INTERMEDIATE

GEOGRAPHY

CLASS X

DEPARTMENT OF SCHOOL EDUCATION
MINISTRY OF EDUCATION AND SKILLS DEVELOPMENT
ROYAL GOVERNMENT OF BHUTAN
THIMPHU

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Advisors:

1. Kinga Dakpa, Director General, Royal Education Council, Paro
2. Karma Tshering, Director General, DSE, Ministry of Education, Thimphu
3. Wangpo Tenzin, Curriculum Specialist, Royal Education Council, Paro

Research & Writing

1. Bak Bir Rai, Shari HSS, Paro
2. Chimi Tshering, Jakar HSS, Bumthang
3. Jampa Choden, Martshalla CS, Samdrup Jongkhar
4. Kuenzang Gyeltshen, Samtse College of Education
5. Norbu Wangchuk, Royal Education Council
6. Pema Lhendrup, Sherubtse College, Kanglung
7. Pemba Tshering, Samtse HSS
8. Rinzin Wangmo, Gonzim Ugyen Dorji CS, Haa
10. Sumitra Pokhrel, Phuntsholing HSS
11. Tshering Dorji, Motithang HSS, Thimphu
12. Ugyen Wangchuk, Jigme Sherubling CS, Khaling
13. Ugyen Dorji, Gelephu HSS
14. Kuenzang Wangmo, S/Jongkhar MSS

Copy Editor/Proof Reading

1. Norbu Wangchuk
2. Holly Krasnuik, Educational Consultant

Illustration, Cover Design & Layout

1. Chandra S. Subba

Foreword

The purpose of education is the wholesome development of learners to equip them with relevant knowledge, skills and values crucial for them to deal with realities in life. Learners ought to learn, how to think, understand, integrate and evaluate diverse situations they face in their lives. This pre-empts that education be visionary and future oriented.

We live in an interconnected global world where Geographical perspectives including time and space, physical environment and people influence the world environment. Therefore, it is important for learners to understand and apply the different strands of geography education to help learners in making wise decisions. This is because human activities directly impact our environment.

Understanding of geography and practices of the basic theories of the subject should find link to higher level and transcend to career opportunities for learners. The diverse geography learning experiences and opportunities should stimulate love and care for our natural world to be educated and responsible citizens.

Thus, this book sets the foundation for the learners to understand Geography based on astronomy, physical, human and economic dimensions of Geography education. In addition, it will help them to appreciate the importance of Geography in the conservation of the natural environment for sustainable socio economic development of the country. This textbook presents with clear and simple text enriched with exciting learning activities, informative maps and pictures are attractive and appealing to the learners.

We are grateful to our writers and reviewers from the Royal University of Bhutan, the Ministry of Education, National Land Commission, Bhutan Council of School Examinations and Assessment and colleagues from the Royal Education Council for their valuable contributions. We hope that our teachers and learners enjoy teaching and learning the subject and contribute to the promotion of Geography education as a whole.

Tashi Delek!

Kinga Dakpa
Director General

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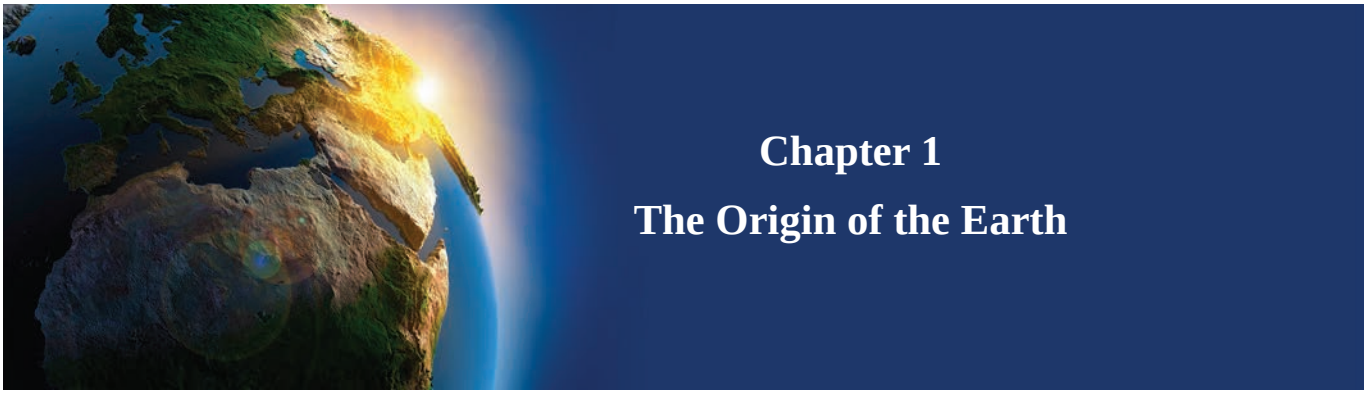


Chapter 1
The Origin of the Earth

Learning Outcome(s):

- Discuss the origin of the Earth
- Compare Big Bang theory with Solar Nebula hypothesis

1.1 Introduction

Our universe is about 13.7 billion years old. It is vast and ever expanding. The Universe comprises of billions of galaxies. The Milky Way galaxy is one of the galaxies where the solar system lies. The evolution of the universe is among the puzzles of cosmology. There are many theories that describe the origin of the universe. The most accepted one is the Big Bang theory. The Earth, along with the other planets, is believed to have evolved about 4.5 billion years ago. The Solar Nebula hypothesis describes the formation of the solar system.

1.1.1 Solar Nebula Hypothesis

The most widely accepted theory on the formation of the solar system is the Solar Nebula Hypothesis. French astronomer and mathematician Pierre-Simon Laplace first proposed

Figure 1.1: Solar System

this theory in 1796. This theory states that the Sun, the planets and all other objects in the solar system were formed from a nebula cloud made from a collection of dust and gas about 4.5 billion years ago.

Gases and dust rotated and formed a big ball in the centre of the nebula. This resulted in the formation of the Sun. The remaining gases and dust formed a disc around the Sun. The disc was made of hot swirling gases and appeared like a gigantic ball in the middle of a Frisbee. During this process, the remaining clouds of gas and dust that surrounded the Sun began to form smaller lumps called planetesimals because of contraction due to gravity. This led to the formation of planets including the Earth which is approximately 150 million kilometers from the Sun.

The inner planets in the solar system consist of Mercury, Venus, Earth and Mars. These planets were mostly formed from heavy compounds such as iron, nickel, aluminum and rocky silicate. These compounds are quite rare in the universe comprising only 0.6% of the mass of the nebula. A nebula is a giant cloud of dust and gas in space. Thus, these planets could not become large and they are called terrestrial or rocky planets. These planets orbit relatively close to the Sun.

The outer planets such as Jupiter, Saturn, Uranus and Neptune are formed from the gases and ice beyond the frost line. A frost line, also accepted as the snow line or ice line, is the particular distance in the solar nebula from the central protostar where it is cold enough for volatile compounds such as water, ammonia, methane, carbon dioxide, and carbon monoxide to condense into solid ice. These planets are also known as gas giants owing to the abundance of volatile gases like ammonia, methane, helium and hydrogen. Thus, they are also known as Jovian planets, meaning: Jupiter-like- planets.

KNOW MORE

Cosmology is the science of the origin and development of the universe.

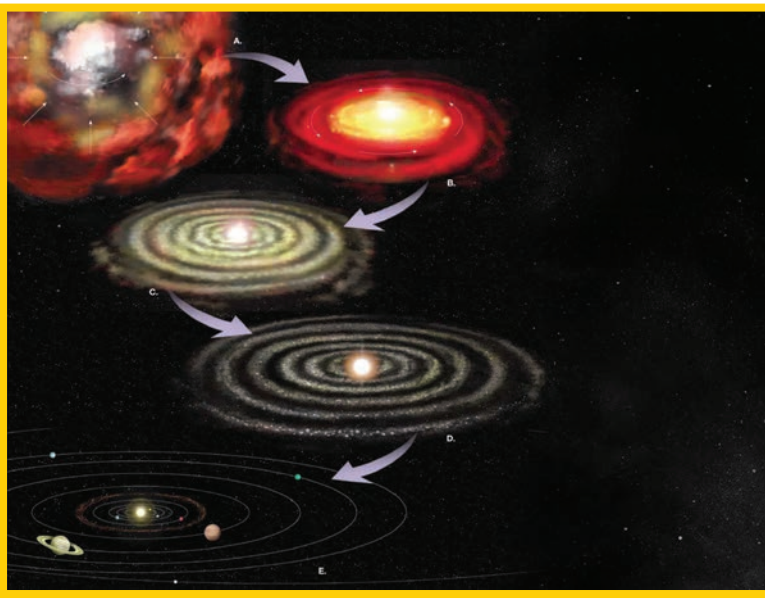


Figure 1.2: Stages of Solar Nebular Hypothesis

Learning Activity

1. Identify the key ideas of the Solar Nebular hypothesis and discuss it in class.
2. Napoleon Bonaparte questioned Lemaitre after reading his theory, 'Where does God fit into your system?' Lemaitre replied, 'Sir, I have no need for that hypothesis. God was simply irrelevant to the everyday world of matter and energy'.

   In the light of the above statement, organise a debate on the topic, "the Universe is not the creation of God".

1.2 Big Bang Theory

George Lemaitre, a Belgian priest and a physics professor proposed The Big Bang theory which explains the origin of the Universe and its expanding nature. The theory explains that the Universe originated billions of years ago in a rapid expansion from a single point of nearly infinite energy density. This single point violently exploded, approximately 13.7 billion years ago, which led to the expansion of the universe.

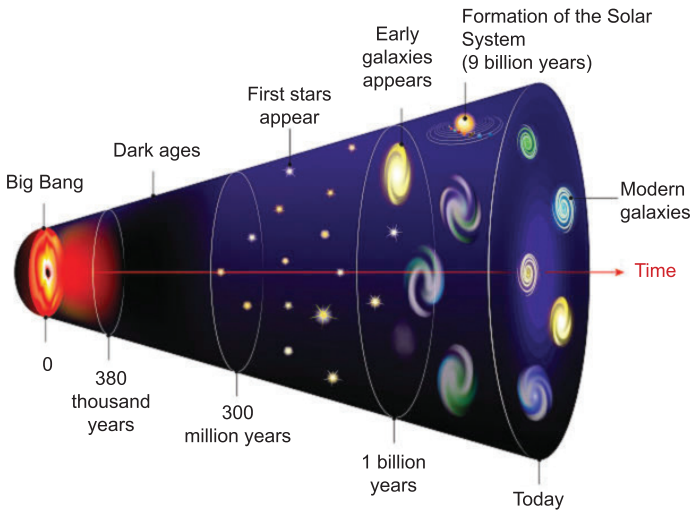


Figure 1.3: Evolution of the earth

Later, Edwin Hubble, an American astronomer provided evidence to prove the expanding universe in the 1920s. Astronomers are able to detect an "echo" from the Big Bang in the cosmic microwave background radiation (CMBR). The CMBR is the remains of the thermal energy from the Big Bang spreading thinly across the whole Universe. It can be detected with a radio telescope. The discovery of the CMBR is the first evidence of the Big Bang theory.

The discovery of red-shift in light from distant galaxies also led to the development of the Big Bang theory. Red-shift of galaxies in general means the light from galaxies shifts to longer wavelengths (redder), which is why it is called 'red-shifted'. Red-shift data provides evidence that the Universe, including space itself, is expanding.

The abundance of hydrogen and helium in the Universe suggests that these elements were first formed during the Big Bang. These lighter elements are the precursors for all other elements.

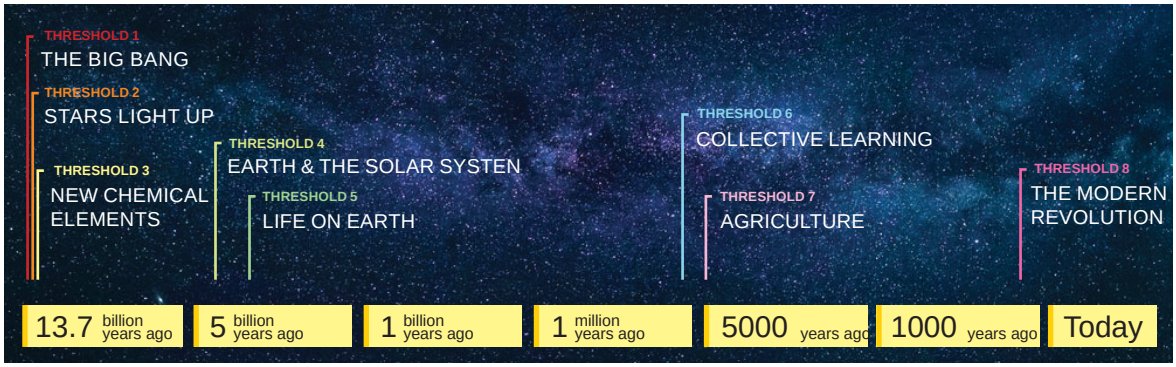


Fig 1.4: Timeline showing the evolution of the Earth.

Learning Activity

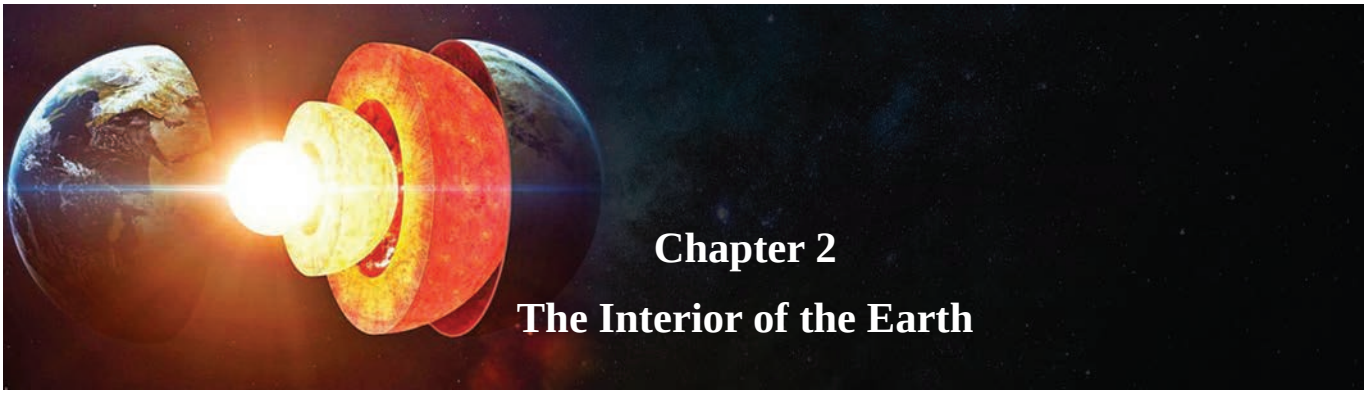
1. Explore internet and watch video clips on The Big Bang Theory and The Solar Nebula Hypothesis. Compare the two theories and list the differences. Share your findings with the class.
   [Suggested video links- ttps://www.youtube.com/watch?v=WG0SPIuqgUc]
2. Find relevant terms related to The Big Bang Theory from the word puzzle and write them in your notebook. Explain at least five terms that you have identified.

S	R	A	T	S	O	L	E	P	T	O	N	F	G
K	S	R	O	U	N	I	V	E	R	S	E	D	G
E	T	A	D	R	C	S	F	R	E	A	U	I	A
T	A	N	S	I	A	E	O	O	S	S	V	S	L
H	R	B	D	R	O	S	R	C	N	C	O	C	A
E	T	N	N	I	O	C	M	K	O	I	P	O	X
E	E	S	E	O	I	O	E	S	T	E	T	V	I
O	S	R	R	S	R	R	D	G	O	N	I	E	E
R	O	E	Y	I	N	S	T	T	R	C	B	R	S
B	I	G	B	A	N	G	O	S	P	E	R	Y	S
Y	U	E	T	R	O	N	R	L	A	E	O	H	U
N	R	I	S	O	R	O	O	R	P	O	I	R	H
R	U	A	N	O	R	T	S	A	T	X	O	L	P
N	E	G	O	R	D	Y	H	O	B	T	E	R	E

Test Yourself

Answer the following questions.

1. How were the planets formed?
2. What do you mean by the term Cosmos?
3. Explain The Solar Nebula Theory and The Big Bang Theory in your own words with the help of diagrams.
4. Compare and contrast The Solar Nebula Hypothesis and The Big Bang theory.
5. What are the possible shapes of the universe? Explore evidences.
6. The Big Bang theory uses “red-shift” as evidence to explain the beginning of the Universe. How does the red-shift from distant galaxies provide evidence for the beginning of the Universe?
7. The Universe is expanding according to the Big Bang Theory. Why is the Solar System not expanding when the whole Universe is expanding? Explore from internet or library resources to find the answer.
8. State whether the following statements are true or false and rewrite the false statement.
   a. Our solar system is located in the centre of the Milky Way Galaxy.
   b. No galaxies existed before the Big Bang.
   c. Redshift data provides evidence of an expanding Universe.
   d. All the planets orbit the Sun in the same direction, and in the same plane.



Chapter 2
The Interior of the Earth

Learning Outcome(s):

- Explain the internal structure of the Earth with illustrations
- Describe the composition of the Earth
- Compare the density of Earth's interior layers with reference to seismic waves
- Interpret The Geological Time Scale to understand different geological periods
- Discuss the formation of The Himalayan Mountain System with reference to Plate Tectonics

2.1 Introduction

The interior structure of the Earth is found in concentric layers. Each layer is composed of different minerals. The understanding of the interior structure of the Earth is enhanced through the study of seismic waves. The Earth is continuously changing due to internal and external forces. Internal forces cause movement of plates. The formation and growth of the Himalayan mountain system is an example of such change.

2.2 Structure and composition

The interior of the Earth is divided into three major concentric layers: crust, mantle and core. Each layer has a unique physical and chemical compositions.

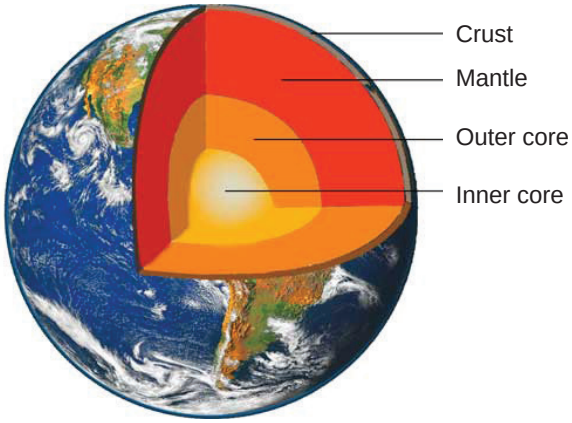


Figure 2.1: Layers of the earth

2.2.1. Crust

The crust is the outermost solid layer of the Earth, and is the thinnest layer. It extends

between 5 to 70 kilometres and is composed of a variety of rocks. In this layer, the density ranges from 2.6 to 3.3 grams per cubic centimetres. The thickness of the crust depends on its kind.

The crust is deepest under the continents and shallow under the oceans. There are two types of crust: continental and oceanic. Various landforms like mountains, valleys and plains are found on the crust. It also supports life.

a. Continental crust

The outermost layer of the Earth is called the continental crust. It is a layer of igneous, sedimentary, and metamorphic rocks. This layer is also called SIAL, as it is mainly composed of silica and aluminium minerals. It is lighter and less dense than the oceanic crust with a density of about 2.6 grams per cubic centimetre. The thickness of the continental crust is about 35 kilometres. This layer is inhabited by terrestrial beings.

b. Oceanic crust

The oceanic crust is the inner layer of the crust found under the ocean. It is a layer of igneous mafic rock. This layer is also called SIMA, as it is composed of silica and magnesium minerals. The oceanic crust is heavier and denser than the continental crust with a density of about 3.5 grams per cubic centimetres. SIAL, being lighter, floats over the SIMA. The average thickness of SIMA is about 7 to 10 kilometres.

The transition zone between the oceanic crust and upper mantle is known as Mohorovicic discontinuity or Moho. Moho was discovered by Andrija Mohorovicic, a Croatian seismologist in 1909. This is a high velocity medium. The velocity of seismic waves increases and their direction changes in this zone.

2.2.2. Mantle

The mantle is a thick viscous layer that lies below the Mohorovicic discontinuity. It extends approximately 2900 kilometres, and is composed mostly of silicate rocks rich in magnesium and iron. Its density ranges from 3.3 to 5.7 grams per cubic centimetres. The molten material that erupts on the surface during volcanism mostly originates from the mantle. This layer is divided into the upper and lower mantle.

a. Upper mantle

The upper mantle is composed of basalt and ultramafic rocks which extends to a depth of about 410 kilometres from the crust. The density ranges between 3.3 to 4.6 grams per cubic centimetres. It is mostly solid but malleable. The upper portion of this layer is called

the asthenosphere over which tectonic plates float. The asthenosphere lies approximately 100 kilometres to 110 kilometres beneath the surface. Here the temperature and pressure is so high that rocks soften and partly melt, becoming semi liquid.

b. Lower mantle

The lower mantle lies 700 kilometres below the Earth, between the upper mantle and the outer core. The density ranges from 4.3 to 5.7 grams per cubic centimetre. It is less viscous and is composed of magnesium and iron bearing silicates.

The transitional zone, known as the Gutenberg Discontinuity, occurs below the lower mantle. It was discovered by seismologist Beno Gutenberg. This zone is also known as the core-mantle boundary. It is marked by a sudden increase in density. At this discontinuity, the velocity of P waves decrease and S waves disappear. Based on this evidence, it is believed that the layer above the transitional zone is solid, and the layer below is in liquid or in molten form.

2.2.3. Core

The core is the innermost layer of the Earth. It is about 4620 kilometres thick. This layer is also known as NIFE as it is composed of nickel and iron. The density ranges from 10 to 13.6 grams per cubic centimetre. It is divided into the outer and inner core.

a. Outer Core

The outer core is a fluid layer composed mostly of iron and nickel along with small amounts of other dense elements like gold, platinum and uranium. It extends from the base of the lower mantle to 4700 kilometres depth. The density of the outer core is between 10 to 12.3 grams per cubic centimetre. A liquid outer core surrounds the solid inner core.

The transition zone between the outer core and inner core is called the Lehmann Discontinuity where the velocity of P waves increase. It was discovered by seismologist Inge Lehmann, and is about 350 kilometres thick.

b. Inner Core

The innermost layer of the Earth is known as the inner core, and it extends 6370 kilometres to the centre of the Earth. The density ranges from 13.3 to 13.6 grams per cubic centimetre. It is in a solid state composed of a dense alloy of nickel and iron. It is solidified as a result of extreme pressure.

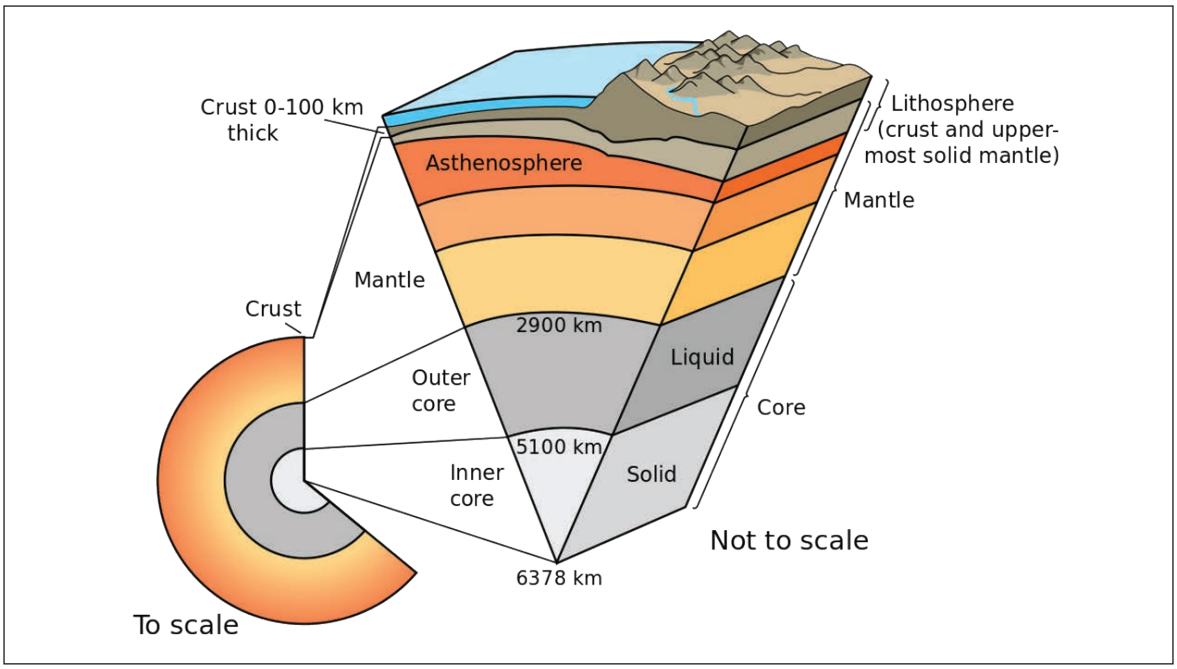


Figure 2.2: Structure of the Earth's interior.

KNOW MORE

- The deepest place ever reached by human technology is the Kola Super deep Borehole (about 12.3 km deep) near Murmansk, Russia.
- Endogenetic force refers to the forces that are coming from within the Earth otherwise known as internal force. Exogenetic force refers to the forces that are generated on or above the Earth's surface, also referred to as external force.

Learning Activity

1. Make a labelled model of Earth's internal structure using locally available materials and colour them appropriately. Display in the class.
2. If there is no mantle in the structure of the Earth, how would this affect life on the Earth?

2.3 Seismic waves

A Seismic wave is a vibration produced most often by an earthquake and sometimes by an explosion. Geologists use these waves to determine the depth and density of the Earth's Interior. Direct evidence from mining and drilling doesn't provide enough information about the interior of the Earth; so more knowledge is attained through indirect evidence such as seismic activity.

Seismic waves behave differently when it interacts with material in different states.

Types of seismic waves

Two main types of seismic waves are: surface waves and body waves.

1. Surface waves

Seismic waves that only travel over the Earth's surface are known as surface or long waves. Their average velocity is about 3 kilometres per second, and travel through all medium. Rayleigh and Love waves are the two types of surface waves.

2. Body waves

The seismic waves that travel through the interior of the Earth with higher velocity than the surface waves are known as body waves, which are further divided into two kinds.

i) Primary waves (P-Waves)

Primary waves (P-waves) are the fastest kind of seismic waves, and travel at a speed ranging from 4 - 8 km per second. Their speed increases with an increase in the density of rock. P-waves can travel through all states of matter.

ii) Secondary waves (S-Waves)

Secondary waves (S-waves) travel with a velocity lower than P- waves, and can only travel through solids. S-waves travel at an average velocity of about 4 km per second.

2.4 Characteristics of seismic waves

Seismic waves behave differently in different layers of the interior of the Earth. The course and velocity change while passing through boundaries of different layers. The velocity of P- and S-waves increase with depth. This indicates an increase in density up to a depth of 2900 kilometres. Beyond this, S-waves disappear and the velocity of P-waves decrease

indicating a liquid outer core. However, the velocity of P-waves increase in the inner core of the Earth due to increase in density and solid nature.

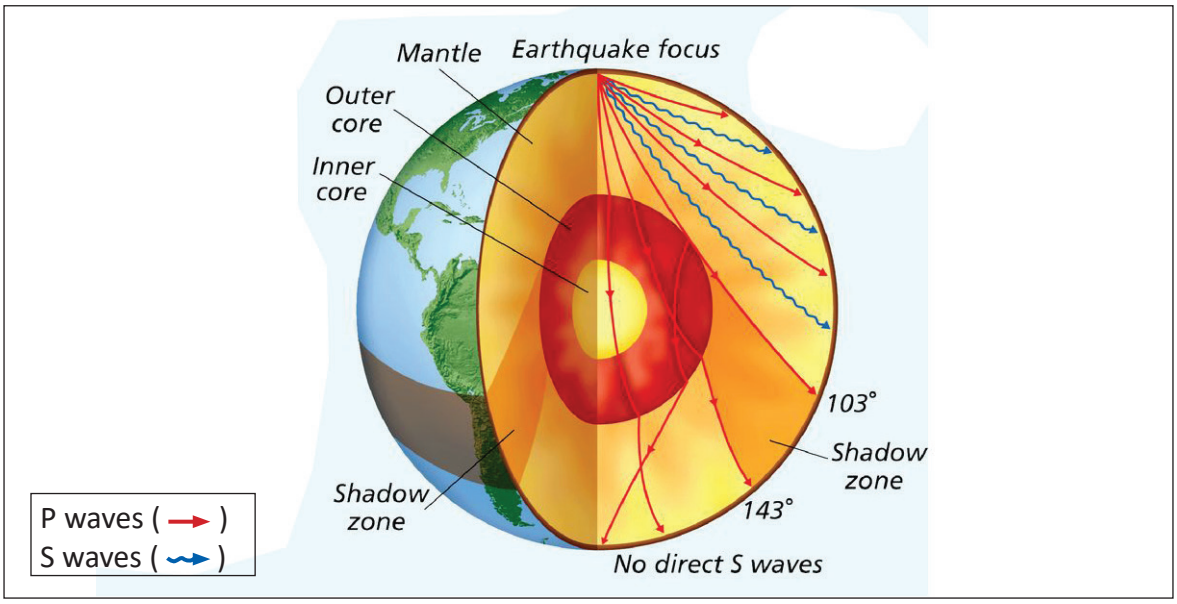


Figure 2.3: Seismic waves

Learning Activity

1. In the interior of the Earth, temperature increases with depth, which results in the melting of the rocks. Despite experiencing the highest temperature, the inner core is in solid state. In teams, explore reasons using different sources and make a PowerPoint presentation in the class.

2.5 Geological Time Scale

The geological time scale (GTS) is a system of chronological dating of geological strata compared to time. The geological time scale is a "calendar" of events in Earth history that describes time and relationships of events. The first geological time scale that included absolute dates was published in 1913 by the British geologist Arthur Holmes.

Geological time begins at the start of the Archean Eon, 4.0 billion to 2.5 billion years ago and continues from there. It is organised into units of duration: eons, eras, periods, epochs, and ages. Each unit of duration is characterised by the evolution of particular kinds of organisms as well as the occurrence of events over time.

Geological Time Scale and Major Events

Eon	Era	Period		Epoch	Major Events
Phanerozoic	CENOZOIC The age of mammals 65 million years ago through today	Quaternary The age of man 1.8 million years ago		Holocene 11,000 years ago	Human civilization
				Pleistocene 1.8-0.011 million years ago	Extinction of large mammals and birds. End of last ice age
		Tertiary 65-1.8 million years ago	Neogene 24-1.8 million years ago	Pliocene 5-1.8 million years ago	Uplift of North West America. Development of mammals continued.
				Miocene 24-5 million years ago	Uplift of Alpine mountain More mammals appeared
			Paleogene 65-24 million years ago	Oligocene 38-24 million years ago	First monkeys and apes appeared
				Eocene 54-38 million years ago	New fold mountains developed, Early mammals expanded
				Paleocene 65-54 million years ago	Development of primitive mammals
	MESOZOIC The age of reptiles 248 - 65 million years ago	Cretaceous 146 - 65 million years ago		Upper Cretaceous 98 - 65 million years ago	High tectonic and volcanic activity; formation of present continents; extinction of some mammals
				Lower Cretaceous 146- 98 million years ago	Feathered dinosaurs appeared
		Jurassic 208- 146 million years ago			Some plants and animal species appeared
		Triassic 248- 208 million years ago			Reptiles expanded and first dinosaurs appeared
	PALEOZOIC 540-248 million years ago	Permian The age of amphibians 282-248 million years ago			Formation of Pangaea, atmosphere developed, reptiles surpasses amphibians
		Carboniferous 360-280 million years ago		Pennsylvanian 325-280 million years ago	Some mountains developed, forming of swamp forests, first reptiles appeared
				Mississippian 360-325 million years ago	Some insects and plants appeared
		Devonian The age of fishes 408-360 million years ago			Fish and land plants became abundant and diversified
		Silurian 438-408 million years ago			Great mountains formed , first small land plants appeared
		Ordovician 505-438 million years ago			Great cooling and glaciations with volcanism
		Cambrian The age of Trilobites 540-500 million years ago			Supercontinent began to break, marine life existed

Proterozoic	**PRECAMBRIAN**	**Late Precambrian** 2000 million years ago	Sedimentary and granite formed, first evidence of life
Archean			
Hadean		**Early Precambrian** 4500 million years ago	Formation of Earth's crust, history unknown

Table 2.1. Geological Time Scale

KNOW MORE

While thousands of climbers have successfully scaled Mount Everest, the highest point on Earth, only two people have descended to the planet's deepest point, the Challenger Deep (11 km deep) in the Pacific Ocean's Mariana Trench.

Learning Activity

Using the geological time scale, find out the eon, era, period and epoch during which the Himalayan Mountains were formed.

2.6 Plate Tectonic Theory

Plate Tectonic Theory was proposed by Tuzo Wilson in the 1960s. According to this theory, the lithosphere is divided into seven primary and many secondary plates consisting of continental and oceanic plates. These plates float over the asthenosphere and move in different directions.

Plate boundaries

The movement of plates away from one another is called *divergent* movement, and the movement of plates towards one another is called *convergent* movement. The divergent movement of plates results in faulting and volcanic eruptions. The formation of the Mid-Atlantic Ridge, on the bottom of the Atlantic Ocean, is the result of divergent movement.

Convergent movement exerts pressure on both sides of the plate boundary and causes the rock strata to buckle and bend and results in the formation of Fold Mountains.

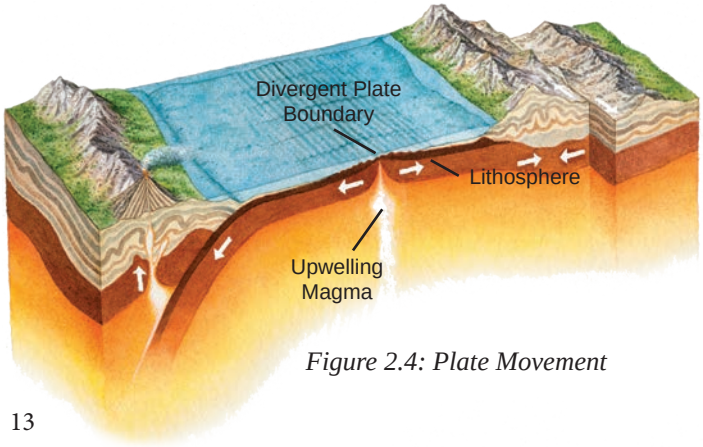


Figure 2.4: Plate Movement

Learning Activity

In teams, explore, suitable simulations/videos/pictures from different sources to learn more about movement of plates on the Earth's surface. Share it to the class.

