butterflies, and beetles, are particularly abundant. Birds also are extremely common, as are many climbing mammals, lizards, and tree frogs. Because of the low light levels and the difficulty of maintaining visual contact with one another, many of the animals communicate by making noise.

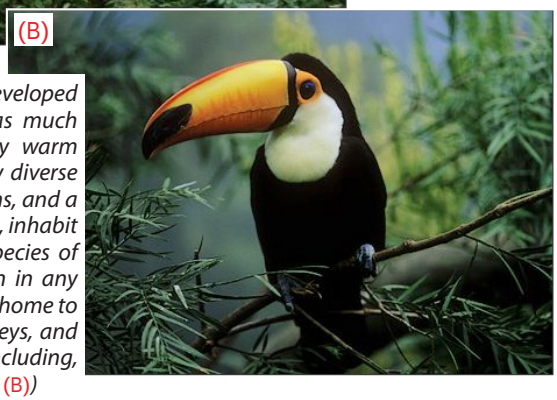


Figure 2.36: Tropical rainforests developed in areas with high annual rainfall (as much as 2400 mm – 4600 mm) and very warm temperatures. They have an extremely diverse mixture of plants – vines, orchids , ferns, and a wide variety of trees (A). Many animals, inhabit tropical rainforests, including more species of insects, reptiles, and amphibians than in any other part of the world. Rainforests are home to all sorts of colorful birds and to monkeys, and to other small and large mammals, including, in some places, elephants (toucan bird, (B))

Activity 2.12

Part I

1 What are some of the adaptive mechanisms of plants in desert ecosystem?
2 What is the reason for desert areas to have little true development of soil?
3 Which plant species form the basic 'building blocks' of the tundra?
4 Write some of the grazing and predator animals in tundra region?
5 What climatic condition influence the soil of tropical grass lands?
6 Which forest ecosystem trees lose their leaves during winter?
7 Why is the coniferous forest plant variety limited?
8 Why is the topical rainforest soils are poor in nutrients?
9 Enumerate some of the hardwoods in tropical rainforest.
10 Compare and contrast the soil types in tundra and tropical rainforest ecosystem.
11 Using Figure 2.38, identify which biome is not found in Africa and North America and why?

Part II

In your geography work group, perform the following tasks.

12 What makes desert soils different from equatorial forest soils?

13 Deforestation of tropical rainforests has become a pressing problem.

a What is the cause of the problem?

b How does the international community address the problem?

c Being a member of the international community, what can be your contribution to the solution?

Work with the other group members to write a report about task 3 and your results and opinions.

