ADVANCED

GEOGRAPHY

CLASS XI

Department of School Education
Ministry of Education and Skills Development
Royal Government of Bhutan
Thimphu

Published by:
Department of School Education (DSE)
Ministry of Education and Skills Development (MoESD)
Thimphu

Tel: 975-2-332885/332880

Website: www.education.gov.bt

Provisional Edition 2022

We would like to sincerely acknowledge the retrieval and use of ideas and pictures from various sources. We reaffirm that this book is purely for educational purposes.

Reprint 2024

ACKNOWLEDGMENT

The Department of Curriculum & Professional Development (DCPD) would like to thank all specialists, professionals, lecturers and teachers from different agencies, colleges and schools for their valuable contributions towards the development of this book.

Advisors

1. Tashi Namgyal, Director, DCPD, Thimphu
2. Kinga Dakpa, Director General, Royal Education Council, Paro
3. Wangpo Tenzin, Specialist, DCPD, Thimphu

Reasearch & Writing

1. Kuenzang Gyeltshen, Samtse College of Eduvcation
2. Pema Lhendrup, Sherubtse College, Kanglung
3. Samten Dorji, Gaselo HSS, Wangdue
4. Sangay Zangmo, Samtengang HSS, Wangdue
5. Sumitra Pokhrel, Phuntsholing HSS, Chukha
6. Ugyen Dorji, Gelephu HSS, Sarpang

Copy Editing & Proof Reading

1. Norbu Wangchuk, DCPD

Illustration, Cover Design & Layout

1. Karma Wangmo, DCPD

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 helps them to appreciate the importance of geography in the conservation of the natural environment for sustainable socio-economic development of the country. This book is presented with clear and simple text enriched with exciting learning activities, informative maps and pictures to stimulate learning.

We are grateful to our writers and reviewers from the Royal University of Bhutan, the Ministry of Education and colleagues from the Department of Curriculum & Professional Development for their valuable engagement and contributions. We hope that our teachers and learners enjoy teaching and learning the subject and contribute in the promotion of Geography education as a whole.

Tashi Delek!

Tashi Namgyal
Director

Table of Contents

CONTENTS

CHAPTER ONE

Internal Structure of the Earth and its Movements

1.1 Introduction

The interior structure of the Earth is found in concentric layers. Each layer is composed of different minerals. The understanding of the internal structure of the Earth is enhanced through the study of seismic waves. The Earth's crust and its surface are constantly evolving due to endogenetic and exogenetic forces. The forces which act in the interior of the earth are called endogenic forces and the forces that work on the surface of the earth are called exogenic forces. These cause the formation and deformation of landforms on the surface of the earth. The endogenetic forces causes slow movement or diastrophism and the sudden movement. The earthquake and volcanism are the two sudden movements while epeirogenic and orogenic are the slow movements. Sudden movements like earthquakes and volcanoes cause mass destruction over the surface of the earth. Due to the devastating consequences of the earthquake, appropriate and effective measures need to be put in place for risk reduction.

This chapter explains the structure and composition of the Earth's interior, and earthquake and volcanism as sudden endogenetic forces that transforms the Earth surface. The risk reduction measures for the destruction from earthquake is briefly presented.

1.2 Structure and composition of the Earth

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.

Crust

The crust is the outermost solid layer of the Earth. It 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 types.

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

Reprint 2024

a. Continental crust

The outermost layer of the Earth is continental crust. It is the layer of igneous, sedimentary, and metamorphic rocks. This layer is also called as SIAL as it is mainly composed of silica and aluminium minerals. It is lighter and less dense than 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

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

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

i. Mantle

Mantle is a thick viscous layer that lies below Mohorovicic discontinuity. It extends to about 2900 kilometres. It 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 mantle. This layer is divided into upper and lower mantle.

a. Upper mantle

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 most portion of this layer is called as asthenosphere over which tectonic plates float. Asthenosphere lies in between 100 kilometres to 110 kilometres beneath the surface. Here the temperature and pressure are high that rocks soften and partly melt becoming semi liquid.

b. Lower mantle

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

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

ii. Core

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. Density ranges from 10 to 13.6 grams per cubic centimetres. It is divided into outer and inner core.

a. Outer Core

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 lower mantle to 4700 kilometres depth. Density of outer core is between 10 to 12.3 grams per cubic centimetres. Liquid outer core surrounds the solid inner core.

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

b. Inner Core

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

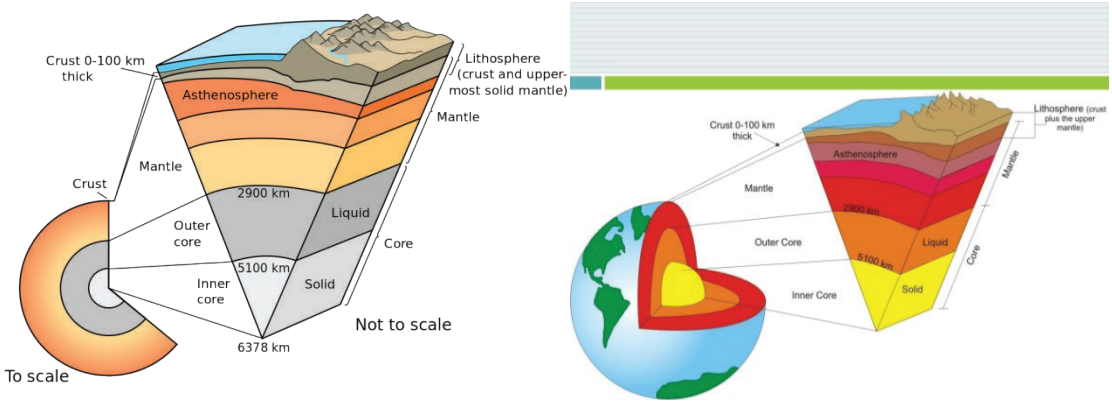


Figure 1.1: Structure of the Earth's interior.

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, Exogenetic force refers to the forces that are generated on or above the Earth's surface.
- 

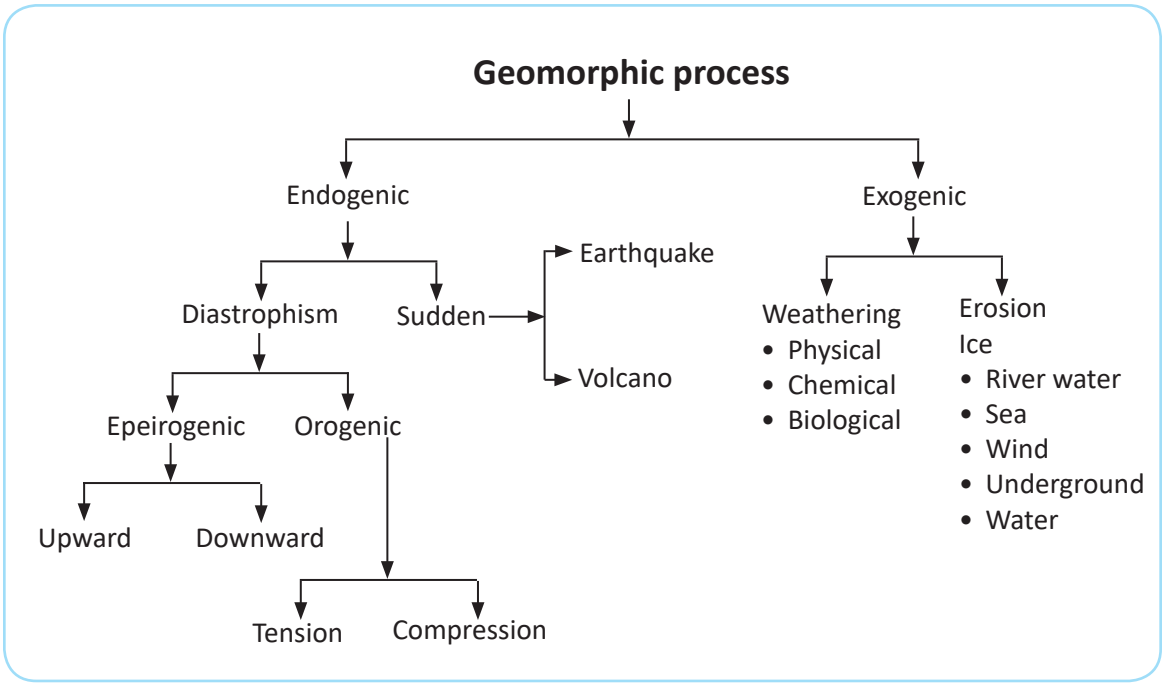
Learning Activity

1. Design a labelled model of Earth's internal structure using locally available materials or Microsoft publisher. Display or share the model in the class.

2. In the interior of the Earth, temperature increases with depth that results in melting of rocks. The inner core, despite experiencing highest temperatures, is in a solid state. Explore possible reasons using the different reference sources and share your findings to the class.

1.2 Earth's Movement

The geomorphic processes continouosly occurs on the Earth's crust and its surface through endogenetic and exogenetic forces.The exogenetic forces arise from above the earth's surface. All the exogenic geomorphic processes are grouped under the term of denudation. The word 'denude' means to strip off or to uncover. Weathering, mass wasting or movements, erosion and transportation are included in denudation. The endogenetic process is caused by the forces emanating from within the earth. Diastrophism or the slow movement is the process that move, elevate or build up portions of the Earth's crust. Orogeny and epeirogeny are the two diastrophic movement that form the landforms. Orogeny is a mountain building process and epeirogeny is continental building process. The sudden movement of the Earth leads to earthquake and volcanism.



1.2.1 Sudden Movement - Volcanism

The interior of the Earth is violently hot and this excess heat has to escape to release the internal pressure. The volcanic eruption occurs when the molten materials and the heat escapes on to the earth surface. Volcanism is a process or phenomena where molten rock, pyroclastic fragments, hot water and steam is ejected from the interior of the Earth. A volcano is an opening in the earth's crust through which gases, molten materials, ash, steam are emitted from the magma chamber of the upper mantle. A funnel shaped hollow at the top of the cone through which the volcanic materials are ejected is a crater.

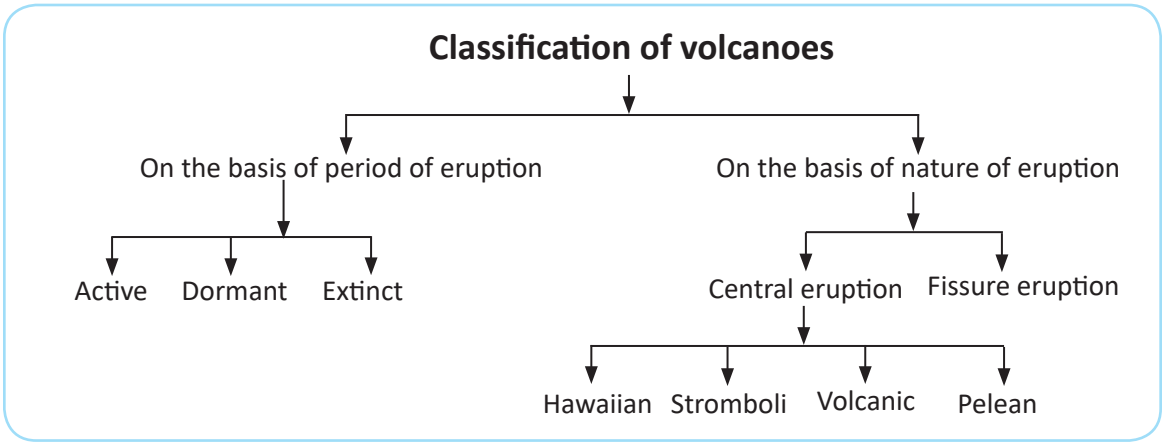
Figure:1.2: Volcano eruption

Learning activity:

1. Watch the video https://youtu.be/VNGUdObDoLk and identify the characteristics and components of a volcano.

1.2. Classification of Volcanoes

Volcanoes are classified on the basis of frequency or periodicity of eruption, nature of eruption and shape and size of the cones. Classification based on the mode of eruption includes central eruption or explosive type and fissure or quite type. The volcanoes based on the periodicity are active, dormant and extinct. The shape and size of the volcanoes depends upon the materials that has been thrown out from the interior.



1.2.1.1 Based on frequency or periodicity

Volcanoes are of three types based on the periodicity or the frequency of their eruption.

a. Active Volcano

These volcanoes constantly eject lava, gases, ashes and the pyroclastic materials. Most of the active volcanoes are found along the plate boundaries. It is estimated that there are more than 500 active volcanoes around the world. Some of the active volcanoes include Mt. Etna and Mt. Stromboli of the Mediterranean Sea.

b. Dormant Volcano

These volcanoes become quiet and stop ejecting lava for a long time and suddenly erupts again after many years damaging life and properties. Mt. Vesuvius and Mt Fujiyama are example of this type of volcano.

c. Extinct Volcano

These volcanoes will be considered extinct when the indications for future eruption are absent for a long time. It is often referred to as Dead volcano. However, no volcano can be declared as dead as it can explode anytime and be considered active. Popa in Myanmar and Mt. Kenya in eastern Africa are the examples of extinct volcano.

1.2.1.2 Based on mode of eruption

The volcanic eruption occurs in different style or formations. Explosive and Fissure are the two prominent type of eruption.

i. The Explosive or Central Eruption type

The explosive or the central eruption volcanoes occur through a central pipe or a small vent. The crustal surface will be blown off by the violent force of the gases and the pyroclastic materials. The eruption is so rapid and violent that huge quantities of volcanic materials are ejected up to thousands of meters in the sky. These materials fall back around the volcanic crater and forms the volcanic cones. These are destructive and disastrous in nature. There are several other sub-categories of the explosive volcano influenced by intensity of eruption, variations in the ejected materials and the time period of eruption. Some of them are Hawaiian, Strombilian, Peleean, Volcanian and Visuvious type.

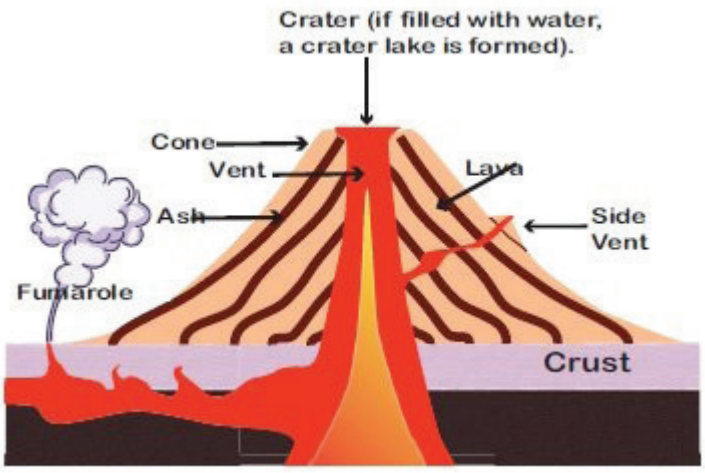


Figure: 1.3: Central / Explosive type

a. Fissure Eruption

This type of volcanic eruption occurs along a long fracture/fissure resulting in slow and silent upwelling of magma from the interior. The over flowing lava spreads over the ground

surface. The speed of the lava movement is influenced by the nature of magma, volume of magma, slope of the ground surface and the temperature conditions. The Deccan plateau of India is formed by such eruption.

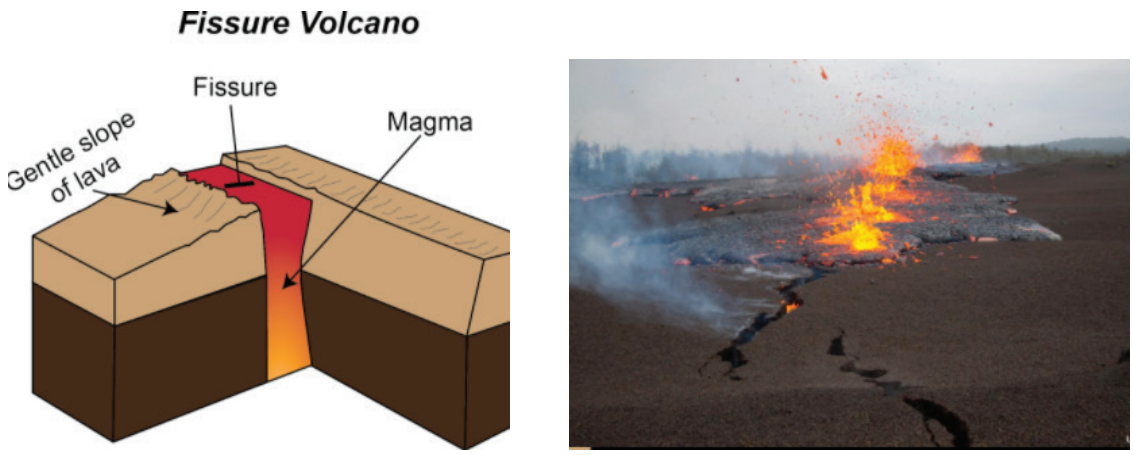


Figure 1.4: Fissure type

1.2.1 Based on Shape and Size

b. Lava domes

Lava domes are dome shaped with steep slope. It results from small quantities of thick lava flowing out quietly around the dome. Lava emanating from volcanic domes piles up over and near the vent as it is not able to flow into long distance due to the viscosity of the lava. The dome increases in size as a result of the swelling of lava and the volcanic mountain rises in height. It is also known as volcanic domes. Lava domes have a history of violent explosions, emitting vast quantities of ash and hot rock.

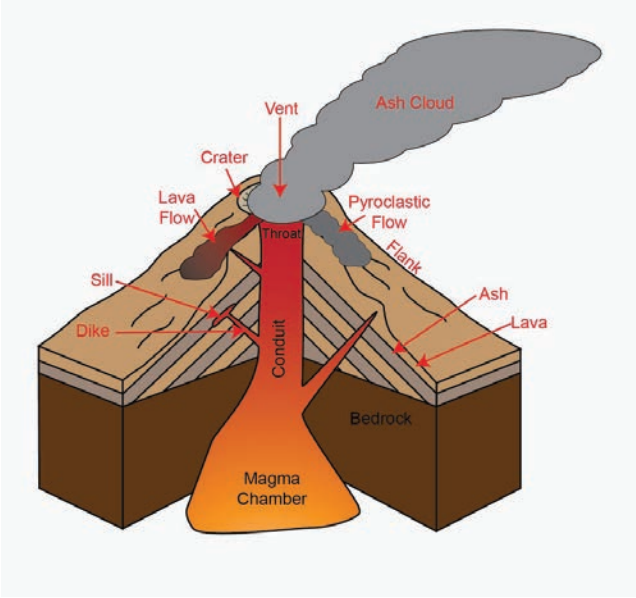


Figure 1.5: Lava Dome

ii. Composite volcanoes

Composite Volcanoes are normally steep-sided, symmetrical cones of large dimension with alternate layers of lava flow, volcanic ash, cinders, blocks, and bombs. These kinds of volcanoes consist of vents that well up from underneath the crust to the surface of the earth. They encompass a network of vents, with lava surging through walls and may rise up to 8,000 feet. They are sometimes known as strato-volcanoes. Some of the spectacular composite volcanic mountains are Mt. Fuji, Mt. Cotopaxi, and Mt. Rainier. With the collection of materials being discharged, they have the capability to grow high up. Composite volcanoes have the capacity to erupt violently.

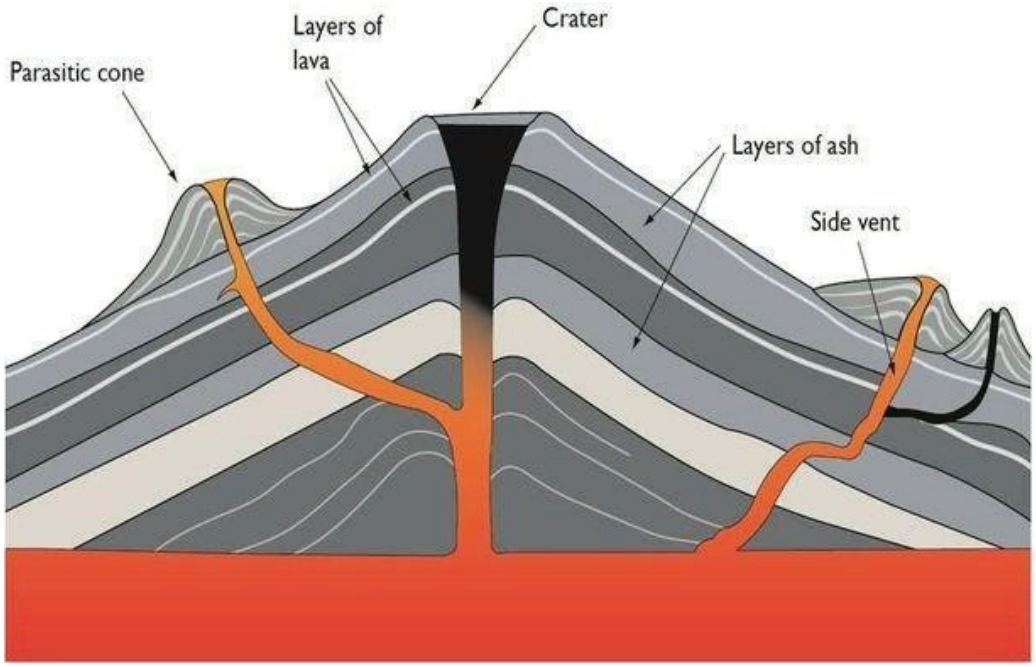


Figure 1.6: Composite volcano

iii. Cinder cone volcanoes

They are considered the simplest kind of volcano. Cinder cone volcanoes occur when pyroclastic and particles of lava are forced up through a volcanic vent. The eruption blows the lava into the air violently. The light particles are carried away by the wind. The heavy ones fall back around the volcanic vent. When this phenomenon continuously occurs, an oval shaped or circular cone builds up. The top of the cone forms a bowl-shaped crater. Most cinder cones have a bowl-shaped crater at the summit and rarely rise more than a thousand feet.

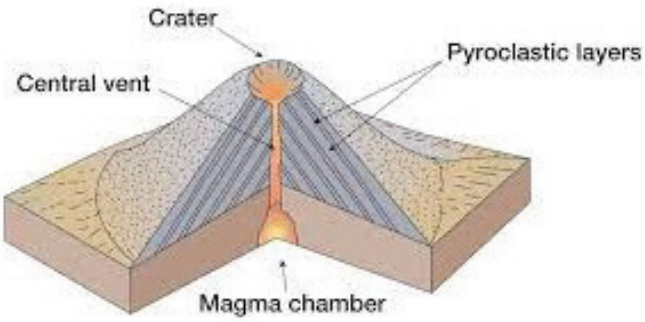


Figure: 1.7 Cinder Cone

iv. Shield volcanoes

Shield volcanoes build up gradually for a long time, experiencing numerous eruptions and forming layers during the period. These kind of volcanoes do not erupt violently like the Cinder cone volcano. Lava stemming from shield volcano is characteristically thin and travels long distance along the slope of the gently sloping cone of flat and domical shape. Hawaii is a classic example of an area where shield volcanoes are prevalent.

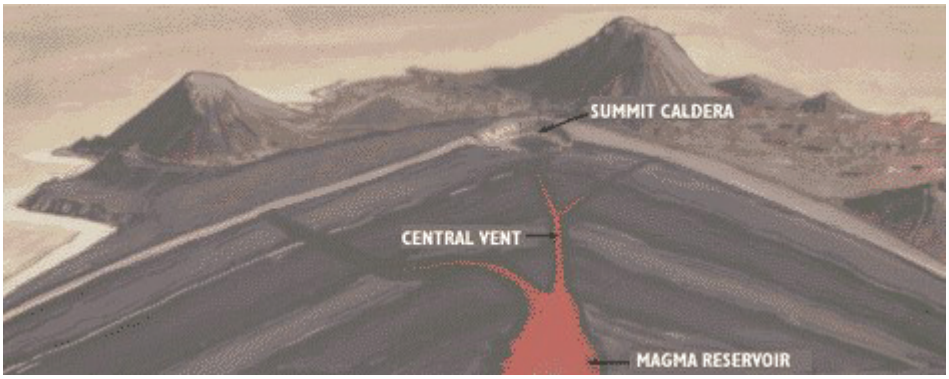


Figure 1.8: Shield Volcano

Learning activity:

1. Watch the video link **https://youtu.be/_YVrhZNEM-Q** and identify the types of volcano based on eruption.

1.3 Causes of Volcanoes

Volcanism is closely related to plate tectonics. Most volcanic activities are associated with convergent plate and divergent boundaries and areas of continental drifting. Volcanic eruptions predominantly occur in areas with vibration activities or weak zones where the continental plates of the earth diverge or converge. It also occurs where the earth's crust constantly melts along the subduction zone.