2.7 The Himalayas

About 225 million years ago, while the Indian subcontinent was located approximately 6400 kilometers in the Southern Hemisphere, a massive body of water called the Tethys Sea existed in place of the Himalayas. The Indian plate gradually moved towards the Eurasian plate in the north.

During the course of 80 million years, the speed of movement was about 9-16 cm per year. During the last 40-50 million years the speed of movement reduced to approximately 2-6 cm per year. The continuous movement of the Indian plate towards the north resulted in a collision with the Eurasian plate. This collision resulted in the uplift of the Tethys Sea floor, which formed the Fold Mountains. This fold mountain range is called the Himalayas. The Himalayas are still rising by more than 1cm per year because of the continuous movement of the plates.

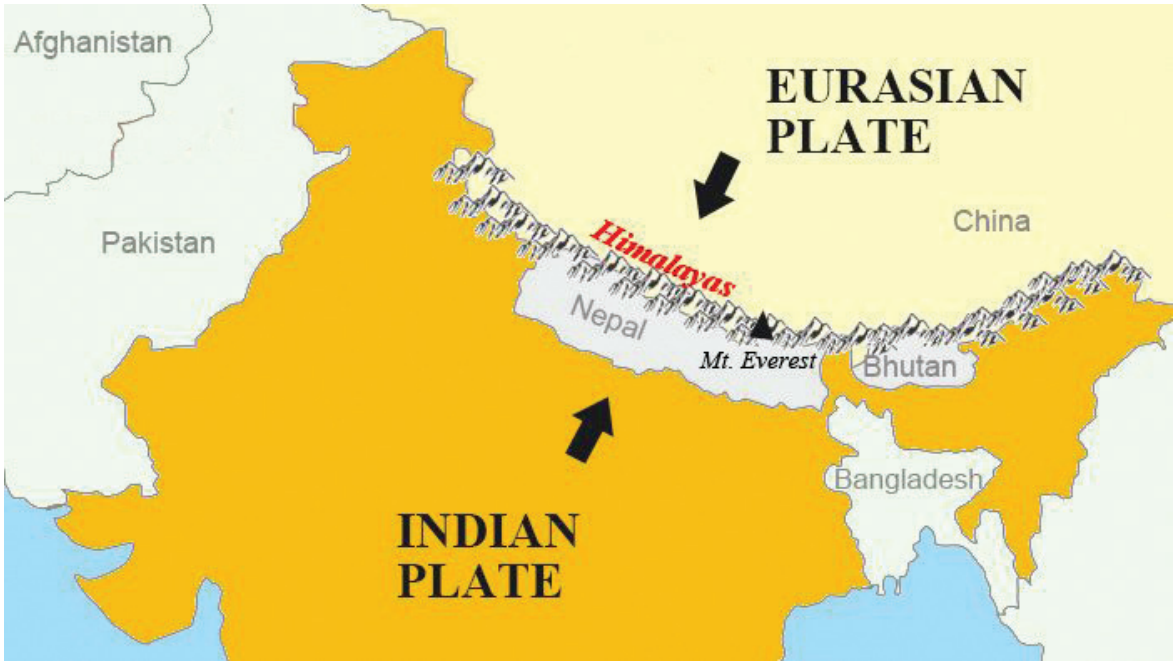


Figure 2.5: Formation of the Himalayas

Learning Activity

Use internet to explore evidences to prove that the Himalayas were formed from the Tethys Sea. Prepare a PowerPoint and present it to the class.

Test Yourself

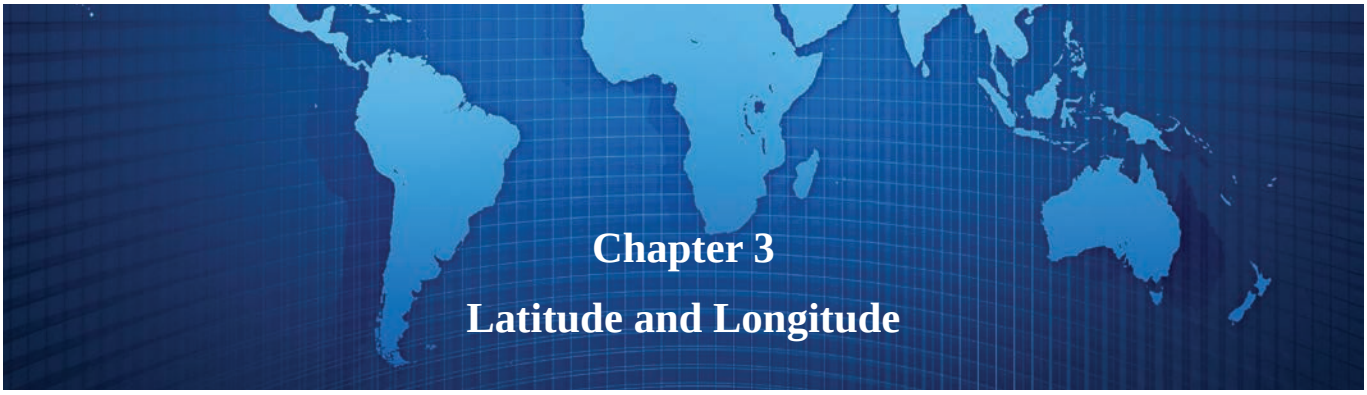
1. Write a short story or letter to a friend describing the most exciting part of your own imaginary journey to the Earth's centre.
2. Copy the table in your notebook and fill in the missing information.

Layers	State	Composition	Density
Continental Crust			
Oceanic Crust			
Upper Mantle			
Lower Mantle			
Outer Core			
Inner Core			

3. Among the three layers of the Earth's interior, which layer do you think is the most important one? Justify your opinion.
4. Discuss the importance of seismic waves in the study of Earth's interior.
5. Copy the table in your notebook and fill in the missing information.

Sl.No.	Eon	Era	Period	Major events
1	----------	Cenozoic	Quaternary	Ice age begin
2	Phanerozoic	----------	Triassic	First mammals appeared
3	Phanerozoic	Mesozoic	----------	Predominantly Dinosaurs
4	Phanerozoic	Canezoic	Quaternary	----------

6. Do you think the location of continents and oceans will change in the future? Justify.
7. The Oceanic crust is heavier than the Continental crust. Give reasons.
8. Examine the evidences to prove that the Himalayan mountain range is still rising.
9. Plate tectonics is responsible for the formation of various landforms on the surface of the Earth. Make a list of landforms formed by convergent and divergent movement.



Chapter 3
Latitude and Longitude

Learning Outcome(s):

- Determine latitude and longitude of a place
- Calculate time and longitude of a given location

3.1 Introduction

In ancient history, people used landmarks and rudimentary maps to locate places. This was useful locally, but standard methods were required to fix the location while travelling far across the sea or a desert. A global grid system was later developed by Hipparchus (190-120 BCE), a Greek astronomer, using lines of latitude and longitude. Different methods were used to determine latitude and longitude with the help of the Sun's position at noon. Astrolabe, a device to measure the Sun's inclination and Gnomon, a clock system were used.

Latitudes and longitudes are now determined electronically using Global Positioning System (GPS), which is a world-wide radio navigation system made up of 24 satellites and their ground stations. These latitudes and longitudes are used to determine the position or location of any place on the Earth.

3.1.1 Determination of Latitude

Geographers in the past measured latitude by comparing the position of a particular place on Earth with the position of either the Sun or the North Star (Polaris).

The latitude of a place is determined by observing the position of the Sun and the Stars using different instruments such as Astrolabe, Gnomon and Quadrant. The observation of the Sun using such as quadrant the zenith distance and declination of the Sun is used to determine latitude. The zenith distance is an angle that the sun makes with the point in the sky directly overhead or at noon. The declination of the Sun or Solar Declination is the angle that the Sun makes north or south of the equator on a particular day as recorded in Nautical Almanac.

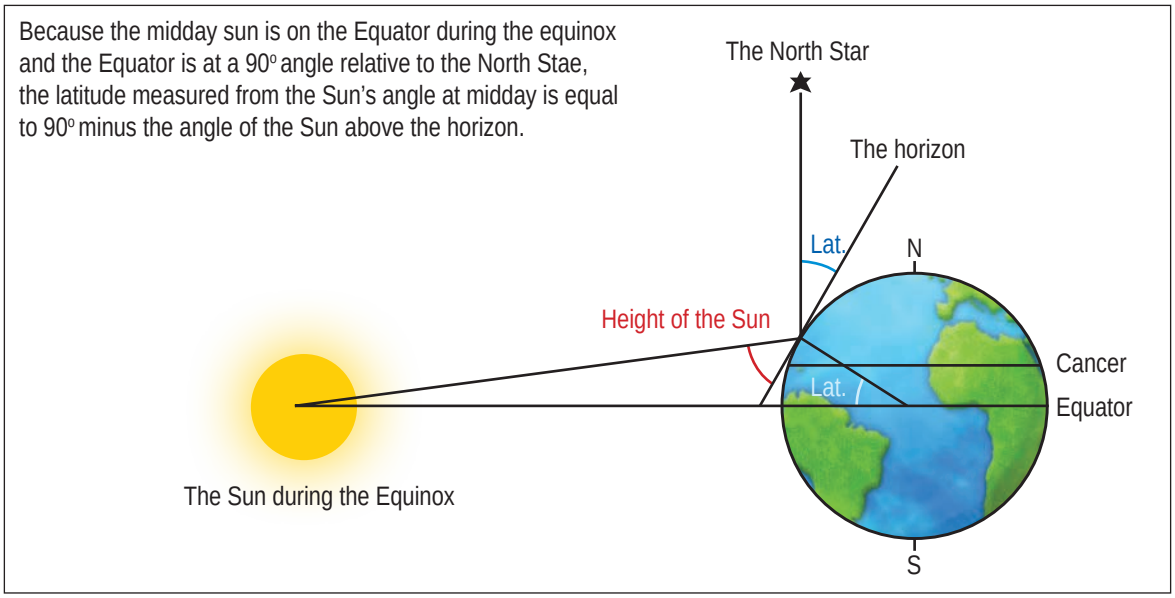


Fig 3.1: Determining latitude by observing the Sun.

In the Northern Hemisphere, the latitude of a place is determined by adding the zenith distance to the solar declination, which is 23½ degrees during 21st June, zero degree on 21st March and 23rd September. In the Southern hemisphere, latitude is determined by subtracting the declination of the Sun with the zenith distance.

The second method of determining latitude is by referring the Pole Star or Polaris. This is possible only in the Northern Hemisphere. The height of the pole star is calculated using a telescope or a quadrant. The angle made by the telescope with the horizontal line is the altitude of the Polaris. This altitude is equal to the latitude of that place.

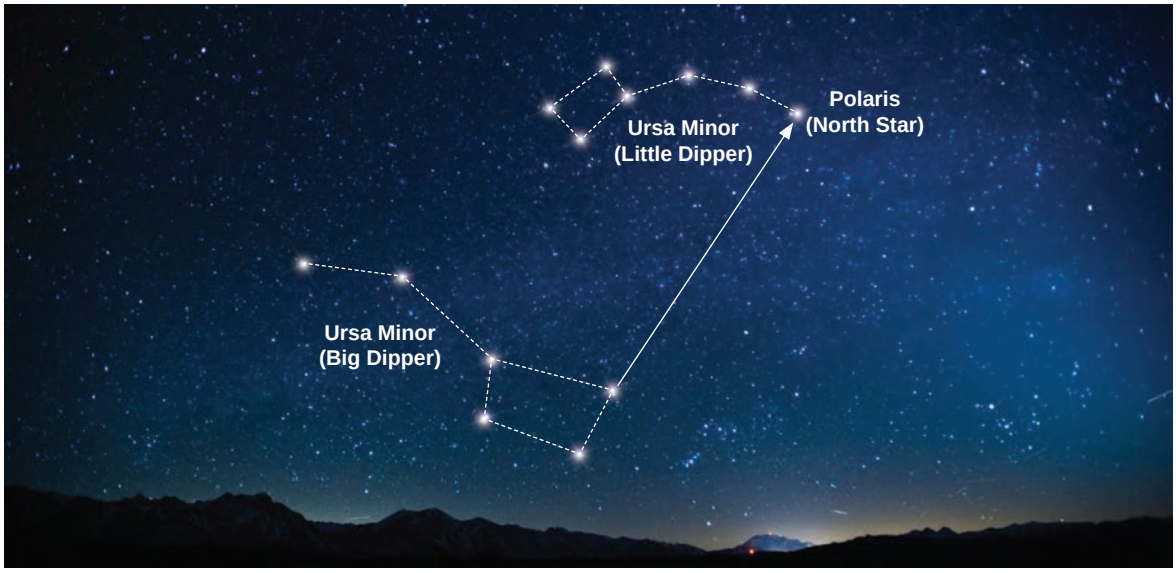


Figure 3.2: Position of North Star or Polaris

Learning Activity

1. What is nautical almanac and how was it used by geographers in the past? Explore from internet or any other resources and report your findings to the class.

3.2 Determination of Longitude

Early navigators determine longitude by relying on dead reckoning. This method was not reliable on long voyages. Determining longitude at sea was more difficult than on land. Land surface provided a stable surface to determine the location using various astronomical techniques that were not practical at sea. Navigators solely relied on their knowledge of latitude which was also known as running down a westing, following a constant line of latitude.

John Harrison, an English horologist invented a marine chronometer, H4, a spring-driven clock that could measure longitude. It is an astronomical method of calculating longitude using local time and the time at some reference point.

Around the same time, Nevil Maskelyne, an English astronomer's work on the Nautical Almanac and the Board of Longitude demonstrated the complementary nature of astronomical and timekeeper methods. This led to the successful determination of longitude at sea and the Royal Observatory became a testing site for marine timekeepers.

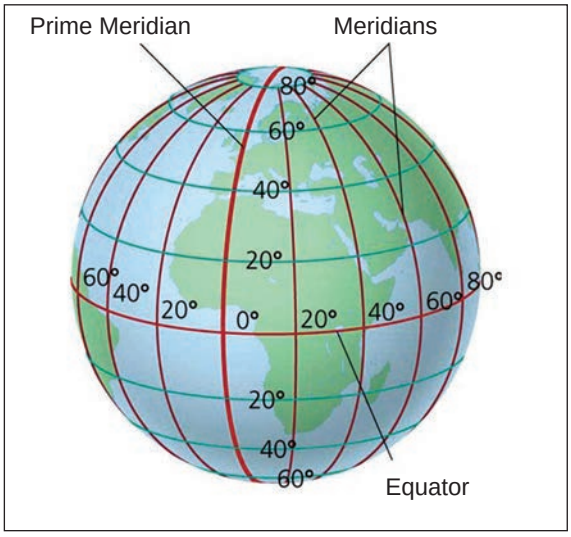


Figure 3.3: Earth's Coordinates

Figure 3.4: Chronometer

Greenwich where Royal Observatory is located became the Prime Meridian, zero degree longitude of the world. The longitude of a place is determined with reference to the local time of a place with the time of the Prime meridian.

KNOW MORE

1. A nautical almanac is a publication describing the positions of a selection of celestial bodies for the purpose of enabling navigators to use celestial navigation to determine the position of their ship while at sea.

2. In navigation, dead reckoning is the process of calculating one's current position by using a previously determined position and advancing that position based upon known or estimated speeds over elapsed time and course.

3.2.1 Global Positioning System

The advanced method of determining latitude and longitude is the use of Global Positioning System (GPS). It is a satellite navigation system used to determine the position on the ground. This technology was first used by the United States military in the 1960s. The use of GPS has expanded into commercial products such as automobiles, smart phones, smart watches, and Geographic Information System (GIS) devices.

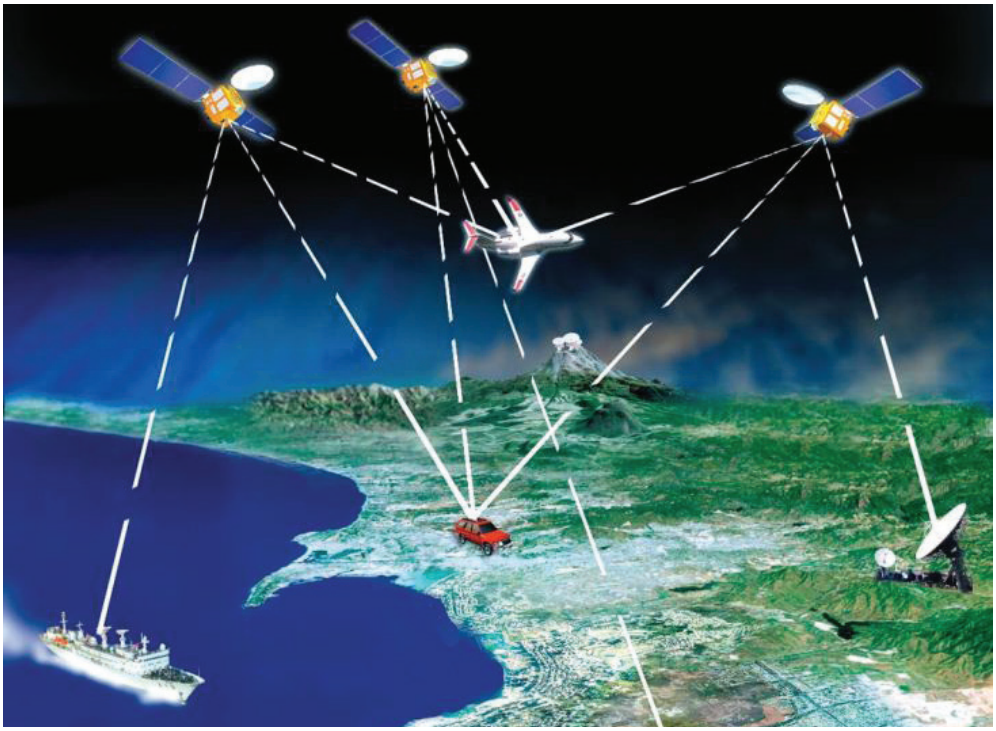


Figure 3.5: Global Positioning System

The GPS functions with 24 satellites deployed in space. They orbit the Earth once every 12 hours at an extremely fast pace. These satellites are evenly spread so that at least three satellites are accessible via direct line-of-sight from anywhere on the Earth in order to determine a receiver's location. A connection of four satellites is ideal since it provides greater accuracy. GPS takes a few minutes to connect, depending on the strength of receiver. Each GPS satellite broadcasts a message that includes the satellite's current position, orbit, and exact time. A GPS receiver combines the signals from multiple satellites to calculate its exact position using a process called triangulation.

Learning Activity

1. The use of GPS is becoming popular. Explore the advantages and disadvantages of using GPS and share in the class using MS PowerPoint presentation.

3.3 Determination of Longitude and Time

The longitude of a place is determined by referring to the local time of a place with reference to Greenwich Mean Time (GMT) of the Prime Meridian. Prime Meridian is an imaginary line that runs vertically around the Earth that converges at the North and the South poles. These lines are known as meridians. Each meridian measures one degree and the distance around the Earth measures 360 degrees.

Time is determined by using longitudes. The Earth takes 24 hours to complete one rotation or 360 degrees. It takes 4 minutes to pass 1 degree longitude. The meridian that runs through Greenwich, England, is internationally accepted as the line of zero degree longitude, or Prime Meridian. The antemeridian is halfway around the world at 180 degrees referred as the International Date Line.

Note:

24 hours = 360^0 Longitude

1 hour = 360 ÷ 24 = 15^0

60 minutes = 15^0 (or)

60 ÷ 15 = 4 minute

Therefore, 1^0 = 4 minutes

Learning Activity

1. What is the time and day at Trongsa 90°E, when it is Sunday 1.30 AM at Tokyo, 140°E?
2. Calculate the longitude of a place where the local time is 6:00 AM, when the time is 3:00 PM in Kolkata 88°E.
3. Athens, the site for the 2004 Summer Olympics, is at 24° E. If an event begins at 2 PM at Athens, what time will it be in New York 74° W?
4. Calculate the longitude of Anchorage in Alaska where the local time is 10:00 AM, when it is 2:00 AM in Bhutan.

Test Yourself:

1. Explain different ways of determining latitude.
2. Give reasons for the development of grid system with reference to maps.
3. A quadrant is one of the ways used by ancient astronomers to determine latitude observing the Sun. Explore internet or other secondary sources and explain a quadrant.
4. Global Positioning System (GPS) is replacing conventional ways of determining latitude and longitude. Can we rely fully on GPS against conventional methods? Justify your answer.
5. Juan, who lives in Madrid (4° W) wants to call his friend, Yoshi, in Tokyo. If it is 9 AM in Madrid, what time is it in Tokyo 140° E?
6. Calculate the time of a place located at 15° E when it is 12 noon at 120° E.
7. What is the time and day at place X situated at 25° N latitude and 33° E longitude when it is 2.30 AM on Friday at place Y situated at 30° S latitude and 25° E longitude?
8. A cricket match was to be held at Birmingham at 9 AM local time. The position of Birmingham is 5° W. Calculate the time the viewers have to tune in their television at Sydney 151° E.
9. An important live programme was to be telecast from New Delhi at 7. 30 PM. At what time will the people at Ivory Coast 20° W be able to watch this programme?
10. When it is 4 AM at Chicago 88° W, what will be the longitude of a place if local time is 1.15 PM?
11. Local time is inconvenient to adopt in practical life. Justify the statement with valid reasons.

Chapter 4
Interpretation of Topographical Map

Learning Outcome(s):

- Discuss the techniques of layout and numbering of topographical maps
- Interpret topographical map

4.1 Introduction

Topographic map is one of the widely used maps. It provides a range of information on physical and cultural features. It is difficult to understand the general appearance of the map at a glance as there are various details recorded using conventional signs and symbols. To understand the information on the map, inferences are drawn using relief and land use. Interpreting a topographic map requires practical skills for analysing and synthesising information. Topographic map interpretation includes marginal information, physical and cultural features of the given map.

4.2 Layout and Numbering of Topographic Map

The numbering of topographic map is based on international series (CIM) on map scale of 1: 1,000,000. This series covers an area of 4° latitude by 6° longitude. The geographical position of the sheet is defined by two letters and a number. The first letter is N or S depending on location of the series towards north or south of the equator. The second letter indicates latitude of a sheet alphabetically in capital letters. Numbering starts from 180° longitude and goes from west to east, changing after 6° longitude.

The Indian numbering system uses India and adjacent countries series (IAC) system. This series extend from 4° N to 40° N latitude and 44° E to 124° E longitude. The scale of this series map 1: 1,000,000 and is used as base map. This series map is divided into sections of 4° latitude by 4° longitude. The numbering increases from north to south and then from west to east. It begins with 1 in the northwest and ends with 136. It covers only land areas and leaves any areas lying completely in sea.

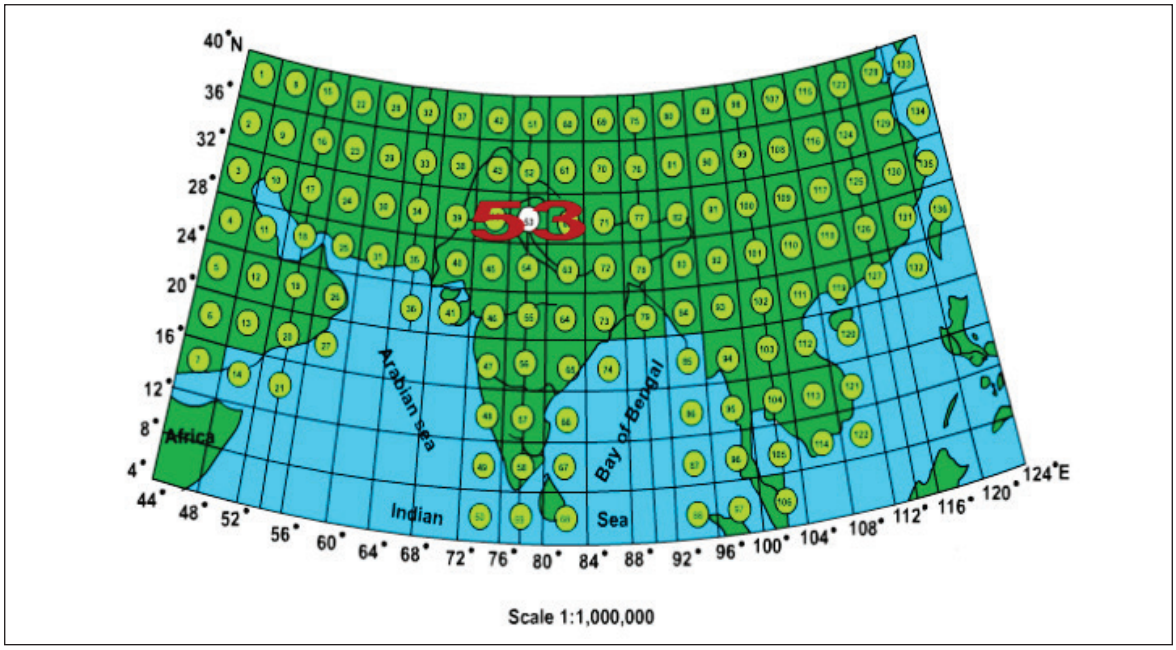


Figure 4.1: India and Adjacent countries numbering series

Topographic map in Bhutan uses India and adjacent countries series (IAC). The 1:1000000 sheet is divided into 16 equal parts. It covers an area of 1 X 1 longitude with a scale of 1:250,000. It is numbered from A to P vertically like in the India and adjacent series (IAC).

The 1:250,000 map is further divided into 16 equal parts to produce maps on a scale of 1:50,000. It is numbered from 1 to 16. It covers an area of 15 minutes latitudes by 15 minutes longitudes. This map series is used in Bhutan and it's numbered as 78E/7, 78E/11 to 78E/16.

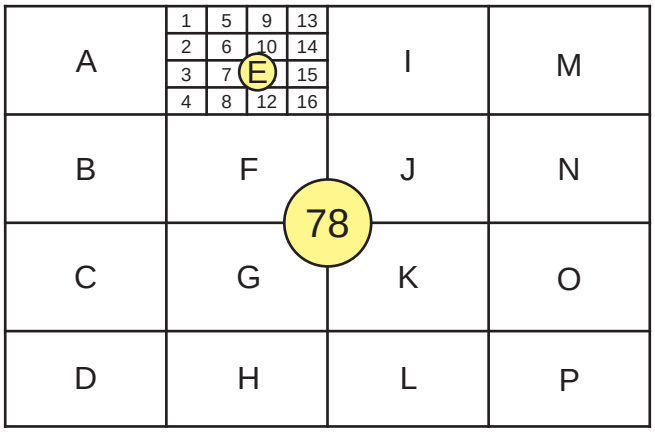


Figure 4.2: Numbering System in IAC

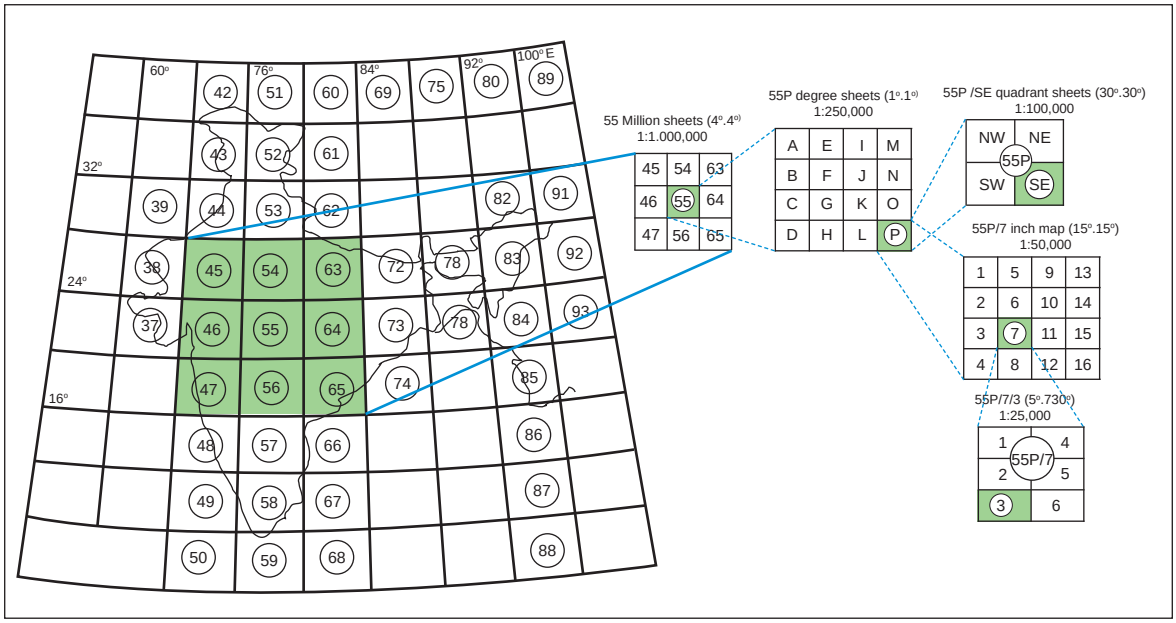


Figure 4.3: Numbering System

KNOW MORE

Carte Internationale du Monde (CIM) or International Map of the World (IMW) is the map series prepared on a scale of 1:1,000,000

Learning Activity

1. Discuss how IAC map numbering systems are used by India and adjacent countries?

2. Explain how topographic map of Bhutan 78/M 11 and 78 E/11 were generated by using IAC system?

4.3 Interpretation of Topographical Map

Map language and sense of direction are essential in reading and interpretation of the topographical maps. The conventional signs and symbols given in the legend of map helps in understanding topographic map.

A topographic sheet is usually interpreted based on marginal information, physical features and cultural features.

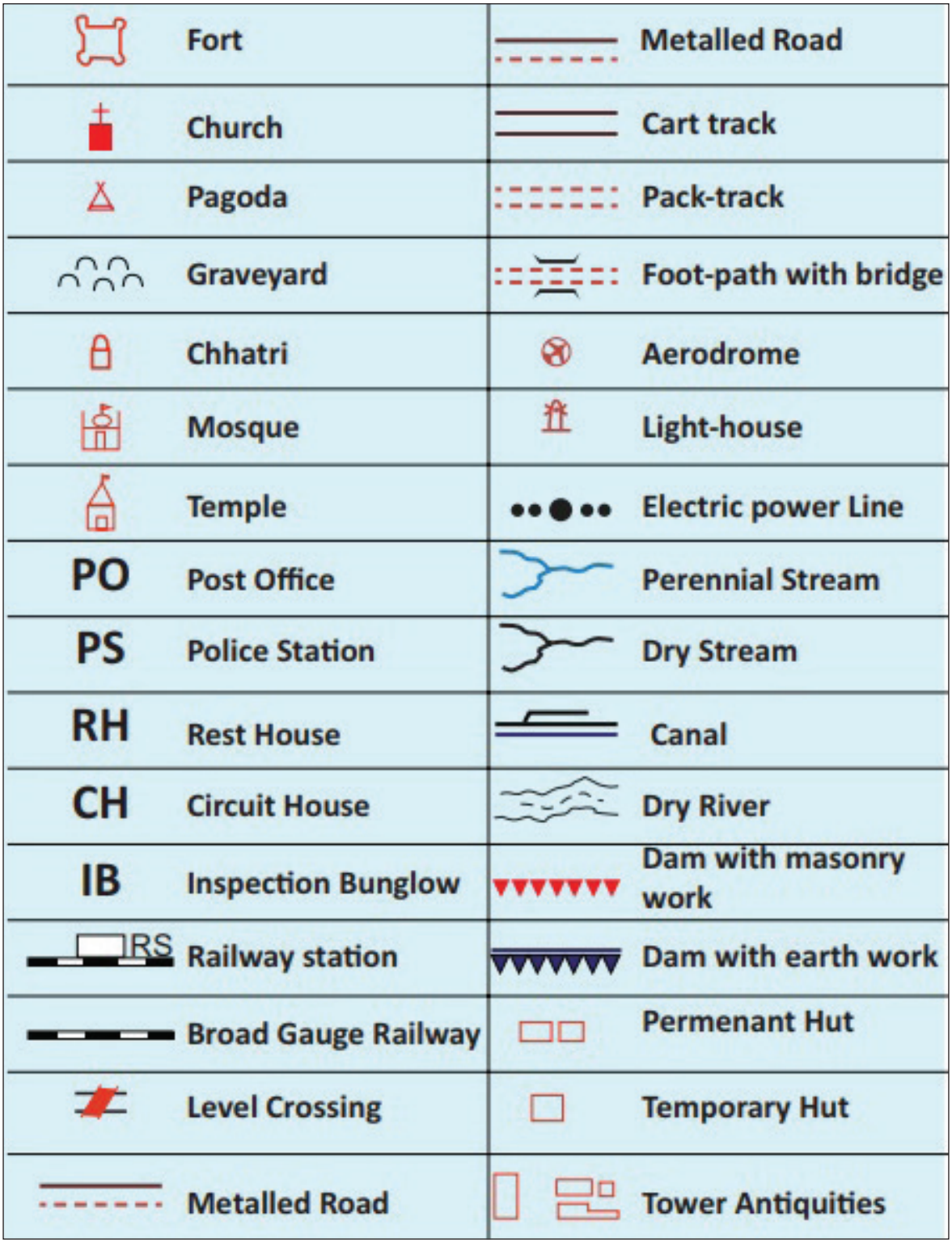


Figure 4.4: Conventional symbols

4.3.1 Marginal Information

Marginal information includes the topographical sheet number, location, grid references, extent in degrees and minutes, scale and the area covered.

4.3.2 Physical Features

The relief of an area includes the general topography to identify the plains, plateaus, hills or mountains along with peaks, ridges, spur and the general direction of the slope. These features are depicted by contour lines on a map. Rivers and tributaries, type and extent of valleys, types of drainage patterns are some of the information related to drainage system.