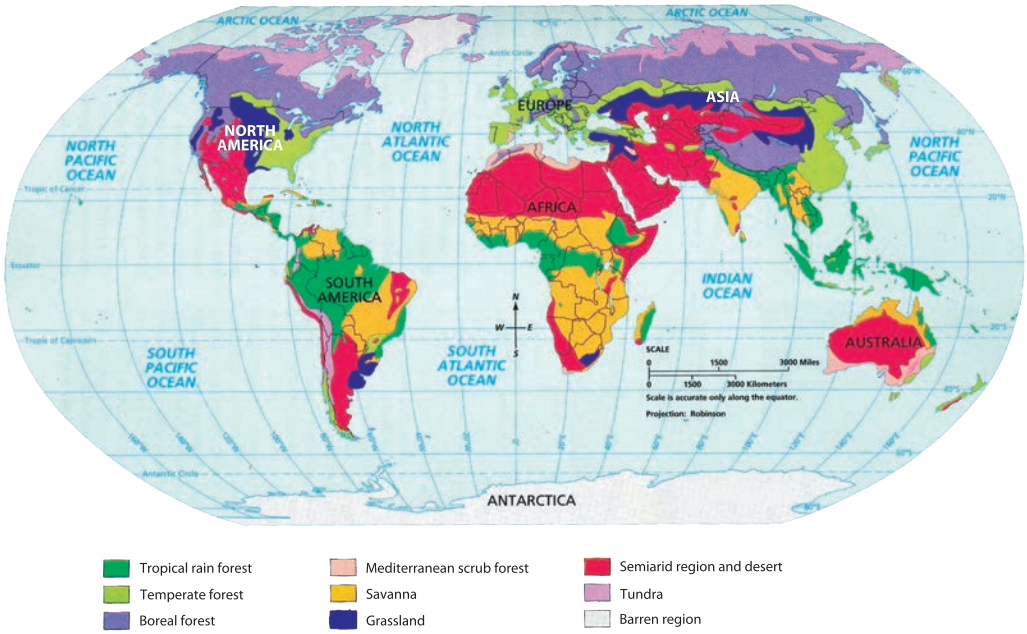


Figure 2.37: **The world's basic biomes**

Unit Review

UNIT SUMMARY

- The birth of our solar system began as dust and gases (nebula). Repeated collision caused the dust particles to change into planets in million years time.
- The earth is one of the nine planets that, along with the others, revolves around the sun
- The earth's origin is related to the process of formation of the solar system
- The earth is composed of a great central core and a series of surrounding layers, collectively known as mantle, and crust.
- Geologists estimate that the earth formed 4.6 billion years ago.
- All divisions in the geological time scale are based on changes in existing fossils of organisms.
- During the Precambrian era, Ethiopia was made up of huge mountains which were folded and faulted.
- Continental drift theory suggests that continents were once joined together and later split and drift apart.
- The earth system can be divided into four physical systems: the atmosphere, the lithosphere, the hydrosphere and the biosphere.
- Rocks are naturally formed solid that is an aggregate of one or more different minerals.
- Igneous rocks cover large areas of the central part of Ethiopia.
- Soil is a complex mixture of inorganic minerals, decaying organic matter water, air and living organisms.
- In the case of good quality soil materials, water and soil, and organic material account 45%, 25% and 5% respectively.
- Some of soil conservation methods in Ethiopia include contour plough, strip cultivation and terracing.
- Water erosion is the main cause of soil erosion in Ethiopia.
- Koppen's widley used classification of world climates is based on seasonsal variations in the annual and monthly averages of temperature and precipitation.
- Climate change may be limited to a specifc region or may occur across the whole earth.
- What the world is more worried about is that the changes that are occuring today have been speeded up because of man's actvities.

- Desertification which is desert-like condition's may spread over human habitats, croplands and wet lands as a consequence of climate change.
- Temperature in Ethiopia is determined primarly by altitude and latitude.
- Rainfall in Ethiopia is seasonal, varying in amount over space and time. There is the long and heavy summer rain accompained by short and moderate rains in autumn, winter and spring collectively known as 'little rains'.
- Ethiopia is a highland country and much of its climate is affected by altitude.
- Drought is a condition that happens when much less rain is received than expected.
- Although famine and starvation can result from drought, they are not its necessary consequences.
- High drought probability zone is Ethiopia include part of the Somali and Afar regions, part of Tigray, eastern Amhara and southern part of the Oromia region.
- Some of drought – coping mechanism in Ethiopia are: careful planned land use, planting crops of low – water dependency, rain water harvesting and planting tree in degraded areas.
- Latitude affects the distribution of vegetation and as a result low latitude support equatorial forests where polar areas entertain tundra vegetation.
- Because of the effect of altitude vegetation variation is similar when we travel up a mountain as one would traveling from the equator to the North pole.
- Climate is the main factor that facilitate the development of soils in different ecosystems.
- Precipitation and temperatrue are major factors that determine the vegetation in an ecosystem.
- As one proceeds from sea level to the tops of mountains, it is possible to pass through a series of ecosystems that are similar to what would be encountered if one traveled from the equator to the north pole.
- Among many factors that shape the type of fauna, flora and soil type of an ecosystem, climate plays a decisive role in their distribution and activities.

REVIEW EXERCISE FOR UNIT 2

I *Match the descriptions given under column 'A' with the terms listed under column 'B'.*

A

1. The study of living and non-living things interacting with their environment.
2. Photosynthesis can be possible only in its presence.
3. Living things in the ecosystem.
4. Includes all species in a certain place.
5. All the populations living in an area.
6. The function and activities of the organism.
7. The area in which an organism lives.
8. Areas with low moisture and low temperature.
9. The most diversified ecosystem.
10. Global temperature has risen by 0.6°C over the past century.
11. Non-living things.
12. Occupies transitional zone between tropical climate and hot deserts.
13. It is dry year round.
14. Flooding is less likely.
15. All forms of moisture that come to the ground from the air.