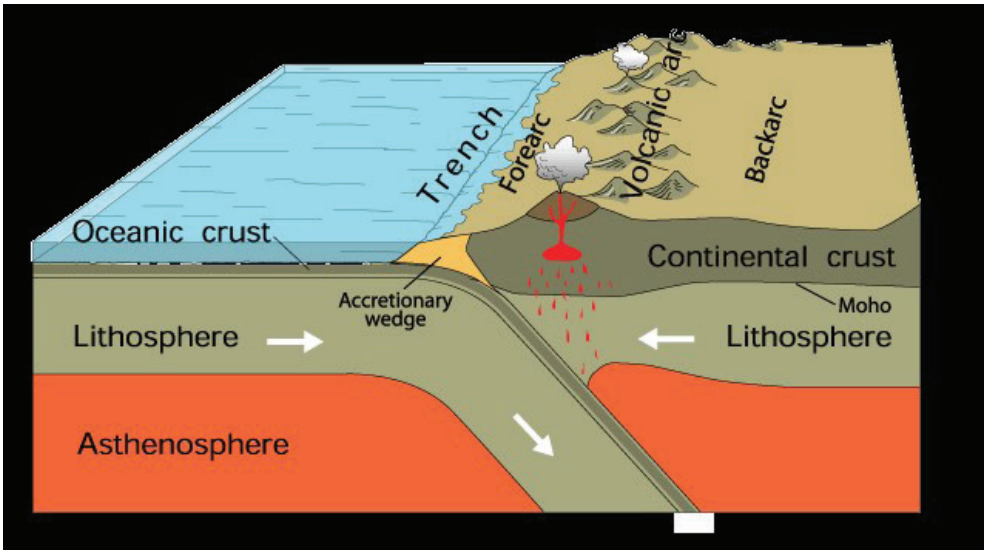


Figure 1.9: Convergent plate boundary and volcanic eruption

1.4 Effects of Volcanoes

Volcanic eruptions are great sights to watch. Eruptions exhibit the ability and strength of nature to shape up the earth in a remarkable way. Volcanic activity has been observed as both beneficial and hazardous to the people and the environment. Most direct volcanic hazards are related to explosive volcanoes. Pyroclastic density currents with very high temperature (1000˚C) moves up to hundreds of kilometer. It destroys anything on its way. Volcano-related mudflows (Lahars) are large enough to destroy entire towns.

1.4.1 Positive effects

Creation of beautiful scenery

The lava from volcanic eruptions creates beautiful landmarks when they cool down. The glittering sceneries becomes tourist attraction leading to revenue generation.

i. Source of minerals and nutrients

The ash and lava deposited during volcanic eruptions eventually breaks down to give valuable nutrients to the soil and enhance the soil fertility. Valuable minerals have also been discovered as a result of volcanic eruption. For example, nickel in Hawaii volcanoes, has fetched billions of dollars for the country's economy.

Figure 1.10: Fertile farmland nearby volcanic mountain.

ii. Energy opportunity

The extreme heat and activities underneath the earth's crust, near a volcano, can present opportunities for generation of geothermal power. However, the technology and skill to tap this may be challenging for most economies.

1.4.2 Negative effects

i. Impacts on environment

When a volcano erupts, gasses such as carbon dioxide, carbon monoxide, sulphur dioxide, hydrogen sulphide, chlorine, fluorine are released into the atmosphere. These gasses pollute the air and makes it toxic to breathe. It also creates visibility problem.

Figure 1.11: Volcanic effect on environment

ii. Threat to aviation

Airplanes bear the biggest brunt of volcanic eruptions. The ash released due to eruptions can take a toll on the airplane engines. Pilots experience loss of power and flight engine getting heated up. This could be catastrophic at times and a serious threat to the aviation industry and bring extraordinary maintenance costs to the airline company.

Figure 1.12: Volcanic Eruption and aviation Threat

iii. Impact on nearby cities and towns

Volcanic eruptions can have a catastrophic effect on nearby towns and cities depending on the magnitude of the explosion. The ashes picked up by the wind could be directed to towns and cities causing respiratory problems, pollution, injuries and other health hazards.

High magnitude volcanoes can displace settlement and affect the economic activities.

Figure 1.13: Hawaii volcanic eruption destroying settlements.

iv. Destruction of infrastructure

Lava flowing for long distance at high speed can reach roads and railways causing serious destruction. This may result in cutting off of these vital transportation system.

Learning Activity:

Carry out a library or online research and do a case study of any one of the active volcanoes around the world, and assess its impact to people and the environment.

1.1 Earthquake

An earthquake is a sudden tremor of the earth due to movements within the earth's crust .It is also known as trembler or quake. The intense energy stored in the Earth's interior is suddenly released along the fractures and cracks as seismic waves. It occurs along geological faults, narrow zones where rock masses move/slip in relation to one another. The major fault lines of the world are found along the fringes of the huge tectonic plates. The point below the earth's surface where earthquakes start is called hypo-center or focus and the point directly above the surface of the earth is called epicenter.

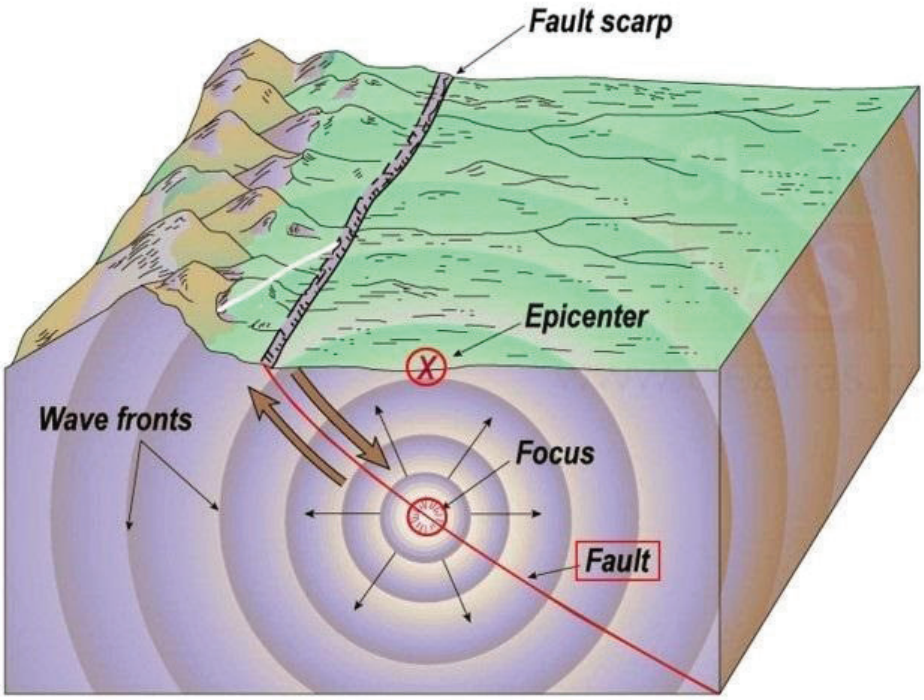


Figure 1.14: Focus and epicenter

Learning Activity

Carry out an experiment to demonstrate the occurrence of seismic waves. Explain the procedure and terminology associated with earthquake.

1.1 Causes of earthquake

Earthquake is caused by various disturbances in the earth's interior. The causes can be based on the type of internal disturbances and their sources.

Tectonic Movements

The disturbances inside the earth causes tectonic movements. These forces bring about changes on the earth surface and forms features such as mountains, plateaus and rift valleys. Most disastrous earthquakes are caused by tectonic movement. Tectonic forces create tension and pressure and the stress begins to build up inside the earth. When the stress tends to be more than what the rocks of the earth can bear, the rocks are broken and displaced from their state of equilibrium resulting in faulting. The energy accumulated during faulting is released in forming seismic waves. For example, the chief cause of earthquakes in California in the USA is along the San Andreas Fault.

i. Volcanic activity

The volcanic eruptions are mostly violent and cause vibrations in the earth crust. Sometimes the vent of a volcano is blocked temporarily and explosive eruption takes place suddenly causing tremors on the earth's crust. The Krakatoa in Indonesia that erupted in 1883 became the cause of a violent earthquake.

ii. Elastic Rebound Theory

This theory was first put forward by American geologist Harry Fielding. When forces push or pull on rocks, it stretches and alter shape when enough force is applied. It can either break or the end of the broken pieces may snap back. This snapping back is called elastic rebound. As the rock layers get strained, change shape and deform over a long period of time, potential energy builds up. This results in breaking and movement causing vibration. The strong vibration as a result of rebound force causes earthquake.

iii. Isostatic Adjustment

The disturbance in the isostatic balance between the raised and the depressed blocks leads to adjustment and readjustment. The sediment are eroded from the raised landforms like continents and are taken to ocean bed that disturbs the balance.

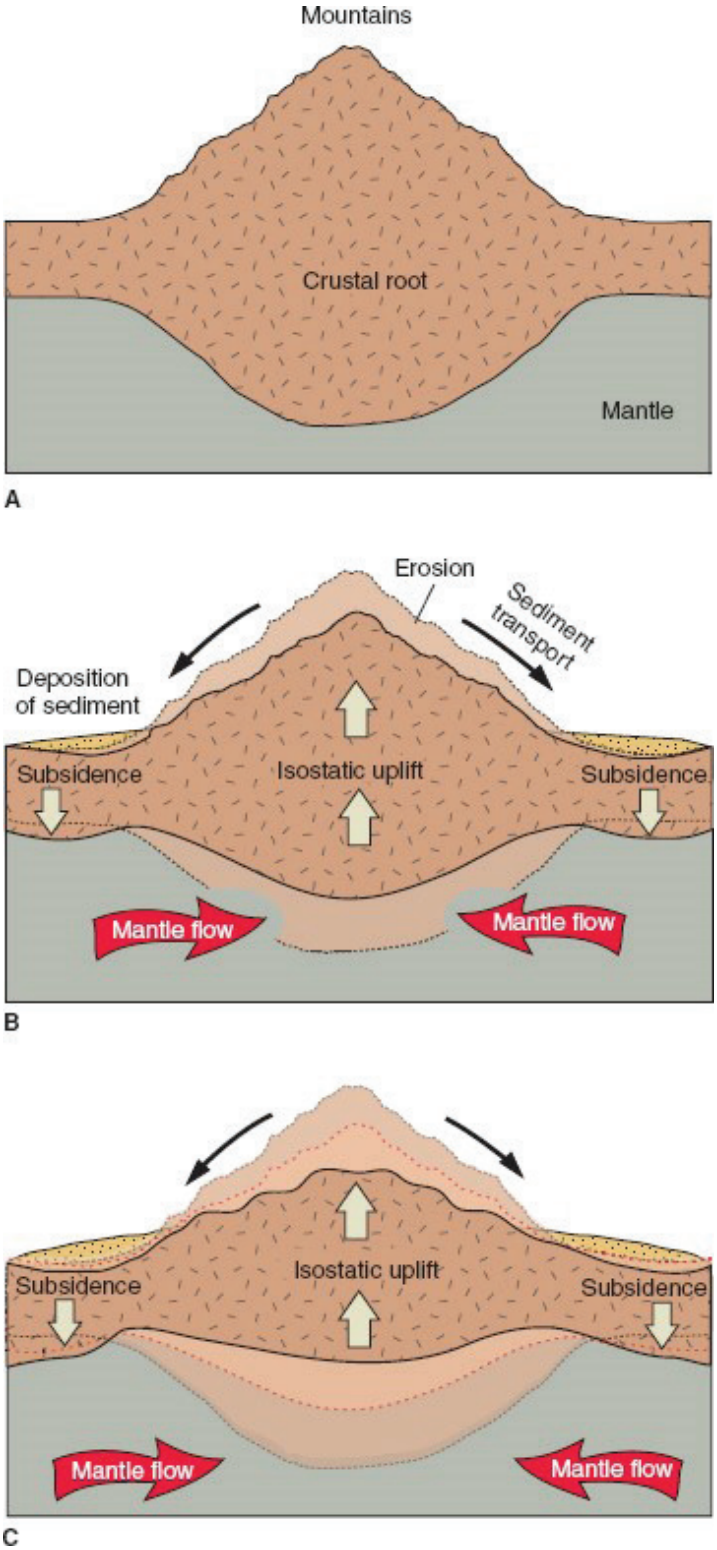


Figure 1.15: Isostatic Adjustment

iv. Miscellaneous Causes

The roofs of underground caverns in the Karst topography collapse and release great force to cause minor tremors in the earth crust. Nuclear explosions also release massive energy causing tremors in the earth crust. Landslide in the mountainous areas cause small tremors around the local areas.

Learning Activity

Based on the causes, explore the ability to forecast when and where an earthquake will occur. Share your finding to the class.

Know More

- The term 'Tectonic' derived from the Greek word 'Tekton' which means builders.
- About 90 percent of the world's Earthquakes and 80 percent of the world's largest earthquakes occur along the Ring of Fire.
- There are about 1500 active volcanoes in the world.

1.7 Seismic waves

Seismic waves are the waves of energy caused by the sudden breaking of rock within the earth or an explosion. After they are produced at the focus, seismic waves travels away from the focus in all directions. They are the energy that travels through the earth and is recorded on seismographs.

Types of seismic waves

Two main types of seismic waves are surface and body waves. Body waves can travel through the earth's inner layers, but surface waves can only move along the surface of the earth like ripples on water. Earthquakes radiate seismic energy as both body and surface waves. The body waves produce sharp jolts, while rolling motions of surface waves do most of the damage in an earthquake.

i. Surface waves

Seismic waves that travel only over the Earth's surface is known as Surface or Long waves. Its average velocity is about 3 kilometers per second. It travels through all medium. Rayleigh and Love waves are the two types of surface waves. The particle motion is transverse and horizontal. Love wave velocities are greater than Rayleigh waves, so Love waves arrive before Rayleigh waves on seismograph. Surface waves are larger in amplitude and longer in duration than body waves.

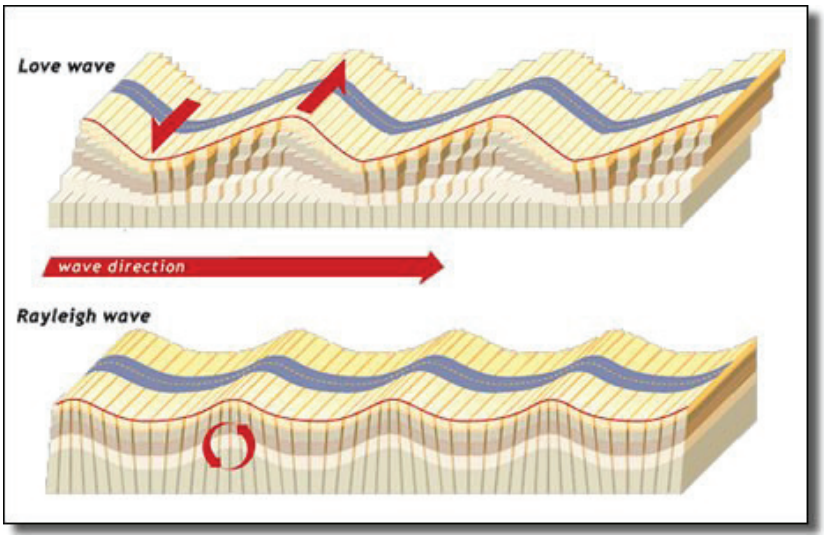


Fig: 1.16 Surface waves

ii. Body waves

The seismic waves that travel through the interior of the Earth with higher velocity than the surface waves are the body waves. They are primary and secondary waves. The course and velocity change while passing through boundaries of different layers. The velocity of P and S waves increases with depth. This indicates the increase in density up to a depth of 2900 kilometers. Beyond this, S waves disappear and the velocity of P waves decrease indicating 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.

iii. Primary waves (P-Waves)

Primary waves are the fastest kind of seismic waves that travel at a speed ranging from 4 - 8 km per second. These waves are also called longitudinal waves or compressional waves due to particle compression during their transport. Its speed increases with increase in the density of rock. It can travel through all states of matter.

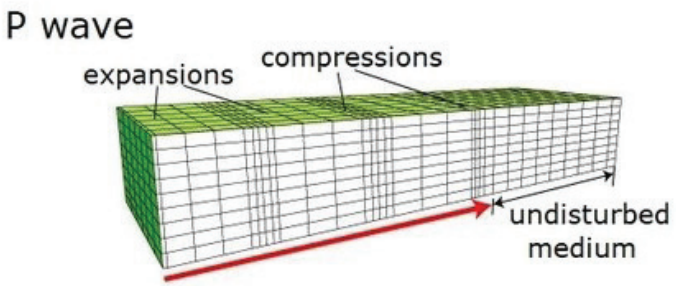


Fig: 1.17 Primary waves

iv. Secondary waves (S-Waves)

Secondary waves travels with velocity lower than P waves and can only travel through solids. It travels at an average velocity of about 4 km per second. The S-waves are also known as transverse waves, because particle motions are transverse to the direction of movement of the wave front.

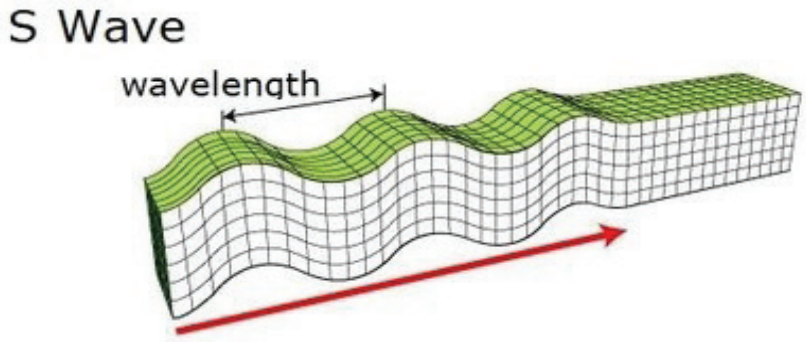


Fig: 1.18 Secondary waves

1.8 Types of earthquake

The Earthquake can be categorized into tectonic, volcanic, collapse and explosion types on the basis of their causes.

Tectonic earthquake occurs when geological forces on rocks and the adjoining plates cause physical and chemical change and results in the breaking of the Earth's crust.

Volcanic earthquake results from tectonic forces and occurs in conjunction with volcanic activity in the nearby areas.

Collapse earthquakes are generally small earthquakes that occur in underground caverns and mines caused by the seismic waves which are produced from the explosion of rock on the surface.

Explosion earthquake occurs due to the exploding of a nuclear or chemical device. Beirut chemical explosion of August 2020 registered earthquake with magnitude of 3.3 on the Richter scale.

Measurement of Earthquake

The magnitude and intensity of earthquake is measured in Richter, Mercalli scale and the moment magnitude Scale. Some of the major consequences of earthquake depends upon their magnitude and intensity.

Richter scale measures the seismic waves, or the energy released and describes the magnitude. While Mercalli scale measure the size of the earthquake at its source. It is a seismic intensity scale used for measuring the intensity of shaking produced by an earthquake.

Richter Magnitude	Earthquake effects
0-2	Not felt by people
2-3	Felt little by people
3-4	Ceiling lights swing
4-5	Walls crack
5-6	Furniture moves
6-7	Some buildings collapse
7-8	Many buildings destroyed
8-Up	Total destruction of buildings, bridges and roads

Fig: 1.19 Richter scale

Modified Mercalli Scale		Moment Magnitude Scale
I	Detected only by sensitive instruments	1.5
II	Felt by few persons at rest, especially on upper floors; delicately suspended objects may swing	2
III	Felt noticeably indoors, but not always recognized as earthquake; standing autos rock slightly, vibration like passing truck	2.5
IV	Felt indoors by many, outdoors by few, at night some may awaken; dishes, windows, doors disturbed; motor cars rock noticeably	3
V	Felt by most people; some breakage of dishes, windows, and plaster; disturbance of tall objects	3.5
VI	Felt by all, many frightened and run outdoors; falling plaster and chimneys, damage small	4
VII	Everybody runs outdoors; damage to buildings varies depending on quality of construction; noticed by drivers of automobiles	4.5
VIII	Panel walls thrown out of frames; fall of walls, monuments, chimneys; sand and mud ejected; drivers of autos disturbed	5
IX	Buildings shifted off foundations, cracked, thrown out of plumb; ground cracked; underground pipes broken	5.5
X	Most masonry and frame structures destroyed; ground cracked, rails bent, landslides	6
XI	Few structures remain standing; bridges destroyed, fissures in ground, pipes broken, landslides, rails bent	6.5
XII	Damage total; waves seen on ground surface, lines of sight and level distorted, objects thrown up into air	7
		7.5
		8

Figure 1.20: Mercalli Scale and Moment magnitude scale

Know More

The moment magnitude (M_W) scale is the total moment release of the earthquake. Moment is a product of the distance a fault moved and the force required to move it. It is derived from modeling recordings of the earthquake at multiple stations.

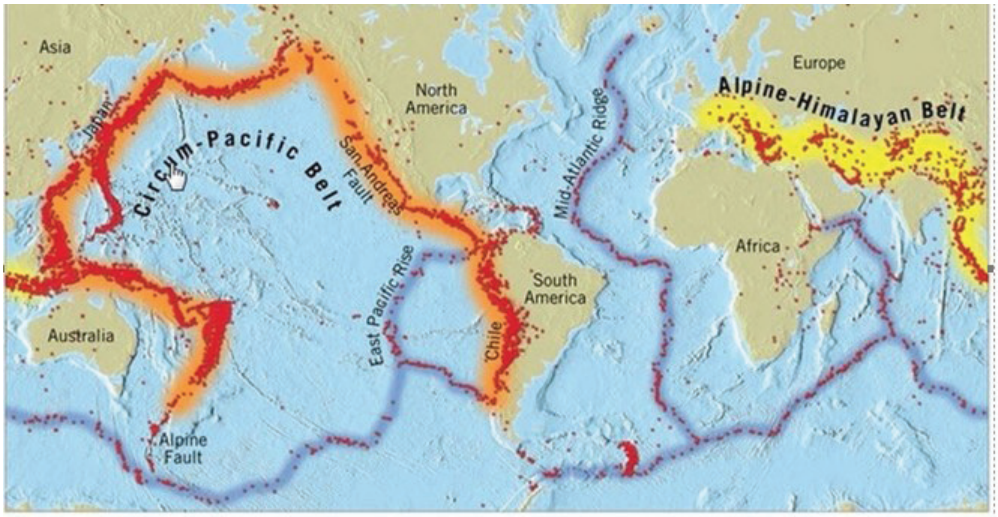


Figure 1.21: Seismic zones of the world

1.9 Consequences of Earthquake

Earthquake though a natural phenomenon becomes catastrophic at times. The impact depends on the location of epicenter, urban or rural, densely or sparsely populated, highly developed or underdeveloped, and on the ability of the infrastructure to withstand vibration. It also depends upon the frequency, type and size of the earthquake experienced over a period of time. Over the centuries, earthquake has caused millions of deaths and an immense damage to property.

About 50,000 earthquakes occur annually over the entire Earth. Of these, approximately 100 are of sufficient magnitude to produce substantial damage if occurred around the areas of habitation. Catastrophic earthquakes occur about once in a year on an average.

The disaster management considers that earthquake do not kill people but poorly built structures do. The building structure damage is more in areas of soft sediments and poor geologic structure, and high - rise buildings than smaller ones.

Fire is commonly associated with earthquakes as fuel pipelines rupture and electrical lines damage when the ground shakes. The bursting and leakage of cooking gas cylinders, gas

lines adds to the falling building leading to catastrophic disaster at times. Earthquakes also trigger major landslide along the geologically unstable and weaker slopes. Ground shaking during an earthquake can weaken rock and unconsolidated materials causing liquefaction. It is a phenomenon in which the strength and stiffness of a soil is reduced by earthquake shaking or other rapid loading. Liquefaction has been responsible for tremendous amounts of damage in historical earthquakes around the world.

Earthquakes that occurs in the sea bed and ocean floor generates tsunami. The coastal area experience disastrous waves sweeping off the settlement completely.

1.10 Measures to Reduce Risk of Earthquake

The natural earthquakes cannot be prevented from occurring but can significantly mitigate their effects by identifying hazards, building safer structures, and providing education on earthquake safety. While preparing for reducing risk from natural earthquakes, we can also reduce the risk from human induced earthquakes. There are many actions that can be taken to prepare and reduce the danger from earthquakes for the self, family and the community.