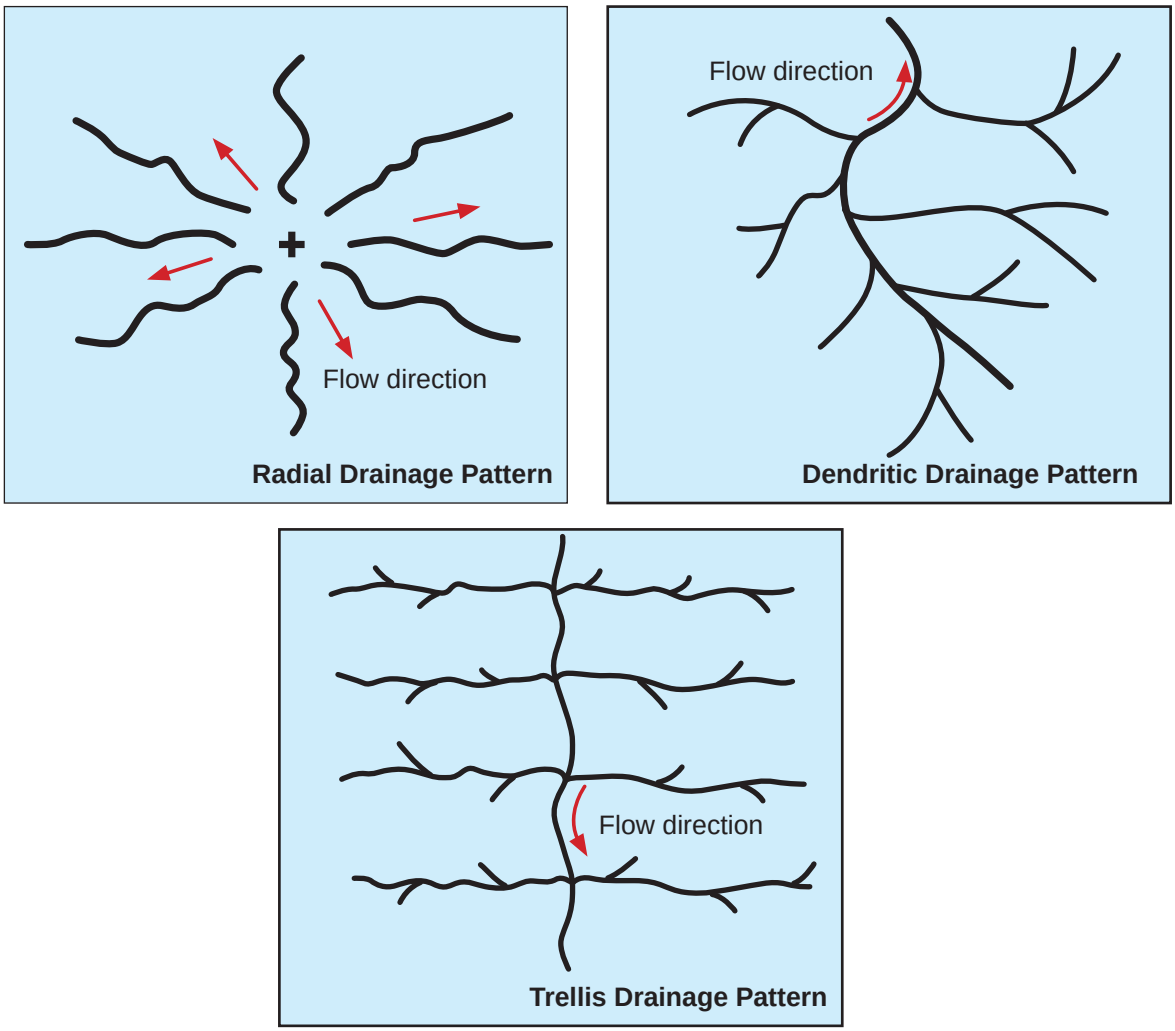


Figure 4.5: Drainage Patterns

Land use information in the map includes the use of land under different categories such as natural and cultural features. Some of the natural features represented on a map are vegetation, forest, and wasteland.

4.3.3 Cultural Features

Cultural features are human-made features such as settlement, irrigation, transport and communication system.

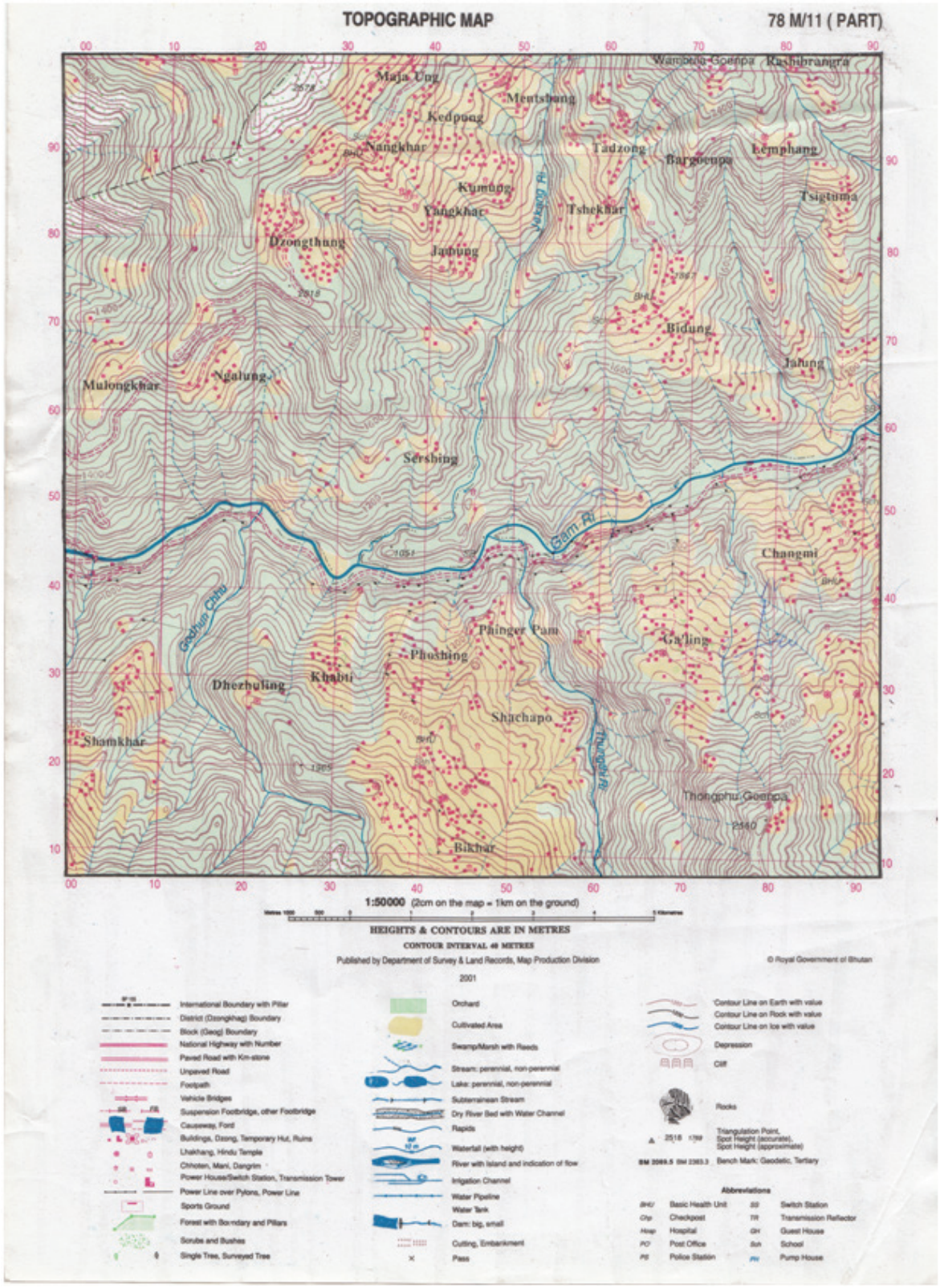
Transportation includes national highways, district roads, cart tracks, mule tracks, footpaths, railways and waterways. Major communication lines and post offices are the components of the communication system. These features are represented by conventional signs and symbols.

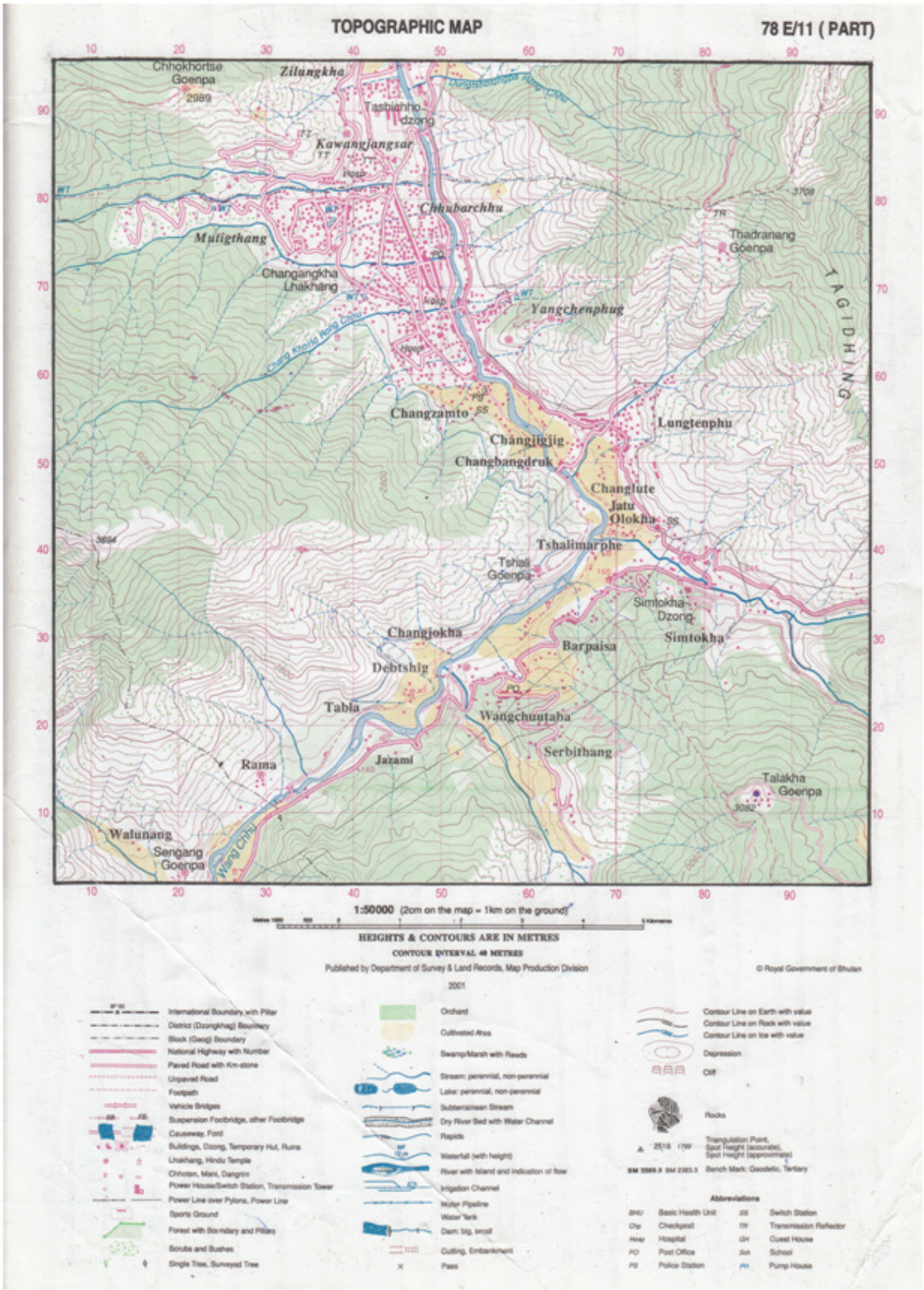
The occupation of the people in the area is deduced with the help of land use and the type of settlement. In rural areas the main occupation of the people is farming; in tribal regions, lumbering and primitive agriculture dominate and in coastal areas, fishing is practiced. Similarly, in cities and towns, services and business are major occupations of the people.

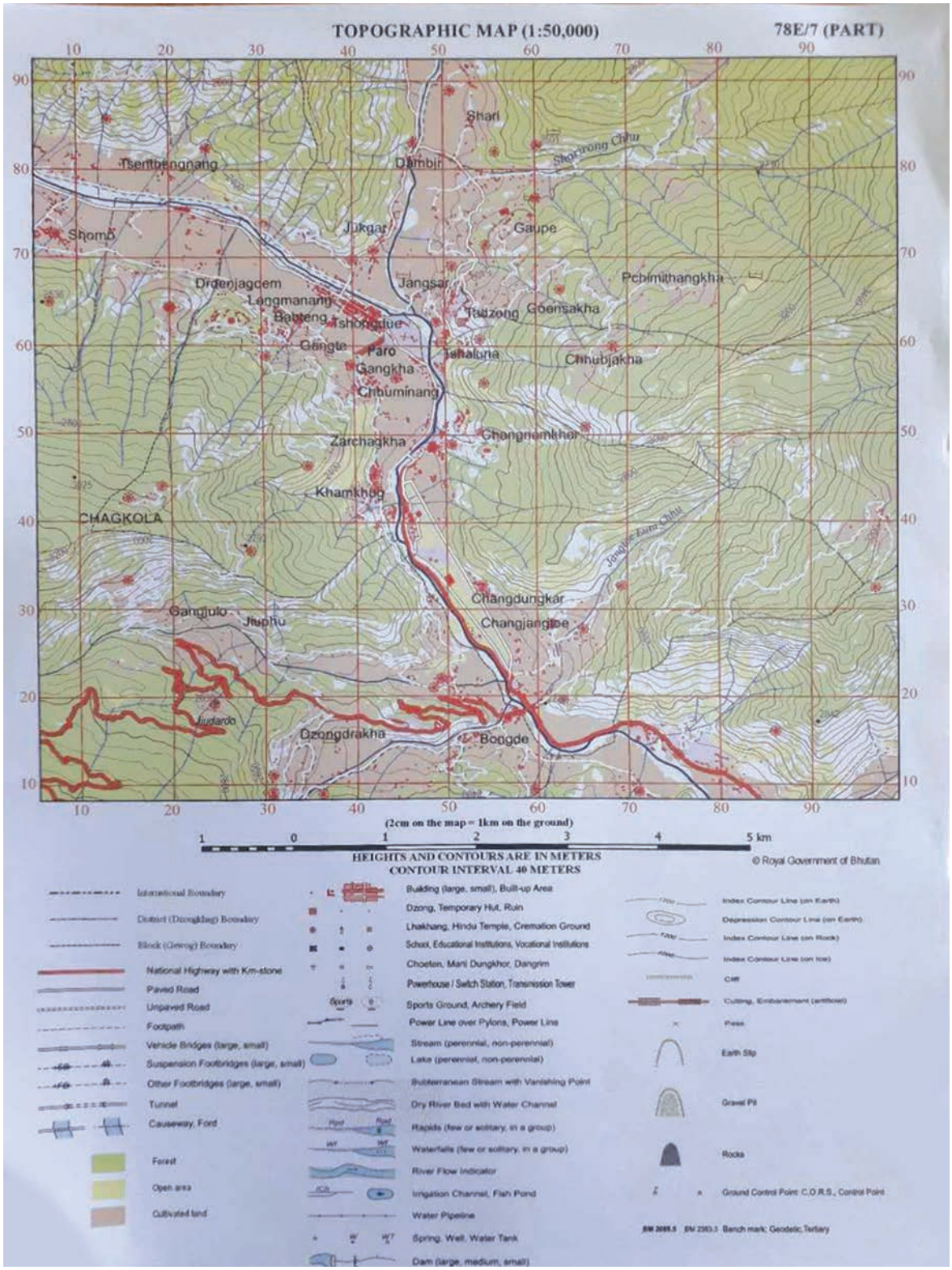
Learning Activity

1. Refer toposheet 78 E /7 and interpret the physical features from the map.

2. Using Topographical map No. 78 M /11 of Bhutan, answer the following questions:
   a. What is the Index Contour of the map?
   b. Provide six-figure grid references for the highest and the lowest Spot heights.
   c. Discuss different settlement patterns found in the map.
   d. Sonam is a close friend of Dema and lives in Bikhar. Which direction will she travel to meet her friend at Bidung?

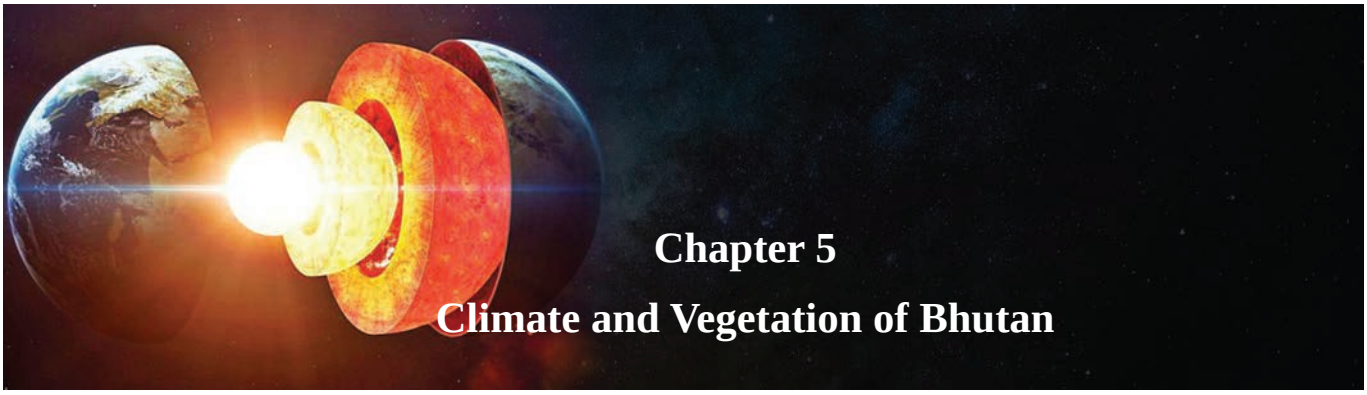

TOPOGRAPHIC MAP
78 M/11 (PART)
Maja Ung
Kedpong
Mentsbang
Nangkhar
Tadzong
Bargoenpa
Kemphang
Kumung
Tsigtima
Yangkhar
Tshekhar
Dzongthang
Jabung
Bidung
Jalung
Mulongkhar
Ngalung
Sershing
Changmi
Phinger Pam
Ga'ling
Phoshing
Khabti
Dhezhuling
Shachapo
Shamkhar
Thongphu Goenpa
Bikhar
Warobeta Goenpa
Rashibrangra
1:50000 (2cm on the map = 1km on the ground)
HEIGHTS & CONTOURS ARE IN METRES
CONTOUR INTERVAL 40 METRES
Published by Department of Survey & Land Records, Map Production Division
2001
© Royal Government of Bhutan
International Boundary with Pillar
District (Dzongkhag) Boundary
Block (Geog) Boundary
National Highway with Number
Paved Road with Km-stone
Unpaved Road
Footpath
Vehicle Bridges
Suspension Footbridge, other Footbridge
Causeway, Ford
Buildings, Dzong, Temporary Hut, Ruins
Lhakhang, Hindu Temple
Chhoten, Mani, Dangtrin
Power House/Switch Station, Transmission Tower
Power Line over Pylons, Power Line
Sports Ground
Forest with Boundary and Pillars
Scrubs and Bushes
Single Tree, Surveyed Tree
Orchard
Cultivated Area
Swamp/Marsh with Reeds
Stream: perennial, non-perennial
Lake: perennial, non-perennial
Subterranean Stream
Dry River Bed with Water Channel
Rapids
Waterfall (with height)
River with Island and indication of flow
Irrigation Channel
Water Pipeline
Water Tank
Dam: big, small
Cutting, Embankment
Pass
Contour Line on Earth with value
Contour Line on Rock with value
Contour Line on Ice with value
Depression
Cliff
Rocks
Triangulation Point, Spot Height (accurate), Spot Height (approximate)
Bench Mark: Geodetic, Tertiary
Abbreviations
BHU Basic Health Unit
Chp Checkpost
Hosp Hospital
PO Post Office
PS Police Station
SS Switch Station
TR Transmission Reflector
GH Guest House
Sch School
PH Pump House


TOPOGRAPHIC MAP
78 E/11 (PART)
Chhokhortse Goenpa
2989
Zilungkha
Tashichho dzong
Kawangjangsar
Chhubarchhu
Mutigthang
Changangkha Lhakhang
Yangchenphug
Thadranang Goenpa
3709
TAGIDHING
Changzamto
Changjigjig
Changbangdruk
Lungtenphu
Changlute
Jatu Olokha
Tshalimarphe
Tshali Goenpa
Simtokha Dzong
Simtokha
Barpaisa
Changjokha
Debtshig
Tabla
Wangchuntaba
Serbithang
Jazami
Rama
Talakha Goenpa
3082
Walunang
Sengang Goenpa
Wang Chhu
1:50000 (2cm on the map = 1km on the ground)
HEIGHTS & CONTOURS ARE IN METRES
CONTOUR INTERVAL 40 METRES
Published by Department of Survey & Land Records, Map Production Division
2001
© Royal Government of Bhutan
International Boundary with Pillar
District (Dzongkhag) Boundary
Block (Geog) Boundary
National Highway with Number
Paved Road with Km-stone
Unpaved Road
Footpath
Vehicle Bridges
Suspension Footbridge, other Footbridge
Causeway, Ford
Buildings, Dzong, Temporary Hut, Ruins
Lhakhang, Hindu Temple
Chhoten, Mani, Dangrim
Power House/Switch Station, Transmission Tower
Power Line over Pylons, Power Line
Sports Ground
Forest with Boundary and Pillars
Scrubs and Bushes
Single Tree, Surveyed Tree
Orchard
Cultivated Area
Swamp/Marsh with Reeds
Stream: perennial, non-perennial
Lake: perennial, non-perennial
Subterranean Stream
Dry River Bed with Water Channel
Rapids
Waterfall (with height)
River with Island and indication of flow
Irrigation Channel
Water Pipeline
Water Tank
Dam: big, small
Cutting, Embankment
Pass
Contour Line on Earth with value
Contour Line on Rock with value
Contour Line on Ice with value
Depression
Cliff
Rocks
Triangulation Point, Spot Height (accurate), Spot Height (approximate)
Bench Mark: Geodetic, Tertiary
Abbreviations
BHU Basic Health Unit
Chp Checkpost
Hosp Hospital
PO Post Office
PS Police Station
SS Switch Station
TR Transmission Reflector
GH Guest House
Sch School
PH Pump House


TOPOGRAPHIC MAP (1:50,000)
78E/7 (PART)
Shari
Tsentobongnang
Dumbir
Shortrong Chhu
Shomo
Jukgar
Gaupe
Drenjagdem
Jangsar
Pchimithangkha
Longmanang
Babteng
Tshongdue
Tsazong
Goensakha
Gangte
Paro
Jahalung
Chhubjakha
Gangkha
Chhuminang
Zarchagkha
Chongnamkhar
Khamkhug
CHAGKOLA
Jangtse Tsum Chhu
Changdungkar
Gangjulo
Jiuphu
Changjangtse
Jiudardo
Dzongdrakha
Boogde
(2cm on the map = 1km on the ground)
5 km
HEIGHTS AND CONTOURS ARE IN METERS
CONTOUR INTERVAL 40 METERS
© Royal Government of Bhutan
International Boundary
District (Dzongkhag) Boundary
Block (Gewog) Boundary
National Highway with Km-stone
Paved Road
Unpaved Road
Footpath
Vehicle Bridges (large, small)
Suspension Footbridges (large, small)
Other Footbridges (large, small)
Tunnel
Causeway, Ford
Forest
Open area
Cultivated land
Building (large, small), Built-up Area
Dzong, Temporary Hut, Ruin
Lhakhang, Hindu Temple, Cremation Ground
School, Educational Institutions, Vocational Institutions
Chorten, Mani Dungkhor, Dangrim
Powerhouse / Switch Station, Transmission Tower
Sports Ground, Archery Field
Power Line over Pylons, Power Line
Stream (perennial, non-perennial)
Lake (perennial, non-perennial)
Subterranean Stream with Vanishing Point
Dry River Bed with Water Channel
Rapids (few or solitary, in a group)
Waterfalls (few or solitary, in a group)
River Flow Indicator
Irrigation Channel, Fish Pond
Water Pipeline
Spring, Well, Water Tank
Dam (large, medium, small)
Index Contour Line (on Earth)
Depression Contour Line (on Earth)
Index Contour Line (on Rock)
Index Contour Line (on Ice)
Cliff
Cutting, Embankment (artificial)
Pass
Earth Slip
Gravel Pit
Rocks
Ground Control Point: C.O.R.S., Control Point
Bench mark: Geodetic, Tertiary

Test Yourself:

1. What are some of the uses of the topographical map?
2. What are different types of scales used in topographic map? How do scales differ from each other?
3. Identify the key cultural features depicted on any topographical maps of Bhutan.
4. Differentiate International series (CIM) from Indian series (IAC) system of numbering the topographic map.
5. Interpret topographical map 78E/11 based on the following features.
   a. The drainage system
   b. Settlement
   c. Occupation
6. Development of an area is dependent on transportation facilities. Which region is more developed among 78E/11, 78M/11 and 78E/7? Justify your answer.
7. Explain the components required to interpret a topographical map.
8. Why are conventional signs and symbols important for understanding the topographical maps? Write at least three reasons.
9. Mention any features in the map (78 E/7) that influence the people to settle there.
10. State reasons for the absence of human habitation in some parts of the area on the map (78 M/11).
11. How can you judge the suitability of land for agriculture from toposheet? Give valid reasons.



Chapter 5
Climate and Vegetation of Bhutan

Learning Outcome(s):

- Explain factors affecting the climate
- Discuss the features of each climatic zone
- Explain the influence of climate on vegetation
- Discuss the impact of climate on inhabitants

5.1 Introduction

Bhutan is located in the eastern part of the Himalayan range varying in altitude. The country experiences a wide range of climatic conditions from hot and wet in the southern foothills to cold and dry in the snow-capped mountains. Different factors determine the climate of a place, and varying climatic conditions determine the type of vegetation as well as inhabitants.

5.2 The Factors Affecting Climate

The climate of Bhutan is influenced by factors such as altitude, monsoon wind, latitude and vegetation.

5.2.1. Altitude

The climate of a place is influenced by altitude. Altitude in Bhutan ranges from 200 to 7500 metres above mean sea level. An increase in altitude leads to a decrease in temperature as the amount of heat absorbed is greatest at a lower altitude. Therefore, the climate is warmer at lower altitudes and cooler at higher altitudes. For example, Limithang which is located at the base of the Kurichu valley, experiences a warmer climate than Phrumseng La.

The temperature decreases with increase in altitude at the rate of 10 degree Celsius for every 165 metres. This is known as the normal lapse rate.

5.2.2 Latitude

The angle of the Sun's rays and the length of the day determine the amount of heat received by a place. The amount of heat increases with an increase in the angle of the rays of the Sun along with the length of the day. The climate becomes colder from the Equator towards the Poles. Since, Bhutan is located in the Northern hemisphere, it receives vertical rays and experiences longer days resulting in hot summers.

During winter, the country receives oblique rays and experiences shorter days resulting in cold winters. Bhutan, located at 26^0 North latitude, experiences a colder climate compared to Sri Lanka which is located at 5^0 North. There is no variation in the climate at the Equator because the length of a day is the same throughout the year.

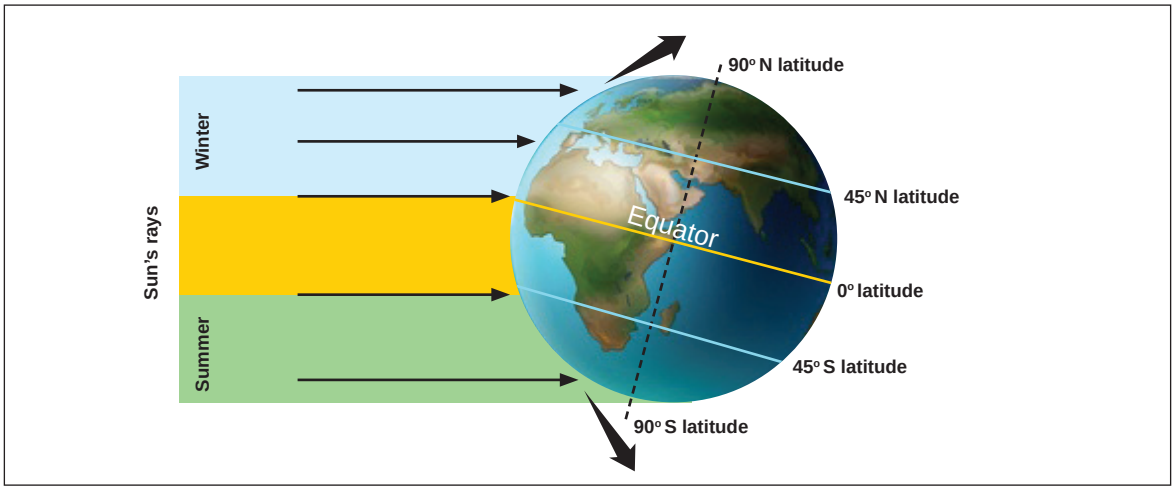


Figure 5.1: Angle of Sun's rays on latitudes

5.2.3 Monsoon wind

Monsoon wind is caused by seasonal variations in atmospheric pressure over the Asian continent. The seasonal change in the climate of Bhutan is caused by monsoon wind. During summer, low pressure is developed over central Asia as it heats up faster than the Indian Ocean. The Indian Ocean remains cool, developing a high pressure. This difference in pressure causes the wind to blow from the Indian Ocean towards central Asia. This moisture laden wind is obstructed by the Himalayan Mountain ranges and causes rain during summer.

During winter, high pressure develops over central Asia because of the cold. The Indian Ocean remains warm, developing low pressure. The wind changes direction and blows from central Asia towards the Indian Ocean. This wind is cold and dry as it blows from cold central Asia which makes Bhutan cold and dry.

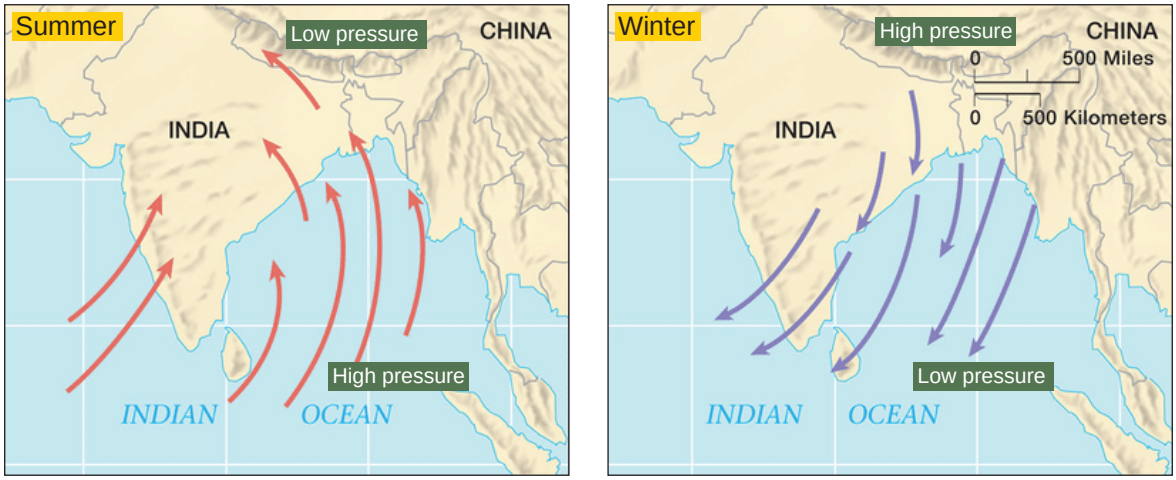


Figure 5.2: Monsoon winds

6.2.2 Orientation of Mountain Ranges

The Himalayan Mountain ranges lie west to east, while the mountain ranges in Bhutan lie almost perpendicular to the Himalayas. As a result, most mountain slopes are either facing east or west. The slopes facing east receive the Sun's rays early in the day while the slopes facing west remain in the shadows until late morning. The slopes facing east receive more heat making them warmer than slopes facing west.

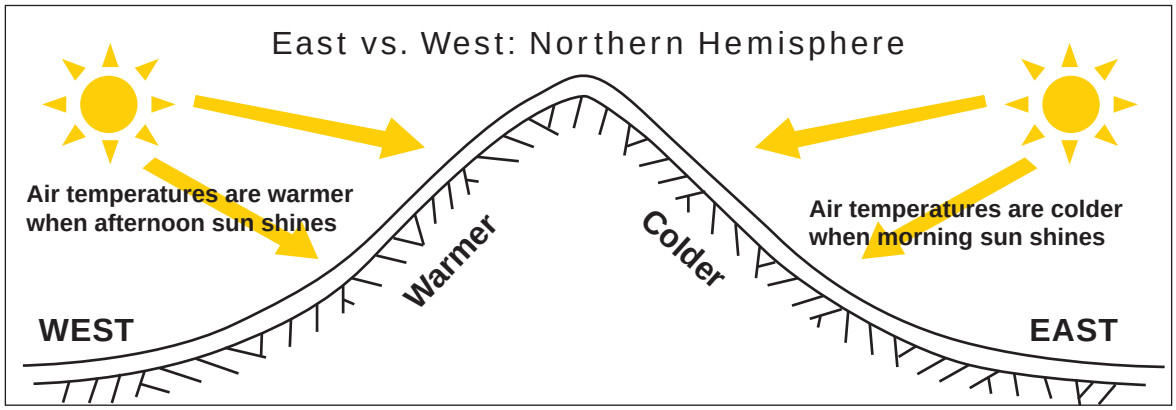


Figure 5.3: Slopes of mountain

6.2.3 Vegetation

Vegetation refers to the natural plant cover on the Earth's surface. Vegetation influences the climate of a place in two ways. Vegetation prevents the ground from receiving direct rays of sun during the day reducing the temperature. It absorbs and stores moisture and causes evapotranspiration forming clouds. These clouds prevent incoming solar radiation and outgoing terrestrial radiation thereby moderating the temperature of a place.

Learning Activity

In teams, identify and discuss the dominant factor that determines the climate of your locality. Present your findings to the class.

6.3 Climatic Zones of Bhutan

Variation in climatic conditions have resulted in a wide range of climatic zones. The climatic zones identified in Bhutan are; sub-tropical, temperate, sub-alpine and alpine.