B

A Tundra
B Water
C Desert
D Savannah
E Tropical rainforest
F Abiotic factor
G Biotic factor
H Ecology
I Community
J Sandy soil
K Niche
L Habitat
M Population
N Precipitation
O Greenhouse gases

II *Choose the word or phrase that best answers the question.*

16. Which one of these had the longest geological time?

A the Paleozoic era
B the Cenozoic era
C the Precambrian era
D the Mesozoic era

17 In which era did the dinosaurs live?

A Mesozoic
B Paleozoic
C Cenozoic
D Precambrian

18 What two important elements constitute the earth's innermost core?

A Potassium and magnesium
B Nickel and iron
C Granite and basalt
D Magma and lava

19 During which era did huge mountain building take place in Ethiopia?

A Mesozoic
B Precambrian
C Cenozoic
D Paleozoic

20 When was the Ethiopian Rift Valley formed?

A Quaternary period
B Tertiary period
C Carboniferous period
D None of the above

21 Who was the first person who tried to explain the present location and distribution of the seven continents, using the Continental Drift theory?

A Darwin
B Alfred Wegener
C Harry H. Hess
D Sir Francis Bacon

22 Which of the following is an example of a clastic sedimentary rock?

A Limestone
B Coal
C Sandstone
D Chalk

23 During what process are sediments pressed together?

A Cooling
B Melting
C Compaction
D Weathering

24 Which of these is a bioclastic sedimentary rock?

A Salt
B Conglomerate
C Coal
D Limestone

25 In which part of Ethiopia do we find metallic minerals in association with Precambrian rock?

A The western part of the country.

B The southern and eastern parts of the country.

C The northern part of the country.

D In all parts of the country.

26 Which of these soil types has a coarse texture?

A Silt

B Sand

C Loam

D Clay

27 Which land use has made the most critical contribution to the problem of soil erosion in Ethiopia?

A Wildfire

B Deforestation

C Overgrazing

D Road construction

28 According to the Kŏppen classification of climate, letter B stands for:

A Tropical climate

B Polar climate

C Dry climate

D Temperate climate

29 Which months are the warmest in most part of Ethiopia?

A September, October and November.

B March, April and May

C June, July and August

D December, January and February

30 Which part of Ethiopia is the wettest?

A Norther

B Eastern

C Southwestern

D Northwestern

31 Which one of these traditional climate zones is dominated by acacia vegetation?

A Woina dega

B Dega

C Bereha

D Wurch

32 Which traditional climate zone is associated with Afro-alpine areas?

A Kolla

B Dega

C Wurch

D Woina dega

33 Which one of these bodies of water is a source of *keremt* rainfall to most parts of Ethiopia?

A Red Sea
B Indian Ocean
C Atlantic Ocean
D Mediterranean Sea

34 Planting trees to replace trees destroyed by deforestation refers to.

A Afforestation
B Logging
C Reforestation
D Terracing

35 What two non-biological factors contribute the most to ecosystem development?

A Soil and temperature
B Precipitation and temperature
C Water and organisms
D None of the above

36 Which of the following services that forests perform is the most valuable one?

A Their soil-conservation functions
B Their contribution to lumbering activities
C Their service as a sink of carbon
D Their service as a habitat

III *Define the following terms.*

a Pangaea
b tectonics
c transform boundaries
d biosphere
e compaction
f divergent boundary
g extrusive
h sedimentary rock
i cementation
j hydrosphere
k lithosphere
l anthracite

IV *Answer the following questions. Support your answers with reasons appropriate to the issues.*

37 Why are the equatorial forests so valuable?

38 Is there any other carbon storage (sink) on earth than equatorial forests?

39 Why are world equatorial forests shrinking over time?

40 Why are equatorial forest soils nutrient-poor?

V *Study the rainfall map of Ethiopia on Figure 2.28 in association with the political map and answer the following questions.*

41 Which parts of Ethiopia receive the highest and lowest amounts of rainfall?

42 In which rainfall regime are the following towns located?

a Gore

b Gambella

c Mekele

d Gonder

e Dire Dawa

f Semera

g Hawassa

h Addis Ababa

i Nekemte

j Jijiga