Earthquakes induced by human activity have been documented in different countries around the world. Earthquakes can be induced by a wide range of causes including impoundment of reservoirs, surface and underground mining, withdrawal of fluids and gases from subsurface, and injection of fluids into underground formations. While most induced earthquakes are small and less destructive, larger and potentially damaging human induced earthquakes have also occurred in the past. The hazard posed by human induced earthquakes can be mitigated by minimizing or in some cases stopping the activity that is causing the earthquakes to occur. For example, avoiding or preventing the unnecessary storage of Ammonium Nitrate that caused huge Beirut Blast in Aug 2020.

The risk reduction measures include the preparedness plan and the other safety measures. The possibility of implementing certain risk reducing measures is dependent on factors such as available technology and cost–benefit analysis. Seismic-resistant construction, appropriate policy on construction type based on location, monitoring and evaluation of plans, continued education and awareness programmes and mock drills are some measures for risk reduction. The measures also include the safety actions to be taken before, during and after the earthquake. The seven steps plan provides comprehensive guide for risk reduction.

Prepare (before the Earthquake)

1. Secure your space by identifying hazards and securing moveable items.
   i. Plan to be safe by creating a disaster plan and deciding how you will communicate in an emergency.
   ii. Organize disaster supplies in convenient locations.
   ii. Minimize financial hardship by organizing important documents, strengthening your property, and considering insurance.
2. Survive and Recover (during the Earthquake);
   i. DROP, COVER, and HOLD ON when the earth shakes.
   ii. Improve safety after earthquakes by evacuating if necessary, helping the injured, and preventing further injuries or damage.
3. After an Earthquake
   i. Reconnect and Recover: Reconnect and restore daily life by reconnecting with others, repairing damage, and rebuilding community.

Learning Activity

Referring to one of the past earthquakes in Bhutan, identify earthquake hazards and disaster experienced in that area. Prepare a list of risk reduction measures that could increase the chances of survival during an earthquake. Use any applications to illustrate it in a digital form (Paint, MS Word, MS Publisher, Photoshop, Illustrator, Picsart etc).

Test Yourself

1. Do you think the frequency of earthquakes increases during the cold weather? Justify.
2. Why do the plate boundaries experience frequent earthquakes?
3. South Asian region did not experience any volcanic activity except for the Deccan trap of India. Explore possible reasons for the absence of volcano, despite its location along the convergent belt.
4. Volcanism is considered as basis for landscape evolution. Justify.
5. Which scale is more commonly used in measurement of Earthquake? Support with valid reasons.
6. “Earthquake do not kill people but poorly constructed structures do”. Justify.

Chapter Two

The Origin of the Universe

Learning Objectives

- Explain the origin of the Universe from a Buddhist perspective
- Examine the significance of the Moon for the Earth.

2.1 Introduction

The Buddhist view of the origin of the universe is discussed in cosmic design. One of the basic tenets of Buddhism is the concept of interdependence which says that all things exist only in relationship to others, and that nothing can have an independent and autonomous existence. The world is a vast flow of events that are linked together and participate in one another. Thus, there is no First Cause, and no creation ex nihilo of the universe, as in the Big Bang theory. Since, the universe has neither beginning nor end, the only universe compatible with Buddhism is a cyclic one. According to Buddhism, the exquisitely precise fine-tuning of the universe for the emergence of life and consciousness as expressed in the "anthropic principle" is not due to a Creative Principle, but to the interdependence of matter with flows of consciousness, the two having co-existed for all times.

According to Buddhism no God has created this universe or this world. Lord Buddha has stated the same thing as the scientists have said about the origin of the universe and the Earth. Lord Buddha knew it even before those scientists who first found out that no God has created this universe and the earth and that it takes even more than trillion years for a universe and an earth to be materialised and not in just a few days as it is written in some religious books.

Abhidharma Tradition

According to the Abhidharma tradition, the origin of universe has three main components or factors which include development of the Outer or physical world, the notion of time, and the arrival of the living beings. The Outer World arises due to the collective good karma of beings, with its firm and solid structure encompassing the four continents, Mount Meru and the heavenly realms which endures across a full kalpa or aeon.

With regard to Time, every eighty cycles of completion of a small aeon comprises one great aeon (kalpa chenpo). This then comes to or equals trillions of human years. A great aeon consists of eighty intermediate aeons (barkal) which are then divided into twenty aeons

which then include components of Formation, Persistence, Dissolution and Vacuity. (Chag, Ney, Jig, Tong).

As for the development of human beings like us, humans are very fortunate among the many countless living beings in the universe because to become a human being requires a great amount of merit within the period of the great aeon in order to take this form. To become a Buddha, one would need to accumulate merit which spans the period of three great countless aeons (Kalchen Drangmed Sum), or in other words, an incalculable aeon. One sixtieth of a great aeon (or the sixty digit numbers of years in calculation) is used to calculate.

The Formation (chagpai kalpa) of universe takes one great aeon, likewise Persistence, (nepai kalpa) Dissolution (jigpai kalpa) and Vacuity (tongpai kalpa) also takes one great aeon each. The Formation of Universe or the cosmology which surrounds us is composed and constituted by the Five Elements which include the Space Element, Wind Element, Water Element, Fire Element and the Earth Element. The Five elements rise up stacked upon one another like the five precious jewel rings stacking up one upon the other in different shapes.

The pure white empty space forms the basis for all of the other four elements to come into existence and this is represented in a triangular shape. From this triangular shaped space, a tiny short tube of the air, known as 'Loong Chabjug Chop' or (Pervasive Wind of Protection) emerges with the sound 'A-wu-wam' by itself three times in the empty space. Then it is said that another wind called 'Nampar Soopjed Loong' (Forceful Churning Wind) which is as small as the breath of a tiny baby mouse emerges which causes a cloud to form in the space, and the wind element is formed in a crossed vajra shape at the base of the universe.

The crossed Vajra wind is formed in a beautiful green color and remains still and firm for the complete period of a great aeon. The crossed Vajra wind is estimated to be one million and eight thousand miles across and its length is four million and sixty hundred thousand miles.

Upon this crossed Vajra wind element, the water element is formed and this arises in the shape of a full moon in a brilliant white color. This is caused from rain falling from the golden cloud in the sky for seven years continuously. Its breadth spans eleven hundred thousand and twenty thousand miles. From between the crossed Vajra wind and water disc element, moisture mixed with wind and water elements emerges and this rises up in the sky and is formed like golden cream on the surface of the water element which is called or known as the golden base land layer (Wangchen Sergyi Sazhi).

Upon this golden base land layer, another thin strip of golden land is formed. Upon these two golden land layers, the fire element of the land arises and is two hundred thousand miles in breadth and length.

Upon this layer of fire element, another wind element known as discriminating wind emerges from the fire element and forms yet another layer. It is upon this layer that the Earth element is perfectly formed much like the cream layer on the sea but taking shape as a square form of land that is held up at each corner by the four earth goddesses. The other four surfaces of the land are held up by the four water goddesses. Its length is said to be four hundred thousand and ten thousand miles.

Each of these mandala-disc cosmos are formed one upon another stacked up like the layers of a stupa. There is also karmic wind which emerges from the bottom in the shape of a golden wheel with a thousand spokes constantly turning around with a mighty force which constantly stirs and churns the water-disc element and earth element for aeons to come.

The result of this then contributes to the forming of the golden colored soil which is called the Earth and this includes both the gross version and the more refined golden earth which becomes the basis for the central Mount Meru to arise. Mount Meru rises one hundred thousand and six thousand miles up in height and its base is anchored into the great golden base land layer (Wangchen Sergyi Sazhi).

The east side of the Mount Meru is composed of silver whereas the south is composed of the yellow jewel Beydurya; the western slope is made of rubies and the northern face is structured with gold. The sky color of each surface shines up as same color based on its own jewel structure. Each surface of Mount Meru has a step of different elements stretching out and these include a turquoise color step for the wind element, a crystal colored step for the water element, a golden colored step for the earth element, and a ruby colored step for the fire element. Each step stretches out two thousand miles long from Mount Meru and is surrounded by the seven chains of the oceans and the seven golden fence-like-mountains with the whole structure surrounded by an iron fence all round of the outer rim.

To the far east of Mount Meru, the eastern continent is formed in a crescent shape, whereas the south continent takes form in the shape of a chariot, while the western continent is found to be in the shape of a stick and the northern continent arises in a the shape of a square. This is known as the Aeon of Formation of the Universe. The second is the Aeon of Persistence, then the Aeon of Dissolution and the last one is the Aeon of Vacuity.

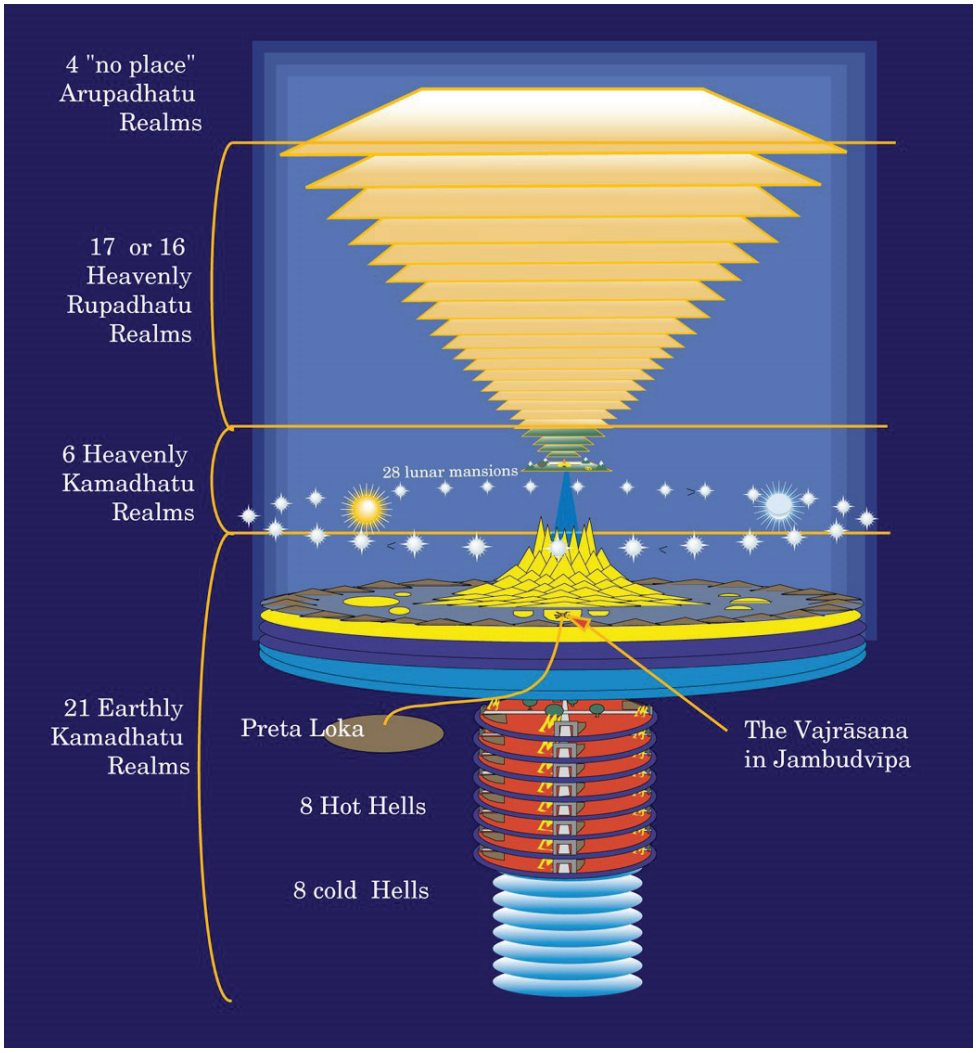


Figure 2.1: Abhidharma Universe

Figure 2.2: Cosmic Mount Meru

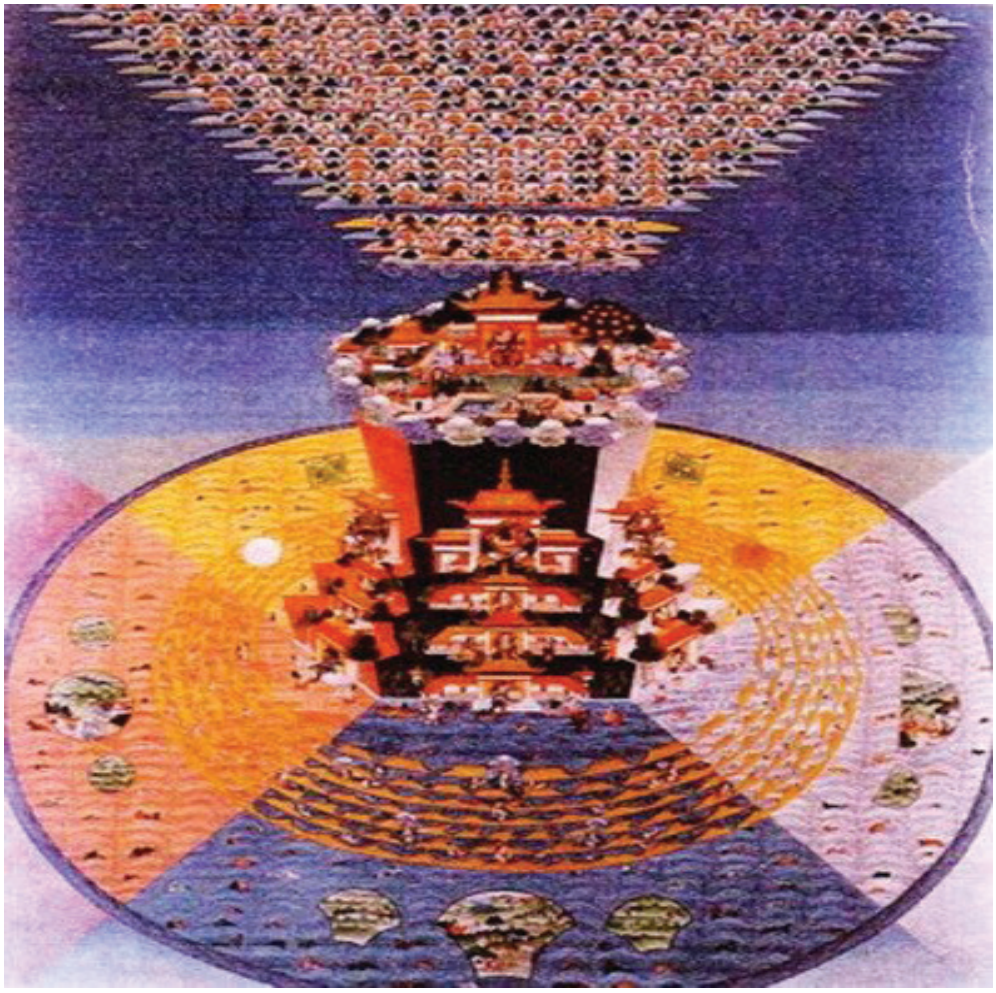


Figure 2.3: Mount Meru continents

Know More

- Buddha described the origin of the Universe and life in the Aganna Sutta 2500 years ago.
- The Aganna Sutta is found in the Pali Canon.
- Mandala: A mandala is a complex representation of the universe, with different parts of the universe representing different aspects of the Buddhist teachings.

i. Kalachakra Cosmology

The Kalachakra teachings present the topic of cosmology is the context of its three-part structure of parallel outer, inner and alternative Kalachakras, or Cycles of Time. The outer one deals with the cycles that the external world passes through, such as the motion of the planets and the calendar, while inner Kalachakra concerns the cycles that the body undergoes, such as the life cycle and the passage of the breath during each day. These two cycles occur due to karmic forces and describe samsara, uncontrollably recurring rebirth in the universe of outer Kalachakra with a body of inner Kalachakra. Such rebirth is completely fraught with problems and suffering. Alternative Kalachakra presents the tantric practices that purify us from experiencing these outer and inner cycles and outline the way to attain enlightenment to be best able to benefit all beings.

In order to get rid of being under the influence of the outer and inner cycles, we need to know their structure and their causes. As in Buddha's teachings of the four noble truths, we need to recognize the true sufferings and their true causes in order to attain a true stopping of them through the true pathway minds that will bring about such a stopping forever. With this purpose in mind, this evening I shall merely discuss the true suffering experienced from uncontrollably taking rebirth over and again in a universe of outer Kalachakra.

ii. The Cycles and Elements of a Universe

As in most traditional Indian presentations of cosmology, including the Buddhist abhidharma ones, there are countless universes, each of which passes through cycles of evolving, enduring, disintegrating and remaining bare. The cycles of each universe are not synchronous with the cycles of the others, so that when one universe is evolving, another will be disintegrating or bare. Because of that, the countless number of limited beings (or sentient beings) always has available to it some universe in which to take rebirth. Although the abhidharma texts provide a great deal of detail concerning how the various realms and the societies in them develop through these cycles, the Kalachakra material does not go into much detail regarding these points.

What Kalachakra does explain is that each universe contains countless world systems, each of which is made up of tiny particles or "atoms" ('rdul-phran) of the elemental sources (khams). These are the sources of the elements of earth, water, fire, wind and space. Each of the five types of particles in this list is progressively subtler than the one before it, almost in the manner of sub-particles and sub-sub-particles, and each has one less sensory quality or property than the previous one.

- Earth particles, reminiscent of an element of solidity, are the grossest. They have five sensory properties: odor, visible form, taste, tangi-

bility and sound. The eight conglomerate particles presented in the abhidharma texts – each having element particles of earth, water, fire, and wind, and derivative element particles of odor, visible form, taste and tangibility – belong to this level of Kalachakra particles.

- Water particles, reminiscent of an element of liquidity, is subtler than earth particles. They lack an odor, and have only a visible form, a taste, are tangible and, when they flow, have a sound.
- Fire particles, reminiscent of an element of heat, lack both an odor and a visible form. We cannot see heat. But fire particles have a taste – we can, in a loose sense, "taste" the temperature of food or drink on our tongues. They also can be detected by physical sensation and make a sound.
- Wind particles, reminiscent of an element of gas or energy, lack not only an odor and a visible form, but also have no taste. However, they are tangible and have sound.
- Space particles are the subtlest of all particles. They have only one sensory quality or property, namely sound. Space allows for the passage of the vibrations of sound.

When a universe is bare, there are only space particles in it – either only one or many, there are several views on this point. A space particle has within it a trace of the other four grosser elements, and not just the potentials for them. However, these traces are not bound together, but rather they are "fragmented," as described in the literature. In modern scientific terms, this condition would be equivalent to a state in which the usual laws of physics are not operating. Because of that, space particles in some ways are reminiscent of black holes, though of course they do not have all the properties of black holes.

It is unclear whether the space particle of a bare universe is immeasurably small or immeasurably large. In the case of asserting it as immeasurably large, then the space particle of a bare universe encompasses the entire space of that universe and, in it, there are only fragmented traces of the particles of the other elements. In this description as well, the usual laws of physics are not operating during the bare phase of a universe.

iii. The Universe in a Single Atom

Galileo, Copernicus, Newton, Niels Bohr, Einstein. Their insights shook our perception of who we are and where we stand in the world, and in their wake have left an uneasy coexistence: science vs. religion, faith vs. empirical inquiry. Which is the keeper of truth? Which is the true path to understanding reality?

After forty years of study with some of the greatest scientific minds, as well as a lifetime of meditative, spiritual, and philosophic study, the Dalai Lama presents a brilliant analysis of why all avenues of inquiry—scientific as well as spiritual—must be pursued in order to arrive at a complete picture of the truth. Through an examination of Darwinism and karma, quantum mechanics and philosophical insight into the nature of reality, neurobiology and the study of consciousness, the Dalai Lama draws significant parallels between contemplative and scientific examinations of reality.

This breathtakingly personal examination is a tribute to the Dalai Lama's teachers—both of science and spirituality. The legacy of this book is a vision of the world in which our different approaches to understanding ourselves, our universe, and one another can be brought together in the service of humanity.

The Universe in a Single Atom is an important exemplar of open-minded engagement between different intellectual traditions, an engagement that enriches our shrinking planet. The Dalai Lama, like physicists, recognizes the powerful role that science has had and continues to play in shaping the world. He has listened and learned much from those scientists who have generously given their time to working with him. He has repaid us with a thoughtful and challenging volume that I believe will become a small classic in the dialog between science and religion.

Learning Activity

Using the link https://www.youtube.com/watch?v=HdPzOWlLrbE, explore the origin of the Universe from a scientific perspective and compare with Buddhist perspective.

The Universe originated around 13.7 billion years ago. It is the whole of space that has matter and energy in it. Scientific and spiritual perspectives help to elucidate the origin of the Universe. Several scientific theories like the Big Bang and Solar Nebula have attempted to explain the origin of Universe more appropriately than others. The Milky Way is one of the billions of galaxies in the observable universe. The Sun is one among hundreds of billions of stars in the Milky Way galaxy, and most of those stars have their own planets that revolves around them. The planets have different numbers of their own satellites which revolves around them. The Moon is the only satellite of the Earth and has significant influence on it. The spiritual perspective also provide the origin of Universe from religious and cultural lens.

This chapter describes the origin of Universe from Buddhist perspective, the Moon as the natural satellite and its influence on the Earth.

2.2 The Moon

The Moon is the only natural satellite of the Earth. It is the largest celestial object visible in the night sky from the earth. There are various theories about the formation of moon. Most researchers and the recent evidence indicates that it was formed when a huge collision tore a chunk of Earth and set the debris off into the orbit. The collision must have occurred about 4.5 billion years ago much after (95 million years) the formation of the solar system. The Moon contains differentiated rocky body with no substantial atmosphere, hydrosphere or magnetic field. Its surface gravity is about one-sixth of the Earth (0.1654 g).

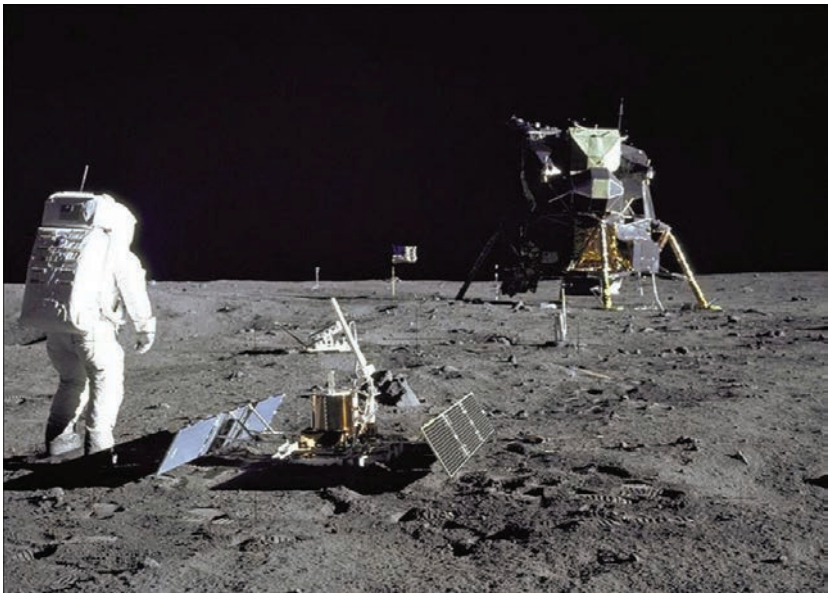


Figure 2.4: Lunar Surface

The internal structure of Moon consists of core with 680 km diameter which contains iron, sulfur and other elements. The mantle is made up of dense rocks rich in iron and magnesium with the thickness of 1330 km. The crust is about 70 km deep and the outer most part of the crust is pockmarked with craters formed by asteroid impacts millions of years ago. Due to the absence of weather phenomena, the craters have not been eroded and are prominently seen till date.

The surface composition of the Moon is rocky like the four inner planets. The average composition of the lunar surface by weight is roughly 42 percent oxygen, 21 percent silicon, 6 percent magnesium, 13 percent iron, 8 percent calcium, 7 percent aluminum and traces of chromium, titanium and manganese.