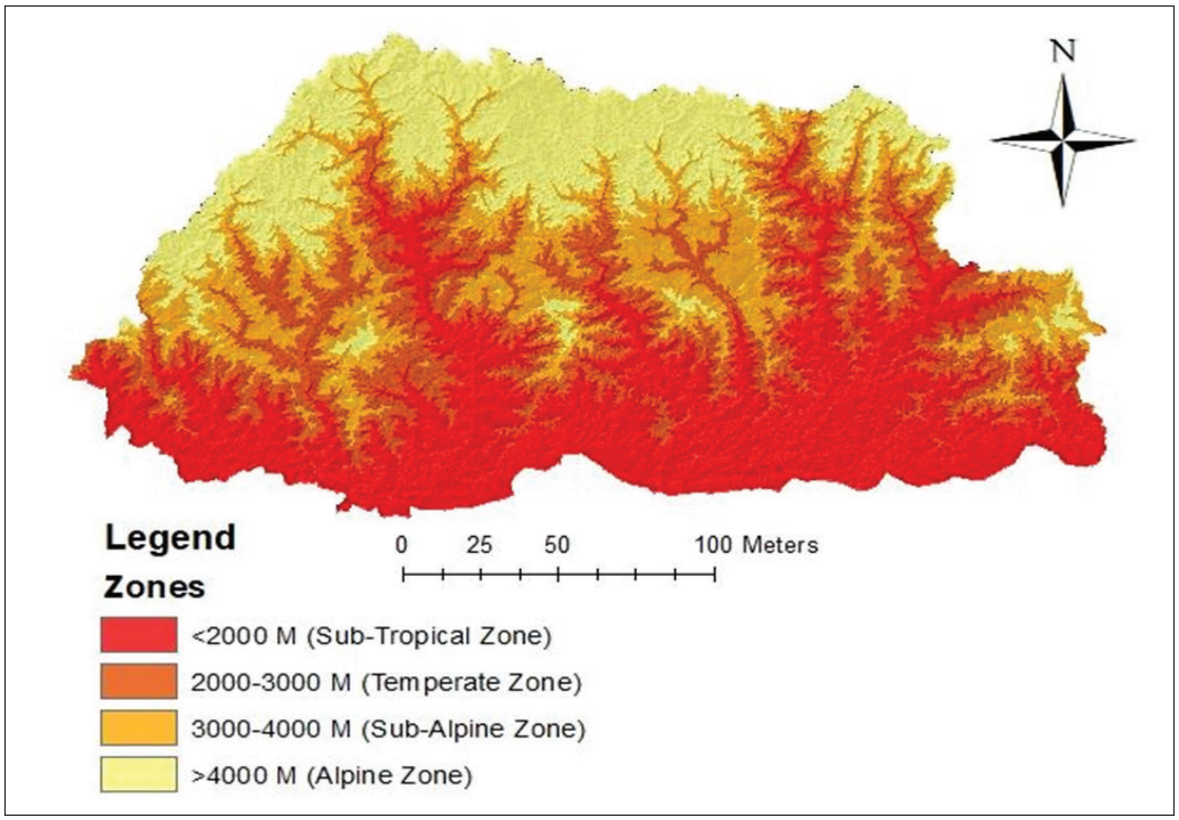


Figure 5.4: Climatic zones of Bhutan

6.3.1 Sub-Tropical Zone

The sub-tropical zone in Bhutan is located along the southern foothills at an altitude ranging from 200 to 2000 metres above the mean sea level. It extends into the lower

valleys of the Inner Himalayas. The mean monthly temperature ranges from 15° Celsius in winter to 30° Celsius in summer. The annual rainfall is above 2000 mm. Temperature and rainfall vary from valley to valley in the Inner Himalayas.

This zone experiences cool and dry weather during winter, and becomes dry during spring. It experiences stormy winds and hailstones during early spring. The monsoon wind causes heavy rainfall that moderates the temperature during summer, accompanied by lightning and thunder followed by heavy rain showers.

There is rapid growth of vegetation on the valley slopes and river banks with undergrowth. The higher altitude regions of this zone have mixtures of evergreen and deciduous broad-leaved trees with chirpine on the mountain tops.

Most parts of Samtse, Chukha, Sarpang and Samdrup Jongkhar, lower parts of Wangdue Phodrang, Punakha, Trongsa, Mongar and Trashigang experience this type of climate.

6.3.2 Temperate Zone

The temperate zone lies above the sub-tropical zone at an elevation ranging from 2000 to 3000 metres above the mean sea level. The mean daily temperature ranges from 5 to 15 degrees Celsius in winter and 15 to 30 degrees Celsius in summer. The total annual rainfall varies from 1500 mm to 2000 mm. It experiences low temperatures at night and moderate temperatures during the day. During spring, the sky becomes clear and violent winds blow. This zone experiences long and cold winters and short and cool summers with rainfall.

There is variation in the growth of vegetation due to an uneven distribution of rainfall owing to the orientation of mountain ranges. The windward side of a slope is dominated by broad leaved trees while the drier leeward side is mostly covered by coniferous trees. Mixed forest with epiphytic plants prevails in the wetter region. Blue pine, spruce, hemlock and fir exist in the higher parts of this zone.

Paro, Thimphu, parts of Bumthang, Haa and higher parts of Wangdue Phodrang, Punakha, Trongsa, Mongar, Lhuntse and Trashigang fall in this zone.

6.3.3 Sub-Alpine Zone

The Sub-Alpine Zone lies at an altitude ranging from 3000 to 4000 metres above the mean sea level. The total annual rainfall varies from 1000 mm to 1500 mm with the mean annual temperature around 8° Celsius. This zone experiences mist and fog, cold winds and light rain during the short summers and snow in the long winters.

In winter, humans and animals like yaks and sheep migrate to lower regions because the weather becomes extremely cold.

Shrubby vegetation like juniper and rhododendron grow in this zone. This zone is floristically rich and has many valuable herbs.

Laya, Lingzhi, Lunana, Gogona, Dur, Busa, Sephug, Merak, Sakteng, Soe and Naro fall in this zone.

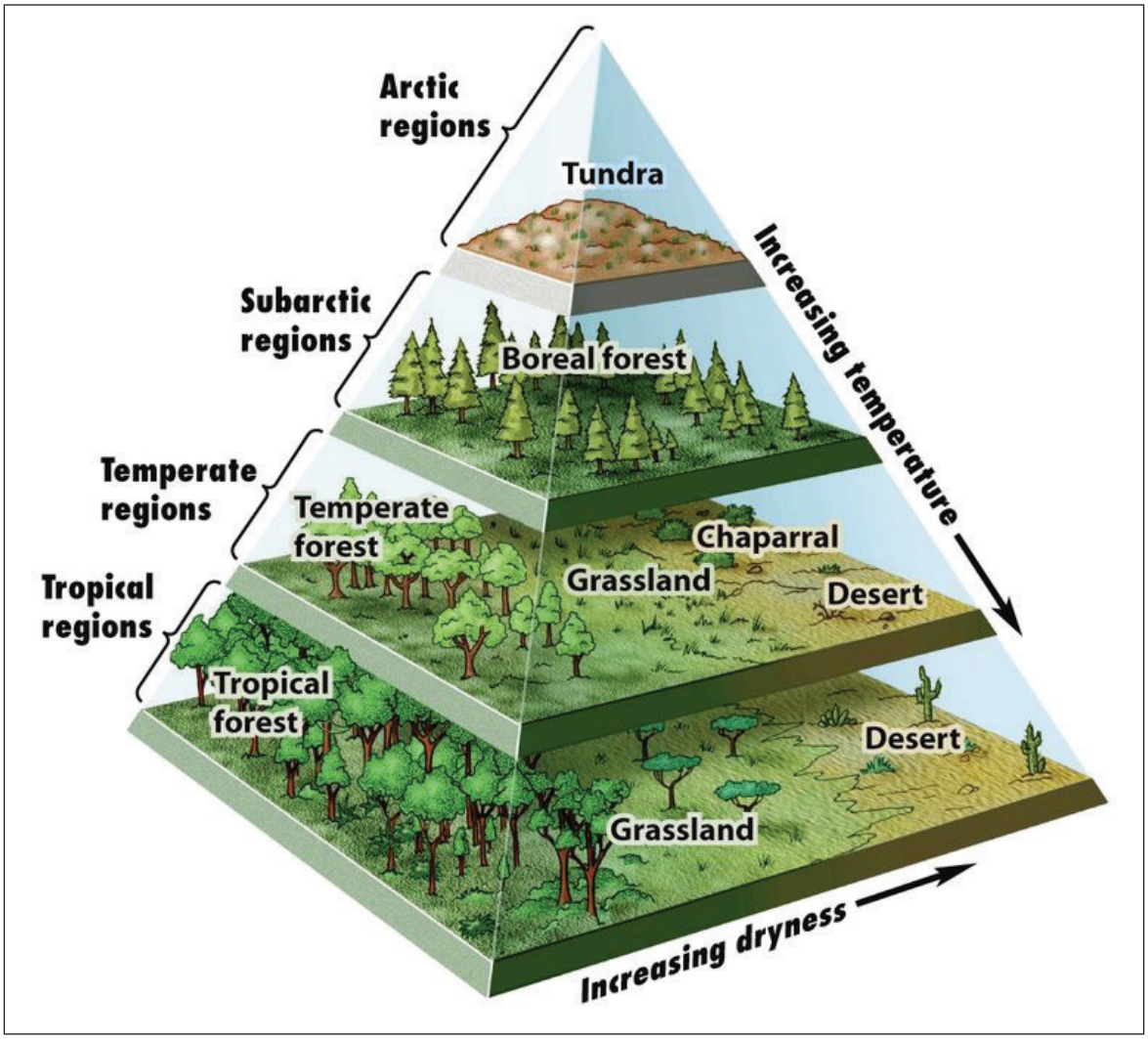


Figure 5.5: Vegetation types

6.3.4 Alpine Zone

The Alpine zone lies over 4000 metres above the mean sea level. Alpine refers to the vegetation or climatic conditions in the high mountains. It is cold throughout the year. A permanent snow line is found at around 4800 metres above the mean sea level. Snow never melts above this line and permafrost prevails. Snow laden winds called blizzards and snow avalanches occur occasionally at this height.

Trees do not grow as the temperature is extremely cold with freezing conditions. Mosses and lichen survive where wind is not very severe. However, plants like balu and sulu grow in the high mountain meadows.

Mountain peaks of Jowo Durshing, Jomolhari, Jiwuchu Drakey, Masa Gang, Gangkar Puensum with perennial snow cover fall in this zone.

Climatic Zone	Vegetation Characteristics	Tree	Wildlife
Sub-Tropical Zone	Dense Forest with evergreen tree species. Hard wood and broad leaved trees with thick undergrowth.	Sal	Elephant
		Sisoo	Tiger
		Teak	Clouded Leopard
		Mahogony	
		Golden Langur	
		Acacia	Rhinoceros
Temperate Zone	Mixture of coniferous and deciduous broad leaved trees. Soft wood with less leaves.	Blue Pine	Wild Boar
		Oak	Barking Deer
		Poplar	Black Bear
		Spruce	Samber
		Maple	Grey Langur
Sub-Alpine Zone	Shrubby and stunted forests occur above the tree line.	Juniper	Black Necked Crane
		Rhododendron	Takin
		Blue Puppy	Raven
Alpine Zone	Absence of trees. Vegetation is xerophytic in nature with shrubs	Junipers Shrub	Blue Sheep
		Alpine Meadow	Snow Leopard
		Flowering Herbs	Elk

Table 6.1 Flora and fauna in different climatic zones

Learning Activity

In teams, find out different plants and animals found in your locality. Identify the climatic zone in which your place falls. Find the names of these plants and animals in Dzongkha and present your findings to the class.

The impact of climate

The climate of a place impacts the people, plants and animals. People usually settle in a place with favourable climatic conditions. The Alpine zone is hardly inhabited by humans due to extremely low temperatures. The most favourable climatic condition prevails in

the temperate zone. Building materials for houses and work habits are also influenced by the climate. People adapt and respond to changes in climate by modifying their dwellings, changing food habits and clothing.

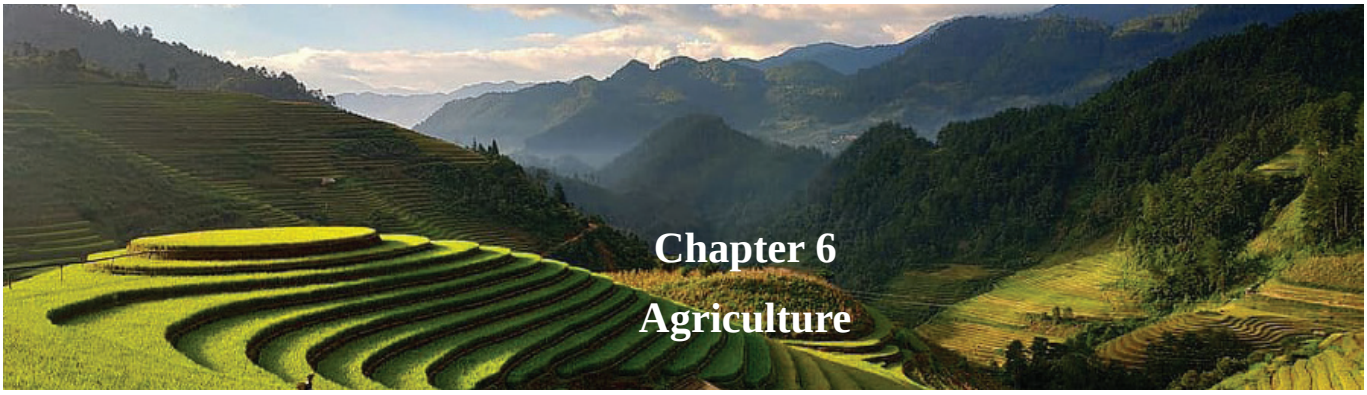
Plants respond to the change in seasons by shedding their leaves, flowering, or breaking dormancy. Deciduous trees shed leaves during winter to conserve moisture. Cordycep sinensis transforms into a plant during summer and caterpillar fungus during winter. Animals and birds adapt to change in climate by migrating, hibernating and aestivating. For example, black necked cranes migrate to Bhutan during winter and back to Tibet during summer.

Test Yourself:

1. Why is the Alpine Zone hardly inhabited by humans?
2. How do humans adapt to overcome the limitations of nature?
3. How does the angle of the Sun's rays and the length of the day determine the amount of heat received by a place?
4. Compare and contrast summer and winter monsoons.
5. If the mountain ranges of Bhutan were parallel to the main Himalayan mountain range, how would this affect the climate of Bhutan? Explain.
6. There is extreme variation in temperatures during day and night in the deserts. Give reasons.
7. What are the advantages and drawbacks of living in a sub-tropical climatic zone?
8. Extreme conditions of climatic factors tend to have a negative influence on its inhabitants. Justify this statement.
9. Discuss problems caused by climate change on human life and wildlife.
10. How does the weather conditions of mountainous countries affect the aviation industry?
11. Refer figures below and explore the differences with regard to vegetation, climate and wildlife.

Figure 5.6

Figure 5.7



Chapter 6
Agriculture

Learning Outcome(s):

- Explain the importance of agriculture
- Examine the challenges associated with farming
- Suggest measures to overcome problems of farming

6.1 Introduction

Agriculture is an invaluable livelihood for a large portion of the global population. Agriculture has evolved from the use of simple tools to machines and technology. Farmers are able to cultivate large areas with machines which increases the yield of their crops.

Agriculture promotes economic growth of a country by providing raw materials, employment opportunities and generating revenue. A country with a developed agriculture sector has the potential to achieve food security. Agriculture in developing countries is confronted with many challenges, however some of these challenges have been addressed through innovations and advancements in science and technology.

Figure 6.1:

6.2 Scope of Agriculture

Agriculture plays an important role in the economy of a country, by providing raw materials to non-agricultural sectors and industries. Agricultural development has enhanced industrialisation in countries like the United Kingdom, U.S.A and Japan. The per capita income of the most developing nations depend on the increase in agricultural production, and accounts for a large portion of the gross domestic product (GDP).

Access to food is one of the major challenges in the world, and is most critical in low-income and food deficit countries. The development of agriculture is necessary to reduce poverty and enhance food security.

Figure 6.2: Agriculture and food security

Agriculture helps to utilize the unused land in developing countries. It is estimated that about 30 percent of land (4.2 billion hectares) is suitable for agriculture. However, only about 11 percent (1.5 billion hectares) of land area is used for crop production. The development and use of large unused land could help to address food insecurity. Agriculture employs about 1.3 billion people and it is the second largest source of employment in the world. It accounts for about 28% of global employment.

Agriculture in Bhutan has a dominant role in the economy of the country and remains a primary source of livelihood. Agriculture employs more than 60% of the population and contributes about 17.37% to the country's gross domestic product (NSB 2017).

Although the agriculture industry in Bhutan consists largely of subsistence farming and animal husbandry, the government is encouraging people to take up commercial farming to enhance food security.

Learning Activity

The unemployment rate in Bhutan is ever increasing and the public sector is only able to employ a limited number of job seekers. Discuss how agriculture can help reduce the unemployment rate in Bhutan. Present your findings to the class.

6.3 Challenges of Agriculture

Agriculture production is limited by various challenges. It is predicted that by the year 2050, with a projected population of 10 billion people globally, there will be a shortage of farmland. This will exert more pressure on arable land and aggravate the challenges in agriculture. Some of the challenges in agriculture are:

1. Climate Change

Climate change affects agriculture leading to reduction in food production. Extreme weather events like heat waves cause sudden reductions in agricultural productivity leading to rapid increase in price. For example, heat waves in the summer of 2010 in countries like Kazakhstan, Russia, and Ukraine caused a reduction in staple foods. A number of people were forced into poverty as the prices of staple foods increased.

Changes in rainfall patterns also occur due to climate change. Some regions experience droughts while other regions experience torrential rain with floods. Warmer climates lead to a shift in the geographical distribution of certain pests and diseases, and the rising of sea levels in coastal areas result in a complete loss of agricultural land.

Bhutan also faces numerous issues and challenges, and climate change is considered the most serious threat. The impacts of global warming induced climate change has been

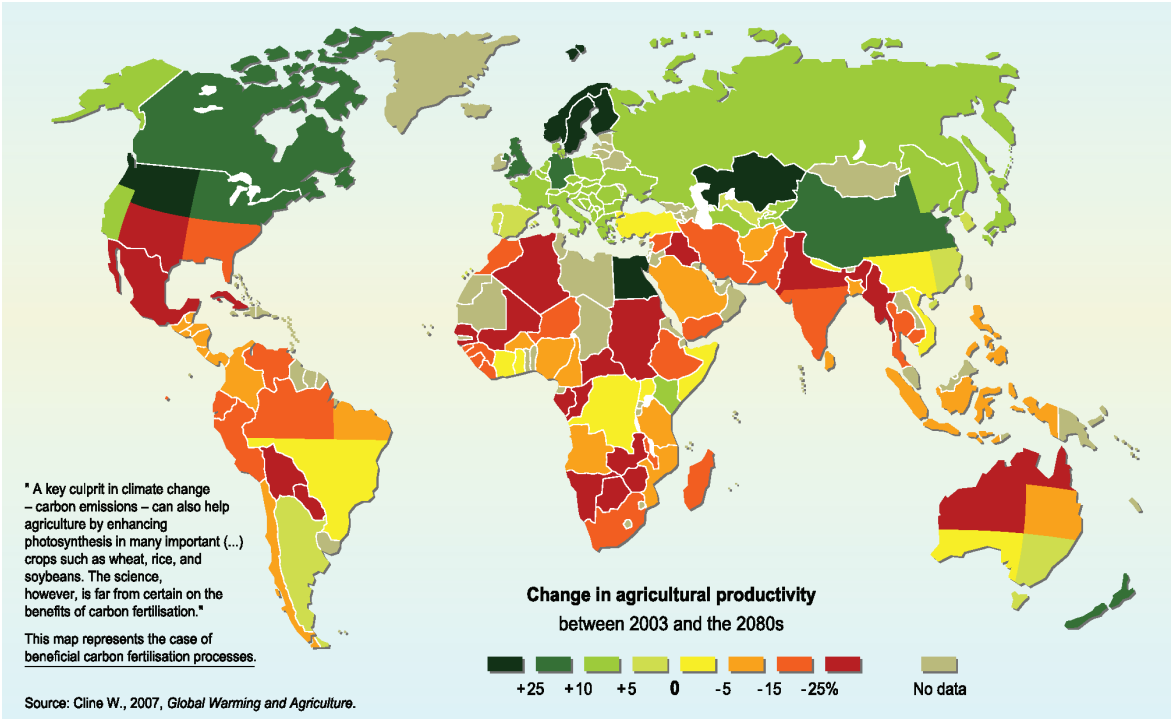


Figure 6.3: Projected impact of climate change on agriculture yields

felt and are likely to intensify in the future. The increased frequency of windstorms and hailstones, erratic rainfall, glacial lake outburst floods (GLOF) and unusual outbreaks of pests and diseases are already being experienced by farmers in different regions. Moreover, the topographic features of our country further makes farmers more vulnerable to the impacts of climate change.

2. Small land holding

An inheritance system with regard to land leads to land fragmentation. Land owned by parents is usually divided among children, and each child will further divide their own land to their children. This results in small land holdings that forces people to migrate to other areas. The shrink in size of land holdings poses a serious challenge to commercial agriculture.

3. Soil erosion

The fertility of soil is indispensable to the livelihood and success of a farming community. Soil compactness, salinity, structure and nutrient composition are the components of soil fertility. These components are lost through erosion due to deforestation, improper tilling, poor irrigation and inadequate construction of embankments. In the last 150 years, half of the top soil on the Earth has been lost due to soil erosion which affects soil fertility.

4. Lack of farm mechanisation

Farm mechanisation has become an important tool in planting, processing and harvesting crops. Implementation of farm mechanisation is difficult in countries with rugged topography and poor economies. Countries with rugged topography face difficulty using farm machinery. Rugged topography is related to difficulty in tillage and poor transportation facilities. For example, farm terraces in China, Nepal, Vietnam, Cambodia and Laos are seen clinging to hillsides at a height of several thousand feet, so the use of farm machinery is not feasible.

Farmers in developing countries cannot afford to purchase farm machinery like motor cultivators, irrigation machines, tractors and harvesters, which leads to underutilisation of cultivable land.

5. Agricultural marketing

There are several challenges involved in marketing agricultural produce. Many developing countries lack organized and regulated marketing systems. The inadequate market infrastructure adversely affects agriculture production. Access to internal and external markets for surplus agriculture produce is in developing stage in many developing

countries. Farmers are often discouraged from cultivating and producing crops on a commercial scale, which affects agricultural productivity around the world.
Marketing of agricultural produce is also constrained by a shortage of store houses and transportation facilities. Lack of these facilities delay selling farm products causing farmers to incur losses.

6. Quality of seeds

High Yielding Variety seeds (HYVs) yield large quantities of crops and enhance continuous agriculture production. Due to the high cost of quality seeds most farmers are unable to purchase such seeds.

In developing countries, farmers are provided HYVs at a subsidised rate, yet due to low literacy rates farmers are unable to follow instructions correctly. Consequently, HYV seeds are not put to their optimum use.

Learning Activity

August 2, 2019, Kuensel

The correlation between leaving land fallow and increasing human-wildlife conflict has been established in the Jomotsangkha Wildlife Sanctuary (JWS).

A survey in the sanctuary revealed that in 2018 alone, 53 percent of people from seven gewogs within the JWS left their agricultural land fallow due to conflict with wildlife. Wild pig topped the list of most common pests with 552 incidences, followed by monkey and bear.

The survey report found about 386.96 acres of dry land and 44.48 acres of wetland were left fallow. The survey covered 291 households within the park's

jurisdiction. About 55 percent of respondents reported increased crop depredation trend compared with past years.

The increase in crop damage, according to people, was because of the increased forest cover near settlements and wildlife population.

With reference to the Kuensel article, *"Land Left Fallow From Crop Predation"*, explore how human-wildlife conflict hampers agricultural activities. Share your findings to the class.

6.4 Advancement in Agriculture

The world population has more than doubled since 1960. The increasing population poses a threat to food security around the world. Demands for global agricultural production have almost tripled due to rapid population and income growth. Agriculture has been successful in meeting this increase in demand due to advancements in technology and improved methods of farming.

Agriculture began to transform in the early 1700s with the inventions of new agricultural tools and technologies. These inventions helped increase food production in Europe, the United States and Canada. The invention of the horse driven seed drill and mechanical reaper have made the work of sowing and harvesting faster and easier. Along with new machines, there were several important advances in farming methods.

High-yield varieties of wheat and rice were developed by scientists during the 1950s and 1960s. These seeds were first introduced in Mexico and parts of Asia. As a result, production of grain increased exponentially. The unprecedented increase in grains due to the use of hybrid seeds along with chemical fertilizers, pesticides, and irrigation is known as the "Green Revolution."

Figure 6.5: Combine Harvester

Transportation is an important component of agriculture infrastructure development. It is not only necessary for the transportation of agricultural products but also to supply fertilizer, machinery, seeds and other important requirements. Efficient transportation saves time for transporting grains and other crops to the market and also to bring in agricultural inputs.

The market stimulates the development of agriculture in any region. Commercial crops can be produced if there are reliable markets. The availability of markets will also encourage surplus production from agriculture. Ready markets enhance transport of surplus agricultural produce and increase profits. Lack of market facilities discourage farmers to adopt commercial farming.

Traditionally, farmers used a variety of methods to protect their crops from pests and diseases. They used herb-based remedies on crops, handpicked insects off plants, and practiced crop rotation to control insects. After the Green Revolution, the method of controlling pests changed with the use of chemicals.

Figure 6.6: Application of pesticides

For many centuries, farmers relied on natural ways of maintaining soil fertility. Materials such as animal waste, foliage, and bird waste were used to replenish soil nutrients. This has been supplemented with the use of chemical fertilizers that help increase crop yield.

The progress of agricultural production will be based on new technologies. Mobile apps on a smartphone or other smart devices using GPS technologies are used to operate farm machines like tractors and drones. Weather modelling and satellite

Figure 6.7: Smart Farm Mechanisation

image technology will also enable farmers to take precautions and mitigate losses. The development in agriculture will also depend on the development of an open market environment.

Learning Activity

Suppose, farming in the world is completely digitalised, what would be the implications? Discuss in groups and share your findings to the class.

Test Yourself

1. Refer figure 6.8 and answer the questions.

Figure 6.8: Land Use and Land Cover

a. List the problems associated with farming in Rubesa.

b. What measures would you suggest to overcome these problems?

2. Do you think achieving 100% organic nation by 2035 would add value to Bhutanese products in the market? Justify.

3. About 3% of the population in Bhutan lives below the poverty line. Efficient use of available agricultural land is the immediate solution. Do you agree? Give reasons.

4. Answer the questions with reference to figure 12.9

Figure 12.9

a. How can you relate figure 12.9 to the Green Revolution?

b. The Green Revolution is not a boon to humanity. Explain.

5. Agricultural production in Bhutan has increased over the years. Give reasons.

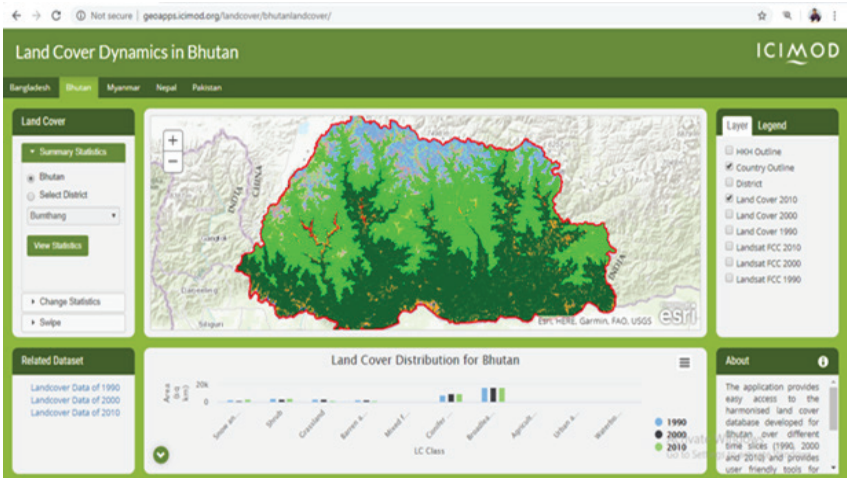
6. Why is commercial farming not so popular among the farmers in our country?

7. How can we improve agriculture in our country to achieve food self-sufficiency?

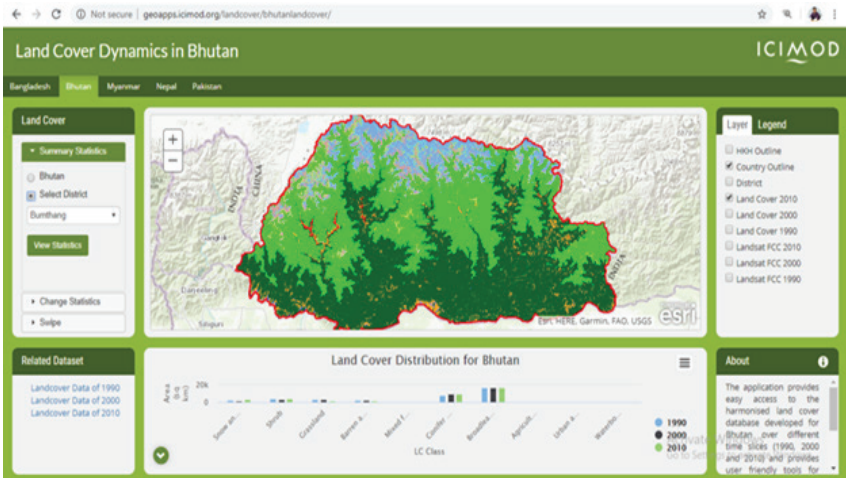
8. How can the government encourage our youth to choose farming as their source of livelihood?

Hands on exercise

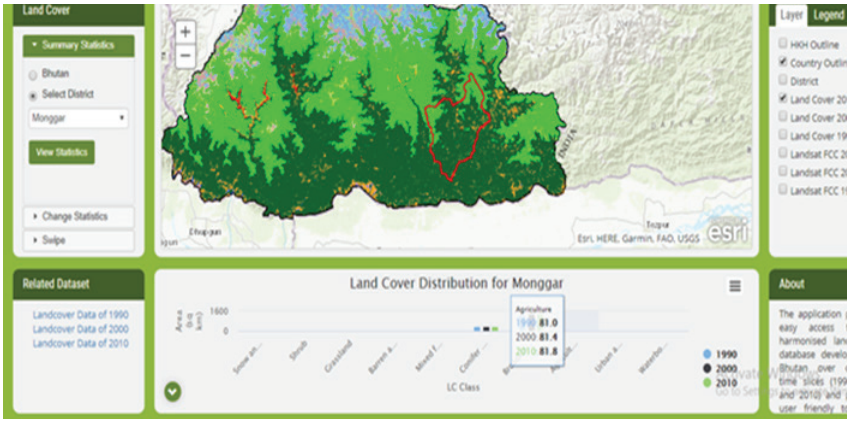
1. Access the website http://geoapps.icimod.org/landcover/bhutanlandcover/



2. Click on Select District under summary statistics on the left hand side of the webpage.



1. Click on drop down button and select the dzongkhag of your choice
2. Click on View Statistics
3. Move the cursor over agriculture on the Land Cover Distribution for Mongar graph and the data for 1990, 2000 and 2010 will pop up.



Question

1. Access the agriculture data of 1990, 2000 and 2010 for any five dzongkhags and prepare a comparative bar graph using Microsoft Excel.
2. Interpret the graph on land cover distribution in Bhutan.

Chapter 7
Biodiversity

Learning Outcome(s):

- Explain the components of biodiversity
- Compare ecosystem with biodiversity
- Analyse the significance of biodiversity
- Explain measures to conserve biodiversity

7.1 Introduction

The global ecological system that integrates all living beings and their interaction with the elements of lithosphere, hydrosphere, and atmosphere is called the biosphere. Biodiversity is formed when living organisms comprised of species with genetic differences exist within the biosphere.

Biodiversity acts as an indicator of how healthy and ecosystem is. An ecosystem is healthy if it has a substantial amount of biological diversity. Wide varieties of species are vital to keep an ecosystem healthy, balanced and thriving. Globally, biodiversity is threatened due to modernization and must be preserved.

7.2 Biodiversity

Biodiversity refers to a variety of life forms and its interactions among the spheres of the Earth, and is a vital and complex phenomenon of the Earth. Biodiversity is not evenly distributed on the Earth. Tropical regions have rich biodiversity compared to Polar regions. Bhutan has rich biodiversity due to a unique geographical setting. Bhutan is recognised as one of the Global Biodiversity Hotspots.

7.3 Components of biodiversity

The elements of biodiversity include species of plants, animals, micro-organisms, diversity of genes, and different ecosystems.

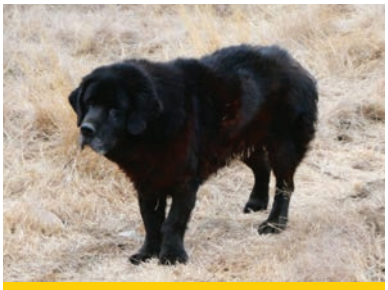
7.3.1 Genetic diversity

All forms of life possess genes. Genetic diversity is the sum of genetic information contained in the genes of individual plants, animals and micro-organisms.

Each species consists of different breeds, and virtually no two members of the same species are genetically identical. Varieties in a species are a result of genetic diversity. For example in Bhutan, the Bhutia Sheepdog, Damchi and Bjopchi are different breeds of dogs. They are not the same, as their genes are different. Similarly, the Yuta, Boeta, and Sharta are breeds of horses with different genes.

Bhutia sheepdog

Damchi



Bjopchi

Figure 7.1: Breeds of dog

KNOW MORE

Gene: Part of the DNA in a cell that controls the physical development and behaviour of an individual plant or animal, and is passed on from its parents.

Learning Activity

Explore genetic diversity of any domestic animal and plant using different sources and compare your findings with friends.

7.3.2 Species diversity

Species diversity is the number of species within a habitat or ecosystem, and is used to help describe the biodiversity of a region. Each species is different from the other. Animals, birds, insects and plants are some examples of species diversity.

Species diversity recorded in Bhutan are:

Species diversity	Types	Species found	Endangered Species	Examples
a. Wild flora	Vascular plants	About 105		
	Pteridophytes	410		
	Mushroom	Over 90		
b. Wild Fauna	Mammals	Over 200	27	Golden Langur, Snow Leopard, Takin, Bengal Tiger, Black Necked Crane and Red Panda.
	Avefauna	Over 768	14	
	Invertebrates (Butterfly):	About 140		
	Fish	Over 50		
c. Domesticated flora/ Agricultural crops	Over 100			Rice, maize, wheat, buckwheat, barley, millet, legumes, oilseeds, all kinds of vegetables and fruits.
d. Domesticated fauna	Yak	2		
	Cattle	Over 2		Nublang, Mithun
	Horse	3		Yuta, Boeta and Sharta
	Pig	Over 2		Sapha, Dompha, etc
	Poultry	3		YubbjaNaap, Belochemand Bailetey
	Sheep	3		Jakar, Saktenpa and Siphu

Table 7.1 Species diversity recorded in Bhutan

Figure7.2 Species diversity

Learning Activity

In teams, draw a species diversity chart of mammals and birds, or flowers and butterflies of your community. Display and carry out a Gallery Walk.