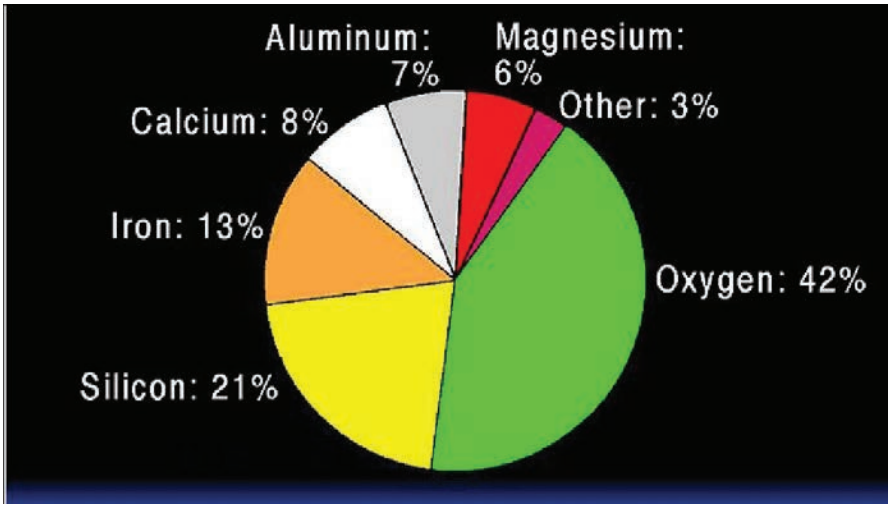


Figure 2.5: Composition of Lunar surface.

Water traces on the lunar surface have been discovered by the Lunar Reconnaissance Orbiter (LRO) during ongoing observations. The water could have come from deep underground and is more abundant on slopes facing the lunar South Pole. Scientists do caution that the water quantity is comparable to an extremely dry desert conditions.

2.2.1 Significance of the Moon to the Earth

The Moon's orbit around Earth has a sidereal period of 27.3 days, and a synodic period of 29.5 days. The orbit of the Moon around the Earth has an average lunar distance of 384,400 km. The synodic period drives its lunar phases, which form the basis for the months of a lunar calendar. Lunar phases is the shape of the sunlit portion of the Moon as seen from the Earth. The same side of the moon always faces the Earth. The different phases of moon are Full Moon, New Moon and the crescent Moon. It gradually changes over a synodic month (about 29.5 days) as the Moon's orbital positions around Earth and Earth around the Sun shift.

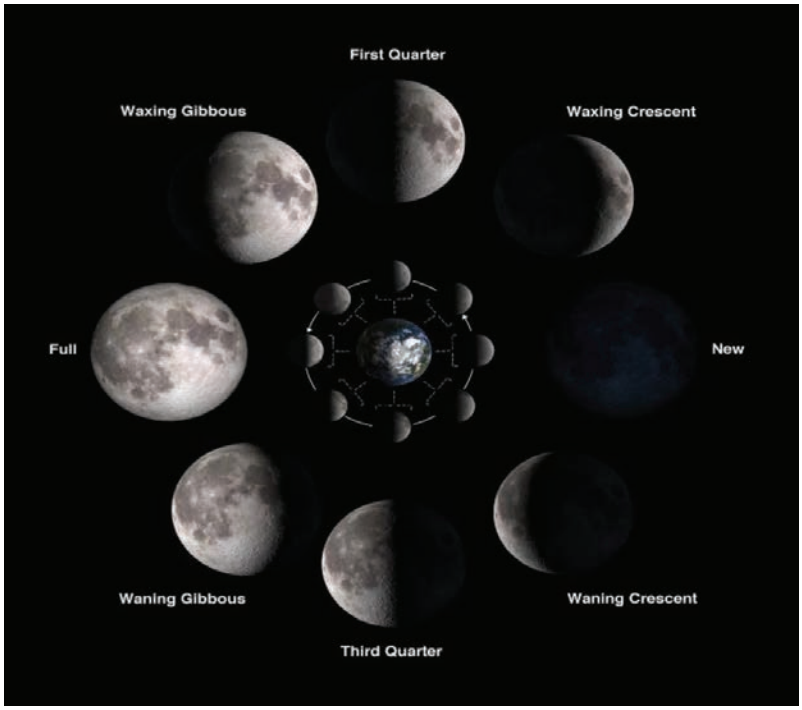


Figure 2.6: Phases of Moon (Credit: NASA/Bill Dunford)

The presence of Moon has several influences on the Earth's geology and the evolution of life forms. It affects the Earth in numerous ways. The most obvious and important influence is the Moon's gravitational pull, which creates the ocean tides that rise and fall every 12 hours 25 minutes. There are 705 tidal formations in a year. The height of those tides follows roughly two-week cycles – the 14.8 day as a spring-neap cycle. This cycle is the result of the combined gravitational pull of the Sun and the Moon, and the 13.7-day as a declination cycle, which is driven by the Moon's position relative to Earth's equator.

Figure 2.7: Tidal waves.

The Moon is tidally locked to Earth, which means that the length of a full rotation of the Moon on its own axis, that is, a lunar day is the same as the synodic period (29.5 days), resulting in its same side always facing the Earth. The Moon's gravitational force also causes the ocean to rise towards the equator, without which ocean would redistribute raising the water level at the poles. It stabilizes the Earth's rotation on its axis. The gravitational pull of the moon causes tidal braking leading to negligible slowing of the Earth's rotation. This results in increase in the length of a day by 2.3 milliseconds per century. Scientists are also of the view that its pull of gravity might have set plate tectonics in motion. Without plate tectonics, the planet might be more like Venus, toasty and dead.

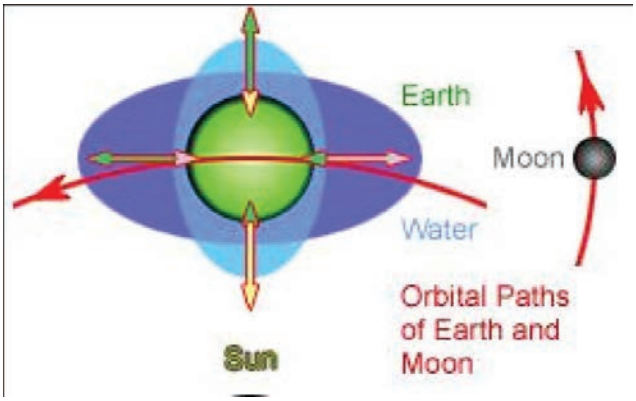


Figure 2.8: Tidal formation.

The subtle effects of the Moon influences the evolution of life. The regular rise and fall of the water during the tidal formation along the coastline allows the environment to be alternatively wet and dry which has contributed to adapt life from aquatic to the terrestrial in the beginning. Nocturnal animals behave differently depending on the phases of the moon. For example, during the full moon, prey fish stay hidden in the reef, when they would be most visible, lions are less likely to hunt and many bats will be less active. Studies on human endometrium have found the link between women's menstrual cycle and the cycle of the moon. Moon is also found to be related to human mind. In literature, the terms lunacy and lunatic are often used to characterize the nature of individuals. For centuries, people believed that the Moon affects human behaviour.

Know More

- Earth's Moon is the fifth largest of the 190+ moons orbiting planets in our solar system.
- The Apollo missions provided data to Scientist for further exploration on Moon.
- NASA currently has three robotic spacecraft exploring the Moon- Lunar Reconnaissance Orbiter and the twin ARTEMIS spacecraft.
- Endometrium is the inner layer of tissue that lines the uterus which thickens and renews itself during the menstruation.

Learning Activity

1. Watch the Video link https://youtu.be/KulEmr7X1HM and explore the importance of moon to the Earth.
2. What would happen if the Earth had more than one Moon like other planets? Discuss in group and identify possible consequences.
3. Visit a nearby monastery or enquire a senior citizen at home, school or locality regarding the influence of Full moon and New Moon in a lunar calendar.

Know More

- Synodic Period: Time for a planet to appear in the same place in the sky relative to the stars (in the same constellation). This is as seen from Earth, and involves the motion of the Earth.
- Sidereal Period: Time for a planet to go once around the Sun (with respect to the stars). This period is independent of where we are, and does not depend on the motion of the Earth.
- Astronomer Galileo Galilei was the first to use a telescope to make scientific observations of the moon in 1609.

Test Yourself

1. Do you believe that the universe is static? Provide evidence to back up your choice.
2. Spiritual perspective of Universe is Cyclical. Do you support the cyclical nature of the universe? Justify
3. Tidal energy is one of the alternative energy sources. How can we tap this resource?
4. Scientists and researchers are exploring the possibility of life on the Moon. Can you make the Moon habitable for humans? Support with reasons.
5. "Moon affects life on Earth". Explain with relevant examples.

Chapter Three

Map Projections

Learning Objective(s)

- Discuss various map projections.
- Demonstrate the skills of constructing map projection using different methods.
- Explain the concept of scales.
- Convert representative fraction into statement scale and vice versa.
- Demonstrate the skills of interpreting topographical maps.
- Identify natural and human-made features on a map.

3.1 Introduction

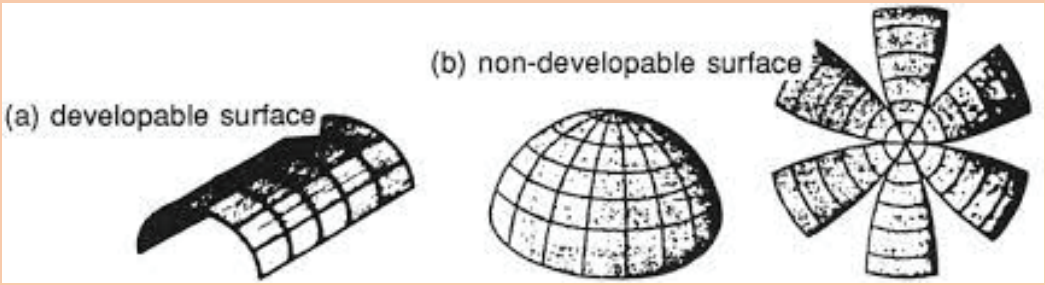
The Globe is considered as the true representation of the Earth. Using the globe, the map is transformed on a flat sheet of paper. The transformation of the globe into a map distorts the geographical relations on the Earth's surface. The geographical relations include distance between places, direction, location, areas and shapes of landmasses, water bodies and political units. Map projections include Cylindrical Equal Area Projection, Simple Conical Projection with one Standard Parallel and Polar Zenithal Equidistant Projection. There are different map projections and each projection has different patterns of distortion. Certain geographical relations are preserved without distorting in some map projections.

Scales are used for representing ground distances on the map with use of representative fraction, statement scale and linear scale. The construction of plain scale are obtained through conversion of R.F. into Statement Scale and vice versa. Map scale is the component of marginal information in the interpretation of topographical maps. Interpretation of topographical maps require practical skills for examining and creating information on human made features and natural features.

Know More

Developable Surface: A developable surface can be cut or unfold into a flat sheet or paper without creases. E.g. cylinder or cone.

Non-developable Surface: A non-developable surface cannot be cut or folded into flat sheet or paper. E.g. globe609.



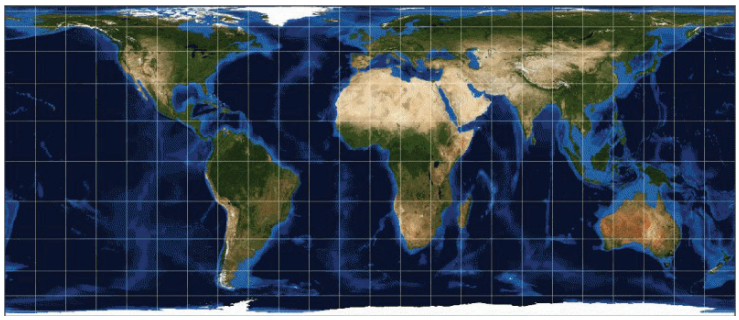
3.2 Projection Properties

Projection properties are the methods where certain geographical relations of the Earth's surface are preserved or distorted. Area, forms, distance and direction are four main properties.

a. Area

On a Mercator's projection, Greenland is larger than South America but in reality Greenland is eight times smaller than South America. As you get closer to the poles, Mercator's projection does not preserve the area accurately.

Figure 3.1: Mercator's Projection



The Cylindrical Equal Area projection preserves the area and is referred to as equivalent or equal-area projections. Greenland and South America look the right size in this projection.

Figure 3.2: Cylindrical Equal Area Projection

b. Form

Azimuthal Equidistant projection stretches, twists and squeezes the 'look' or 'form' of the places. It does not preserve the form. In this projection, New Zealand is pushed to the left edge of the map and Australia is unrecognizable on the right side.

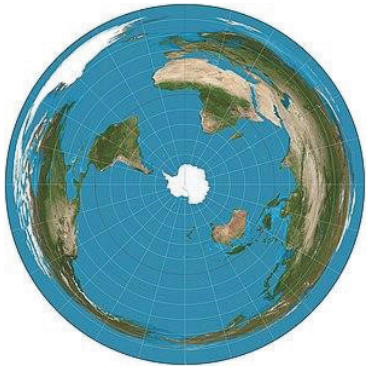


Figure 3.3: Azimuthal Equidistant Projection

Lambert Conformal Conic projection preserves the general form of the landmasses. Conformal projections are complex and preserve the local angles. For cartographers, places are not distorted and appear as it is.

Figure 3.4: A Showing directions

c. Distance

On an Equi-rectangular projection, the distance between Madison to Madrid and Madison to Buenos Aires are the same as the projection does not preserve distance. In reality the trip from Madison to Madrid is shorter compared to the trip from Madison to Buenos Aires. There is not a single map projection that can preserve distances everywhere. Azimuthal Equidistant projection shows the distances in the true form. Equidistant projection preserve distance when it passes from the center but the distance gets distorted between any other two points.

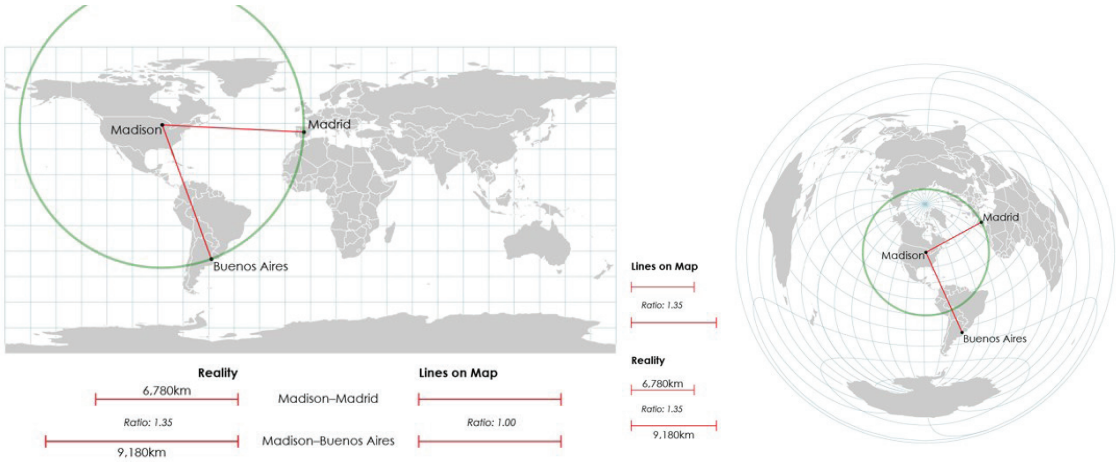


Figure 3.4:A Showing directions

Mercator's projection shows loxodromes as straight lines and great circles as curved lines. The straight line in Mercator's projection makes navigation of ship and air easier. The straight line between New York and Istanbul does not show the shortest distance between the two cities. The shortest path is the great circle because of the curved surface of the Earth. Stereographic projection shows great circles as straight lines and loxodromes as curved lines. The great circle in stereographic projection is used for figuring out the shortest distance between two places.

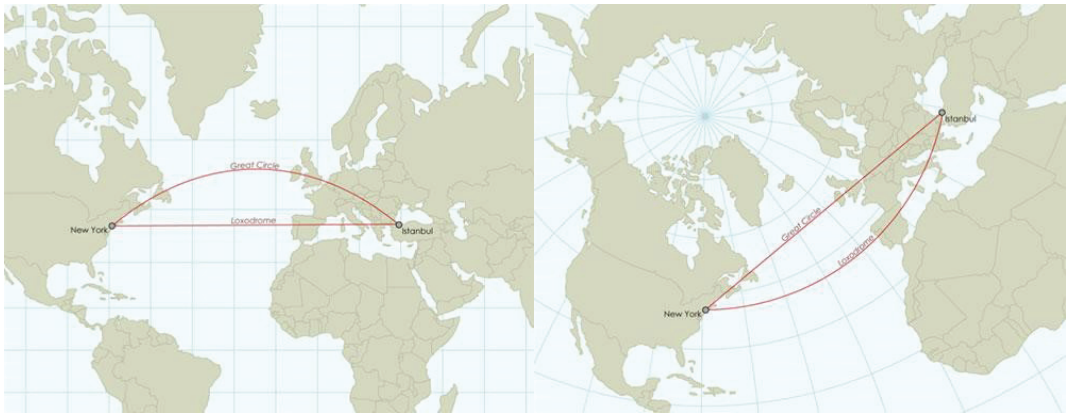


Figure 3.4: B Showing directions

3.3 Construction of Map Projections

The construction of map projections is based on the globe and it requires finding out the radius of the globe according to the given scale. The radius of the globe is calculated by multiplying R.F. with the actual radius of the Earth. The actual radius of the Earth is 6400 km (640,000,000 cm) or 3960 miles (250,000,000 inches). The parallels and meridians are drawn after calculating the radius of the globe.

Example: Find the radius of the globe when R.F.=1/450,000,000

Solution. Radius of the globe=**R.F. x Radius of the Earth**

a. Radius of the globe in inches = 1/450,000,000 x 250,000,000 =0.56 inch.

b. Radius of the globe in centimetres = 1/450,000,000 x 640,000,000 =1.42 cm.

Learning Activity

Accessing QGIS application, show the Coordinate Reference System (CRS) or projection of the world using Mercator and Cylindrical Equal Area Projection. Discuss the differences between these two projections.

3.4 Map projections

a. Cylindrical Projections

Swiss mathematician Johann H. Lambert first described the cylindrical projections in 1772. His projection represents the poles as straight lines similar to the length of the equator across the top and bottom of the grid. Cylindrical map projections have straight coordinate lines with horizontal latitudes crossing longitudes at right angles. The longitude lines are equally spaced and the scale is regular along each latitude line. The latitude and longitude lines are straight and do not consider the curvature of the Earth. In this projection, areas near the equator are likely to be accurate compared to the actual curvature of the Earth.

Cylindrical map projections are rectangles but are referred to as cylindrical as the hollow cylinder touches the globe along the equator and its axis coincides with the axis of the globe. The latitudes and longitudes are shifted from the globe to cylinder. The cylinder is cut open along a line running from top to bottom. It is finally unfolded and the cylinder takes the shape of a rectangle.

The use of different scales for spacing the latitude lines on the map is the only factor that categorizes different cylindrical map projections. The cylindrical map projections are not the correct method of picturing the Earth but it is used for teaching, visualizing the World and comparing the parallels.

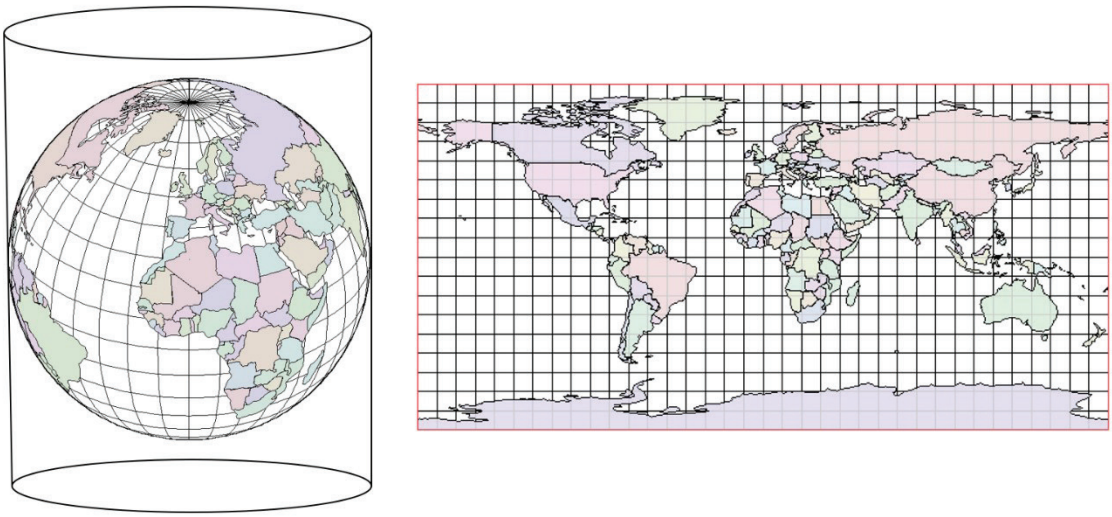


Figure 3.5: Cylindrical Projection

Construction of Cylindrical Equal Area Projection

The construction of cylindrical projections requires the following steps:

a. Calculate the Radius of the globe using the formula R.F x Radius of the Earth

b. Calculate the length of the equator using the formula $2\pi r$ (where $\pi=22/7$ and r=radius of the globe).

c. Calculate the distances between two successive meridians using the formula

$2\pi r$ x Meridian interval (in degrees)/Circumference of the earth (or 360^0)

Example 1. Draw a cylindrical equal area projection on a scale of 1: 260,000,000 when the graticule interval is 30^0.

According to the given scale,

a. Radius of the globe = R.F. x Radius of the Earth

= 1/260,000,000 x 640,000,000

= 2.5 cm

b. Length of equator = $2\pi r$

= 2 x 22/7 x 2

= 12.6 cm

c. Central Median = $2\pi r/2$

= 12.6/2

= 6.3 cms

d. Distance between two meridians at 30^0 interval = $2\pi r$ x Meridian interval/360^0

= 12.6 x $30^0/360^0$

= 1.05 cm

Construction Methods

i. Draw a circle WNES with O as centre and 2.5 cm radius in which NS and WE represent polar and equatorial diameters respectively.

ii. Draw the length of the equator from WE upto D, so that ED = 12.6 cm.

iii. Draw perpendiculars UV at E and YZ at D. It represents 180^0 West and 180^0 East longitudes respectively.

iv. At 35^0 interval, take OE as base and draw lines OI, OJ, OK and OL.

v. Draw lines N, J, I, K, L and S parallel to ED. It shows parallels of 90^0N, 60^0N, 30^0N, 30^0S, 60^0S and 90^0S.

vi. Divide ED with 1.05 cm long divisions and draw meridians.

vii. Draw lines parallel to UV or perpendicular to ED through these points to represent meridians.

viii. Write the values of parallels and meridians and complete the projection.

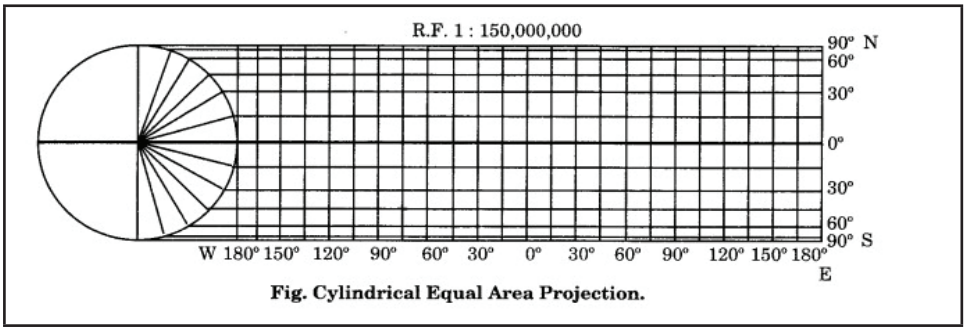


Fig. Cylindrical Equal Area Projection.

Properties

1. All parallels are horizontal straight lines parallel to the equator and meridians are vertical straight lines drawn perpendicular to the equator.

2. At right angles, parallels and meridians intersect with each other.

Uses

Cylindrical equal area projections are useful for showing the distribution map of tropical products, such as tea, cotton, sugarcane, coconut and jute.

Limitations

The distortion at temperate and polar areas limits the use of the projection in these areas.

Learning Activity

Draw a cylindrical equal area projection on a scale of 1: 300,000,000 when the parallels and meridians are placed at 15^0 and 30^0 respectively.

b. Conical Projections

The parallels cross the meridians at right angles with constant measure of distortion everywhere in this projection. The visualization of regional or hemisphere maps, such as weather maps, climate projections and temperate regions are appropriate with distortion in conical maps. Conical map projections are not geometrically accurate and are designed to be wrapped around a cone on top of a globe. Central meridian is a line along which the cone is balanced from top to bottom. Standard parallels are those parallels that touches the inner surface of the cone.

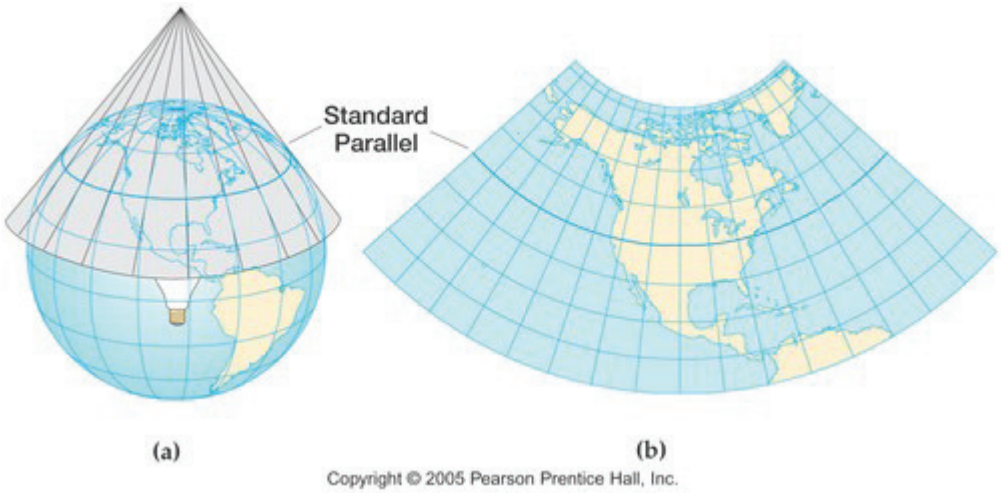


Figure 3.6 Conical Projection

Learning Activity

1. Refer available toposheet and interpret the physical and cultural features of the map.
2. Accessing internet sources, explain the cross profile and longitudinal profile. Discuss and present the findings.

Construction of simple Conical Projection with One Standard Parallel

The construction of conical projection requires the meridian to lie at the centre of the network and is called central meridian. To find the central meridian, the longitudinal extent of the area should be known. For example, on a graticule interval of 10^0 with longitudinal extent of 30^0 E to 170^0 E, the central meridian will be 100^0 E. The construction of conical projection depends on scale of the projection, standard parallel, latitudinal and longitudinal extent of the area and graticule interval.

Example. Draw a Simple Conical Projection with one Standard Parallel on a scale of 1: 225,000,000 when the standard parallel is at 60^0 N and the graticule interval is 10^0.

According to the given scale,

Radius of the globe= R.F. x Radius of the Earth

= 1/225,000,000 x 250,000,000

= 1.1 inch

Construction Method

i. Draw a circle NWSE with O as center and 1.1 inch as radius in which NOS is polar diameters and WOE is equatorial diameters.

ii. Draw lines OC making angle of 60^0 with OE showing standard parallel and line OD making angle of 10^0 with OW representing graticule interval.

iii. To represent a tangent to the circle at C, draw a perpendicular at OC and produce ON to Y. It cuts the perpendicular at Y. Point Y would represent the tip of the cone and CY is the radius of the standard parallel of 60^0 N.

iv. Draw a semi-circle with O as center and WD (distance between parallels along the central meridian) as radius. It would cut OC at T.

v. Draw a perpendicular TU (distance between meridians along the standard parallel) from T on ON.

vi. To represent the central meridian, draw a line PQ on the right side. Draw an arc MLK (standard parallel) to cut PQ at L with P as center and CY as radius.

vii. Open the compass equal to WD and divide PQ into eight equal parts.

viii. Draw arcs with P as center to show parallels passing through these points. On standard parallel (MLK) mark nine points on both sides of the central meridian at TU distance.

ix. Complete the projection by joining all these points with P.

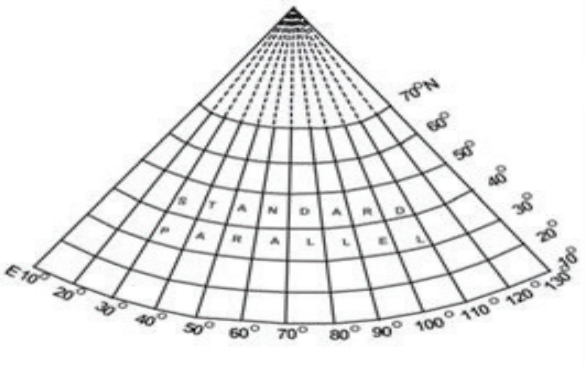


Figure 3.7: A simple conical projection with one standard parallel

Properties

1. Standard parallel and other parallels are shown as arcs of concentric circles whose center is the tip of the cone.
2. Meridians radiate from the tip of the cone and are drawn as straight lines.
3. At right angles parallels and meridians intersect as meridians are drawn as radii of arcs showing the parallels.

Uses

The projection is used for a narrow belt running east-west direction along the standard parallel.

Limitations

The parallel scale is correct along the standard parallel and is used for the temperate zone. It cannot be used for polar and equatorial regions.

Student Activity

a. Access internet sources and find the examples of roads, railways, rivers and international boundaries running east-west direction along the standard parallel in conical projection.

b. In teams, draw a Simple Conical Projection with one Standard Parallel on the scale of 1:100,000,000 when the standard parallel is at 50^0 N and the graticule interval is 15^0.

c. Zenithal Projection

This projection is used for Polar Regions as it equally divides all parallels and meridians to maintain equidistant property. Zenithal projection draws the network of parallels and meridians from the globe on a flat surface touching the globe at a point. It preserves direction and distance from the central point.

Construction of Polar Zenithal Equidistant Projection.

Example. Draw a Polar Zenithal Equidistant Projection for the northern hemisphere on a scale of 250,000,000 placing parallels at 15^0 and meridians at 30^0.

According to the given scale,

a. Radius of the globe= R.F. x Radius of the Earth

= 1/250,000,000 x 640,000,000

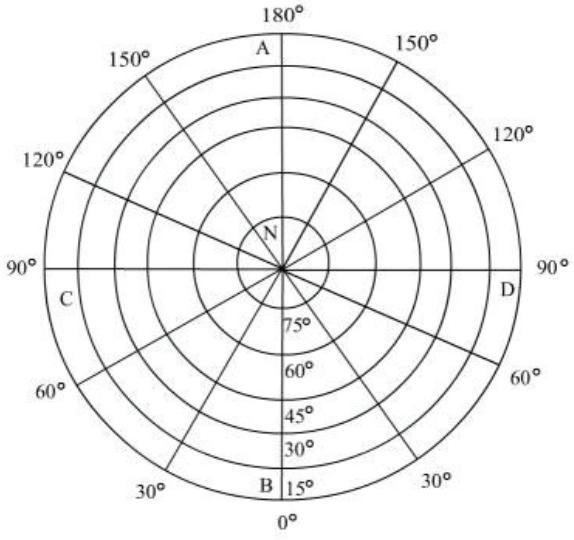
= 2.6 cm

Calculate the arc distance of 30^0 according to scale by drawing parallels at 30^0 interval using the formula:

b. $2\pi r \times I/360$ (where r=radius of the globe and I=Interval of parallels)

=2x22/7x2.6x15/360

= 0.7 cm



Construction Method

i. Show the pole by taking a point N and draw six circles at 0.7 cm interval representing parallels.

ii. Draw lines at 30^0 interval radiating from N.

iii. Complete the projection by writing down the values of parallels and meridians.

Properties

1. From the center of the projection, the parallel scale is exaggerated but meridian scale is accurate. The map projection is useful along the meridians for a narrow strip in Polar Regions.

Uses

This projection is useful for showing areas from poles to 60^0 latitudes and in drawing the general map of a hemisphere. The direction and distance from the center are accurate to show air routes and diverse radio waves such as, infrared radiation and micro waves.

Limitations

Areas away from the center of the projection have distortion and are not useful for showing large areas.

Learning Activity

Draw a Polar Zenithal Equidistant Projection for northern hemisphere if the radius of the globe is 4cm and graticule interval of 15^0.

3.5 Scale

The ratio that corresponds map distance to the actual ground distance is called map scale. The distance measurement of landmarks is presented on the map using scale. For example; the ratio of 1:100,000 represents 1 centimeter is equal to 1 km on the ground. The word 'Not To Scale' (NTS) is specified to a map that does not follow a specific scale. The graphic style maps such as 'we are here' or 'how to get here' used on invitations have NTS notations. Geographic Information System based maps have scales which give precise and accurate information.

Types of Scale

i. Fractional or Ratio Scale

The ratio of map distance to ground measurement with a colon between two measurements is termed as fractional or ratio scale. It is a text based scale with no units shown. The R.F. scale of 1:250,000 shows that every one unit on the map is equal to 250,000 units on the ground.

ii. Verbal or Statement Scale

A statement scale is a text based with scale shown as a number. The unit of measurement shown on the left side of the verbal scale is the map measurement. The ground measurement is represented on the right side of the scale. The verbal scale 3”=350’ displays 3 inches on the map representing 350 feet on the ground.

iii. Linear or Graphical Scale

The distance on the map equal to a real-world distance is represented on linear or bar or graphical scale. Graphical scales are printed on the map and during reproduction when it is reduced or enlarged, the size remains the same.

3.6 Conversion of Representative Fraction into Statement Scale

The conversion of R.F. into Statement Scale requires dividing the equation on the right side by 100,000 (centimetres into kilometres), 63,360 (inches into miles), 8 (miles into furlongs) and 100 (centimetres into metres).

Example: Convert R.F. 1:200,000 into Statement Scale in centimetres and kilometres.

1cm on the map=200,000 cm on the ground

1cm on the map=200,000/100,000 km on the ground

1cm on the map=2 km on the ground

Conversion of Statement Scale into Representative Fraction

The conversion of Statement Scale into R.F requires multiplying the equation on the right side by 100,000 (kilometres into centimetres), 63,360 (miles into inches), 8 (furlongs into miles) and 100 (metres into centimetres).

Example: Convert Statement Scale 1 cm on the map=2 km on the ground

1 cm on the map=2 x 100,000 cm on the ground

1 cm on the map=200,000 cm on the ground

Therefore, R.F.=1/200,000 or 1:200,000

Construction of Plain Scale

The R.F. or Statement Scale of the map should be provided for the construction of plain scale. The entire scale is divided into suitable divisions known as primary divisions. The first primary division on the left hand is further divided into smaller divisions known as secondary division. Zero should be marked at the end of the first main unit. The scale length should vary from 12 to 20 cm or 5 to 8 inches. The accepted length is 15 cm or 6 inches. Round figures such as 2, 5, 10 and 20 should be used to divide the scale.

Example: Construct a plain scale on the R.F. 1: 250,000 and represent miles and furlongs.

Solution: The given R.F. is 1: 250,000

1 inch on the map represents 250,000 inches on the ground

1 inch= 250,000 inches

1 inch= 250,000/63,360 miles

1 inch=3.946 miles

Let's take the length of the scale as 8 inches

8 inches= 3.946 x 8 miles

= 31.57 miles

Since 31.57 is not a round figure, we take 30 miles as a round figure.

Therefore, 3.946 miles= 1 inch

1 mile= 1/3.946 inches

30 miles=1/3.946 x 30 inches

=7.60 inches (7.6 inches) approximately.

Construction Method

i. Draw a line with a length of 7.6 inches long. This will represent 30 miles.

ii. Representing 6 miles on each division, divide it into 5 primary divisions.

iii. Divide the first primary division into 4 secondary equal parts. These secondary equal

parts would represent 12 furlongs.

iv. Mark the distance of the scale and complete the construction.

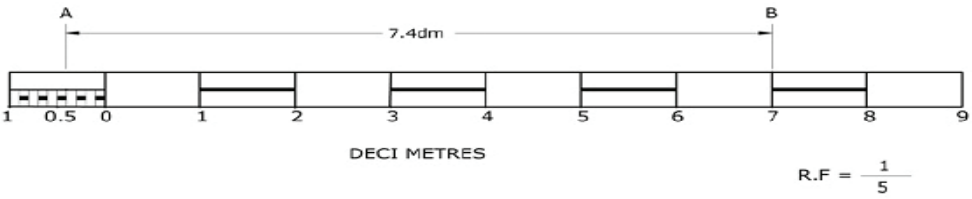


Figure 3.8: Plain Scale

3.7 Interpretation of Topographical Map

Topographical map represents natural and human-made features. The Earth's three-dimensional landscape is represented as two dimensions on a topographic map. The features shown on the map are represented by conventional signs and symbols. Marginal information, physical or natural features and cultural or human-made features are the basis of topographical map interpretation.

i. Marginal Information

The map users acquire peripheral information like grid references, scale, location, topographical sheet number and its extent from the map. Marginal information is categorized into extra, intra and inter marginal information.

ii. Physical or natural features

Natural features such as vegetation, mountains and rivers are shown on topographic maps using shapes, colours, numbers and contour lines. Contour lines indicate the landscape patterns and landform types besides providing information about gradient and height.

iii. Cultural or human-made features

Transportation and communication facilities, such as railway lines, road systems, footpaths, mule tracks, post office and communication lines attract people to settle in these areas with abundant facilities. Reading symbols, contours, labels and names on a topographic map helps people to understand how human culture has changed the natural landscape.

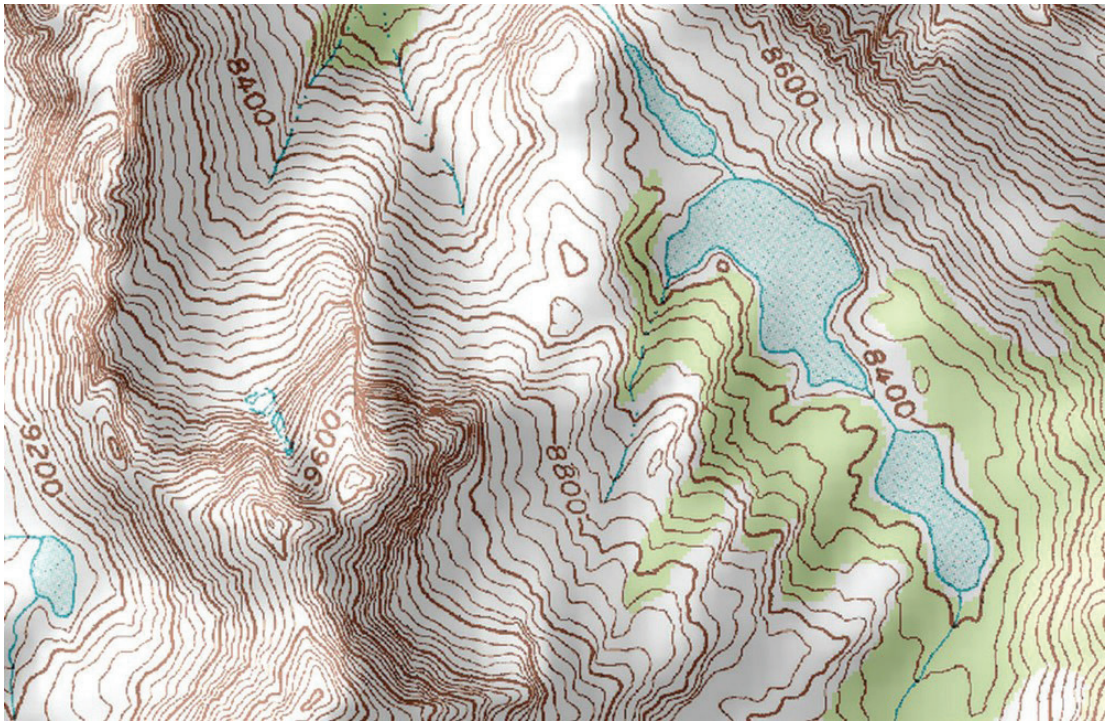
Rural features displayed on a map helps in building a picture of what an area looks like. It includes irrigation drains, dams and place names, field patterns with fences or windbreaks in between them.

Learning Activity

1. Refer available toposheet and interpret the physical and cultural features of the map.
2. Accessing internet sources, explain the cross profile and longitudinal profile. Discuss and present the findings.

Test Yourself

1. Convert R.F. 1:330,000 into statement scale in miles and furlongs. Convert the statement scale back into R.F.



2. Construct a cross profile by drawing a line AB from the center of the topographical map. Draw only the index contours.
3. Construct a longitudinal profile for Marambir Chhu from topographical map number 78M/3 covering Easting 10 to 60 and Northing 60 to 80. Draw the major contours along with the linear features.
4. Refer topographical map 78M/3 and interpret the following features:

   a. Road network

   b. Drainage system

   c. Land use pattern

Practical Record Keeping

1. Draw a simple conical projection with one standard parallel on the basis of following information:

   Scale: 1: 320,000,000, Standard Parallel at 45^0 N and Graticule Interval 15^0

2. Draw a Cylindrical Equal Area Projection on a scale of 1: 200,000,000 placing parallels and meridians 15^0 and 30^0 apart respectively.

3. Draw a Polar Zenithal Equidistant Projection for the northern hemisphere on a scale of 1:230,000,000 placing parallels at 15^0 and meridians at 30^0.

4. Draw a plain scale on the R.F. 1: 150,000 and represent miles and furlongs.

Chapter Four

Remote Sensing and Geographic Information System

Learning Objective(s)

- Explain Remote Sensing and Geographic Information System
- Examine the significance of Remote Sensing and Geographical Information System

4.1 Introduction

Advancements in the Digital Age have been dazzling and transforming every walk of life. It is marked by emergence of new technologies, increased use of data and high computational capacity. The convergence of artificial intelligence (AI), big data (BD), machine learning (ML) and geospatial technology has offered tremendous opportunities to understand, analyze, visualize real-world phenomenon according to their locations. Geospatial technologies like Geographic Information System (GIS) and Remote Sensing (RS) are important tools that collect information from the earth's surface. Remote sensing data is interpreted using GIS software for use in various organizations to produce better outcomes. GIS and RS are used in detecting and overcoming challenges such as disasters, land cover changes and weather forecasting.

Remote Sensing data are sophisticated tools and it requires specialized individuals to handle these data. Geographic Information System software such as ArcGIS, QGIS and SAGA GIS require constant training and application. Despite these challenges, GIS and RS have provided technologically advanced platforms in acquiring data without coming into direct contact with the physical World.

4.2 Remote Sensing

The term 'remote sensing' was first used in the United States in the 1960s and included photo-geology, photo-interpretation and photogrammetry. Remote sensing or earth observation is collecting information from the Earth's surface without coming in direct contact with the object or area using electromagnetic radiation. Remote sensor detects the electromagnetic radiation reflected from an object. Scanners and cameras are examples of remote sensors. Satellites and aircrafts are used as platforms which carry the sensor. Remote sensing is commonly used in acquiring information about land cover changes, vegetation dynamics, water quality dynamics, agricultural crop growth and urban growth.

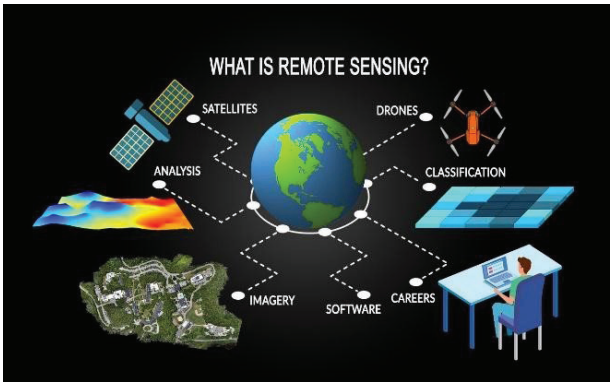


Figure 4.1: Remote Sensing

4.3 Development of Remote Sensing

During the First and Second World War, aerial photography became a valuable tool in capturing pictures of the ground using the newly invented photo camera in the 1840s. The earth observation and remote sensing started in 1859 when Gaspard Felix Tournachon took photographs of a small village from a hot air balloon in Paris.

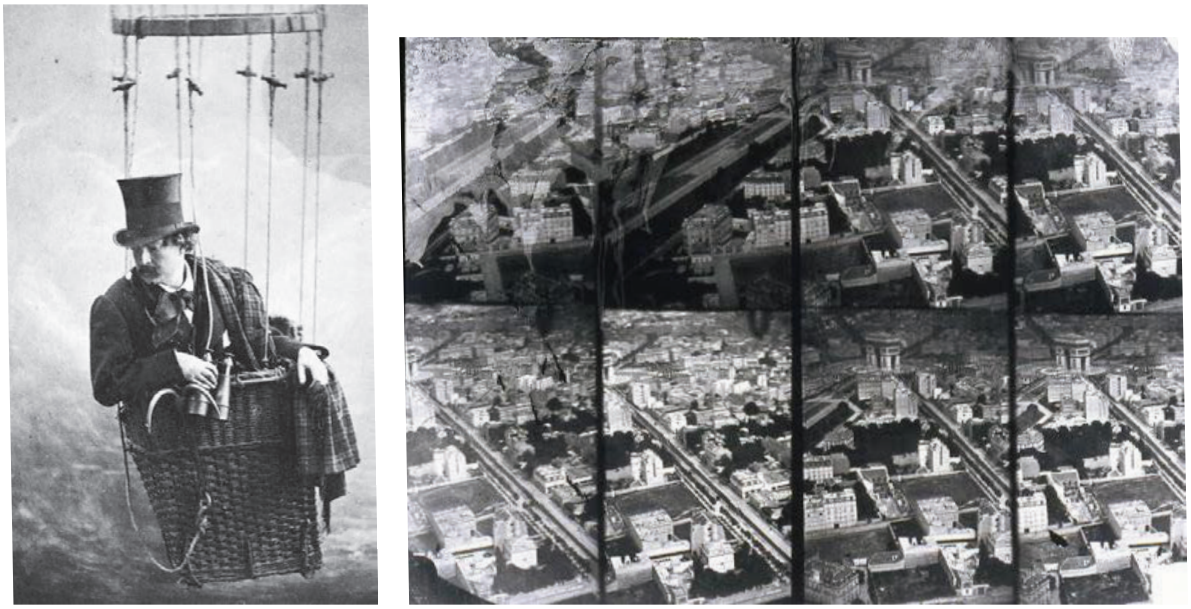


Figure 4.2:Gaspard Felix Tournachon and photograph of Paris

Remote sensors entered into space with the inclusion of an automated photo-camera on German V-2 rockets launched from White Sands in New Mexico. Film cameras were attached on orbiting spacecraft (Sputnik) in 1957. Astronauts and cosmonauts orbited the globe carrying cameras to document selected regions and targets of opportunity. In the 1960s, meteorological satellites were attached with sensors that obtained black and white TV-like images of the Earth. The measurements of atmospheric properties from different

heights was achieved using the sensors on these satellites.

During the 1970s, remote sensing advanced in collecting information about the Earth when instruments were flown on Skylab and on Landsat satellites. These satellites were used to monitor ocean and land surfaces to map cultural and natural resources. The U.S.A., France, Russia and Japan privatized Landsat satellites for commercial utilization. Specialized sensors such as Coastal Zone Color Scanner (CZCS), HCMM (Heat Color Mapping Mission) and AVHRR (Advanced Very High Resolution Radiometer) were placed in orbit for feasibility and research programs by the 1980s.

Figure 4.3: Remote Sensing data

The operational responsibility of satellites were shifted from National Aeronautics Space Administration (NASA), a research and development agency to National Oceanic and Atmospheric Administration (NOAA) by 1990s. NOAA is an agency that deals with weather satellites. Satellite platforms were added with Thematic Mapper (TM) that scanned earth in different spectral bands. The spectral bands comprises of red, blue, green, near-infrared, mid-infrared and thermal infrared of the electromagnetic spectrum. Numerous development in satellite programs circle the earth, remotely sensing the planet and providing big data for analysis and implementation in 21st century.