1. Study the information in table and using internet resources complete the activity in your notebook.

Sl no.	Genetic diversity	Types of biotic orgnaism	Species type
1	Abyssinian, American Shorthair, Birman, Egyptian Mau, Japanese Bobtail, Norwegian Forest cat	Animal	Cat
2		Animal	
3	American crow, Jamaican crow, Cuban crow, White necked crow, Rook, Hooded crow, Pied crow	Bird	Crow
4		Bird	

7.3.3 Ecosystem Diversity

An ecosystem is a community of living organisms in a particular area. Ecosystem diversity is a variation in an ecosystem in a particular region, or within a geographical location. Variation in habitat and interaction among species leads to the development of ecosystem diversity. A variety of species live in different ecosystems and species vary within a single ecosystem because of different habitats.

A forest ecosystem consists of different vegetation including: tropical, deciduous trees and shrubs. Freshwater ecosystems consist of lakes, ponds, and rivers; whereas, rocky

coastlines, sandy beaches, estuaries, salt marshes, and coral reef are examples of marine ecosystems.

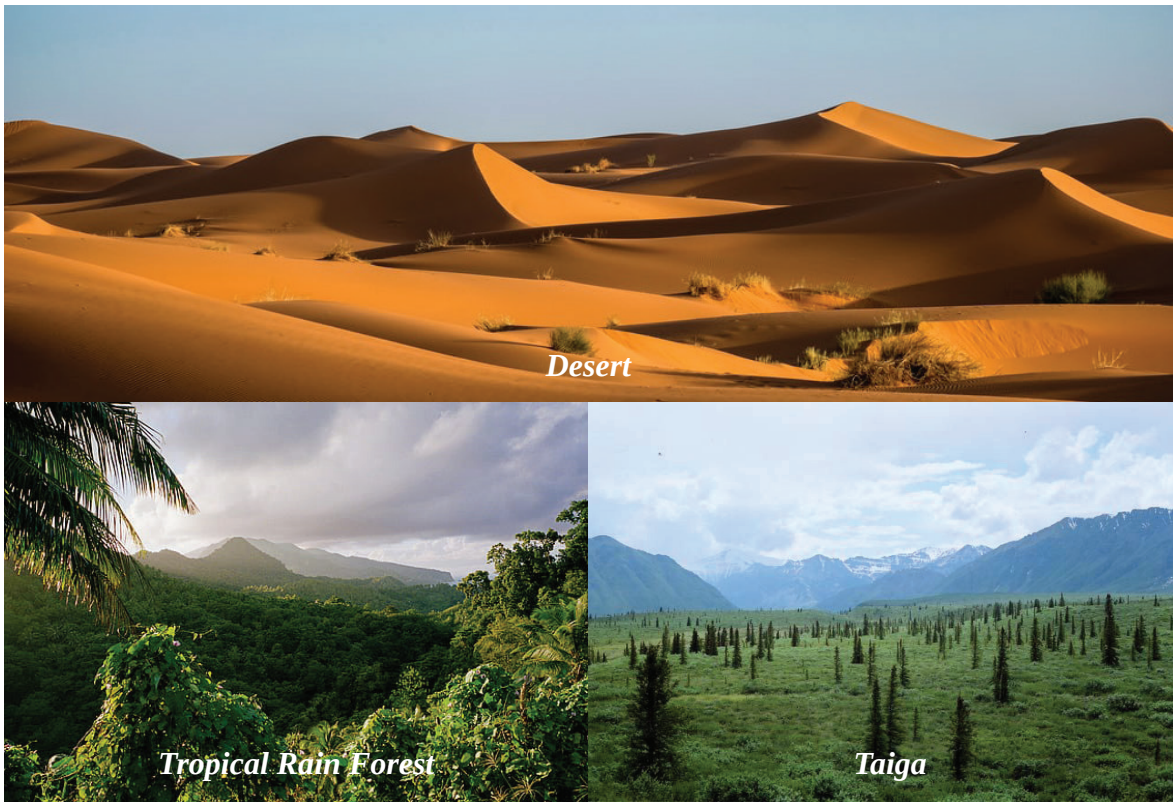


Figure 7.3 Ecosystem diversity

Ecosystem diversities identified in Bhutan are:

1. Forest Ecosystem

The country is categorized into three eco-floristic zones with different forest types:

a. Sub-tropical Zone (200-2,000 metres): Broad leaf Forests (1,000 -2,000 metres), Chir Pine Forests (700 – 2,000 metres), Tropical Lowland Forests (<700 metres).

b. Temperate Zone (2,000 – 4,000 metres): Fir Forests (>3000 metres), Mixed Conifer Forests (2,500 – 3,500 metres), Blue Pine Forests (1,500 – 3,200 metres), Broadleaf mixed with Conifer Forests (2,000 – 2,500 metres).

c. Alpine Zone (>4,000 metres): Alpine meadows and scrub forests.

2. Aquatic Ecosystem

a. Rivers

The presence of a large number of glaciers and glacial lakes, a high level of precipitation and the relatively well preserved forests and watersheds has endowed Bhutan with tremendous inland water resources in the form of rivers, rivulets, springs and streams. The five major river basins are Amo Chhu (Torsa), Wang Chhu (Raidak), Puna Tsang Chhu (Sunkosh), Drangme Chhu (Manas) and Ngyera Ama Chhu (Bada).

b. Lakes

There are many lakes spread across the country. The largest of all the lakes is a glacial lake at the terminus of the Luggye glaciers at an elevation of 4,506 metres.

c. Marshlands

Important marshlands in Bhutan can be found in several key locations, including Phobjikha, Bumdeling, and Khotokha. These marshlands are crucial for maintaining biodiversity, supporting a wide range of plant and animal species.

d. Hot springs

Some of the popular hot springs are Gasa Tsachhu (Gasa), Chubu Tsachhu (Punakha), Duenmang Tsachhu (Zhemgang), Gelephu Tsachhu and Dhur Tsachhu (Bumthang). People mainly use them for therapeutic benefits, and to ease various bodily ailments.

3. Agricultural ecosystem

There are six major agro-ecological zones corresponding with different altitudinal ranges and climatic conditions.

a. Wet sub-tropical (150 – 600 metres)
b. Humid sub-tropical (600 – 1,200 metres)
c. Dry sub-tropical (1,200 – 1,800 metres)
d. Warm Temperate (1,800 – 2,600 metres)
e. Cool Temperate (2,600 – 3,600 metres)
f. Alpine (3,600 – 4,600 metres)

Besides the six major agro-ecological zones, the main land uses defined for agriculture in Bhutan includes Chhuzhing (Wetland cultivation), Kamzhing (Dry land cultivation), apple orchards, citrus orchards, areca nut, and cardamom plantations.

7.4 Ecosystem

The complex system of interactions between organisms and the physical environment in any unit area is known as an Ecosystem. The size of an ecosystem ranges from a small pond to the entire world. Three components of an ecosystem are:

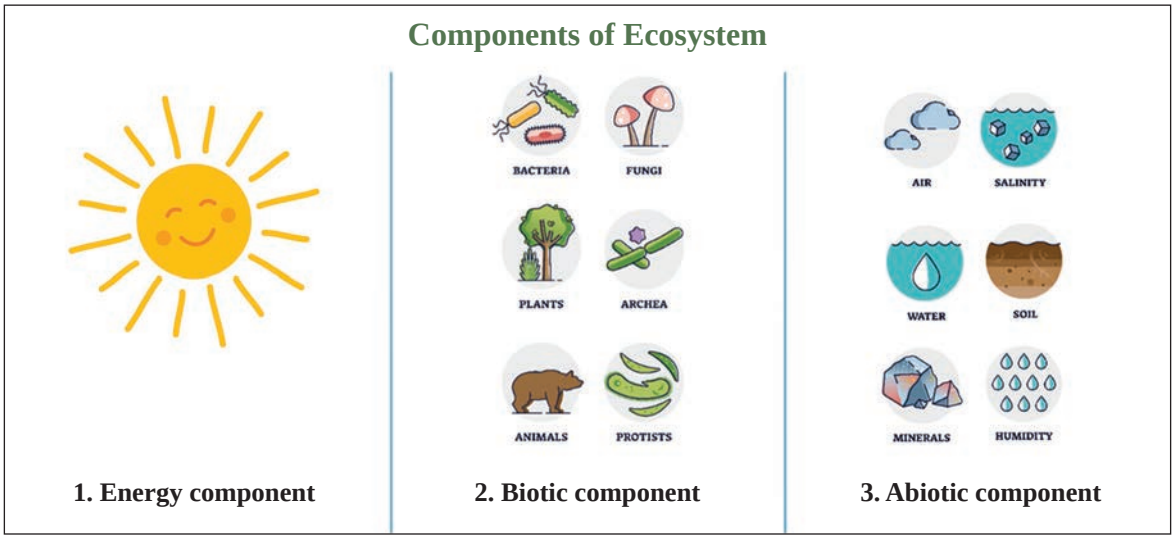


Figure 7.4: Components of ecosystem

7.4.1 Energy

Energy is an important component of an ecosystem as it is used for all life processes. The existence of life and functions of an ecosystem is due to the transfer of energy. Energy is derived from the Sun and is used by plants and animals.

7.4.2 Biotic components

Biotic components are living organisms that include plants, animals and micro organisms. These components are classified based on energy consumption. Producers, consumers and decomposers are the three broad categories of biotic components.

a. Producers

Plants and certain bacteria are producers because they produce food for all other organisms through photosynthesis and chemosynthesis. Plants prepare food through photosynthesis using solar energy and are called phototrophs. Certain bacteria prepare food through chemosynthesis from inorganic substances by oxidation and are called chemotrophs. Producers are also known as autotrophs.

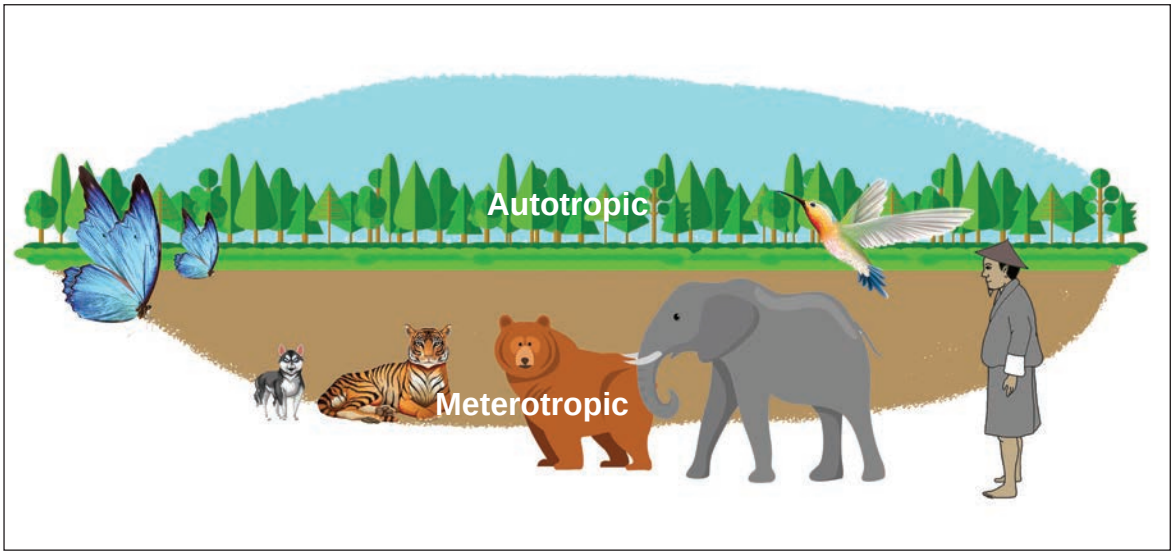


Figure 7.5: Biotic components

b. Consumers

Consumers are organisms that depend directly or indirectly upon the producers for food. Consumers, or heterotrophs are herbivores, carnivores and omnivores. Herbivores are living organisms that feed on plants. Living organisms that survive on other living organisms are carnivores. Omnivores are the living organisms that depend on both plants and animals. These consumers are also known as phagotrophs or primary consumers.

c. Decomposers

Decomposers are fungi and bacteria that feed on the decaying organic matter and convert into nitrogen and carbon dioxide. Decomposers are also known as saprophytes.

Producers use energy from the sun to produce food. Herbivores depend on plants for energy. Carnivores feed on herbivores and other carnivores. All producers and consumers are decomposed by microbes. After chemical reactions, decomposers release molecules back to the ecosystem in the form of chemicals. These chemicals are again used by the producers and the cycle continues.

7.4.3 Abiotic Components

Abiotic components, or ecological factors, are the physical and chemical elements that are necessary for the growth of living organisms. The lithosphere, hydrosphere, atmosphere, and solar energy are considered abiotic components, and vary from one ecosystem to another.

In an aquatic ecosystem, the abiotic factors include: water, sunlight, turbidity, water depth, salinity, available nutrients and dissolved oxygen. Abiotic factors in a terrestrial ecosystem include: soil, temperature, rain, altitude, wind, nutrients and sunlight.

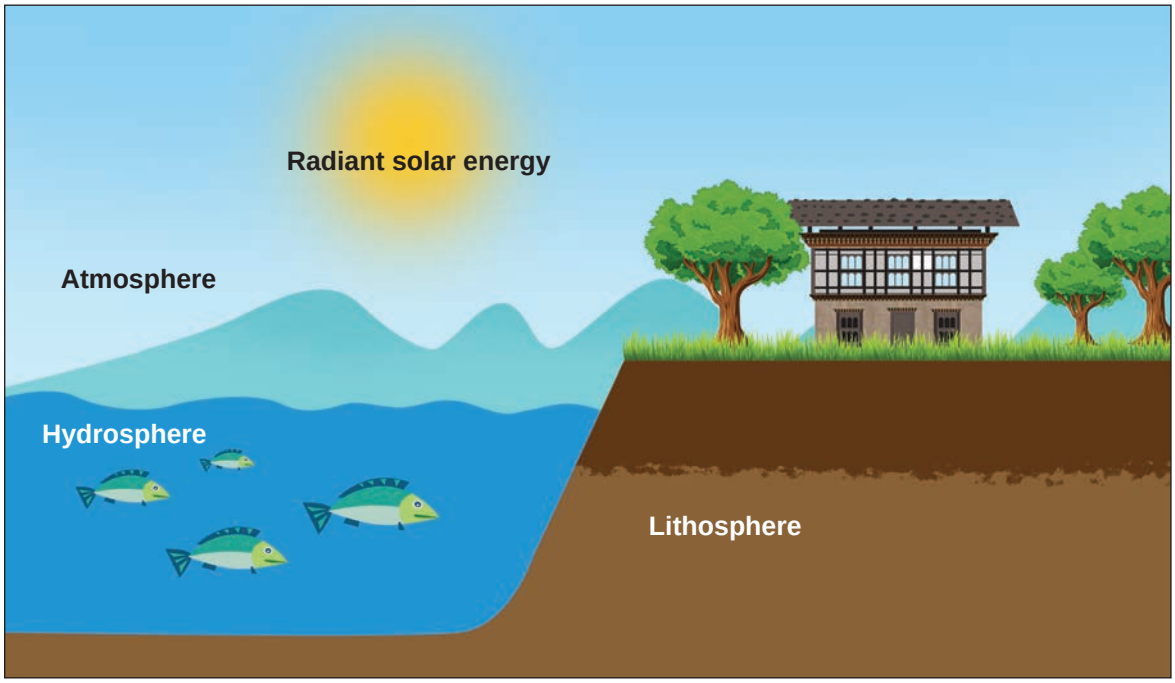


Figure 7.6: Abiotic components

Learning Activity

"Ecosystems have no definite size. It can be as small as a pond or a tree, and as large as an ocean or a forest." Visit an area nearby your school and choose an ecosystem. In teams, identify its components and present the findings to the class.

7.5 Importance of biodiversity

Biodiversity is essential for human existence as it provides a wide range of products and services. These are;

i. provisioning services such as food, water, timber, fibre, genetic resources and medicine

ii. regulating services such as the regulation of climate, water and soil quality and pollination

iii. cultural services such as recreational, aesthetic and spiritual benefits

iv. supporting services such as soil formation and nutrient cycling.

Biodiversity also plays a significant role in mitigating and adapting the impact of climate change.

7.6 Threats to biodiversity

The diversity of wild species is mainly threatened by land conversion, overexploitation, dependence on wood for fuel, pollution by domestic sewage, climate change and forest fires. Forest biodiversity is threatened by population growth, infrastructure development, rapid urbanization, agricultural expansion, over grazing and forest fires.

Pressure on water resources is increasing due to rapid urbanization and industrialization. Specific threats to domesticated biodiversity include: unsustainable cropping practices, agricultural land conversion, cultivation of exotic agricultural crops and land degradation in the form of erosion.

7.7 Conservation of biodiversity

In 1998 Bhutan implemented the Biodiversity Action Plan, which helped establish protected areas and biological corridors that constitute 42.70% and 8.60% of the country's area. The protected areas cover a continuum of major ecosystems found in the country. Plans like these help sustain the provision enshrined in the Constitution of the Kingdom of Bhutan to maintain over 60% of the area under forest cover for all times.

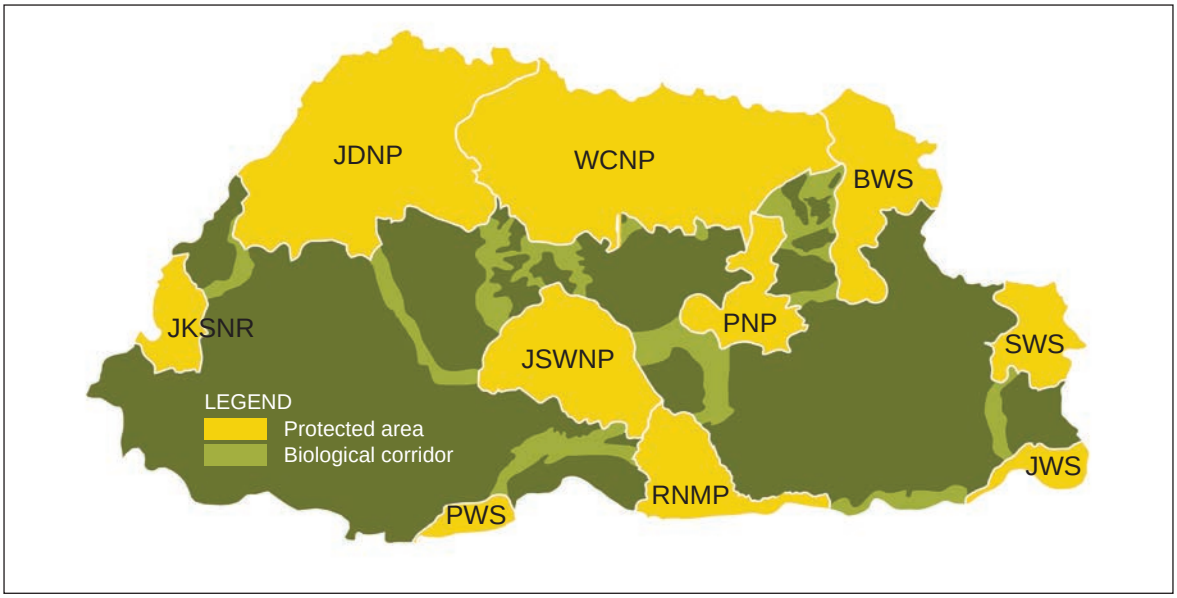
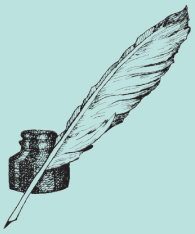


Figure 7.7: Protected areas and biological corridors of Bhutan

The Government has also implemented several conservation programmes for endangered species. Strategies have been developed to control unsustainable harvesting of wild medicinal plants by domestically growing medicinal plants. Conservation of species such as the tiger, snow leopard, elephant and non-wood forest species is are carried out through the Tiger Action Plan and Snow Leopard Information System.

The establishment of botanical and medicinal gardens aid in the conservation of genetic crop resources. Community forests and gene banks are other strategies that promote social conservation in Bhutan.



Learning Activity

Read the case study and answer the questions.

Conservation Challenges in Bhutan: A Case Study of Phrumsengla National Park, Central Bhutan. Conference Paper / October 2016

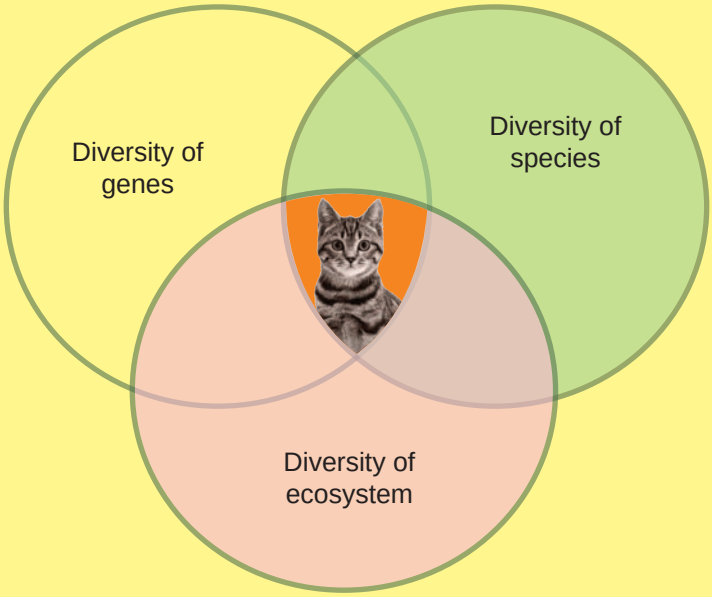
Bhutan is internationally recognised for successfully maintaining 51.44% as protected area (PA) network. One of the issues this study determined was the conservation challenges that occur in Phrumsengla National Park (PNP) located in Central Bhutan. The methodology consisted of document analysis and interviews with twelve participants. They were the PNP residents, park officials, policy and decision makers at the Ministry of Agriculture and Forests and Department of Forests and Park services. The challenges faced by the park management in delivering conservation objectives and residents' perception of park challenges were investigated. All levels of respondents reported common challenges such as human-wildlife conflict (HWC) and illegal activities like poaching, illegal timber harvesting and collection of non-wood forests produce. Some of the recommendations based on the study were to strengthen enforcement and implementation of existing strategies on HWC. The legislations and policies need effective enforcement to curb different illegal activities inside the park. The policy and decision-making agencies need to support the park management in developing human resources. In addition, timely implementation of planned activities should be supported through the development of sustainable funding mechanisms. The study also recommends implementation of the monitoring and evaluation programs by the relevant agencies to address the conservation challenges and to understand the delivery of objectives by the park management.

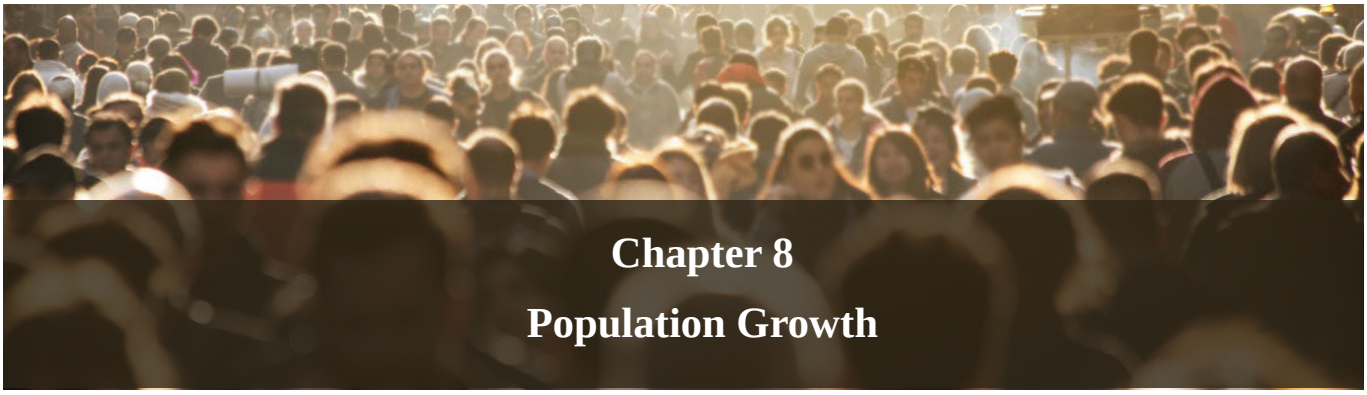
1. What are the conservation challenges discussed in the study?
2. What would be the impacts, if these challenges are not addressed?
3. How would you address the issue if you are one of the members of the policy and decision-making agency? Discuss in groups and present your ideas to the class.

Test Yourself

1. Explain biodiversity using an example from our country.
2. "Energy, biotic, and abiotic are components of an ecosystem." Which component do you think is the most important? Explain.
3. State the importance of biodiversity in your daily life.
4. Suggest ways to preserve biodiversity in your community.
5. Why Bhutan is considered one of the global hotspots of biodiversity?
6. How do human activities impact biodiversity?
7. Compare and contrast biodiversity and ecosystems.
8. How does Bhutan's high value, low volume or impact tourism policy, relate to biodiversity?
9. Refer to the Venn diagram and complete the activity.

Venn diagram showing three components of biodivesity





Chapter 8
Population Growth

Learning Outcome(s):

- Explain population growth
- Discuss the causes of population growth
- Assess the impact of population growth
- Discuss population trends
- Explain population projection
- Discuss the concept and types of migration

8.1 Introduction

Population is dynamic in nature. There are numerous factors that affect population growth. These factors cause the population to either increase or decrease. Population growth has an impact on the environment and resources.

The world population is increasing and the analysis of population trends in many countries indicate positive growth. Thus, demographers have projected that the world population will continue to increase.

8.2 Population Growth

The world population was estimated at around 2.6 billion people in 1950. It reached 5 billion in 1987 and 6 billion in 1999. In October 2011, the global population was estimated at 7 billion and a global movement called “7 Billion Actions” was launched. Since then, the number of people in the world has increased to approximately 7.7 billion in 2019. The increase in population of a particular place over a space of time is known as population growth.

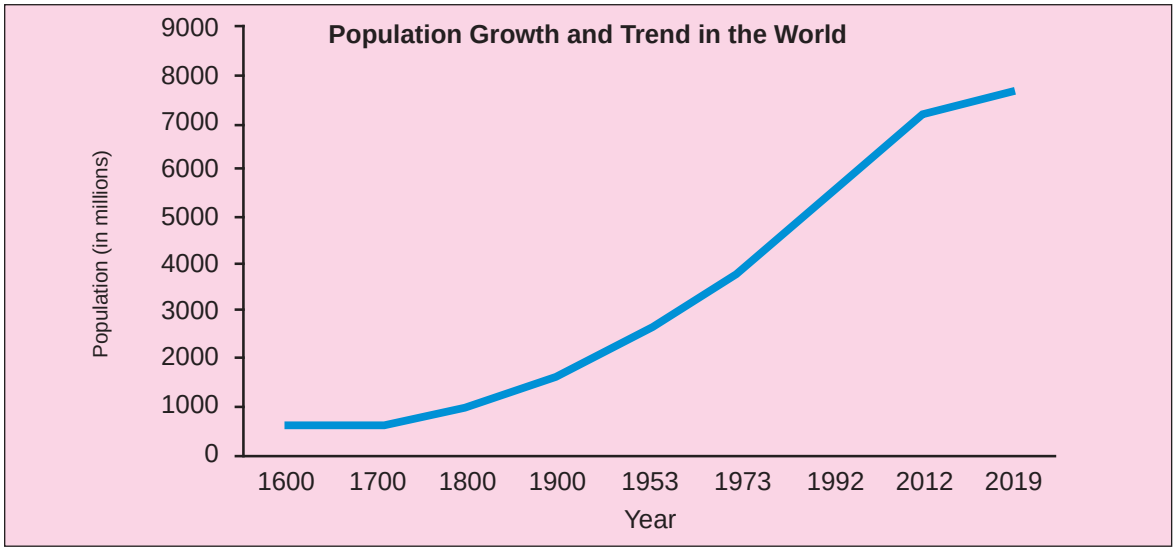


Figure 8.1: Population growth in the world. Source: UN Population Division (2019)

The growth rate of the world's population peaked in 1965-1970, when it was increasing on an average, by 2.1 percent per year. Conversely, the global population growth has slowed by half as a result of the growth rate falling below 1.2 per cent per year from 2015-2020. Furthermore, the population growth rate is projected to continue to decelerate through the end of this century.

$$\text{Population Growth Rate} = \frac{\dfrac{\text{Present Population} - \text{Past Population}}{\text{Past Population}}}{\text{No. of years}} \times 100$$

Population growth helps us understand the cause of changes in population size and growth rate. Accordingly, it helps to make better predictions about future changes in demographic characteristics. It also provides adequate information for policy makers to distribute resources as per the needs and size of the population.

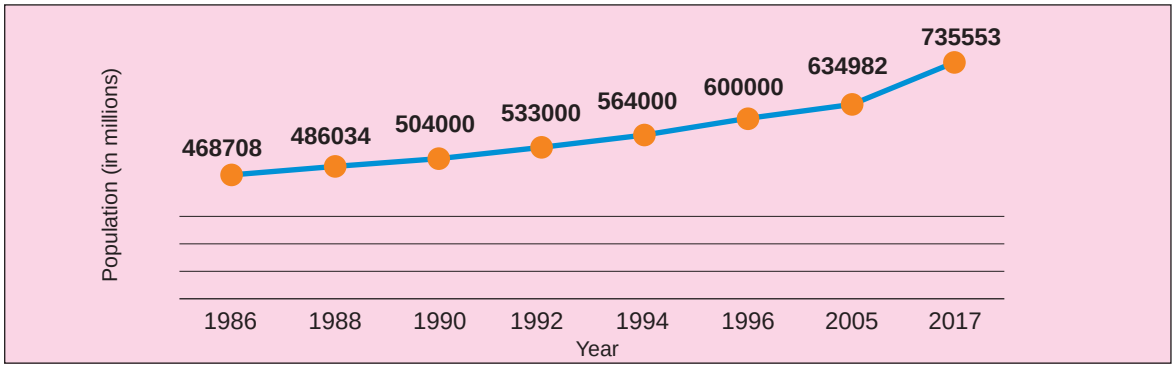


Figure 8.2: Population growth and trends of Bhutan

Learning Activity

Interpret figure 8.2 and support your interpretation with suitable reasons.

8.3 Population Projection

Population projection is an empirical estimation of the future population of a place for a particular time. It is based on current and future fertility, mortality and migration trends. The population of the world is expected to increase by 2 billion persons in the next 30 years, from 7.7 billion to 9.7 billion in 2050 and could reach about 11 billion by around 2100.

Of the 2 billion people that may be added to the global population between 2019 and 2050, 1.05 billion could be in countries of sub-Saharan Africa. Another 25 percent of global population growth is expected to be concentrated in Central and Southern Asia, which accounts for 505 million people.

Population projection = Present population + (Growth Rate x Present Population)

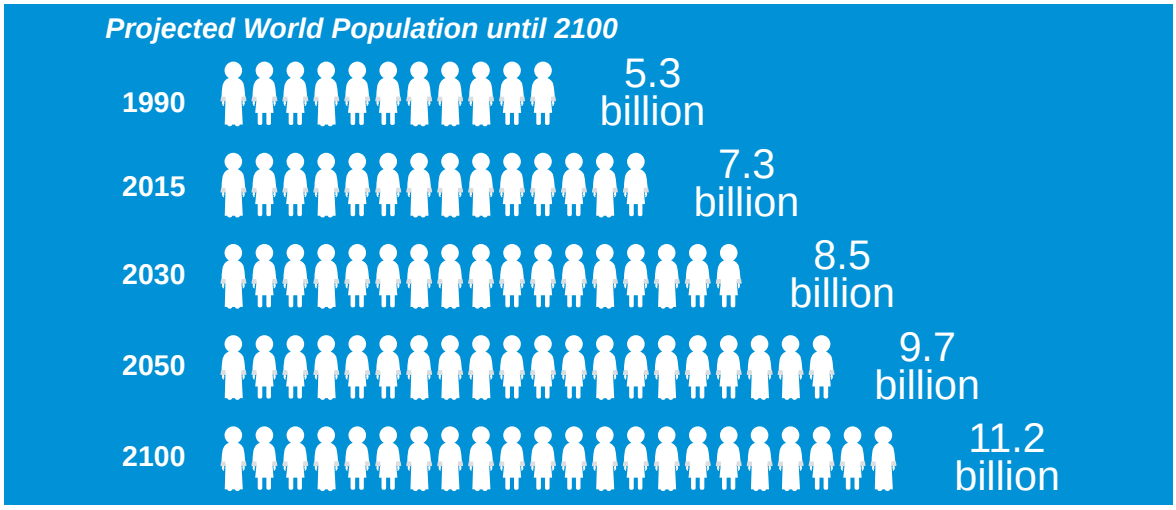
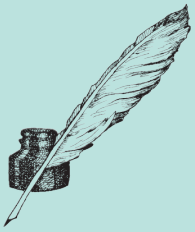


Figure 8.3: Projected world population, Source: UN Department of Economic and Social Affairs, Population Division, World Population Prospects: The 2015 Revision



Learning Activity

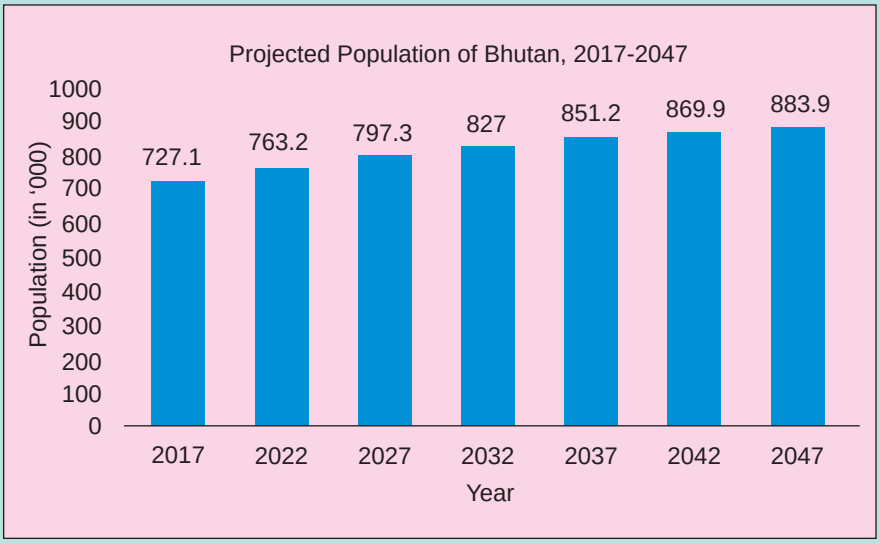


Figure 8.4 Projected population of Bhutan

Refer to figure 8.4 and complete the following questions.