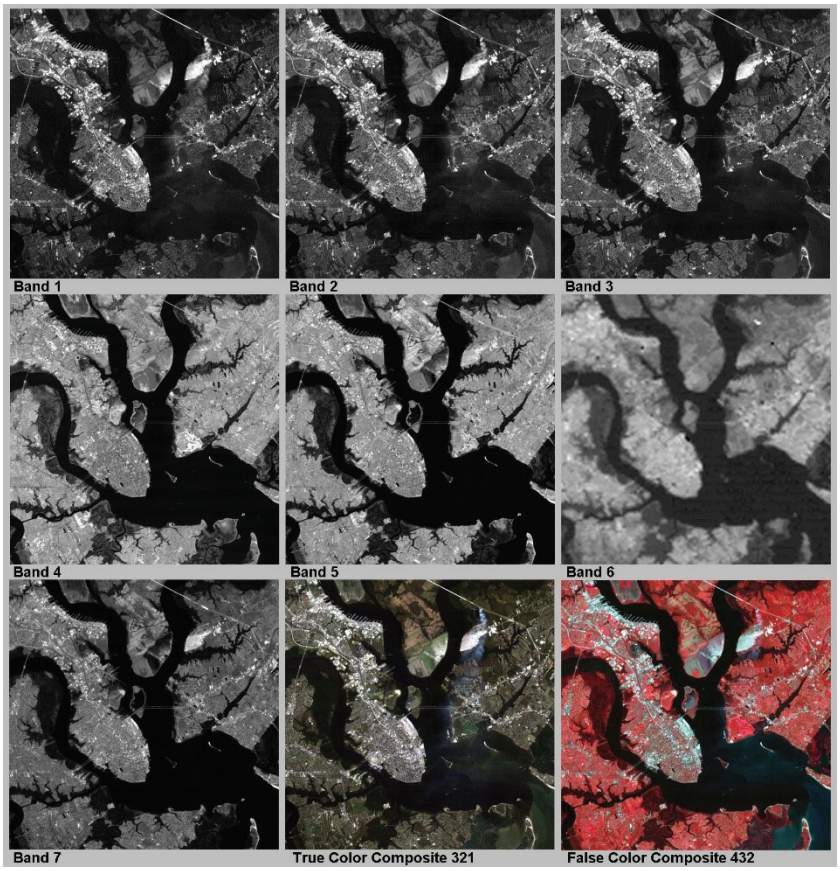


Figure 4.4

Learning Activity

Referring internet sources, frame a timeline on the history of Remote Sensing. Discuss in groups and present your findings.

4.4 Electromagnetic Radiation and Electromagnetic Spectrum

Electromagnetic radiation is the energy that Earth receives from the sun. It travels through space as wave with magnetic and electric characteristics. These wave frequencies in solar radiation is called the electromagnetic spectrum. The electromagnetic spectrum includes shorter and longer wavelengths. Sun radiates shorter wave energy with surface temperature of 5880 kelvin, approximately 10,000 degrees Fahrenheit. The Earth's surface re-radiates longer wave energy with surface temperature of 288 kelvin, about 59 degrees Fahrenheit. Satellite detectors capture a small portion of the electromagnetic spectrum.

Satellite detectors measure electromagnetic energy radiated from the earth and atmosphere. The detectors are attached on satellites and are called radiometres. Radiation of different wavelengths in separate intervals are measured using mirrors that scan places and reflects digital data to the satellites. Satellite radiometres transmits these data to earth for processing and analysis.

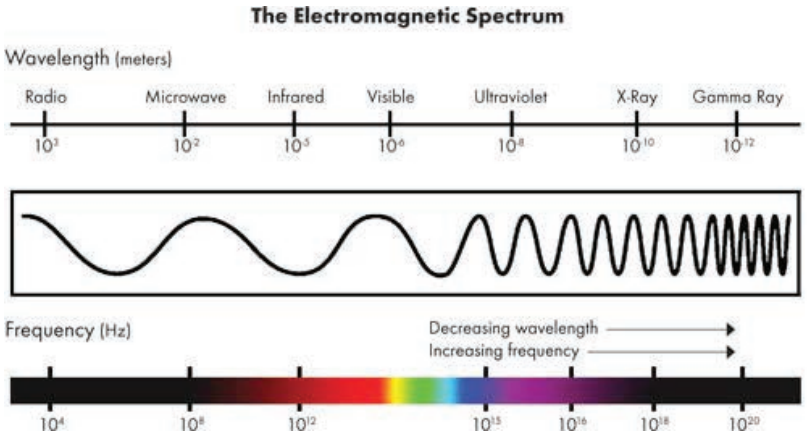


Figure 4.5

Region	Frequency range/Hz	Wavelength range/m	Applications
Radio	$10^{5} \sim 10^{10}$	$10^{4} \sim 10^{-2}$	- Electromagnetic oscillations produced by electric circuits - Received by aerial and used in communication
Microwave	$10^{10} \sim 10^{11}$	$10^{-2} \sim 10^{-3}$	- Used for rapid heating in microwave - Used to communicate with satellites i.e. mobile phones
Infrared	$10^{11} \sim 10^{14}$	$10^{-3} \sim 10^{-6}$	- All hot objects produce infrared - Used for night googles, burglar alarms etc. (since all humans emit infra-red)
Visible	10^{14}	10^{-7}	- Produced by very hot objects such as the sun - Detected by the eye - Used in optical fibre communication
Ultraviolet	$10^{15} \sim 10^{17}$	$10^{-7} \sim 10^{-9}$	- Causes fluorescence in some materials - - Used with sunbeds to produce sun tan
X-radiation	$10^{17} \sim 10^{19}$	$19^{-9} \sim 10^{-11}$	- Blackens photographic film - Used in diagnosis (x-ray scan) - Dangerous in high doses
Gamma radiation	$10^{19} \sim 10^{22}$	$10^{-11} \sim 10^{-14}$	- Produced in nuclei of radioactive elements - Used in medical diagnosis but dangerous in high dosage

Satellite radiometres comprises of diverse electromagnetic spectral intervals called spectral bands or channels. Spectral bands are combined to enhance the contrast between different

categories to measure vegetation health, track forest fires and monitor biomass.

Combination Name	Band 1	Band 2	Band 3
Natural Color	red	green	blue
Urban False Color	swir22	swir16	red
Agriculture	nir	red	green
Atmospheric Penetration	swir22	swir16	nir
Healthy Vegetation	nir	swir16	blue
Land/Water	nir	swir16	red
Natural With Atmospheric Removal	swir22	nir	green
Vegetation Analysis	swir16	nir	red

Figure 4.6

Know more (Atmospheric Window)

- Atmospheric Window is a range of wavelengths over which there is relatively little absorption of radiation by atmospheric gases.
- SWIR16 and SWIR22 are two Short-Wave Infrared bands because there are two windows in the short-wave IR region where the atmosphere is transparent with one centred around 1.6 microns, and the other centred at 2.2 microns.
- The Near-infrared (NIR) is beyond the range of human vision but is widely used in a variety of applications to separate out water and vegetation.

4.5 Types of Remote Sensing

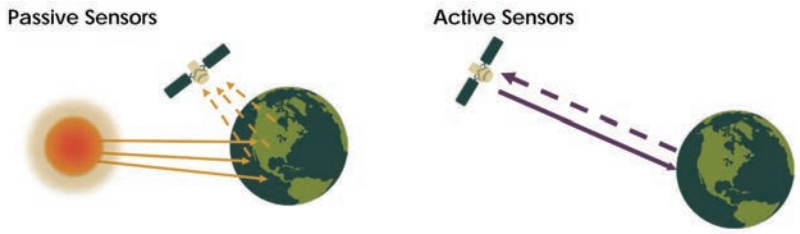


Figure 4.7: Passive and Active Remote Sensors

a. Passive sensors- Reflected sunlight is the source of radiation measured by passive sensors. It detects radiation emitted by the object being observed from the surface. Spectrometer, radiometer, spectro-radiometer, hyper-spectral radiometer, imaging radiometer, sounder and accelerometer are passive remote sensors.

b. Active sensors- The sensor provides its own source of energy for radiation in the direction of the target to be examined. It detects and measures the radiation that is returned from the target. Active remote sensors include radar, lidar and laser altimeter, ranging instruments, sounder and scatterometer.

Learning Activity

a. Access the link

https://www2.geog.soton.ac.uk/users/trevesr/obs/rseo/types_of_platform.html and complete the activity.

1. Write short notes on three types of remote sensing platforms.
2. Discuss about the three types of orbit and present the findings.

b. Complete the table

Remote Sensors	Uses
Spectrometer	
Imaging radiometer	
Accelerometer	
Radar	
Altimeter	
Sounder	

4.8 Application of Remote Sensing

a. Agriculture

Remote sensing are used for crop production forecasting, identifying planting and harvesting dates, and monitoring irrigation and management. Estimating crop production, observing weather patterns and soil types for planting and harvesting are recorded with remote sensing technology. It provide farmers with big data for increasing crop production and improve the fertility of the soil.

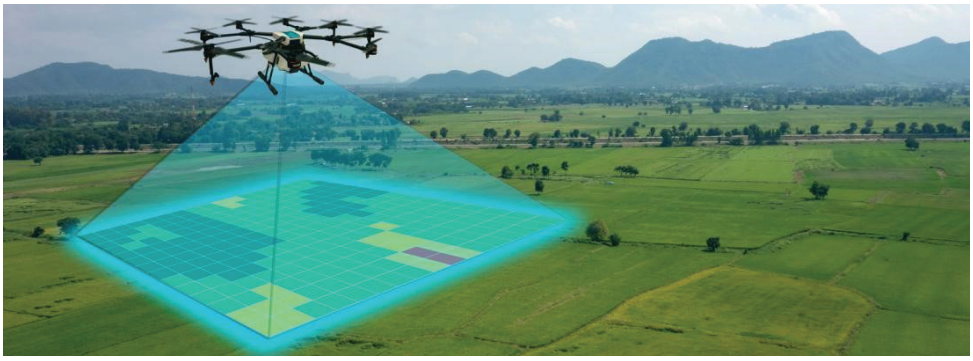


Figure 4.8 :Remote Sensing and agriculture

b. Land Use Mapping

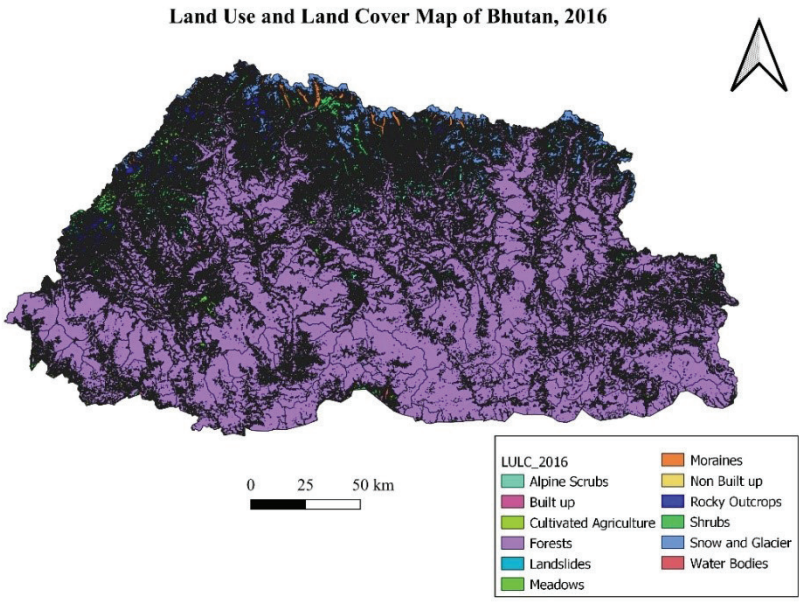


Figure 4.9: land Use and Land Cover Map

Obtaining latest information on land use patterns of vast areas and observing changes require remote sensing data. The administrator and planner uses remote sensing data to frame policies for the development of the region. The data are used for wetland and dry-land demarcation, wildlife habitat protection, urban expansion and resource management, and updating road maps.

c. Resource exploration

Updating geological, tectonic and contour maps involve remote sensing data.

These maps are used in identifying the sites for quarrying minerals and locating fossil fuel deposits. Remote sensing is used for measuring the quality and quantity of minerals being identified for exploration.

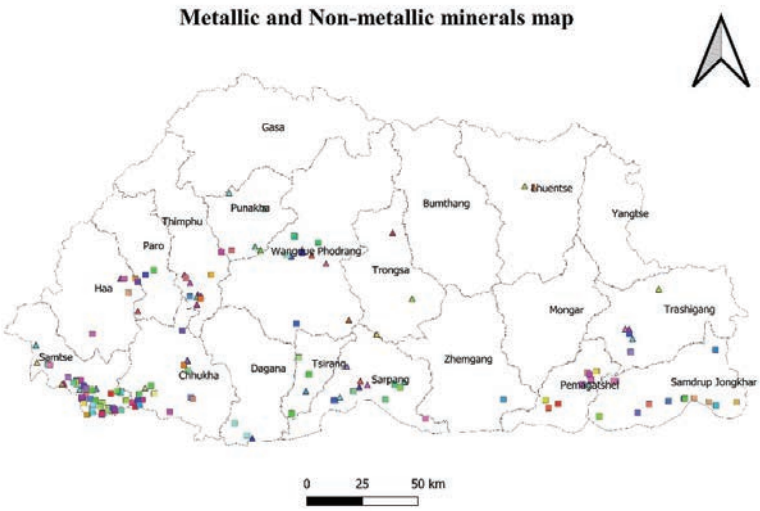


Figure 4.10: Remote Sensing and mining

d. Study of Hazards

Remote sensing data is useful in predicting the occurrence of natural and human induced hazards. Earthquakes, volcanoes, landslides, floods, polar ice melting, industrial pollution, chemical spills and ionizing radiation are studied using remote sensing. Hazard zonation and disaster preparedness maps are generated for risk assessment and making decisions.

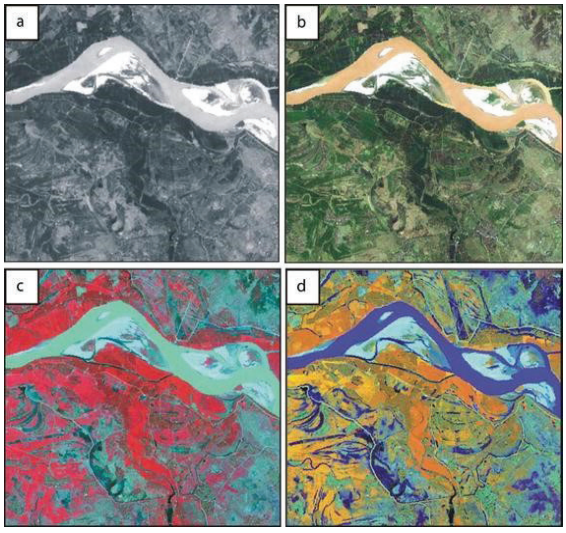


Figure 4.11: Remote Sensing and hazards

e. Weather Forecasting

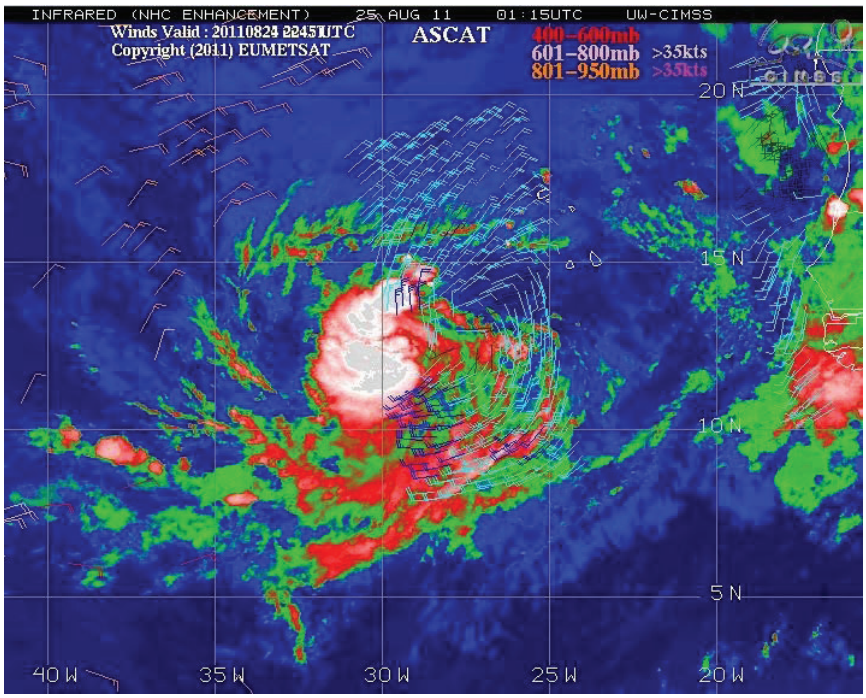


Figure 4.12: Remote Sensing and weather forecast

Remote sensing is used for observing wind pattern, atmospheric temperature and chemical concentration, and measuring the surface radiation. Remote sensing data are used for warning people about approaching cyclones and anticyclones, snowfall, rainfall and storm.

4.6 Potentials of remote sensing technology

1. Identifying and covering large areas for regional surveys is achieved through remote sensing.
2. On a variety of scales and resolutions, collection of remote sensing data becomes easier.
3. Map revision at small to medium scale is cheaper and faster with remote sensing technology.

4.7 Limitations of remote sensing technology

1. Radar emits its own electromagnetic radiation which is backscattered as signal to the sensors. These signals are disturbed when satellites are exposed to solar energy and cosmic rays.
2. Extracting information from remote sensing data for conducting biological, physical and scientific research is limited as no single sensors combine the optimal spectral, spatial and temporal resolution.

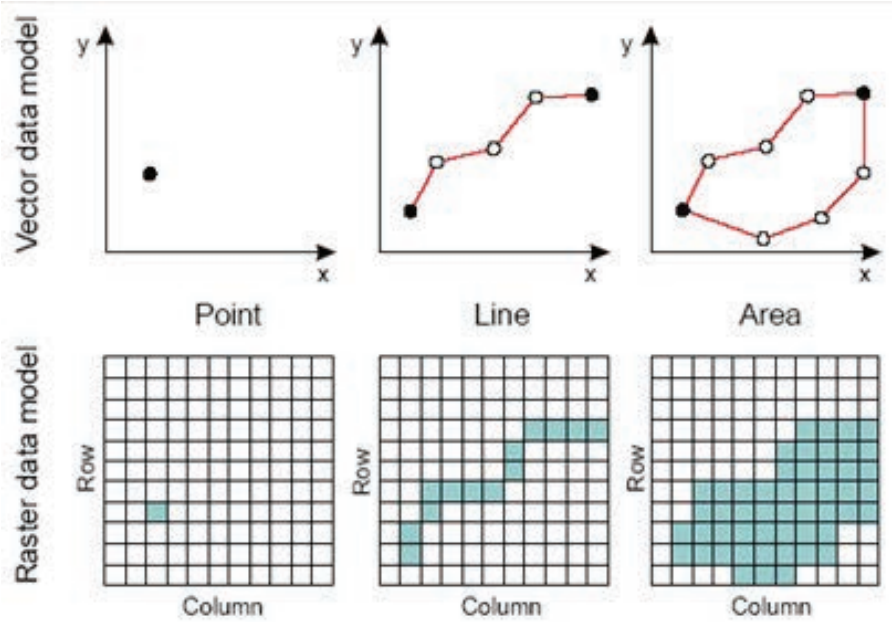
3. Large scale engineering maps cannot be prepared from satellite data.

4.8 Geographic Information System

GIS is a tool designed to capture, store, manipulate, analyze, manage and present all types of geographical data or spatial data. It is used as a tool in decision making, problem solving and visualization of data in a spatial environment. Locations on the earth, such as schools are the spatial data.

Attribute data provide additional information about spatial features, such as student capacity, level of education and school name. Spatial data coupled with attribute data enables GIS to conduct spatial analysis for problem solving. Components of GIS support and manage large datasets, conduct spatial analysis, and display information in a map or a graphical form.

Spatial and Non-spatial Data



Spatial data are in raster and vector formats. Spatial data is the representation of shape, size and location of earth, such as mountains, boundaries, settlements, buildings and roads. Raster data is the representation of images in pixel or matrix of cells into rows and columns. Raster data types, such as image palette, image, classified and continuous are stored as single colour data and composite colour data.

Vector data are represented as point, line and polygon. Point features have zero dimension and it provides latitude and longitude of respective location. Linear features are one

Reprint 2024

dimensional representation and provides the length of the element. Polygon features are two dimensional and measures the area and perimetre of a geographic feature.

	DzgName	Area_sqkm	total_po_1
1	Dagana	1722.830000000000	22375
2	Gasa	3134.450000000000	3116
3	Haa	1904.870000000000	12745
4	Lhuentse	2858.700000000000	15395
5	Mongar	1944.260000000000	37069
6	Paro	1287.130000000000	35260
7	Pemagatshel	1022.100000000000	22287
8	Punakha	1109.570000000000	23462
9	Samdrup Jongk...	1877.070000000000	33889
10	Samtse	1304.850000000000	59003
11	Sarpang	1655.380000000000	37191
12	Thimphu	1795.870000000000	94102
13	Trashigang	2203.960000000000	48783
14	Trongsa	1813.710000000000	17740
15	Tsirang	637.834000000000	13344
16	Wangdue Phod...	4035.650000000000	18667
17	Yangtse	1449.050000000000	31120
18	Zhemgang	2416.580000000000	18636
19	Bumthang	2717.330000000000	16116
20	Chhukha	1879.770000000000	74682

Non-spatial data are represented as tabular format. For example, the Dzongkhag boundary table has area and population information. Additional information are added in QGIS and ArcGIS through open attribute table option.

://www.agiratech.com/what-are-spatial-non-spatial-data-formats-in-gis

4.9 Development of Geographic Information System

Space photography, global satellite positioning and search engines like World Wide Web is improving the digital mapping concept. Digital mapping documents the real world and integrates the information into computers and smartphones for users to incorporate in day to day life. The development of GIS as desktop based format dates back to 18th century when computers were used in the field of cartography. MIMO (Map In Map Out) system and photo zincography were used for developing and printing maps.

In the mid-1960s, Roger Tomlinson developed Canadian Geographic Information System (CGIS) to store, organize and analyze data about land use in Canada. SYMAP (Synagraphic Mapping System) and GRID (Global Resource Information Database) laid the theoretical foundation for the analysis of vector and raster data for encoding and storing geographical information.

Jack Dangermond developed the first vector GIS called ODYSSEY GIS in mid-1970s. It was used for digitizing boundaries, urban areas and roads. By late 1980s, the focus was on improving the technology and making the facilities user-friendly. GIS with satellite imaging technology became the focus of commercial activity and was initiated for private and business use. The GIS application was driven by mainframe hardware with data sets from Canadian landmass in the 1990s.

The internet saw widespread adoption of GIS heading into the millennium. The technology reached governmental authorities when software company ESRI (Environmental Systems Research Institute) released ArcView, a desktop solution for mapping systems throughout the 1990s. Companies such as Nobel Systems provided services to municipalities, private organizations and cities using the technology. It allowed users to gather business intelligence and transfer data to the company headquarters for evaluation.

The turning point in the advancement of GIS marked the advent of web based cartography services such as Google Maps and GPS navigators in the beginning of the 21st century. It allowed non-professional audiences with minimal GIS technical knowledge to interact with GIS applications and use it.

4.10 Components of Geographic Information System

The Geographic Information System has five main components namely hardware, software, data, people and methods.

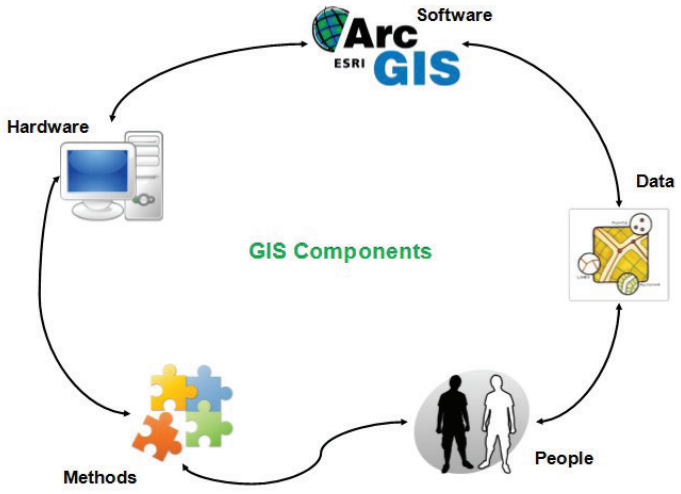


Figure 4.13: Components of GIS

a. Hardware

GIS software runs on a computer that include hardware components, such as motherboard, processor, printer and hard drive. Hardware components must have high capacity for computers to perform well. GIS software runs smoothly if all these components function together. Network computer or cloud based server allows ArcGIS software to create maps based on spatial and non-spatial data.

b. Software

GIS software includes ArcGIS, ArcView, QGIS and SAGA GIS provide tools to run and edit spatial information. It also helps in editing and displaying GIS data. Relational Database Management System (RDBMS) tool is used for storing data.

c. Data

GIS data is in the form of Raster and Vector which is the combination of graphic and tabular data. Global Positioning System (GPS) records the coordinates on the ground. These data are generally known as fuel for GIS and are considered as an expensive component of GIS. Creating GIS data from paper format or analog data is called digitization. The process of digitization involves recording of coordinates or ground control point (GCP) on a raster image and is known as geo-referencing or rubber sheeting.