1. Calculate the population growth from 2017 to 2027.
2. Calculate the growth rate of the population for Bhutan using the populations from 2017 and 2027.
3. Estimate the population of Bhutan in 2052 if the growth rate is 1.2 percent in 2047.

8.4 Factors affecting population growth

The population of a place increases or decreases depending on numerous factors. Fertility and mortality are common factors that determine global and national population growth.

1. Fertility

Fertility refers to the number of births per woman in her childbearing (15-49) years. The world population has increased over the years because the birth rate is higher than the death rate. For example, from 2000–2005 population increased at a rate of 1.17 per cent per year compared to 2.1 percent in the 1960s. The most widely used fertility indicator is the total fertility rate (TFR).

Total Fertility Rate is the total number of births a woman would give during the reproductive years. In the 1950s, the TFR for many countries was as high as six births per woman on average. This high level of fertility reflects a near absence of birth control, a situation that prevailed for centuries.

Fertility in many parts of the world decreased by the end of the twentieth century. This decrease is mainly due to deferred marriages, preference of small family size, high cost of living, and easy access to modern family planning. For instance, in 1989 the TFR for Japan was the lowest at 1.57. This is far below the replacement rate of two children per woman during the reproductive years. The global population continues to increase despite declining population growth rate because of the sheer size.

Region	Average number of live births per woman			
	1990	2019	2050	2100
World	3.2	2.5	2.2	1.9
Sub-Saharan Africa	6.3	4.6	3.1	2.1
Northern Africa and Western Asia	4.4	2.9	2.2	1.9
Central and South-Eastern Asia	4.3	2.4	1.9	1.7
Eastern and South-Eastern Asia	2.5	1.8	1.8	1.8
Latin America and the Caribbean	3.3	2.0	1.7	1.7
Australia/New Zealand	1.9	1.8	1.7	1.7
Oceania*	4.5	3.4	2.6	2.0
Europe and Northern America	1.8	1.7	1.7	1.8
Least developed Countries	6.0	3.9	2.8	2.1
Land-Locked Developing Countries	5.7	3.9	2.7	2.0

Figure 8.5: Total Fertility Rate (Source: United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019).

Learning Activity

General Fertility Rate (GFR) is the number of births during a year, per 1,000 women of reproductive age (15–49 years). Bhutan's GFR in 2017 is 57.3, indicating that there are about 57 births per 1,000 women in the reproductive age. The GFR of Bhutan has reduced from 79.4 in 2005 to 57.3 in 2017. (Source: PHCB, 2017)

Bhutan's General Fertility Rate (GFR) has reduced from 79.4 percent to 57.3 percent. Discuss the reasons for this, and share your findings to the class.

2. Mortality

Mortality is the occurrence of deaths in a population during a particular period of time. In the past, the mortality rate was very high due to epidemics, famine, and wars. Around one-quarter of the infant population died in their first year of life and around half of the children, before puberty. This explains the prevalence of low life expectancy in the past. Life expectancy refers to the average number of years a person is expected to live. In the past, low life expectancy and high death rates have caused the global population to grow at a slow rate.

Due to improvements in nutrition, sanitation, development in medical science and technology, the global average infant mortality rate is much lower than in the past. Life expectancy has increased in many parts of the world. For example, the life expectancy is over 80 years for many developed countries in the world such as Australia, Japan, and Switzerland. In developing countries, life expectancy has also increased between 50 and 60 years. These factors have caused the population of the world to increase in recent years.

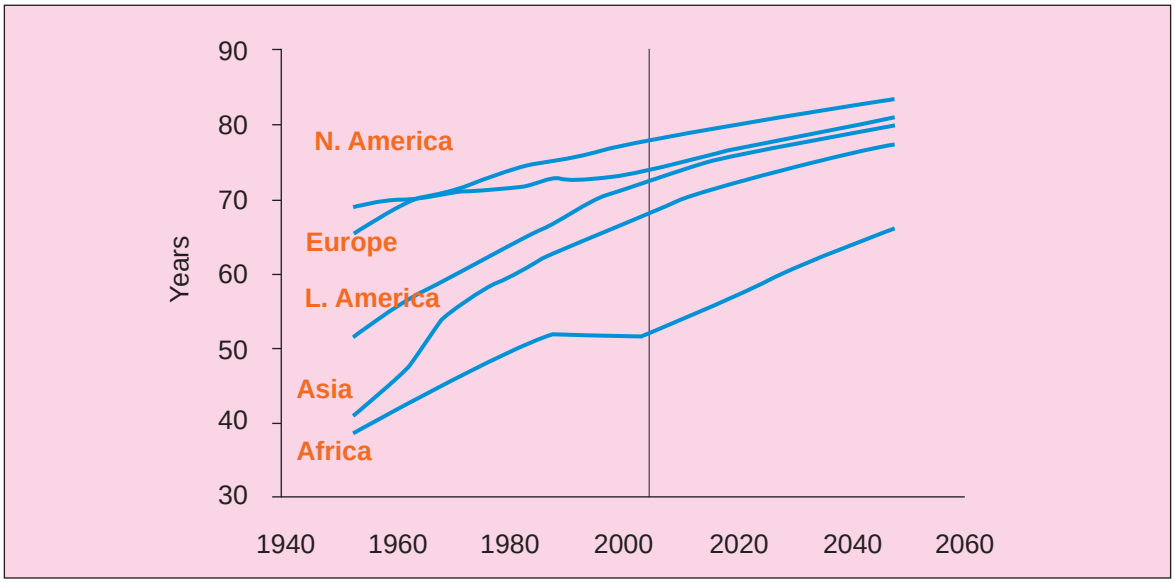


Figure 8.6 Trends in Life Expectancy by region

$$\text{Mortality Rate} = \frac{\text{No. of deaths occurred in a specified period of time}}{\text{Size of population among which the deaths occurred}} \times K$$

The value of K is 1,000 and 100,000 for most types of mortality rates.

Learning Activity

The overall life expectancy of Bhutan in 2017 was 70.2 years, which is an increase of 3.9 years from 66.3 years in 2005. (Source: PHCB, 2017)

In teams, analyse how the increase in life expectancy will affect the mortality rate of Bhutan in the future?

8.5 Migration

Migration refers to the movement of people from one place to another. Globally, it does not cause any population change. However, migration affects the population at a national level by increasing or decreasing the population of a country.

Two types of migration are *internal* and *international* migration.

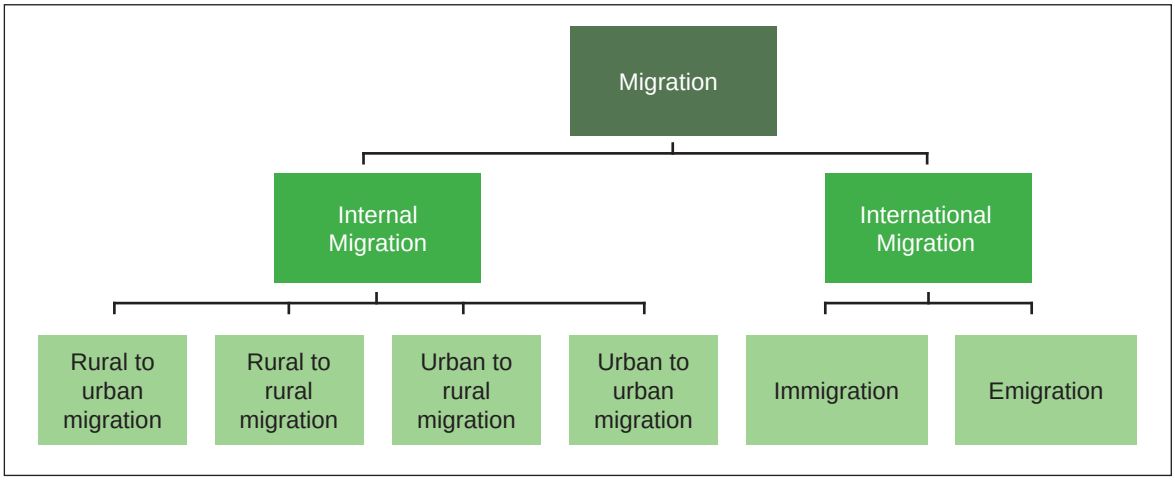


Figure 9.7 Types of Migration

8.5.1 Internal Migration

Internal migration is the movement of people from one area to another within a country. It does not affect the overall population of a country but it can cause the population to increase or decrease in different regions of the country. There are four types of internal migration:

I. Rural to urban migration

In rural to urban migration, people move from rural to urban areas. People migrate to

urban areas due to the availability of job opportunities and modern facilities. This causes the population of urban areas to increase while rural population decreases.

II. Rural to rural migration

In this type of migration, people move from one rural area to another rural area. This migration usually happens due to marriage, disasters and availability of fertile lands. This redistributes the rural population and has no effect on urban population.

III. Urban to rural migration

In urban to rural migration, people move from urban areas to rural areas. This type of migration mainly takes place due to preferences of a peaceful lifestyle after retirement from employment. It increases the rural population while it decreases the urban population.

IV. Urban to urban migration

In this type of migration, people move from one urban centre to another mainly due to transfer of place of work and better economic opportunities. It does not have any impact on the rural population but the urban population of one region increases while another region decreases.

8.5.2 International migration

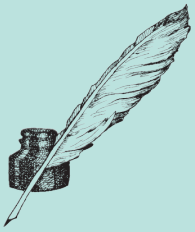
International migration refers to the movement of people from one country to another. This causes the population of a country to increase or decrease. There are two forms:

1. Immigration

An individual or group of people leaving their homes and entering into a foreign country is known as immigration. “Immigrate” usually refers to the crossing of a political boundary where “migrate” means just moving to a new region. Immigrants usually leave their countries or habitual residence for a variety of reasons such as lack of access to resources, desire for economic prosperity, family reunification, and to pursue higher education.

2. Emigration

Emigrate means to move or leave one’s country or region to settle in another. This process is known as emigration. People are usually pushed out of one place or attracted to another. Some of the common reasons to emigrate could be circumstances such as: shortages of land, job and other economic opportunities. People are pushed to those countries where opportunities are available and life is comfortable. For example, a Bhutanese migrating to Australia is an immigrant for Australia and an emigrant for Bhutan.



Learning Activity

Case Study

Gungtong, labour shortage, roads and budgetary issues impede growth in Lhuentse

The most emerging trend in Lhuentse, as is in most of the other rural parts of the country is the alarming rate of Gungtongs, attributed primarily to rural urban migration. Noticeably, majority of the people working in the fields and looking after the livestock are elderly population with the younger population having moved away from villages in search of other employment opportunities and in pursuit of higher education. This has resulted in serious labour shortage. With only so much the aging population can do in the fields, the villagers are now facing severe labour shortage as the younger generation moves out, which is why the focus and shift hasn't changed much from the subsistence farming despite support from the government.

"Gungtong is a emerging issue which is on rise every year and although the government has programs in place to address the issues, I think it requires a wholesome approach to address this very challenging issue in the rural pockets," said the Jarey Gup. The gewog has around 42 Gungtongs as per the record. Khoma Gup, Sithar Tshering said that Gumtongs are bound to be on the rise as the country is going through a series of developmental transition. "It is going to be a challenging issue to tackle, but plans and policies that are aimed at regional balanced development might dissuade some people from leaving their hometown, said Sithar Dorji. Khoma has 26 gungtong cases so far.

Dungkar gewog has 27 Gungtongs and Gangzur at highest amongst all gewogs has 54 gungtong cases.

Source:https://thebhutanese.bt/gungtong-labour-shortage-roads-and-budgetary-issues-impede-growth-in-lhuentse/

1. What do you understand by the term Gungtong?
2. Discuss in group and list the reasons for having a higher rate of gungtong in rural Bhutan.
3. If you are a Rural Development Officer, what would you do to minimise gungtong in rural areas?

8.6 Causes of Migration

People migrate for a number of reasons. A vast majority of people migrate voluntarily for economic, family and educational reasons. However, only a relatively small share of all migrants are forced migrants.

The causes of migration can be studied as *Push* and *Pull* factors of migration. *Push* factors are those that force the individuals to move voluntarily. These factors include conflict, drought, famine, or extreme religious activity. Poor economic activity and lack of job opportunities are also strong *push* factors for migration. Other *push* factors include racial and cultural discrimination, political intolerance and persecution of people. For example, the migration of Rohingya tribes from Myanmar to Bangladesh.

Pull factors are those factors that attract the individual or group to leave their home. Better economic opportunities, and a better life often pull people into new locations.

Learning Activity

Identify and write the following factors under the appropriate headings.

Earthquake, Fertile soil, Famine, Drought, Favourable climate, Abundant Food Supply, Business, Religious Freedom, Community Vitality, Employment, Rainfall, War, Tsunami, Racism, Governance, Persecution

Environmental Factor	Socio-Cultural Factor	Political Factor	Economic Factor

8.7 Impact of Population Growth

The impact of population growth of a country can be both positive and negative. A high population growth has the potential to accelerate economic development. However, it also exerts pressure on limited resources. There are numerous negative impacts of population growth:

I. Air and water pollution

Rapid growth of a population leads to an increase in air and water pollution. It exerts pressure on the limited clean drinking water. Rivers and streams are flooded with domestic and industrial waste which is disposed from houses and factories. Polluted water releases a pungent smell and does not allow flora and fauna to flourish in the river ecosystem. Smoke emitted from vehicles and industries is directly released into the atmosphere which pollutes the air.

II. Unemployment

An increasing population aggravates unemployment problems. The number of jobseekers increases more than the available jobs. Therefore, it becomes difficult for the countries to solve the problem of unemployment.

III. Poverty

The per capita income decreases with an increase in population. This leads to an increase in poverty and puts pressure on limited resources. Food scarcity becomes a major problem in developing countries.

IV. Depletion of natural resources

Increasing human activities like mining, felling of trees, hunting of animals, and extraction of natural oil result in the depletion of natural resources. Increase in population leads to an increase in human needs and wants. These actions continuously put pressure on the limited resources.

Learning Activity

a. *Discuss the positive impact of population growth in teams. Present your findings to the class.*

b. *"Bhutan's unemployment rate stands at 3.4 percent as per the Labour Force Survey Report of 2018. This means nearly 10,500 people were without work during the reference period, actively seeking and available for work. The figure is an increase from 3.1 per cent in 2017."*

In the light of the above extract, analyze the unemployment scenario in the country.

Test Yourself

1. Study figure 8.8 and answer the following questions

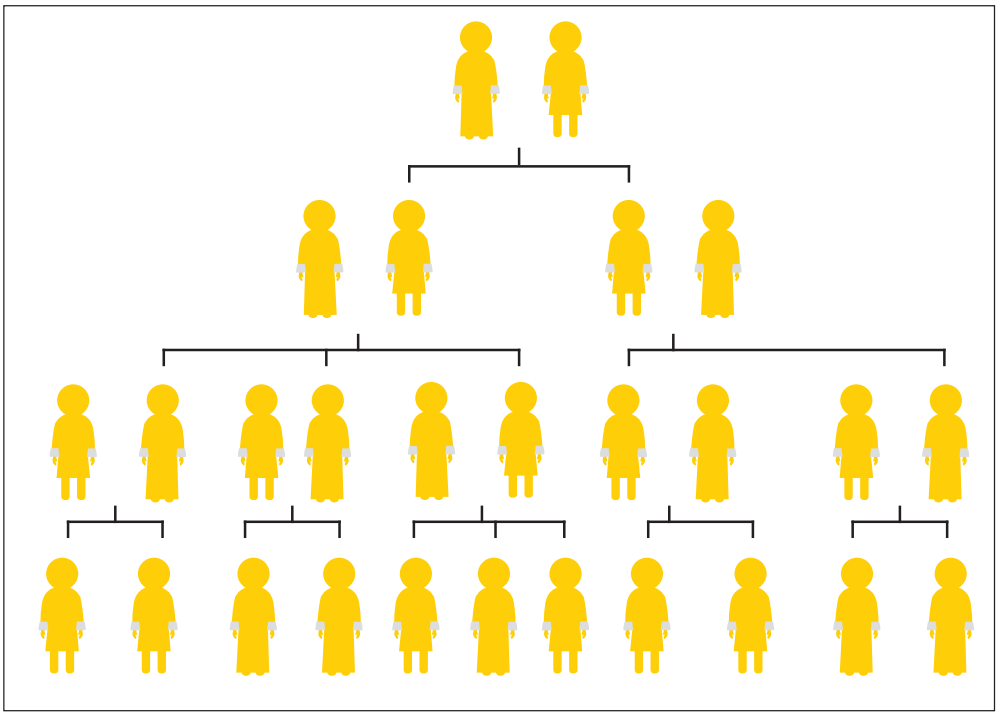


Figure 8.8

i. Describe the picture in relation to population growth.

ii. Explain the future if this trend of population growth continues.

2. Read the extract and answer the questions:

   Sonam is a 23 year old fresh graduate who lives with his mother in one of the villages of Sarpang. Recently his mother has been diagnosed with an illness that requires regular visits to the hospital. As luck would have it, Sonam was offered a good job in Gelephu town and he will soon be moving to Gelephu with his mother to live there.

   i. Which type of migration will happen in the given scenario?

   ii. Identify the factors that are encouraging Sonam and his mother to migrate.

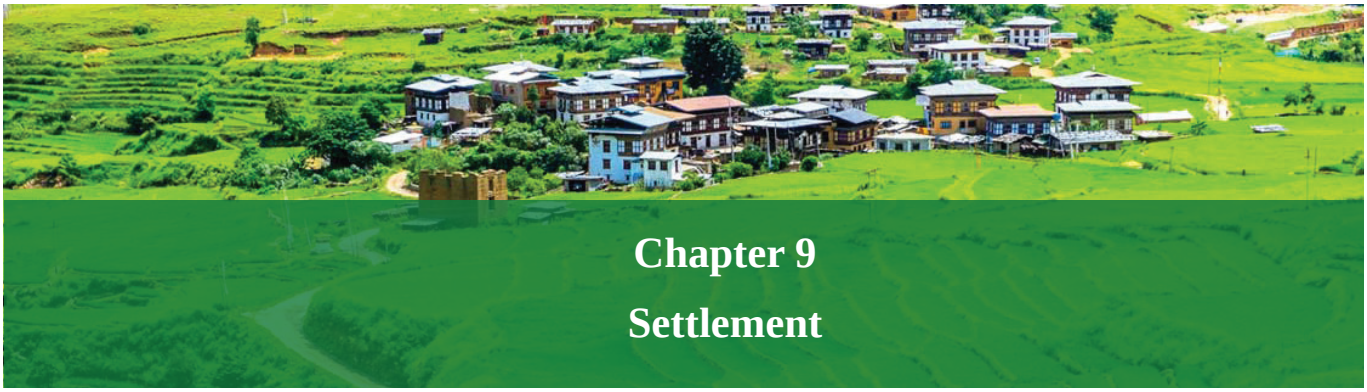
3. Imagine that the population in your community has doubled. What would be the positive and negative impacts?

4. What is Total Fertility Rate? What would happen to a country if the Total Fertility Rate is below the replacement rate of 2.1?

5. Bhutan's overall life expectancy has increased from 66.3 years in 2005 to 70.2 years in 2017. Explain the consequences of this increase.

6. The population of Bhutan stands at 735,553 persons according to the Population and Housing Census of 2017. Do you think the size of Bhutan's population is small? Justify.

7. As per the PHCB 2005, the population of Bhutan was 634,392 persons which then increased to 735,553 persons in 2017. Calculate the growth rate of population.



Chapter 9
Settlement

Learning Outcome(s):

- Discuss spatial distribution of settlements
- Explain Central Place Theory
- Compare Christaller's Central Place Theory with Losch's theory

9.1 Introduction

A settlement is a human-made habitat on the Earth's surface. Settlements are found across the globe ranging from a single unit to large cluster dwellings. Spatial distribution explains the spread of human settlements over the Earth's surface, which are affected by factors such as fertile land, water and topography.

The Central Place Theory helps us understand spatial distribution of settlements, and was introduced by Walter Christaller and later modified by August Losch. This theory provides insight on the growth and spatial distribution of settlements.

9.2 Spatial distribution of Settlement

The distribution and arrangement of settlements is an important part of human geography. The term distribution refers to the way human settlements are spread over a landscape. Settlements are located on the Earth's surface where people agglomerate. The pattern may be isolated homes, separated by great distance, or random, regular or clustered homes. The early development of human settlements were influenced by locational factors such as security, availability of water, fertile land, and flat land.

Settlements may continue for centuries even after the initial influential factors have become irrelevant. However, the distribution pattern of settlements may not remain the same. Settlements may shrink or expand and some may disappear while new ones develop.

Settlement expansions are mostly driven by the development of an economy. The variation in settlement expansion is due to change in the functions of settlements. The expansion varies depending on place, time and type of settlement. The expansion rate is faster in urban settlements and slower in rural settlements. Settlements in developed countries are relatively stable, while in developing countries settlements have changed significantly due to economic development and urbanization. Many settlements have transformed into towns and cities with an increasing complexity of interactions and functions.

The morphology of a settlement depends on factors such as the spatial scale of a given country, density of an urban network, the type and level of socio-economic development, and the natural environment.

Learning Activity

In teams, visit a town nearby your school, and complete the questionnaire. Share your findings to the class.

a) What is the name of your town or the nearest town?

b) How did the town originate?

c) What are the major functions?

d) What are some of the problems faced by the people in that town?

9.3 Central Place Theory

Central Place Theory was first introduced by Walter Christaller, a German Geographer, in 1933. This theory explains the location, size, number and functions of a settlement. According to Christaller, the primary purpose of a settlement is to provide goods and services to the surrounding areas. Such settlements are centrally located and may be called central places.

9.3.1 Assumptions of Central Place Theory

Walter Christaller made assumptions to explain the Central Place Theory, which formed the basis for other theories. These assumptions take into account the growth and development of towns, human behaviour and the fundamentals of economics. The assumptions are:

1. There is an isotropic plane (flat surface) on which natural resources are evenly distributed.
2. Population is evenly distributed.
3. All consumers have similar purchasing power with the same taste or demand for the goods and services.
4. There is an existence of perfect competition with no excess profit.
5. Transportation cost is equal in every direction and it varies linearly with distance.
6. Consumers visit the nearest central place to minimise the transportation costs.

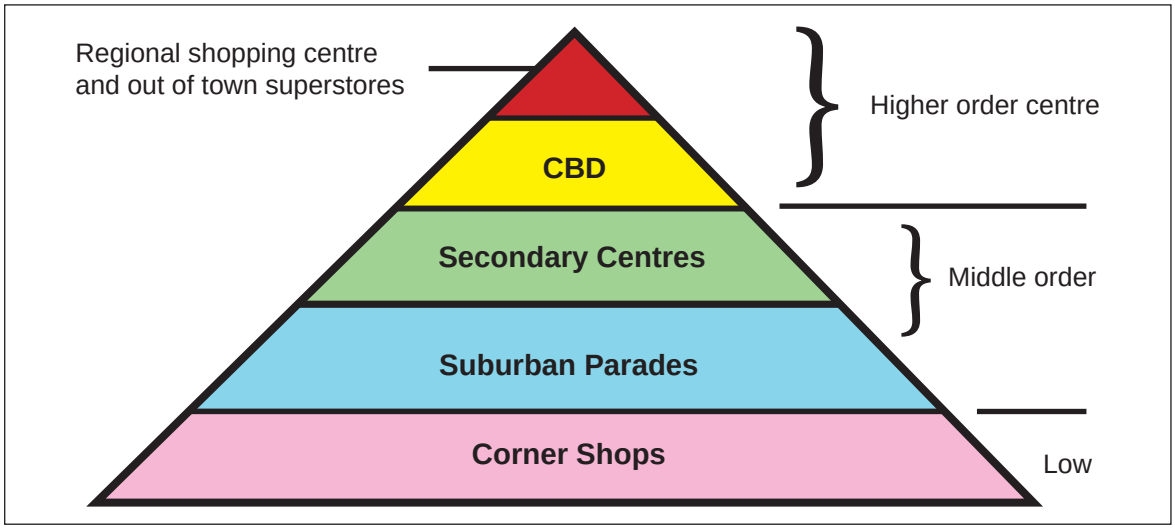


Figure 9.1: Order of goods and services

The theory is explained from the point of centrality, hinterland, threshold population and range of goods and services.
Centrality of a place refers to the extent to which a settlement serves its surrounding areas. It is measured in terms of goods and services offered. According to Christaller, settlements providing more goods and services are called higher-order central places. Lower-order central places have small market areas and provide goods and services that are purchased more frequently.

The hinterland is the surrounding settlements served by a central place. This settlement would be larger for higher-order central places and smaller for lower-order central places. Threshold is the minimum population needed to sell particular goods or services. Some goods and services need a large population and others a small population. The economic activity will not start or will be closed if the population size is below the threshold.
For example, a grocery shop needs a small population to continue business, while an automobile dealer needs a larger threshold population.

Range of goods and services is the maximum distance that a consumer is willing to travel to buy certain goods and services. People are economic in nature and they travel shorter distances to purchase basic necessities such as salt and rice. In order to purchase luxury commodities people travel longer distances. People avail basic medical services for minor diseases from nearby BHUs and hospitals. For major medical treatments like kidney dialysis and surgeries, they visit referral hospitals that provide high-order services.

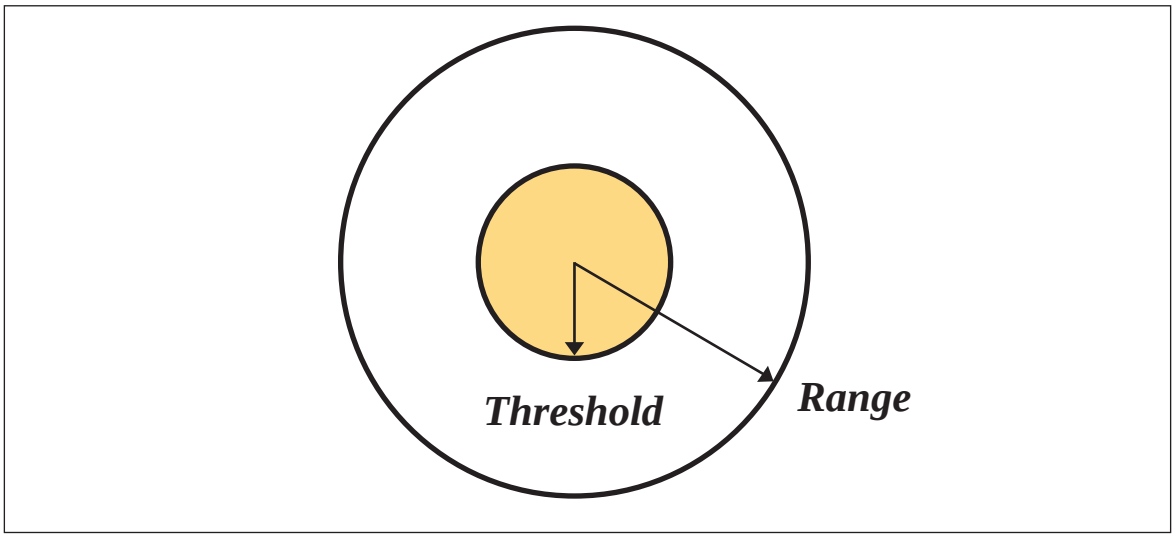


Figure 9.2: Threshold and Range of goods and services

Settlements of various sizes will emerge due to a range of goods and services. The size of a settlement will increase with an increase in the number of high-order goods and services.

The distance between higher-order settlements will be greater than the lower-order settlements. Villages are usually found closer to one another while cities are far apart. The larger the settlement, the fewer the number. There are many villages but only a few metropolitan cities.

Learning Activity

In teams, discuss the following questions and present your answer to the class:

a. If you were to buy a kilogram of salt, would you buy from a nearby shop or from a town far away? Give reasons.

b. Why do people travel longer distances to buy certain goods?

9.3.2 Principles of Central Place Theory

The three principles of Central Place Theory are: marketing, transport, and administrative principle. These principles explain the arrangements and formation of hierarchy. Same order centres are regularly spaced, while large centres are farther apart compared to smaller centres. The market area is assumed to be hexagonal. This shape is most efficient in terms of number and function as there is no overlapping. Christaller used K- values to show the sphere of influence of central places.

1. Marketing Principle (K=3)

The Marketing principle is also referred to as the K=3 hierarchy. According to this principle each central place is located midway between three neighbouring centers of the next higher order centre. The midway points are the corners of hexagonal market areas of the next higher order. Therefore, a high order center serves 1/3rd of the population of each satellite settlement (6 in total) and each higher order center is surrounded by six places of the next lower order. Thus, K = 1 + 6 x 1/3 = 3

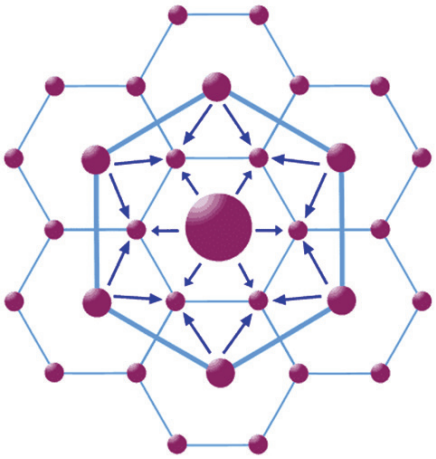


Figure 9.3: Christaller's Marketing Principle K=3

2. Transport Principle (K=4)

Transport or the K=4 principle assumes that lower order settlements are located midway between two higher order centres that are connected by a transportation route. Transportation serves the total population of the higher order centre and half the population of six lower order settlements. Thus the transport principle produces a hierarchy in which central places are nested according to the rule of four (1 + 6 x ½ = 4).

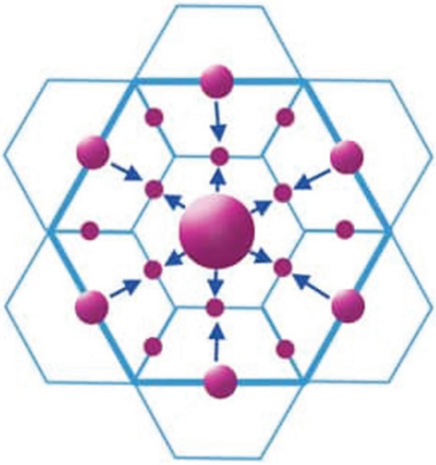


Figure 9.4: Christaller's Transportation Principle K=4

3. Administrative Principle (K=7)

Administrative or the K=7 principle explains the arrangement of settlements in which lower order centers are entirely dependent on higher order canters. For administrative purposes, the whole population of six lower-order centres, along with its population is served by the higher order centre. Therefore, the central places are nested according to the rule of 7 (1 + 6 x 1 = 7).

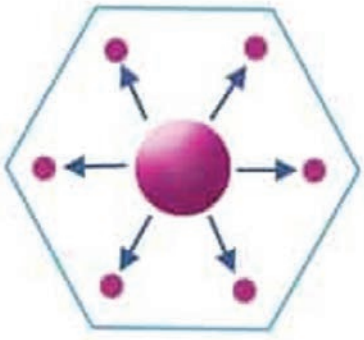


Figure 10.5 Christaller's Administrative Principle K=7

9.3.3 Criticisms of Central Place Theory

The Central Place Theory is used to explain the spatial distribution of settlements over an area. However, it has its own criticisms.

1. The assumptions made in this theory are unrealistic as it is impossible to have very large areas of flat land where there is equal distribution of resources and population.
2. Transportation costs vary from one region to another and consumer travel behaviour cannot be predicted. Changes in preferences and greater mobility will enable people to travel farther to shop and obtain required services.
3. Settlements are generally randomly placed, and not evenly spaced as suggested by Christaller.
4. The concept of perfect competition does not exist in reality.

5. Technological advancements have brought changes in location and organisation of goods and services.
6. Government intervention like planning and policy making, legislation and setting up economic or residential areas affect the growth of settlements.

The Central place theory may not be wholly applicable to the real world but it provides some insights that are helpful in understanding a particular pattern found in the real world.

9.4 Losch Central Place Theory

In 1954, August Losch, a German economist modified Christaller's Central Place Theory as it was too rigid. Losch critiqued that Christaller's theory was based on the distribution of goods and accumulation of profits. Losch instead focused on creating an ideal landscape and maximising consumer welfare.

Losch's model emphasizes profit maximisation in its locational analysis. According to him, the best location of a firm lies where the difference between sales income and production cost is greater. This model consists of layered hexagons in a pattern around a capital or central city. The hexagons show the land around industries in order to determine at which location the population will have the lowest cost.

9.4.1 Assumptions of the model

The model has the following assumptions:

1. There is an isotropic plain of flat land throughout the plain and no barrier would exist to hinder peoples' movement.
2. There is a homogeneous preference among people as they purchase goods from the nearest place possible.
3. There is a hexagonal hinterland which rejects equal distribution of population.
4. Consumers bear the burden of transportation in terms of cost.
5. People act economically rational.
6. New production plants would enter the market if there is profit.

9.4.2 Criticisms of the model

This model has been criticized on the following grounds:

1. The hierarchical system would be distorted by the construction of primary or manufacturing industries.
2. It is static and not dynamic.

3. The assumption that consumers will act rationally and patronize the nearest centre is not realistic.
4. The theory determines one superior centre as the most profitable; it may have been the same over a larger area.

Learning Activity

In teams, discuss and compare Christaller's Central Place Theory with Losch's Theory. List the differences and share with the class.

Test Yourself

URBAN ←

RURAL →

Figure 9.6 Rural and urban settlements

1. Study figure 9.6 and mention their characteristics.
2. Discuss the problems associated with urban settlements in developing countries.

3. Study figure 9.7 and answer the questions.

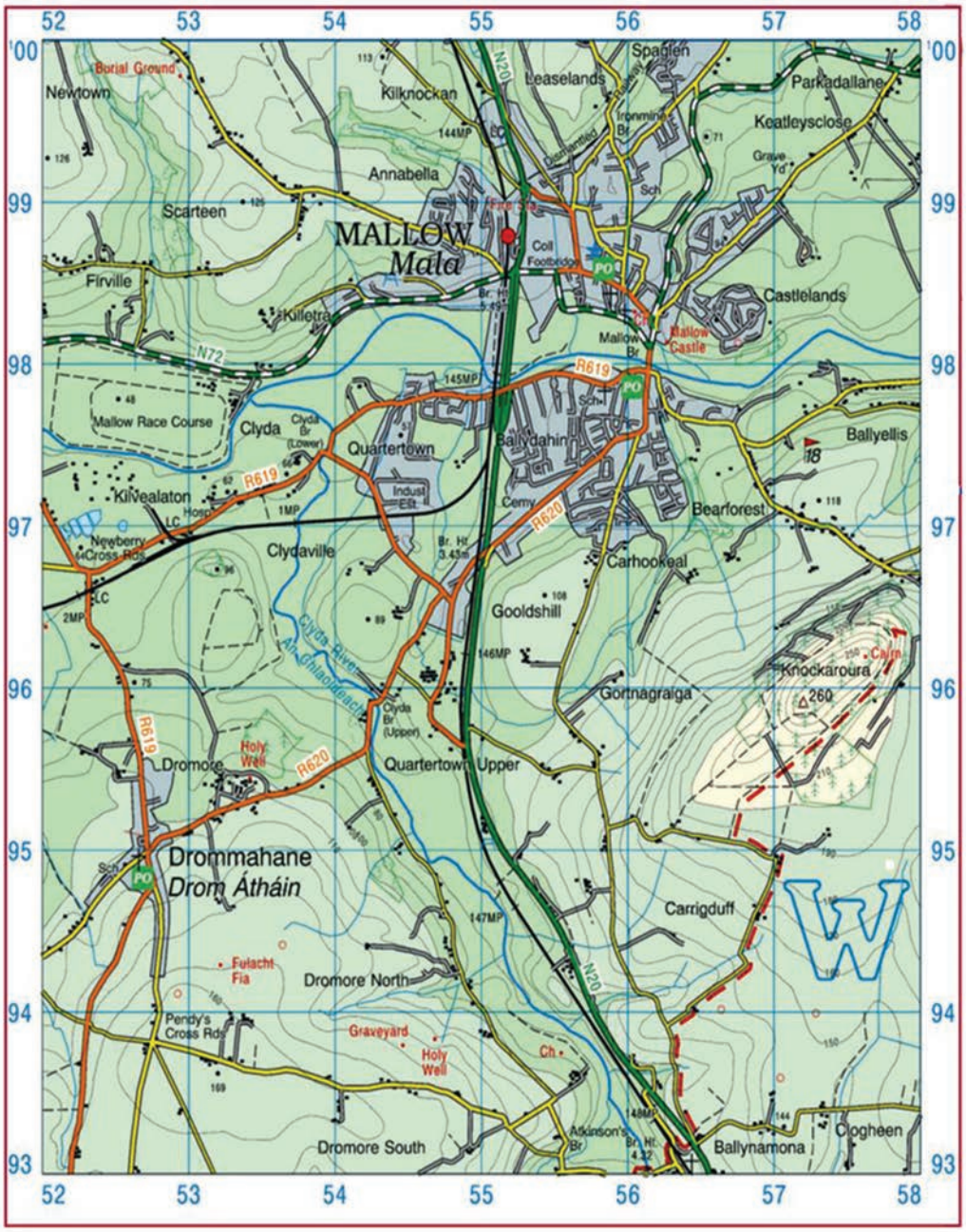


Figure 9.7 Topographic sheet of Mallow

a. Arrange the following three settlements in the order of their rank using urban hierarchy (city, town, village, etc); Ballynamona, Dromahane, Mallow.

b. What do you understand by the term hinterland?

c. Which of these three settlements has the largest and the smallest hinterland?

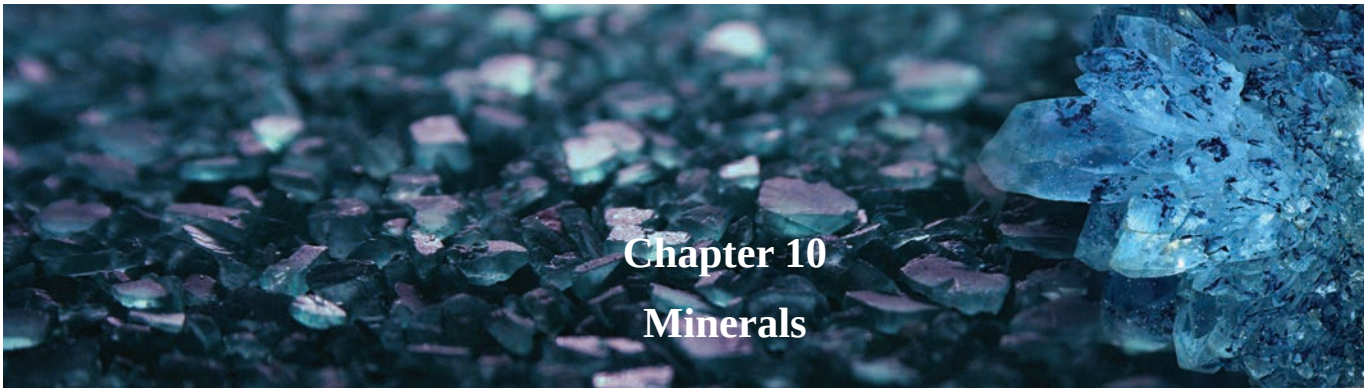
d. Using map evidence, compare the level of services provided by the largest settlement compared to the smallest settlement.

e. Why is Mallow an important urban centre? Give justification.

4. How does the Central Place Theory describe the spatial pattern of a settlement?

5. Do you think Christaller's Theory is applicable in Bhutan? Justify.

6. Why did August Losch modify Christaller's Central Place Theory?



Chapter 10
Minerals

Learning Outcome(s):

- Explain minerals and types of minerals
- Identify characteristics and properties of minerals
- Discuss the significance of minerals
- Locate different minerals found in Bhutan

10.1 Introduction

A mineral is a natural substance with definite properties and is classified by its basic characteristics. Minerals exist on the Earth and play a key role in the origin and evolution of life. Rocks are the main source of minerals.

Minerals are broadly categorised into metallic and non-metallic. Numerous minerals exist on the Earth's crust, and only few are found in Bhutan. Minerals are commonly used in construction, agriculture and chemical industry. The importance of minerals intensified after the industrial revolution.

10.2 Minerals

A mineral is a natural, organic or inorganic substance, with definite chemical and physical properties. The most common minerals are silicates and carbonates.

10.3 Characteristics of minerals

There are five main characteristics that determine a mineral. However, substances with at least three of these characteristics are still considered minerals.

i. Naturally occurring

Minerals are naturally formed and are not human made. For example: coal, gypsum and gold.

ii. Inorganic

Minerals are not formed from organisms. Some examples of inorganic minerals are aluminium, copper and zinc.

iii. Solid

Minerals are solid at standard temperature and pressure. Dolomite, gypsum and slate are some examples.

iv. Definite chemical composition

The chemical formula for minerals are always the same and never change. For example, calcite (calcium carbonate - CaCo3) and quartzite (silicon dioxide - SiO2) have a fixed chemical composition.

v. Ordered internal structure

The atoms in minerals are arranged in a systematic and repeating pattern. For example, halite is composed of sodium and chlorine (NaCl).

KNOW MORE

There are over 5,300 known mineral species, and over 5,070 of these have been approved by the International Mineralogical Association (IMA).

10.4 Properties of minerals

There are many different types of minerals on the Earth. Each mineral has a unique set of properties that are used for identification. These include colour, crystal form, hardness, lustre, density, cleavage and fracture.

10.4.1 Colour

Colour is one of the obvious properties of a mineral. Many metallic and earthy minerals have distinct colour while transparent minerals do not have distinct colour.

Figure 10.1 Different types of mineral

10.4.2 Crystal form

A crystal is a solid, homogenous, orderly arrangement of atoms. The external shape of its crystals is determined by the arrangement of atoms within a mineral.

10.4.3 Hardness

The resistance of a mineral to scratching or abrasion by other materials is referred to as its hardness. For example, a diamond that can scratch any mineral is the hardest mineral.

10.4.4 Lustre

Lustre is the ability of a mineral to reflect light. A diamond has more lustre than iron.

10.4.5 Density

Density is the degree of compactness of a substance. The density varies from one mineral to another. For example, the density of pure iron is 7.6 grams per cubic centimetre and aluminium is 2.7 grams per cubic centimetre.

10.4.6 Cleavage and Fracture

Cleavage and fracture is the tendency of a mineral to break along the smooth planes and curved surfaces without a definite shape. This is determined by the arrangement of atoms and strength of the chemical bonds.

10.5 Types of Minerals

Based on their metal content, minerals are classified into two major types: metallic and non- metallic.

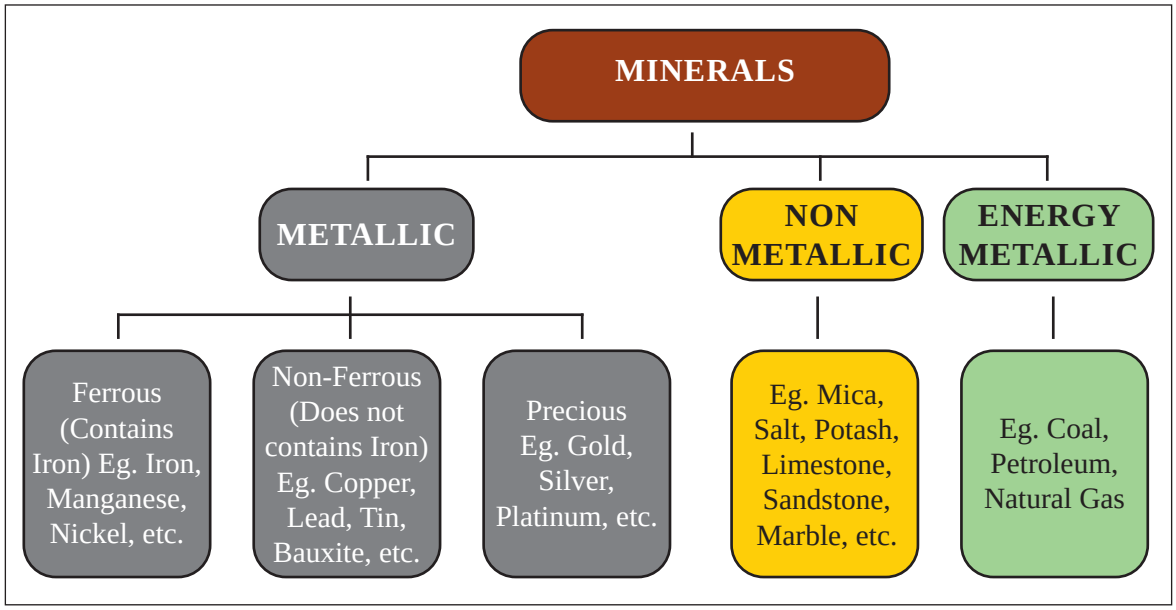


Figure10.2: Types of minerals

10.5.1 Metallic minerals

Minerals that contain metal in their raw form are called metallic minerals. These minerals are malleable and ductile, and are good conductors of heat and electricity. Metallic minerals are associated with igneous and metamorphic rocks, and are characteristically hard and shiny. Gold, silver, copper and iron are some examples. Metallic minerals are classified as:

i. Ferrous metallic minerals

Ferrous metallic minerals contain iron and are strong. All ferrous metals are corrosive and have magnetic properties. These metallic minerals are used in architectural and industrial

Figure 10.3: Metallic minerals

fabrication; as skyscrapers, bridges, vehicles, and railroads. Iron ore and Manganese are some examples of ferrous metallic minerals.

ii. Non-ferrous metallic minerals

Non-ferrous metallic minerals do not contain iron. These minerals do not have magnetic properties and are non-corrosive. They are malleable and lightweight. These minerals are used in industrial applications like aircraft making, gutters, roofing, pipes and electrical appliances. Aluminium, copper and zinc are some examples.

10.5.2 Non-metallic minerals

Non–metallic minerals do not contain metal and are associated with sedimentary rocks. These minerals are soft, non-malleable and non-ductile. They are used as insulators of heat and electricity. Carbon, precious stones, fuels, and bitumen are some examples. Non-metallic minerals are classified as organic and inorganic.

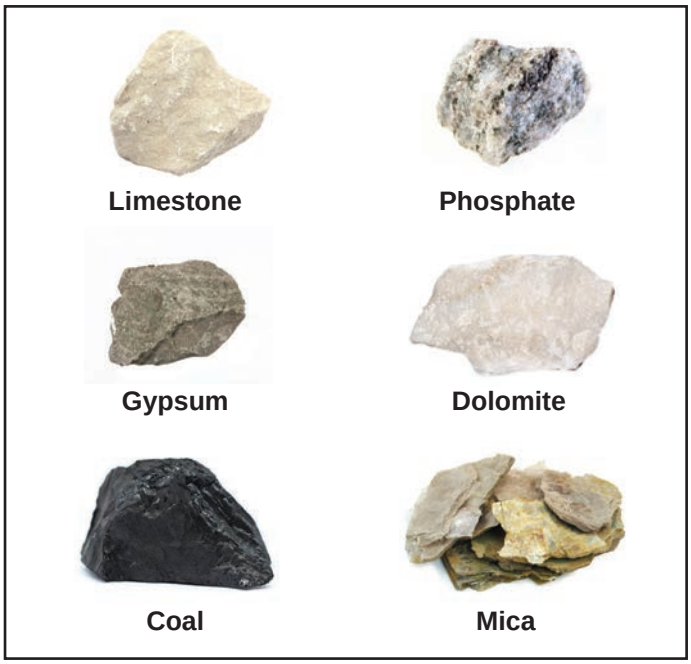


Figure 10.4: Non-metallic minerals

i. Organic non-metallic minerals

Organic non-metallic minerals contain carbon and are commonly known as fuel minerals. These minerals are formed from buried plants and animals. Coal, petroleum, and natural gas are few examples.

ii. Inorganic non-metallic minerals

Inorganic non-metallic minerals contain oxides, carbides, nitrides and many other inorganic substances. Gypsum, limestone and mica are some examples.

10.5.3 Energy Minerals

Energy minerals are used in the production of electricity, fuel for transportation, heating homes and offices and in plastic manufacturing. Few examples include: coal, oil, natural gas, uranium and thorium.

Learning Activity

1. Explore five minerals found in your locality and answer the following:
   a) Classify into metallic and non-metallic.
   b) Describe uses of each mineral.
2. Study figure no. 10.5 and identify the minerals from the picture and its use. Copy the table in your notebook and complete the activity.

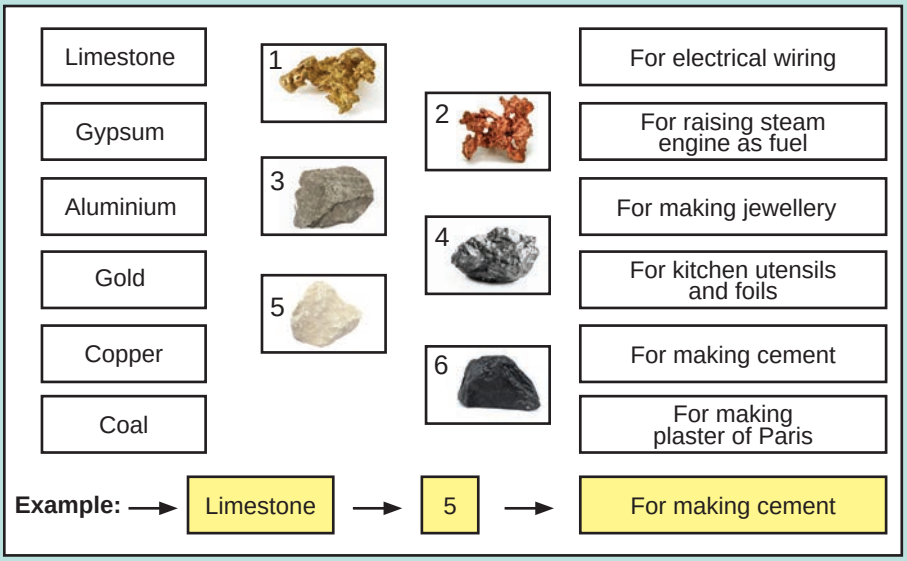


Figure 10.5

Minerals	Picture no.	Use

i. Importance of minerals

Minerals are largely used in the construction industry to aid in the construction of houses, bridges and roads.

In agriculture, minerals are used to manufacture fertilizers, pesticides and animal feed. Large amounts of minerals such as limestone, coal, gypsum and dolomite are used by industries to produce different products like cement and plaster of Paris. Minerals are also used in metallurgical industries.

Learning Activity

Everything we depend on is made from minerals for its production and distribution.

Should Bhutan encourage extraction of all the minerals found in our country to boost the economy? Discuss in teams and present the findings to the class.

ii. Minerals in Bhutan

The Department of Geology and Mines (DGM) has geologically mapped an area of about 6500 square kilometres in Bhutan. A host of metallic and industrial minerals have been discovered in the course of mapping the country. Some minerals found in the country are gypsum, coal, limestone dolomite, talc, slate, marble and quartzite.

Mineral	Location
Copper Ore	Gongkhola in Black Mountain area, Zhemgang Dzongkhag
Lead-Zinc Ore	Genekha area, Thimphu Dzongkhag
Tungsten Ore	Dholpani and Bhurkhola , Gelephu Dungkhag
Coal	Deothang and Bangtar, S/Jongkhar Dzongkhag
Dolomite	All along the foothills of Southern Bhutan.
Graphite	Khepchishi (above 3992 m altitude) Paro, Dzongkhag

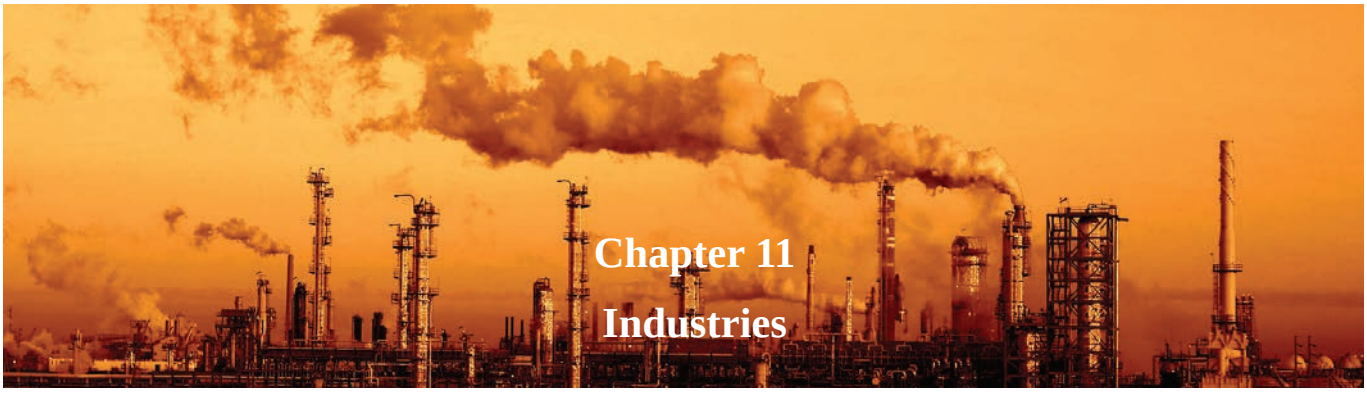
Gypsum	Khothakpa and Uri Chu, Pemagatshel Dzongkhag
Limestone	Pugli –Titi, Gholtey area, Samtse Dzongkhag, Kanamakra, Gelephu Dungkhag, Kurongri and Kerungri, Pema Gatshel Dzongkhag
Marble	Khangkhu (Paro Dzongkhag) In the northern region of Bhutan: Haa Wangtsa, Chelela-Paro, Jemina-Thimphu, Sha Bhel Wangdue Phodrang, Neyphug and Pangpeysa, Paro and Bunakha-Chukha Dzongkhag
Slate	Bhel (Bonsegeoma) and Kobja areas in Wangdiphodrang Dzongkhag
Talc	Foothill belts of SW Bhutan
Ferrosilicon Grade Quartzite	Quartzite in Shumar Formation, Pema Gatshel

Learning Activity

In an outline map of Bhutan, locate and name the following minerals: dolomite, copper, lead, zinc, tungsten, coal, graphite, gypsum, limestone, marble, slate, talc, ferrosilicon and quartzite.

Test Yourself

1. What are the essential characteristics of minerals?
2. Draw a flowchart to display the types and examples of minerals.
3. Why are most of the mineral deposits extracted from the southern foothills of Bhutan?
4. Distinguish;
   a) Metallic and Non-Metallic Minerals
   b) Ferrous Metallic and Non- Ferrous Metallic minerals
5. Mining in Bhutan, a country that prides itself on its environment friendly policies, is not only affecting local people but also the environment. Do you agree? Give reasons to support your answer.
6. Find the location of any four minerals in Bhutan that are exported to other countries. Mention their uses.
7. According to recent findings, “Bhutan’s mineral industry is small and insignificant to its economy.” Justify the statement with examples.
8. Using various sources, explore some of the problems faced by the mining industry. Suggest measures to address these problems.



Chapter 11
Industries

Learning Outcome(s):

- Classify different sectors and types of industries
- Explain factors affecting the location of industries
- Analyse the impact of industries
- Discuss trade and its characteristics

11.1 Introduction

The development of industries plays an important role in the economy of a country. Industries provide a wide variety of goods and services and generate employment opportunities. Over the years industrial development has undergone significant change due to technological advancements, which has intensified the impacts on people and the environment.

Industries are generally divided into three sectors - primary, secondary and tertiary. The distribution of industries is uneven as the location is determined by various factors. The distribution and growth of industries has promoted trade.

11.2 Industry

There is a misconception that industry is a collective large-scale manufacturing of goods in well-organised plants with automation and specialization technology. However, industry also includes other commercial activities that provide goods and services such as: agriculture, transportation, and hospitality.

The inventions of technology in the later half of 18th century enhanced manufacturing industries. There was a transition from manual to auto-manufacturing processes, mostly in the textile industry. A variety of goods and services were produced on a mass scale. Large agrarian societies in Europe and America transformed into industrialised and urban societies. This marked the period of industrialisation.

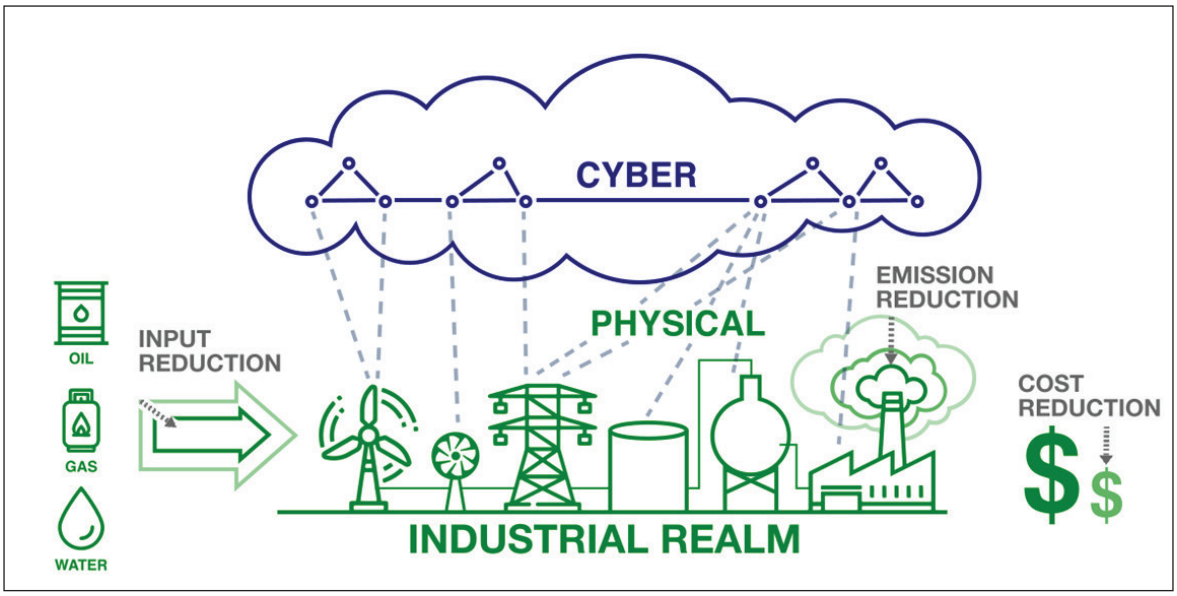


Figure 11.1: The impact of intelligent cyber-physical systems on the decarbonization of energy

Industries are transforming into a new phase of industrialisation. This transformation of industries is based on the Smart Factory concept. The Smart Factory concept was introduced by the Cyber Physical System. It uses the Internet of Things (IoT) as a social network for communicating among people, machinery, and resources. The Cyber Physical System based interconnectivity enables dynamic design of business processes based on quality, time, risk, robustness, price, and environmental computability

Learning Activity

In teams, explore the concept of the fourth industrial revolution by relating it to the Internet of Things and Cyber Physical Systems to this new concept. Share your findings to the class.

11.3 Classification of industries

The four sectors of industry are primary, secondary, tertiary and quaternary. The primary sector includes production and extraction of raw materials. Activities such as agriculture, mining, forestry and fishing are primary sectors. This sector is more prominent in developing countries.

Industries in the secondary sector transform raw materials into products. This process increases value and results in more profits. It generates employment and helps improve living standards and per capita income. Some examples of the secondary sector are: heavy manufacturing, light manufacturing, food processing and energy production.

The tertiary or service sector is the part of the economy that provides services and goods to consumers. This includes various businesses such as financial, educational, and medical institutions; as well as tourism and hospitality divisions. This sector helps develop the primary and secondary sectors.

The quaternary sector is an advanced form of the tertiary sector. It provides the services related to knowledge and information. Most of the quaternary industries in the United States involve computer and information technologies. Some industries in the quaternary sector are consulting, financial planning, designing, information technology, research and development (R&D) and generation of information. Highly paid specialised workforce are involved in this sector.

TAKE IT	**Primary Industry** - involve taking raw materials from the ground or growing things.	
MAKE IT	**Secondary Industry** - involves the making of things (manufacturing).	
SELL IT	**Tertiary Industry** - involves selling things or providing a service.	
PROVIDE IT	**Quaternary Industry** - involves providing information and expertise. Eg. A researcher.	

Industries are classified based on raw materials, size and ownership.

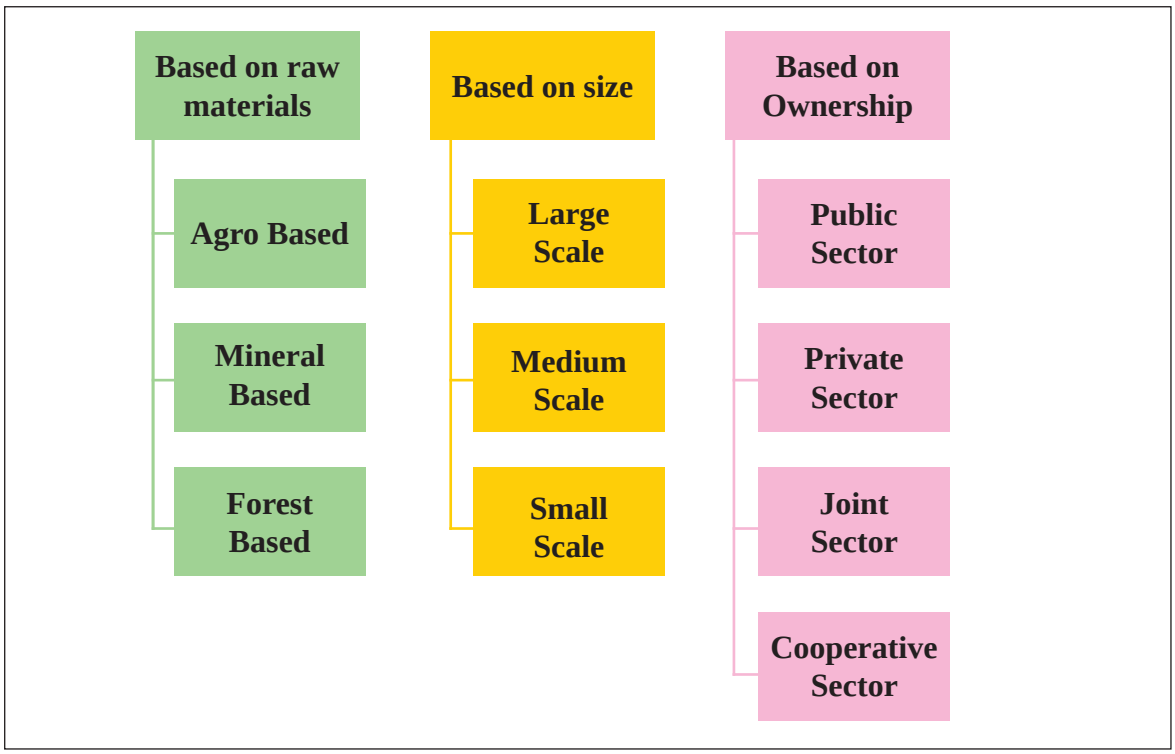


Figure 11.2: Classification of Industries

Raw material based industries are agro, mineral and forest. Agro based industries use plants and animal products as raw materials.

Food processing, ie. vegetable oil, dairy products, textiles and leather industries are examples of these industries.

Mineral-based industries use minerals as raw materials to which other industries are highly dependent on Iron and steel, copper smelting, aluminum and cement production are examples of mineral based industries.

Forest-based industries use raw materials from the forest. Paper, matches, silk and handicrafts are examples.

Industries are also classified based on size. The size of employment, capital investment and volume of production determine the type of industry. However, the size of employment, amount of capital investment and production volume differs from country to country. For instance, industries with a capital investment of less than 30 million ngultrum are considered small scale industries in Japan, while in Bhutan they are considered as medium scale industries.

Scale	Employment size	Investment (Million Nu.)	National Total (in 2013)	Types in the country
Cottage	1-4	Less than 1 million	7,293	Bumthang Cheese, Bee Keeping, Poultry Farming, Home-made Potato Chips, Pickles, Daga Tshingdre Tsongpa
Small	5-19	1-10 million	5,255	Chharu Tshongdrel, Poultry Farming, Bakery
Medium	20-99	10-100 million	N/A	Bhutan Fruit Products Ltd., Bhutan Agro Industries Ltd., Rice Mills, Dairy Processing Plants
Large	100+	Greater than 100 million	N/A	

Source: Department of Cottages and Small Industry, MoEA, 2013

Figure 11.3: Scale of Industries

Learning Activity

Growing unemployment in Bhutan can be attributed to several intra-personal and societal reasons. The demand and preference to join the public sector by jobseekers is one of the main reasons for the rising unemployment problem, especially among the youth and highly educated people. The scenario is further aggravated by the country's underdeveloped private sector.

1. With reference to the given extract, explore the characteristics of public and private sector industries.
2. Discuss reasons for people preferring employment in public sector than private sector. Present your findings to the class using a PowerPoint presentation.

11.4 Factors affecting location of an industry

The location of an industry is determined by a number of factors. Some of the factors are;

1. Availability of raw materials

Raw materials are necessary input for the establishment of an industry. An industry is usually located near the source of raw materials to reduce transportation costs.

2. Infrastructural facilities

Industries are usually located in places where infrastructural facilities like power and water supply, transport, and communication are available. These facilities enable an industry to function optimally. Industries are less likely to be established in places where these facilities are not available.

3. Proximity to market

Finished products need to be distributed to a market. Industries located near a market incur minimum transportation and distribution costs. Industrialists prefer to establish industries close to a market.

4. Labour

Industries require human resources in the form of skilled and semi-skilled labourers. The availability of labour influences the location of an industry and are generally located in areas with adequate and inexpensive labour.

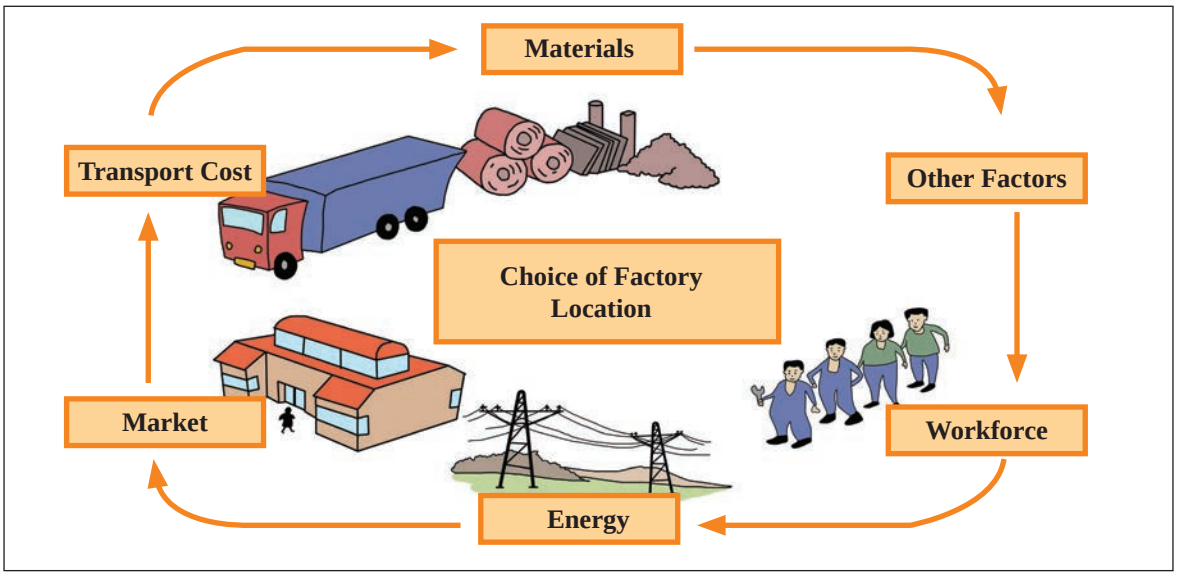


Figure 11.4 Factors affecting location of an industry

Learning Activity

Road to Pasakha industries in bad condition

October 7, 2017, Kuensel

With numerous potholes along the one- kilometre (km) stretch of the Pasakha road between Baunijhora and Bhalujhora streams,

officials of the association of Bhutanese industries' (ABI) say it is time the road is maintained. The road becomes dusty and polluted in winter and rainwater fills the potholes in summer, posing risk for the vehicles plying on it.

Programme officer with the ABI, Pema Namgyel Ghaley, said that the state of the road is getting worse every day. He said that the numerous potholes along the way and the worsening road condition has caused difficulty for the transporters to export and import raw materials and goods in and out of Pasakha industrial estate. He said that the road condition has become an additional cost for maintenance of vehicles. Pema Namgyel Ghaley also said private passengers and industrial employees plying on the road are complaining of the road condition.

With reference to the Kuensel article, discuss how critical transportation is to the location of a prosperous industry. Explore the factors that led to the establishment of the Pasakha industrial estate in Phuentsholing.

11.5 Distribution of Industries

Industries are unevenly distributed in the World. Before 1800 BCE, industries developed in areas with abundant raw materials, running water and power supplies. After the industrial revolution, industries developed near coal fields, canals and railways. The location of industries in these areas meant easy access to raw materials and transportation facilities.