Know More

GPS uses satellites that orbit Earth to send information to GPS receivers that are on the ground. GIS software program helps people to use the information that is collected from the GPS satellites.

d. People

The development in software and hardware tools allow people to access GIS software efficiently. People are considered as users of Geographic Information System. People perform advanced GIS analysis or create basic maps using computer and GIS software.

e. Methods

GIS methods include GIS software and hardware, data storing process, data management and GIS expertise. These methods are documented by different organizations for successful GIS operation. Operation of GIS, therefore, requires well-designed plan and business operation rules.

4.11 Applications of GIS

a. Urban Planning

Urban planners use GIS technology to find suitable sites for urban development, analyze the direction of expansion and its growth. For instance, identifying suitable sites for urban growth depends on accessibility, topography, water supply and electricity.

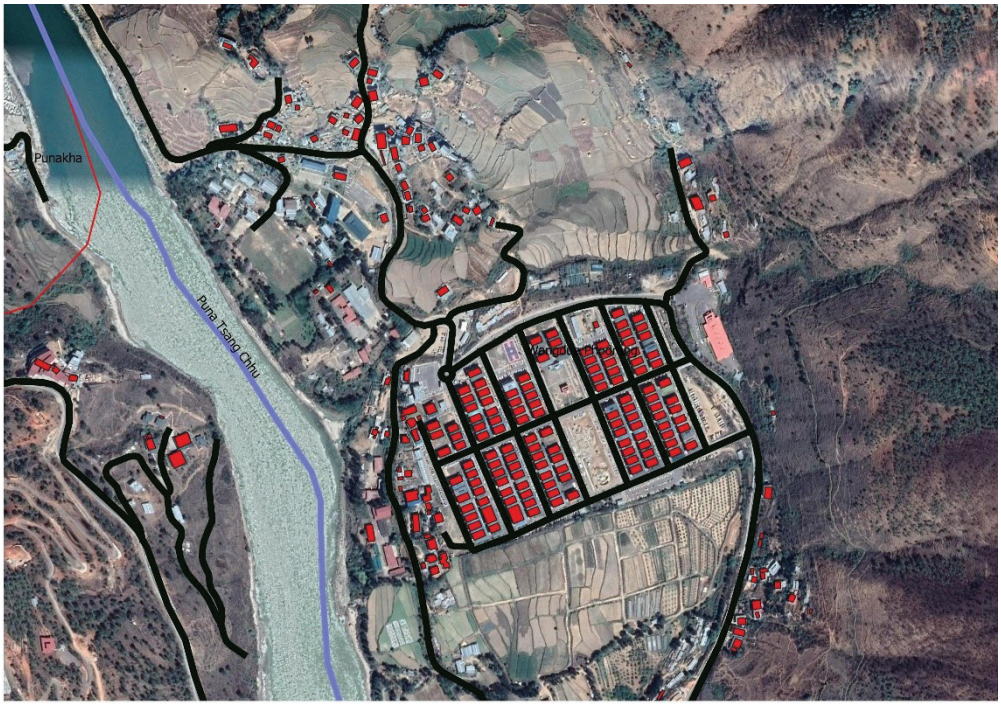


Figure 4.14: GIS and urban planning

b. Transportation Planning

GIS helps in monitoring and controlling airways, waterways, railways and road traffic. It supports the supervision of transportation and logistical problems. The construction of roads and airways is performed by adding environmental and topographical data into the GIS platform. For example, finding least environmental disturbances, selecting shortest travel distance, and finding location of amenities are achieved using GIS.

Figure 4.15: GIS and transport

c. Environmental Impact Analysis

GIS helps in analyzing the environmental impact caused by human activities. Environmental Impact Analysis (EIA) is one of the important tools to assess the impact for conservation and sustainable use of resources. This is done through integrating various GIS layers.

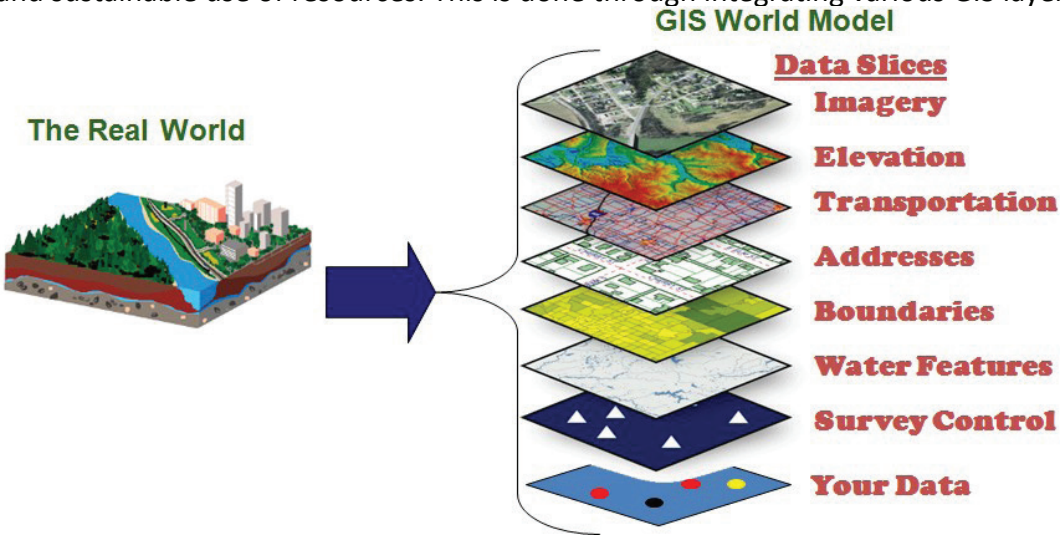


Figure 4.16:GIS and EIA

c. Disaster Management and Mitigation

GIS supports in mitigation and disaster management. Areas prone to man-made and natural disasters are displayed and identified through GIS. Preventive measures, risk management and analysis are carried out after identification of risk.

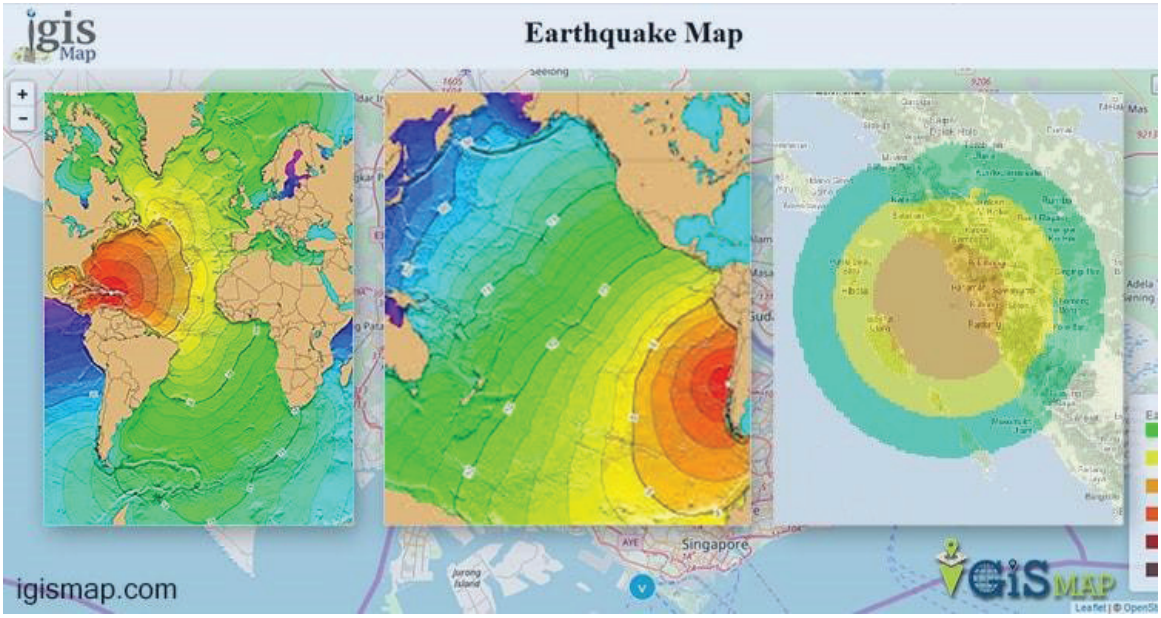
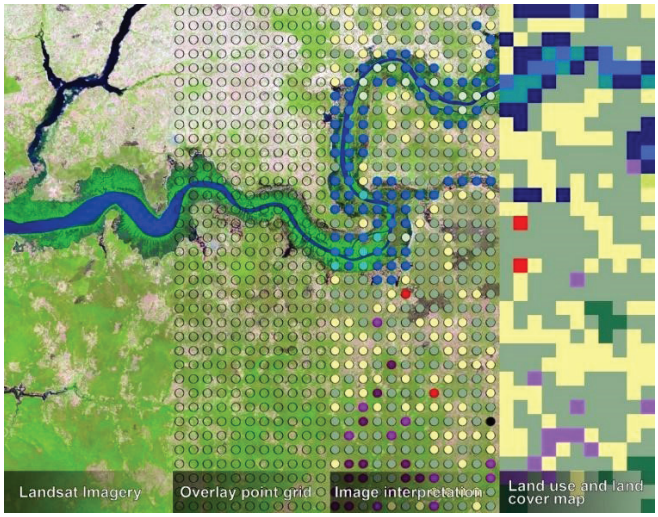


Figure 4.17: GIS and disaster management

d. Determining Land use and Land cover changes



Land use refers to area utilized for particular use and land cover is the feature covering the barren surface. It supports in detection and estimation of land use and land cover changes in different areas.

Figure 4.18: GIS and Land Use

e. Wildlife management

Threats to wildlife health and biodiversity includes pollution, climate change, invasive species introduction and habitat loss. Wildlife management professionals use GIS technology to manage, analyze and visualize wildlife data for monitoring and implementation of international management practices like maintaining wildlife habitats and populations.

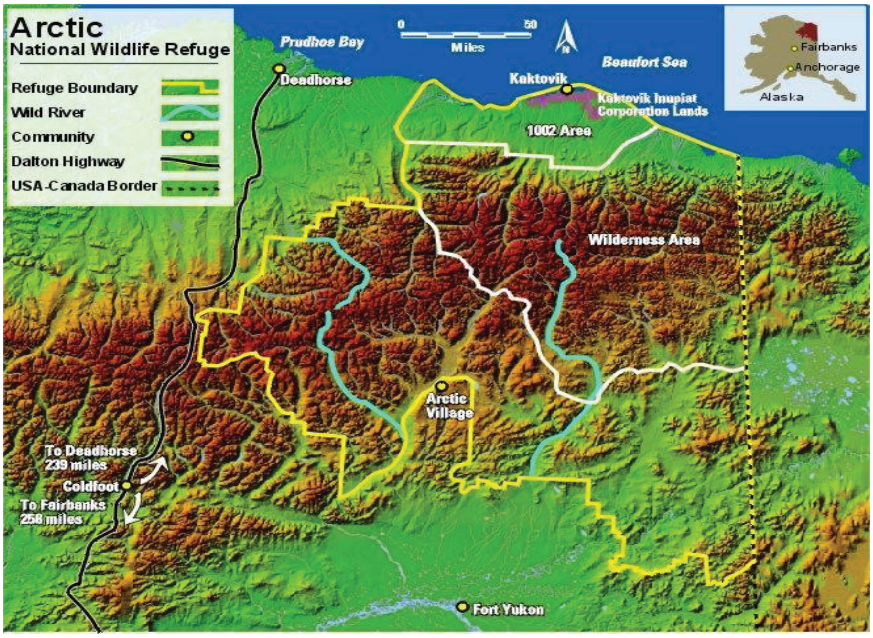


Figure 4.19: GIS and wildlife management

f. Forest Fire Hazard Zone Mapping

Forest fire causes widespread damage to natural environment and communities. GIS supports in estimating loss of forest and mapping forest fire hazard zone. Global Navigation Satellite System (GNSS) and satellite remote sensing captures real time monitoring of fire prone areas.

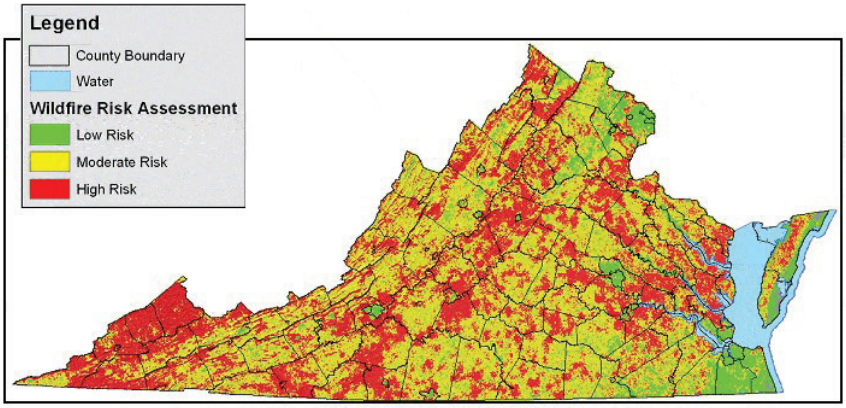


Figure 4.20: GIS and forest fire mapping

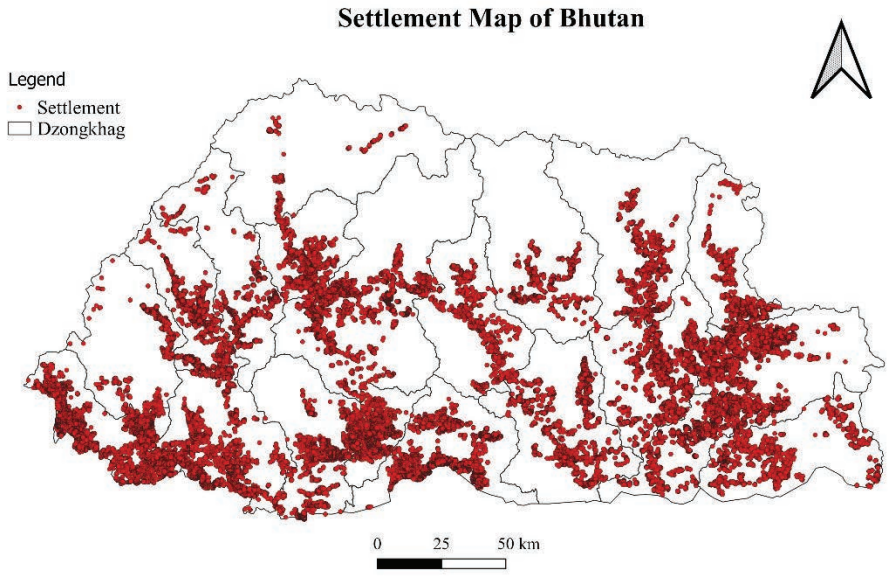
Learning Activity 2

a. Using Google Earth application, zoom into the area surrounding your school and identify different land use and land cover pattern.

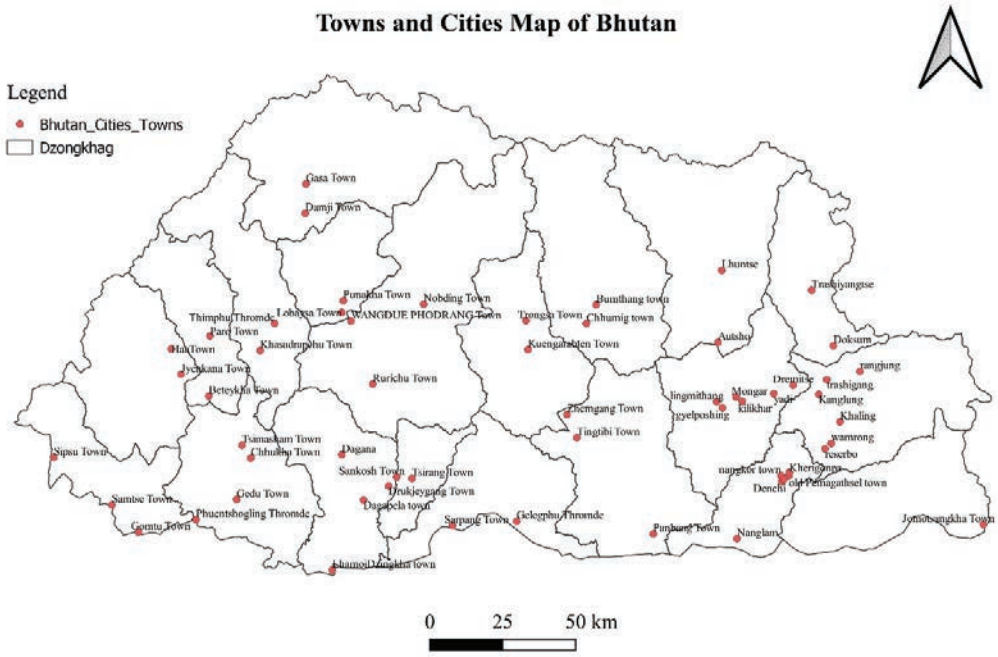
Sl. No	Land Use and Land Cover	Identity and put a (✓) where LULC pattern are visible
1.	Water body	
2.	Urban Area	
3.	Snow and Glacier	
4.	Shrub	
5.	Mixed Forest	
6.	Grassland	
7.	Conifer forest	
8.	Broadleaved forest	
9.	Barren Area	
10.	Agriculture	

b. Accessing QGIS application, create a vector based (settlement, population, rivers and buildings) map of Bhutan. Provide a brief analysis on the map.

Example 1:



Example 2:



4.12 Potentials of GIS

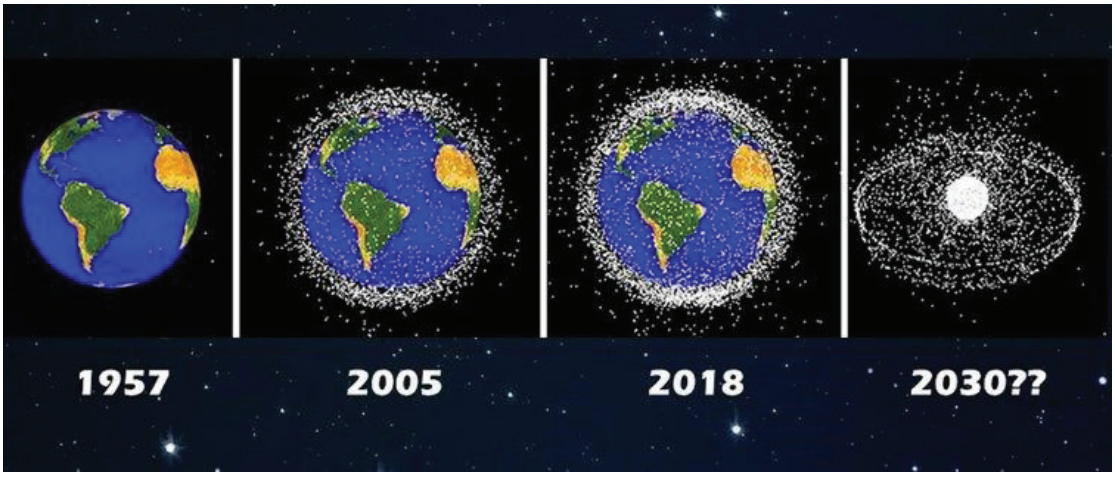
1. GIS supports capturing, analyzing, managing and displaying information being geographically referenced.
2. GIS provides employment opportunities as it can be integrated into any enterprise.
3. Integrating GIS software reduces cost and increases efficiency. Labour cost is saved, improving work flow with inclusion of big data and artificial intelligence.

4.13 Limitations of GIS

1. GIS deals with a massive data input that requires specialized personnel to handle hardware and software components.
2. It consists of complex map structures which is difficult to integrate with traditional maps.
3. Collecting, storing and analyzing data is tedious and time consuming. Analyzing enormous data leads to generalization and loss of information.

Test Yourself

1. The given figure shows debris from satellites termed as space junk. Explain in detail.



2. How can students use GIS and remote sensing data for educational purposes?

3. Access Google Earth application and zoom into the capital city of Bhutan, Thimphu. Click on the show historical imagery button and a time slider will pop up. Slide the button on the slider into the year 2003 and year 2019.

   Note down the observations between 2003 and 2019.

Area/Structures	2003	2019
Changlimithang stadium		
Golf Course Area		
Taba Area		
Babesa Area		

4. Refer to the link https://earthengine.google.com/timelapse/ and complete the following questions:

   a. Critically examine and explain the changes seen on the time lapse of Columbia glacier from 1984 to 2020.

   b. What are the advantages and disadvantages of using the web-based application on monitoring glacier retreat in Columbia?

Chapter Five

Properties of Soil

Learning Objectives:

- Describe the properties of the soil.
- Distinguish soils for various uses.

5.1 Introduction

Soil is a complex mixture of minerals, water, air and organic matter consisting of decayed remains of plants and animals. It contains minerals, organic matter, water, air and combination of these elements determine the soil's properties. The physical properties of the soil include texture, structure, density, moisture, infiltration and porosity of the soil. Nutrient content, salinity, pH, organic matter and mineral content in the soil describes the chemical properties of the soil and the biological component of the soil includes activity of microbes, biomass, biodiversity and biological activity.

A healthy soil is important for healthy growth of plant, human nutrition and healthy environment. Soil provides nutrients and water to the plants and it provides nutrition, services and various products to the humans. The soil nitrogen cycle helps to maintain and balance life in the Earth's ecosystem.

Know More

Pedologist is a scientist who studies origins, composition and distribution of soils and the materials from which soils are formed.

Learning Activity

Collect different sample of soils from your school surrounding or locality and examine its similarities and differences. Present your findings to the class.

5.2 Properties of Soil

The soil properties can be categorized into three: physical, chemical and biological properties.

i. Physical properties of a Soil

It includes colour, texture, structure, porosity, density, consistence, temperature and air. The colour of the soil is determined by the minerals present in it. Soils with high iron content are deep orange- brown to yellowish-brown, whereas dark brown or black soil indicates presence of high organic matter. The water holding capacity of the soil also determines the colour of the soil.

Figure 5.1: Different colours of soil

The soil texture refers to the proportion of sand, silt and clay, which make up the mineral fraction of the soil**.** Most soils are a combination of the three. The relative percentage of sand, silt, and clay gives soil texture.

Soil structure is the arrangement of soil particles into small clumps, called peds or aggregates. The structure of the soil relates to the pore space in the soil which determines the plant root growth, air and water movement. Soil particles (sand, silt, clay and organic matter) bind together to form peds. Soil are granular, blocky, columnar, platy and massive or single-grained depending on the composition and conditions in which the peds are formed.

Know More

peds refers to structural units of soil.

The soil structure can be best explained through textural triangle. The textural triangle describes proportions of different sized mineral particles in the soil or relative amount of sand, silt and clay present in the soil expressed as percentages.

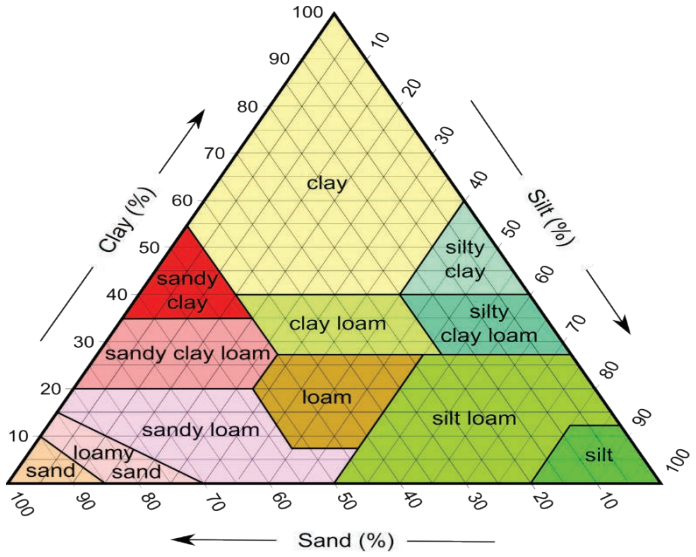


Figure 5.2: Soil textural triangle

Learning Activity

Refer figure 5.2 (soil textural triangle) and complete the table

Sl.no	% sand	% Silt	% Clay	Soil Texture
Example	75	10	15	Sandy loam
1	42		37	
2		52	21	
3		35	50	
4	64	30		
5	50		40	

The amount of air and water present in the soil vary from place to place and time to time. The concentration of water will be higher compared to air in wet places and during rainy season. The rate at which soil can absorb water is called *infiltration rate*. Soil water helps dissolve nutrients which move through pores. The processes of removal of dissolved material from one layer to another due to movement of water during excessive rainfall is called *Eluviation*. The loss of nutrients and minerals in the upper layer of the soil due to eluviation is *leaching.* The rate of leaching depends on the amount of rainfall, temperature and vegetation.