The development of the iron and steel industry in the 1950s led to the location of industries near sea ports to minimise transportation cost. Iron and steel industries are located in countries such as China, Germany, Japan, Russia and the USA. Textile industries are located in countries like Hong Kong, India, Japan, Korea, South Korea and Taiwan. The latest industrial developments, like information technology, are based in the Silicon Valley of Central California, USA and Bangalore in India.
Considerable industrial development has taken place in China, India and Japan. China is the leading producer of iron and steel, light metal goods, household goods, textiles and consumer goods like toys.

In India, private and public sector industries developed after its independence. India is the leading producer of cotton and silk textiles, heavy engineering, chemical fertilizers, petrochemicals, pharmaceuticals, leather, and paper cloth products.

Industries in Japan developed at a faster rate despite a shortage in raw materials and solid fuel. Skilled labour, technological development, government encouragement and proximity

of a large Asian market fueled rapid industrial development. Japan is the leading producer of industrial robots, locomotives, aircrafts, silk products, heavy equipment and machinery.

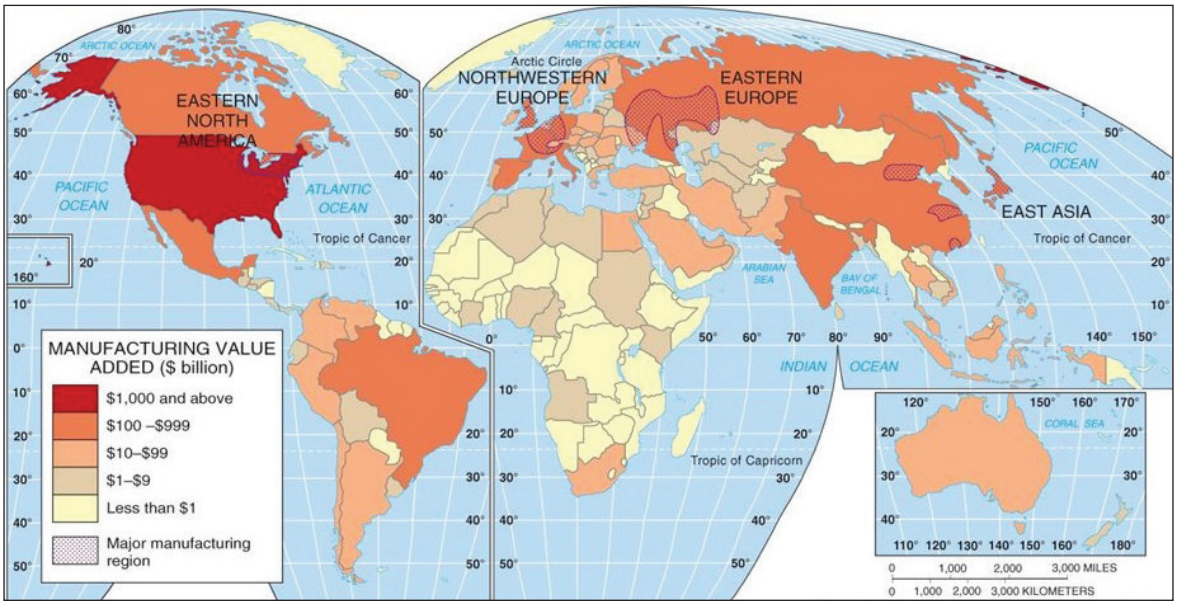
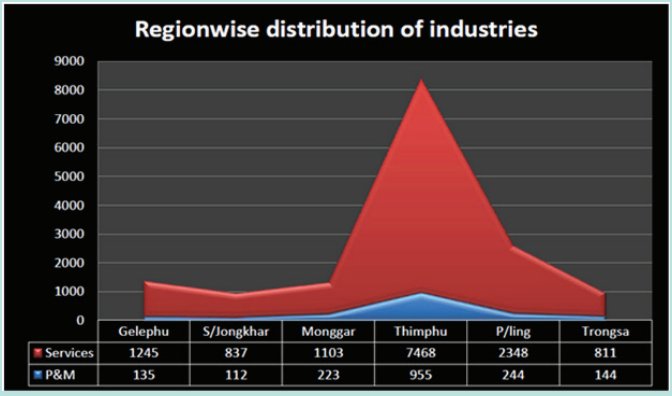


Figure 11.5 Major industrial regions and manufacturing value added ($ billion)

Learning Activity



	Gelephu	S/Jongkhar	Monggar	Thimphu	P/ling	Trongsa
Services	1245	837	1103	7468	2348	811
P&M	135	112	223	955	244	144

Source: Department of Cottage and Small Industry, MoEA, 2011

Figure 11.6: Region Wise Distribution of Industries

Refer figure 11.6 and discuss the following questions:

1. Describe the distribution of industries in Bhutan.
2. Why do you think the Trongsa region has minimal service industries?
3. Which region in Bhutan is concentrated with industries? Justify your answer.

11.6 Impacts of Industries

The establishment and development of industries have both positive and negative impacts on a country. Industries accelerates economic growth and can bring prosperity to a country; however, this can have an adverse impact on the environment.

Industries create employment opportunities and improve the living standard of people. The location of an industry leads to the development of other infrastructure facilities like healthcare, education, communication and transport. Better quality goods are also produced using the local raw materials. Export of finished products can also generates higher revenue for the country.

Industries can have a detrimental impact on the environment. Waste released from industries pollutes water resources. Smoke and harmful gases emitted by the industries pollute the air. An Increasing number of industries require a greater amount of resources, which leads to the depletion of natural resources. The extraction of raw materials destroys the ecosystem. The working conditions in some industries can also be risky and hazardous for the workers.

Learning Activity

Figure 11.7 Impacts of Industry

Refer figure 11.7 and explore various impacts of this industry. Suggest ways to reduce adverse impacts and recommend some safety measures. Share your findings to the class.

11.7 Trade

Trade refers to the exchange of goods and services. A system or network that allows trade is called a market. Two types of trade are internal and international trade. Internal or domestic trade is the buying and selling of goods or services within a country.
Exports and imports are the two components of international trade. Export refers to selling of goods and services produced in the home country to a market outside the country. Buying of goods and services from other countries is called imports.

The first agreement of trade and commerce between Bhutan and India was signed in 1972. The agreement has been renewed several times.

Particulars	2013	2014	2015	2016	2017	2018
Exports to Bhutan from India (Nu. Million)	43890	47850	53740	55290	53790	60110
Exports to Bhutan from India a % to total Bhutanese import.	82.4%	84.1%	79%	82.08%	80.56%	84%
Imports from Bhutan to India (Nu. Million)	28980	31800	31800	32050	31620	32170
Imports from Bhutan to India a % to total Bhutanese export.	91%	89.4%	90.3%	90.90%	84.77%	78%

Figure 11.8: Exports and Imports

In 2018, bilateral trade reached Nu. 92,280 million. Imports from India were Nu. 60,110 million accounting for 84% of Bhutan's total imports. Bhutan's exports to India stood at Nu. 32,170 million including electricity and it constituted 78 % of its total exports.

Learning Activity

Refer figure 11.8 and discuss the following questions:

1. What are the differences in Bhutan's international trade with India from 2013 to 2018?
2. Calculate the balance of payment for 2018.
3. Why is the balance of payment always negative for Bhutan? What does it indicate about our economy?

Test Yourself

1. State True or False. Correct the false statements.
   a. Industrialization in the world started with large scale production of mineral products.
   b. Industries today use state-of-the-art-technologies to produce products.
   c. Industries based on Cyber Physical Systems are very expensive and cause the industries to operate under financial loss.
   d. Bhutan has more large scale industries compared to small scale industries.
   e. The growth and development of industries today are highly influenced by geographical factors.

2. Why are primary sector industries dominant in most of developing countries?

3. Explain reasons for unequal distribution of industries in our country.

4. How does the development and growth of industries benefit the economy of a country?

5. Service sector industries are more important than manufacturing industries. Do you agree? Give reasons.

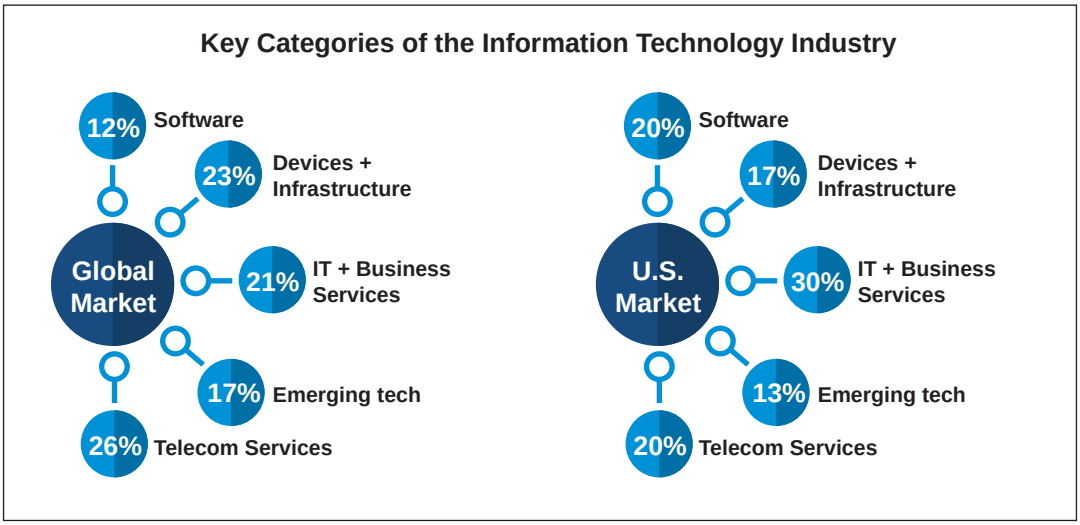


Figure 11.9: IT industry outlook 2020

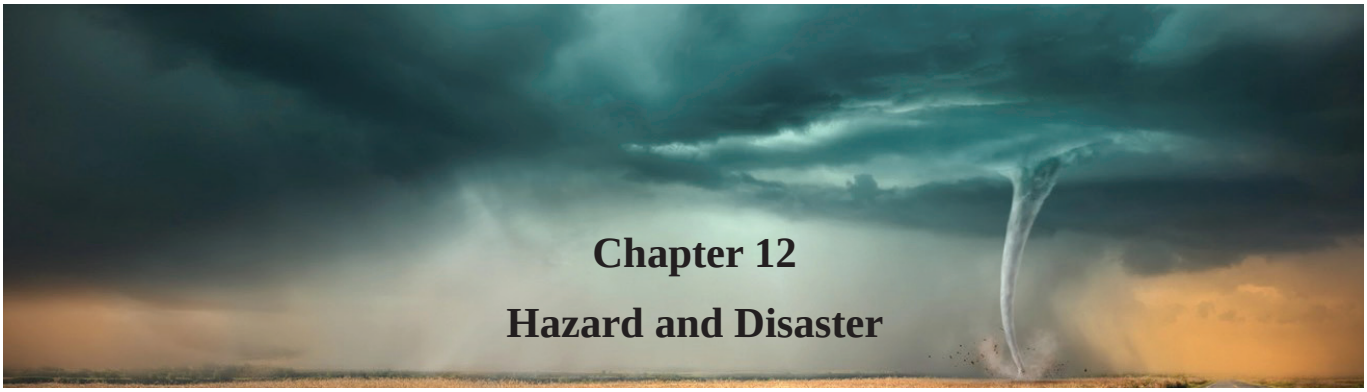
a. Refer to figure 11.9, and explain the reasons why USA has a higher rate of IT and business services compared to the rest of the global market?
b. Draw a comparative bar graph using the data from figure11.7 and interpret the graph.

7. The Bhutan Dairy Cooperative is making a difference by empowering farmers in Bhutan. Describe any one of the cooperatives in your community or elsewhere.

8. Modern industries have developed since the 1960s in Bhutan. What are some of the factors that have contributed to the growth of industries?

9. If you are given an opportunity to work in either the secondary or tertiary sector, which sector would you choose and why?

10. Explore the future scope of a quaternary industry in Bhutan. How will it contribute to our economy?



Chapter 12
Hazard and Disaster

Learning Outcome(s):

- Discuss common disasters in Bhutan
- Suggest mitigation measures to reduce impact of disaster
- Demonstrate measures to reduce risk during disaster

12.1 Introduction

A disaster is an occurrence of a hazard that causes destruction to lives and infrastructure with devastating consequences. Exposure to hazards is increased due to poverty, lack of early warning systems, poor risk-governance and an absence of civil protection mechanisms. Bhutan is exposed to a wide range of hazards due to the geological settings, fragile ecosystems and changing climatic conditions. Natural hazards cannot be prevented, but risk reduction and management are used to prevent hazards from becoming a disaster. Mitigation measures such as awareness programmes, capacity building, risk management activities and post-disaster management are initiated at a national and local level.

12.2 Common disasters in Bhutan

A disaster is a serious disruption occurring within a short period of time that often causes widespread loss of human lives, materials. Disasters also drastically impact the economy and the environment. Due to an increasing population, hazards, risks and disasters have become a serious concern in recent decades. Some of the common disasters in Bhutan are earthquakes, flooding, landslides, fires and windstorms.

12.2.1 Earthquake

An earthquake can cause large scale destruction in a place. Earthquakes occur frequently in Bhutan as it is located in a seismically active zone. Bhutan has been affected by earthquakes in 1897, the Shillong earthquake, 1934 the Bihar-Nepal earthquake, and

1950 the Arunachal-Tibet earthquake. Bhutan was also affected by major earthquakes in 2009 and 2011. On September 21st 2009, a 6.1 magnitude earthquake hit the country. The epicenter was located at Narang in Mongar. Similarly, on September 18th 2011, an earthquake with a magnitude of 6.9 hit northern Sikkim.

The earthquake was felt across north-eastern India, Nepal, Bhutan, Bangladesh and southern Tibet. These earthquakes caused destruction to lives, properties and disrupted social services leading to economic loss.

Therefore, it is important to understand the possible consequences of earthquakes and to initiate a prepared response to reduce disastrous impacts. Proper planning and organization, emergency procedures and safety precautions help to reduce the devastating effects.

Figure 12.1: Earthquake damage

Before an Earthquake	During an Earthquake	After an Earthquake
Check for Hazards in the Home… • Ensure that your home is safe. You can strengthen an existing building by retrofitting it. • Repair any deep cracks in ceilings or foundations. Get expert's advice if there are signs of structural defects. Fasten shelves securely to walls. • Hang heavy items such as pictures and mirrors away from beds, couches, and anywhere people sit. • While constructing new buildings, ensure that it complies with building and seismic codes. • Teach family members how to turn off electricity, gas and electric supply at the main source. • Repair defective electrical wiring and leaky gas connections. These are potential fires. • Rehearse **DUCK, COVER & HOLD.** Duck under a sturdy desk or table, hold on and protect your eyes by pressing your face against your arm. If there is no table or desk nearby sit on the floor against an interior wall. SAVE YOURSELF DURING EARTHQUAKE  DUCK onto your hand and knees. COVER your head and neck. HOLD onto your shelter. • Keep a list of important telephone numbers to be contacted in case of an emergency.	**If you are indoors** • Do not exit the building during the tremors. • Stay indoors! Do not panic, **DUCK, COVER & HOLD.** Take cover under a sturdy table, desk and bench or brace yourself in a door- way or corner. • Stay away from windows, book racks, cabinets, heavy mirrors, hanging plants, etc which may slide and topple. • Grab anything handy (coat, blanket, book, bag, etc) to shield your head and face from falling debris and splintering glass. **If you are outdoors** • Move to an open area cautiously away from power lines, poles, trees, high buildings, and walls. • Stay in open areas till the vibration stops. • Stay away from fallen power lines. • If driving, stop in an open area away from structures especially bridges, overpasses, tunnels and overhead power lines. **If in a crowded place/store/ room** • Do not rush for the doorway or exit since hundreds may have the same ideas. • Move away from display shelves containing objects that may fall.	**Stay Calm** • Check yourself for injuries. • Move cautiously, and check for unstable objects and other hazards above and around you. • Expect aftershocks. **DO'S** • Check for fire and if any have it controlled. • Check your water and electrical lines for defects. If any damage is suspected, turn the system off at the main valve. • Obey Public safety precautions. • Leave a message stating where you are going if you must evacuate your residence. • If trapped under debris, then signal for help by shouting or banging nearby objects. **DON'Ts** • Do not enter partially damaged buildings, Strong aftershocks can cause further damages to the building and weak structures may collapse. • Use a telephone only for emergency purposes. • Do not use two wheelers or cars to drive around the area of damage. Rescue and relief operations need the road for mobility.

Figure 12.2: Safety tips

Learning Activity

Watch a video on Earthquakes and complete the activity. **https://youtube/YlVZLREDx1w** (source- Department of Disaster management)

1. Discuss the safety tips given in the video.
2. Prepare a disaster preparedness plan and present it in the class.

12.2.2 Floods

Floods pose a greater threat during the monsoon season due to torrential rainfall. Sometimes, floods are triggered by an outburst of glacial lakes.

i. Glacial Lake Outburst Flood

Glacial Lake Outburst Flood (GLOF) is caused by retreating glaciers. Glaciers are receding at a faster rate due to global warming and climate change. Melting ice from receding glaciers increases the volume of water in glacial lakes forming supraglacial lakes. These lakes are destabilized leading to the collapse of ice-cored dams, which increases the likelihood of Glacial Lake Outburst Flood. Glacial Lake Outburst Flood possesses

potential threat to life, property and the environment.

The Department of Geology and Mines and the International Centre for Integrated Mountain Development (ICIMOD) listed 25 out of 2674 glacial lakes in Bhutan as a threat for GLOFs in the near future. In October 1994, 90 kilometers upstream from Punakha Dzong, a GLOF caused massive flooding along the Pho Chhu. This threatened lives and caused damage to the Dzong.

One measure to help mitigate risk is to reduce the water level in lakes that have GLOF potential. A project from 2008 to 2011 drained out 17 million cubic meters of water from Thorthormi lake. Early warning sirens were set up and safety evacuation zones have been identified along the high risk areas.

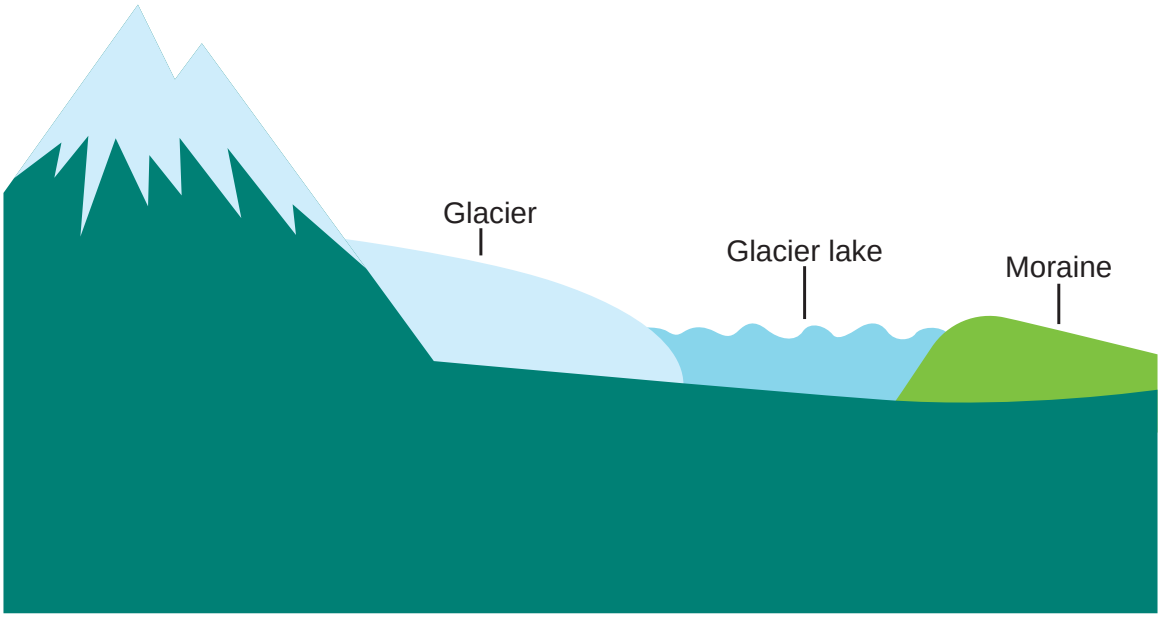


Figure 12.4: Schematic diagram of a moraine-dammed glacial lake formed by glacial melt water.

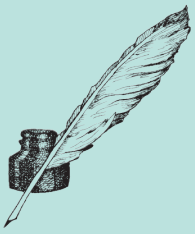
ii. Flash Flood

Flash floods are caused by sudden heavy rainfall over a short period of time. The occurrence of flash floods depends on the intensity, location and distribution of rainfall. They also depend on land use, topography, vegetation growth, soil type, and soil water content. Flash floods sometimes occur due to the collapse of dams or levees, and debris flow.

Urban areas are more prone to flooding than the rural areas. The impervious surfaces in urban areas prevents water from seeping into the ground. Water flows over the surface

as run-off to lower areas. Flood prevention and mitigation includes construction of embankments, desilting, and diversion of rivers.

Figure 12.5: Flash Floods



Learning Activity

Watch the video given in the link and complete the activity.
https://youtube/mekJcjoe0ws

1. Suggest mitigation measures to avoid damage from disasters given in the video. Display your work and do a Gallery Walk.

2.3 Landslide

In the rugged mountain topography of Bhutan, landslides are a common hazard. A landslide is the mass movement of a portion of the Earth's surface, and are caused by earthquakes, heavy rainfall, flooding and human activities. Landslides destroy buildings, roads, and other infrastructure like bridges and dams. They can also cause death, injury and economic loss. Sometimes landslides cause irreparable damage to cultural and natural heritage. Without proper management and materials, clearing landslide debris takes a long time.

Landslide management is necessary to help reduce and mitigate risk around landslide prone areas. Public education and awareness also play a vital role in the overall management of a landslide before, during and after.

Landslide hazards are mitigated mainly through precautionary measures. Landslide zonation mapping, unstable land use restrictions, and vegetation management are some

mitigation methods.

There are also direct methods of preventing landslides such as, modifying slope geometry, installing structures like piles and retaining walls, diverting debris pathways, and rerouting surface and underwater drainage; however these direct methods are constrained by cost, landslide magnitude and frequency, and the size of human settlements at risk.

Figure 12.7: Landslide damage

12.4 Fire

Fire is a disaster that is mostly caused by human negligence. Sometimes it is also caused by natural phenomena like lightning. It has an impact on lives, property, the environment and the economy. Two types of fire disasters are forest and structural fire.

Figure 12.9: Structural Fire

12.4.1 Forest Fire

Bhutan is prone to frequent forest fires caused by agricultural debris burning, deliberate burning, and human carelessness. Most of the forest fires occur during the dry season. They cause large scale destruction to the forest, and can also lead to ecological devastation, infrastructure destruction (power line damage), and threatening and endangering wildlife. Forest fire management is the process of planning, preventing and fighting fires to protect people, property and forest resources. Prevention of forest fires save damages and fire suppression expenses. Fire hazards cannot be completely prevented, but prevention strategies reduce the probability of fires. Successful fire prevention depends on utilising "the three E's" - Education, Enforcement and Engineering. Education promotes self-restraint as it informs people about proper fire practices, damages and costs, legal responsibilities, and dangers during fire. Awareness campaigns, training, media broadcasts and posters are all methods that help inform and educate the public.

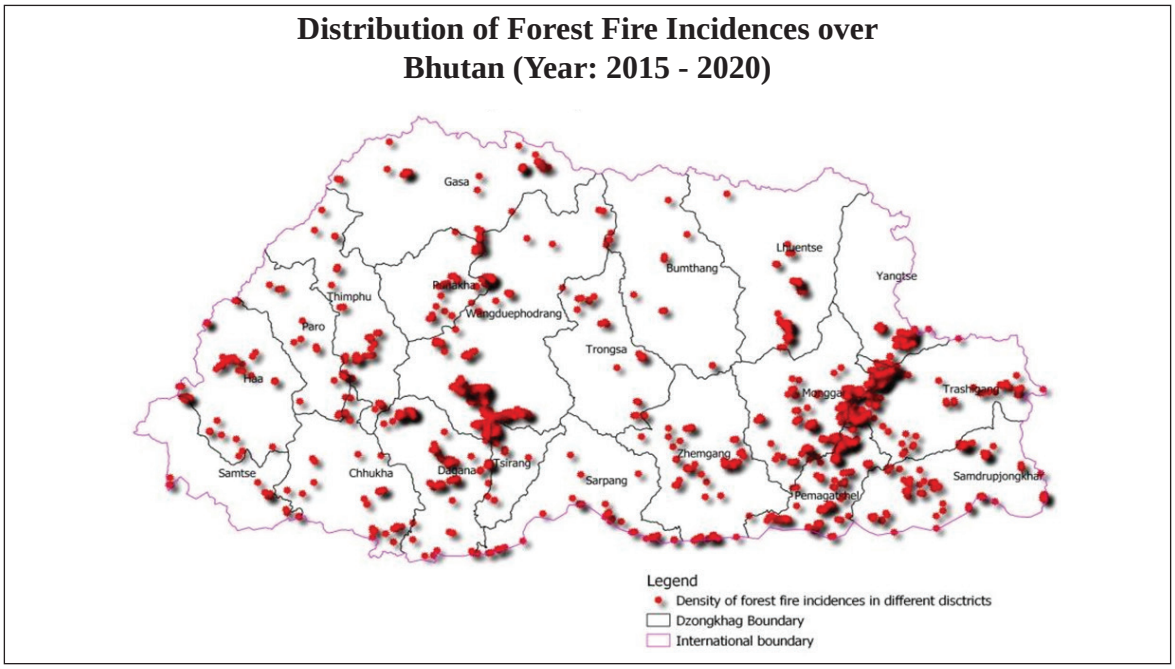
Enforcement of the law for violating the rules and norms helps reduce forest fire incidences, as it regulates the behaviour of people under the threat of legal action. The third E – Engineering, pertains to structural durability and striving to build structures that are fire resistant to help reduce the loss caused by fire damage.

12.4.2 Structural Fire

Structural fires are also becoming more frequent in Bhutan. Some causes of structural fires are: defective heating systems, improper storage of inflammable substances, poor electrical wiring, and negligence. A destructive structural fire completely destroyed the Wangdue Phodrang Dzong on June 24th, 2012. Three consecutive fires of Chamkhar town in Bumthang also caused a huge loss of multiple properties.

Mitigation and preparedness are essential for fire safety. Structural fire mitigation includes monitoring fireplaces, and using electricity safely by unplugging appliances.

Figure 12.9: Structural Fire



Map 12.1: Distribution of forest fires in Bhutan.

KNOW MORE

STOP, DROP and ROLL if your cloth catches fire. Do not waste time getting dressed or searching for valuable item during fire incidents.

Learning Activity

Fire disasters may happen anytime and anywhere. Prepare a fire evacuation plan of your house using MS paint and display it in the class.

12.5 Wind Storm

Bhutan experiences frequent windstorms that cause damage to property. Rural areas suffer the most damage. Wind storms often destroy roofing, houses and crops. In the past, windstorms have damaged over thousand houses as well as crops, which causes economic loss due to compensation and reconstruction costs.

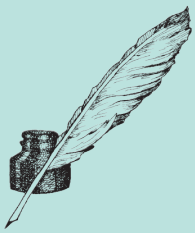
Large scale destruction caused by windstorms call for an urgent and necessary intervention. The Windstorm Resilient Roofing System Guideline, initiated in 2017, is a method used to improve and strengthen the traditional roofing truss system without losing the traditional Bhutanese architectural design.

Figure 12.10: Windstorm damage

12.6 Education in Emergency

Education in Emergency is the provision of quality education to children affected by emergencies. It is a lifesaving response that works to protect children in conflict and disaster prone regions. Education in Emergency provides children with opportunities that meet the physical protection, psychosocial, developmental and cognitive needs of these children. In doing so, their right to education is preserved and they can experience some normalcy, stability, structure and hope.

Figure 12.11: Schooling in tents



Learning Activity

Read the case study of the wind storm disaster at Daksa primary school in Gondue, Mongar, which is an extract from the Kuensel dated. Answer the questions.

The Case Study: Education in Emergencies

Three weeks after the new academic year, a windstorm struck Daksa Primary School in Gongdue, Monger damaging most of the school structures on 28th February 2019. Gangdue is one of the remotest counties in Monger district

The school lost the roofs of its three academic blocks, an administration block and a dining hall to the windstorm. Most structures were old and needed renovation, according to the school administration. Worried, the school administration informed the district education sector for help. Half day later, UNICEF's disaster support kit arrived from its eastern region centre in Trashigang. The pitching of eight tents to open a temporary school was completed in a day with the help of 30 people from the district, Daksa village, and school

"We were fortunate to receive an immediate response from the authority concerned," officiating principal, Jamtsho said. "We were worried that it would take not less than two weeks to build temporary sheds."The tents are pitched about two meters away from one another and sound from one classroom can be heard in another. The tents have also started to become warmer. The school is located in one of the remote Gewogs in Monger and for the last three months, the school has been functioning out of tents.

Jamtsho said the tents and support kits reduced pressure on the community and saved resources to build temporary structures. "It was cost effective and took less time to set up the tents."The officiating principal said that the school could have lost at least 14 instructional days if the school was to develop their own temporary shelters. "The school planned to build a temporary shed using CGI sheets but it could have been risky and time consuming."The temporary tents house classes from PP to VI and an office for the teachers. There are 92 students enrolled from the county, of which 60 are boarders.

"The students thoroughly enjoyed their classes during the first whole week. It was like taking the whole school to a different and new environment," said a teacher, Jamyang Loday. "I felt like I was teaching in a new class with this whole different set-up. We could see the excitement in students."

Construction and renovation of the damaged structures are expected to complete next month. Worth more than Nu 6 million (US$ 85,714), the construction project is awarded to three contractors to complete the project within a short period of time. The new structures are being built with new techniques that would reduce the damage if such disasters happen in future.

Source: Kuensel

i. Why is Education in Emergency an important post-disaster activity?

ii. How would you respond to this disaster if you were the School Principal?

iii. Is continuing education in tents practical and wise? Support your views with valid reasons.

Test Yourself

1. Bhutan lies in a seismically active zone. Prepare an earthquake hazard contingency plan for your school.
2. Why should Bhutan be prepared to face GLOF? Give suitable reasons.
3. Which hazards are likely to become a disaster in your area? Give reasons.
4. Prepare fire safety rules for your family.
5. What would you do to save yourself during a flood? Write at least five strategies.
6. Education in Emergencies is a post disaster measure. What are some of the roles and responsibilities of a community?

7. Wind disasters occur frequently in Bhutan. Suggest some measures to prevent houses from destruction during a windstorm.
8. The historic rural roofing system was replaced by a new roofing system after 2017 through a guideline. How often do you think people follow the guideline in rural areas? Justify your answer.
9. Many fire disasters across the country are caused by human negligence. Support this statement with your own justification.
10. Duck, Cover, and Hold is one of the measures to protect ourselves during an earthquake. How useful would it be during an earthquake?
11. Identify the consequences of frequent landslides in your area. Suggest some measures to minimise the impacts.

Assessment Matrix- Broad assessment based on Knowledge, Skills and Values & Attitudes (KSA)

Assessment type	Formative assessment			Continouos assessment			Summative assessment	
Domains	**Knowledge**	**Process (skills)**	**Values & Attitudes**	**Knowledge**	**Process (skills)**	**Values & Attitudes**	**KSA Term I**	**KSA Term II**
Techniques	Self and peer assessment, quiz, debate, homework, classwork, class interaction	Map work, Case study, sketching, drawing, making models, using instruments	Field work, group work, self and peer assessment, interaction, case analysis, resolving social and environmental issues, moral dilemma	Homework, Class work, Project work and Test	Project work, map work, test, models, field work, case study, sketching, drawing, making	Field work, group work, test, interaction, case analysis, resolving social and environmental issues and moral dilemma	Term Examinations	Term Examinations
Assessment tools	Question & answer, checklist, rating scale and rubrics	Question & answer, checklist, rating scale & rubrics	Question & answer, checklist, rating scale, rubrics	Question & answer, checklist, rating scale & rubrics	Question & answer, checklist, rating scale and rubrics	Question & answer, checklist, rating scale, rubrics	CBT-MCQs, completion, matching, true/ false, short answer and essays	CBT-MCQs, completion, matching, true or false, short answer and essays
Frequency	Maintain either checklist/ rating scale/ rubrics for each chapter	Maintain either checklist/ rating scale/ rubrics for each chapter	Maintain either checklist/ rating scale/ rubrics for each chapter	Minimum two Homework and two classwork to be graded for each term	One Project (different types)	Maintain either checklist/ rating scale/ rubrics for relevant content	Once a term	Once a term
Weighting			**Term I**	**Term II**	**Term I**	**Term II**	30	50
			HW, CW & Test =7	HW, CW & PW=7	FW,GW, Test=3	FW,GW, Test=3		

Criteria for project and field work

Name	Criteria					Total 20
	Content (4)	Language (4)	Presentation (4)	Process (4)	Originality & creativity (4)	

Weighting and instructional time

Sl	Strands	Chapters	Weighting	Instructional time in Minutes	No of periods (40 Min)	Weighting
1	Time and Space	1. Origin of the Earth	5	240	6	36
		2. The interior of the Earth	4	240	6	
		3. Latitude & Longitude	6	400	10	
2	Physical Environment	4. Interpretation of toposheet and map work	25	480	12	30
		5. Climate	8	280	7	
		6. Agriculture	7	240	6	
		7. Biodiversity	8	360	9	
		8. Population Growth	7	240	6	
3	People & Environment	9. Settlement	8	360	9	34
		10. Minerals	8	280	7	
		11. Industries	7	240	6	
		12. Hazards and Disaster	7	240	6	
Total			**100**	**3600**	**90**	**100**

Question pattern for examinations

1. Section A - Compulsory questions (50 Marks)

1. Toposheet
2. Map work
3. MCQ,
4. Matching
5. True or false
6. Fill in the blanks

2. Section B - Essay and short answer question with choice (50 Marks)

Note:

Bhutan Map-includes mountains, rivers, towns, plateaus, plains, lakes, biological corridors, passes, parks, minerals, industries, places, and crops.

Asia Map -includes mountains, rivers, seas, oceans, cities, plateaus, plains, deserts, and lakes.

Project work – List of topics

1. *Disasters in Bhutan*
2. *Rocks and Minerals in the locality*
3. *Soil types in the locality*
4. *Crops grown in the locality*
5. *Pollution*
6. *Urbanisation*
7. *Vegetation and wildlife in the locality*
8. *Weather station (instruments) and weather recording*
9. *Resource management (waste management)*
10. *Climate change and global warming*