Know More

Accumulation of dissolved materials in one layer of soil due to Eluviation is called Illuviation. Illuviation helps in studying composition and ages of rock.

Sometimes water on the surface of the soil is lost through evaporation so plant roots pull the water from beneath. This process is called *capillary action*.

Learning Activity

Study figure 5.3 and discuss the impact of capillary action on plants.

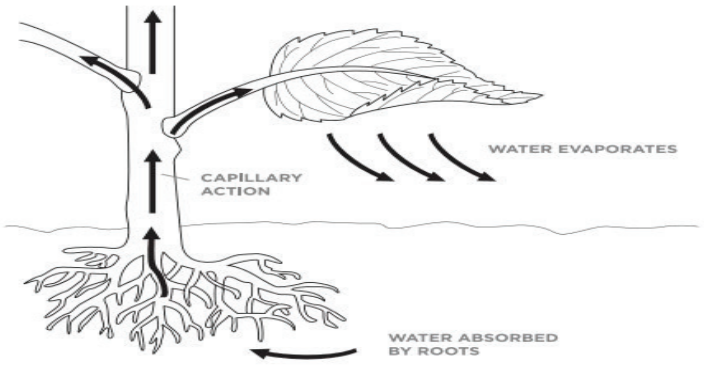


Figure 5.3: Capillary Action of Plants

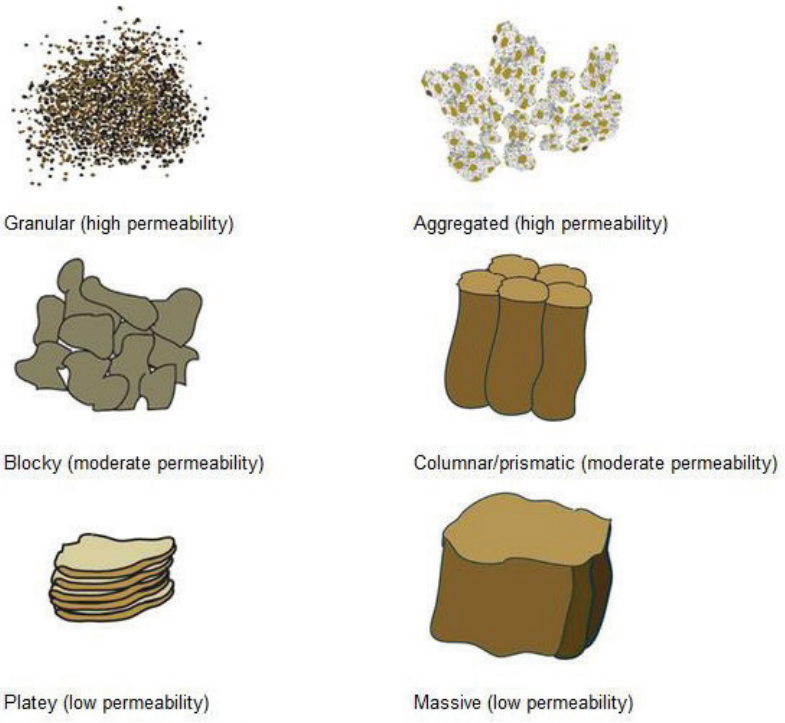


Figure 5.4 : Structure of soil

Know More

Combination of organic fragments with inorganic particles is called the "**clay-humus complex**."

ii. Chemical Properties of a soil

The chemical properties of soil is determined by organic and inorganic component. The nutrient contents, pH, and salinity are the major dissolved inorganic solutes in the soil. Soils are Acidic or Alkaline based on its chemical properties. The chemical properties of a soil has great importance in soil formation and crop production.

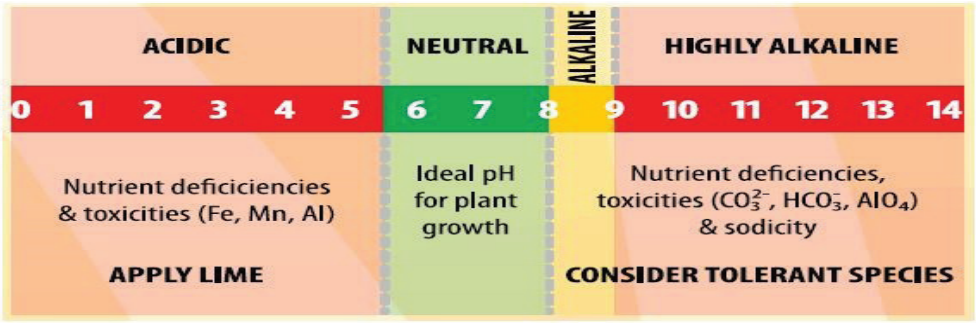


Figure 5.5: Soil pH level

Learning Activity:

Identify different areas with diverse structure of soil in your locality and conduct soil test with soil testing kit or Pantry pH test and share your findings.

iii. Biological Properties of a soil

The biological properties of the soil include organic matter and soil organism. Organisms play an important role in maintaining quality and fertility of soil. Organisms in the soil determines the formation of humus which is essential for growth of plants and crops.

Learning Activity:

Study the figure 5.6 and discuss the importance of humus soil for the growth of plants.

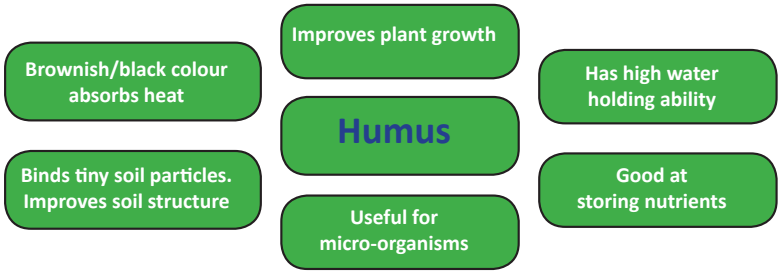


Figure 5.6 Characteristics of Humus soil

Know More

Soil taxonomy or classification is the grouping of soils on the basis of its morphology(texture and structure), appearance, form and fertility.

5.3 Uses of Soils

Soil provide humans with many services and products. These services are broadly categorized into four by the soil scientists; supporting soil ecosystem services, regulating soil ecosystem services, provisioning soil ecosystem and cultural soil ecosystem services.

Supporting soil ecosystem services: Soil is a home to the world's largest biodiversity. Soil also holds the nutrients plants need to survive, and provides strong support for the roots and stems.

Regulating soil ecosystem services: These are services that regulate the quality of air, water, and other resources, and provide controls on climate, flooding, and even disease. For example, soil act as a sponge in cleaning water.

Provisioning soil service ecosystems: The plants that are grown in soil can be used for food, clothing, recreation, aesthetics, building materials and medicines. The minerals that make up soil particles can be used for dyes, make-ups, and medicines, or shaped into bricks, plates, and vases. Soil minerals have unique properties that provide people with hot springs, adobe brick, quartz jewelry, and clay for pottery.

Cultural soil ecosystem services: Soils have a strong link with culture. Egyptians used soils for paint, many famous paintings include soils in their landscapes and even songs and books have been written about soils.

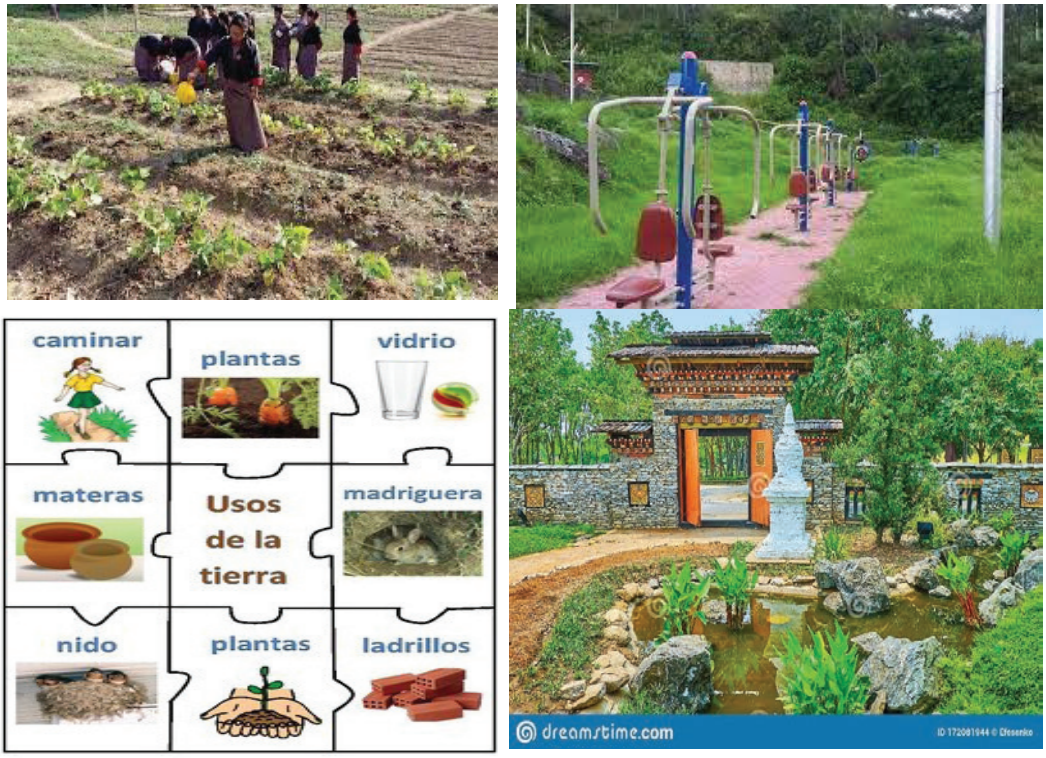


Figure 5.7: uses of soil

Soils are of various types according to its properties and each type of soil has its own uses. For instance clayey soil is used to make pottery, sturdy building, ceramics, paper coating and paper filler. Soil also produce energy like any other sources. The microbial fuel cell uses microbes to generate energy from organic materials like soil.

Know more: Microbial fuel cells exploit the electrochemical characteristics of certain bacteria or micro-organism and plant systems for low-temperature reactions that generate electricity.-Earth Systems and Environmental Sciences, 2016

Soil serves as a storage reservoir for nutrients and water needed for plant growth. Soil properties are essential for crop production and plays an important role in examining the soil quality favorable for the growth of plants. The proper study of soil properties will also help in risk assessment of the particular environment. For instance, Intervention like soil conservation, green manuring, soil testing, remineralization and addition of fertilizers play major role in establishing, self-sufficient fertile soils. Appropriate intervention at the right time will help in regeneration of soil fertility.

Test Yourself

1. Discuss the impact of use of natural and chemical fertilizers on farming.
2. Soils are of various types and each of this types plays a vital role. How does a change in soil type cause change in other organism on the Earth surface? Explain.
3. Examine the factors responsible for degradation of soil in a mountainous country like Bhutan.
4. What is the reason for infertile top soil in an area which receives heavy and continues rainfall? Suggest measures to overcome it.
5. Is acidic soil bad for the growth of all types of plants? Support your answer with reasons.
6. A region which was once green and lustrous changes into desert. The soil that supported varieties of plant growth and animal habitat turns hard and dry. Explain some of the factors that might have caused these changes.

CHAPTER SIX

Agriculture

Learning Objectives

- Explain the features of agriculture.
- Discuss the development of agriculture in Bhutan.
- Examine the scope of agriculture in Bhutan.

6.1 Introduction

Agriculture is one of the most important and oldest activities in Bhutan. According to RNRS statistics, 2019 approximately 80% of the population of Bhutan is involved in agriculture. Agriculture is the main source of livelihood for 69% of the population. The major crops cultivated in Bhutan are rice, maize and potatoes. The majority of Bhutanese farmers are small land holders with an average farm size of 3 acres and practice a self-sustaining integrated farming system. The agriculture sector employs about 70 % of the population, and the rural economy is still primarily based on subsistence agriculture.

In recent years vigorous development has taken place in terms of approaches, methods and use of technologies for farming.

6.2 Features of Agriculture in Bhutan

The Bhutanese agriculture is determined by the following features:

i. Landscape

Bhutan is a mountainous country with a variation in altitude. The variation in altitude has led to diverse climatic conditions. The climatic conditions ranges from hot and humid in the south to cold alpine climate in the north. These variation in climatic conditions has resulted in variation in growing season which affects the growth of crops. The type of crops grown varies with altitude, agro-ecological zone and types of crops cultivated across the country.

Agro-ecological zone	Altitude range (masl)	Annual rainfall (mm)	Farming systems, major crops and agricultural produce
Alpine	3 600–4 600	<650	Semi-nomadic people, yak herding, dairy products, barley, buckwheat, mustard and vegetables.
Cool Temperate	2 600–3 600	650–850	Yaks, cattle, sheep & horses, dairy products, barley, wheat & potatoes on dryland, buckwheat & mustard under shifting cultivation.
Warm Temperate	1 800–2 600	650–850	Rice on irrigated land, double cropped with wheat and mustard, barley and potatoes on dryland, temperate fruit trees, vegetables, cattle for draft and manure, some machinery and fertilizers used.
Dry Temperate	1 200–1 800	850–1 200	Maize, rice, millet, pulses, fruit trees and vegetables, wild lemon grass, cattle, pigs and poultry.
Humid Subtropical	600–1 200	1 200–2 500	Irrigated rice rotated with mustard, wheat, pulses and vegetables, tropical fruit trees.
Wet Subtropical	150–600	2 500–5 500	As for the humid zones – irrigated rice rotated with mustard, wheat, pulses and vegetables, tropical fruit trees.

Source: MoA, 2002

Figure 6.1: Agro ecological zones of Bhutan

ii. Size of land holding

According to the RNR Census of Bhutan 2019, the percentage of arable land was estimated at 2.83 percent. Farmers are not able to use modern technology due to small land holding. Moreover, the inheritance system of land has led to land fragmentation making it difficult for commercial agriculture.

iii. Land use and land cover

The nature of landscape and climatic factors has determined the nature of land use and land cover in Bhutan. The land use types are dry land (Kamzhing), Wet land (Chhuzhing) and orchards are the main agriculture land use types in the country.

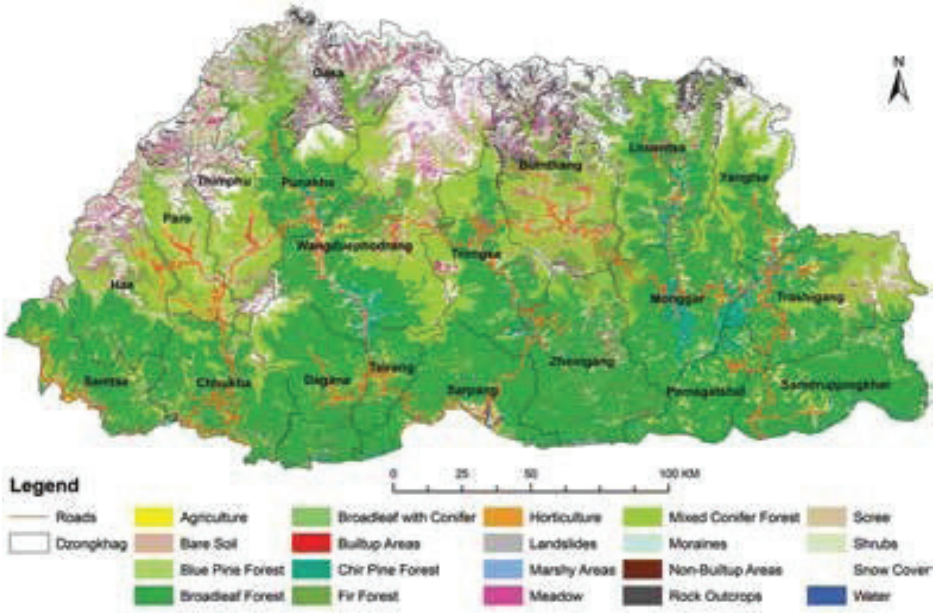


Figure 6.2: Land use land cover map

iv. Methods of farming

Subsistence farming is an integral part of the Bhutanese agriculture. In recent years efforts have been made towards semi-commercialization. The predominant farming practices in Bhutan is mixed farming which is characterized by crop cultivation, raising livestock and using forest resources. Farming practices are livestock farming, organic farming, conventional crop production and aquaculture.

Cropping pattern: Multiple cropping is a common feature of farming in Bhutan. The farmers have innovated and adopted multiple cropping as one of the simple mechanisms to produce more per unit area. The predominant multiple practices are crop rotation mainly in the form of sequential planting; intercropping, relay cropping, random mixed cropping, line sown mixed cropping, multiple cropping of forage with food and horticulture crops, strip cropping and agro-forestry.

Figure 6.3: Different types of cropping pattern

a. Crop Rotation

It is a method of sequential planting of two or more varieties of crops in the same field.

b. Intercropping

It is a multiple cropping practice that involves growing two or more crops in proximity. It is common in the maize production zone in the rain fed drylands. Some examples of intercropping are soya bean and maize and cow pea & millet

c. Relay Cropping

Relay cropping is a method of multiple cropping where one crop is seeded into standing second crop well before harvesting of second crop. The key feature of this system is that

the tall and robust maize plants are used as the physical support by the beans to complete its life cycle.

d. Mixed Cropping

Farmers plant various combination of crops depending on market demand and it is more dynamic in vegetables.

e. Strip Cropping

The growing of different crops on alternate strips of ground that usually follow the contour of the land, a recourse to minimize erosion.

Multiple cropping offers opportunity to develop subsistence production system to an intensive agriculture system which can help meet food and nutritional security of the small farmers.

i. Monsoon Fed

Agriculture in Bhutan depends on monsoon rain. The amount of rainfall received determines the growth and types of crops grown in an area. Different stakeholders have initiated to provide adequate irrigational facilities in some parts of the country..

ii. Market

Most of the farmers sell their surplus products in a locality. In the past, lack of transportation facilities was the main hindrance for farmers to access market. Development activities has resulted in easy access. Farmers in Bhutan practice multiple cropping where farmers grow varieties of crop in small land holding restricting production of large quantity of one crop. Thus, products are not able to compete at the international level.

6.3 Development of Agriculture in Bhutan

The Department of Agriculture was formed in 1972. Until 1970, vegetable production was limited to kitchen gardening. In the early 1980s, release of 30 different crop varieties and diversification of vegetable cultivation of new crops like cabbage, cauliflower, peas, beans, asparagus, broccoli, onion and carrots significantly contributed to cash income and nutrition of the rural population. Organic farming, hydroponic, value added enterprises, and digital farming are some of the latest developments in agriculture.

Bhutan has embraced the ambitious goal of becoming the world's first 100% organic nation. Organic agriculture generally promotes systems that are built on ecosystem management

rather than external chemical inputs. The Ministry of Agriculture and Forests (MoAF) has adopted an Organic Masterplan in 2012.Organic farming is a strategy to produce high value crops for sustainable agriculture.

Figure 6.4: *Hydrponic* farming

Know More

The concepts of organic agriculture were developed in the early 1900s by Sir Albert Howard, F.H. King, Rudolf Steiner, and others who believed that the use of animal manures (often made into compost), cover crops, crop rotation, and biologically based pest controls resulted in a better farming system.

Learning Activity

1. Hydroponic is a recent development in Bhutanese agriculture. How has this improvised methods of faming in Bhutan? Refer relevant source and share your findings.
2. Bhutanese farmers produce huge quantity of potatoes but they are not able to make much profit. Discuss some ways for profit maximization and share.

The most recent development in agriculture is Climate Smart Agriculture (CSA).The water accessibility has serious consequences to overall agriculture. The Royal Government of Bhutan has identified climate smart sustainable management and utilization of natural resources as one of its priority goals. CSA focuses on adapting strategies for sustainable agriculture development. The most common impacts of climate change to agriculture in Bhutan is predicted to be water insufficiency both in terms of rain and irrigation water. CSA aims to achieve food security and broader goals.

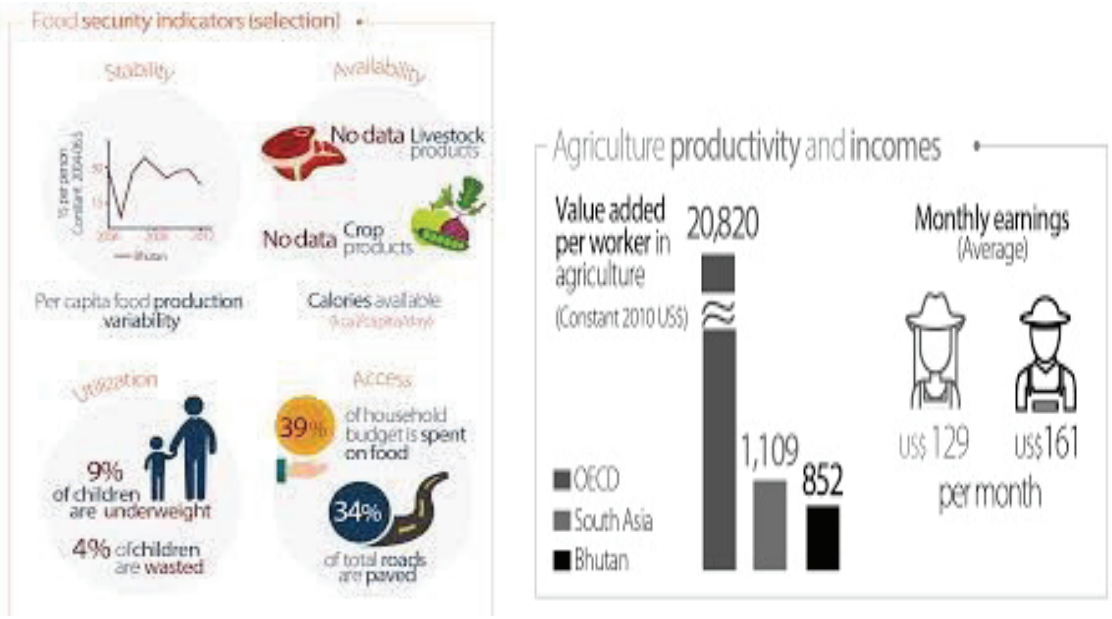


Figure 6.5: steps of CSA in Bhutan (replace with high resolution picture)

6.4 Scope of Agriculture in Bhutan

The adoption and implementation of new ideas in agriculture has provided ample scope for Bhutanese population. Bhutan's ability to increase Gross National Happiness (GNH) is highly dependent on the performance of its Renewable Natural Resources (RNR) sector, which agriculture, livestock and forest. Agriculture practice in the past was based on imported ideas and technology. Over the years the department initiated a massive development in use of tools, farming methods and started adopting farming technology as a package. Research and extension system has come a long in Bhutan. The MoAF has gradually built a comprehensive network of research centres and an effective extension system.

Figure 6.6: Research Centers

In 2001, Bhutan enacted the Co-operatives Act, which provides a legal framework for co-operatives and farmers' group encouraging farmers to set up co-operatives besides providing them with technical and financial support. Co-operative farming has provided employment through partnership and entrepreneurship. This approach has not only provided employment to youths but also platform for exchange of ideas and experiences among various stakeholders.

The agricultural activities has helped unleash, strengthen and maintain the ability of people, organization and society as a whole.

Learning Activity

Refer the article given and discuss how agriculture has become a promising enterprise? Present your findings.

Article

While men of his age are either working as civil servants or running a business, 50-year-old Sherub Nima from Thrizor village in Khaling, Trashigang, is going strong as a farmer and has become an inspiration to those who shy away from agriculture.

Sherub, who is into commercial vegetable cultivation for the last three years, has made farming a lucrative affair earning him more than Nu 100,000 annually. This year, he earned around Nu 300,000, making it the highest so far.

He grows varieties of vegetables such as broccoli, cauliflower and potatoes. His wife, Ugyen Tshomo, is not just his companion, but his farming partner as well. Recently, they ventured into onion cultivation after the prices shot up amid the pandemic.

"My husband is responsible for marketing our farm produce. I would say that vegetable cultivation is a lucrative business," said Ugyen Tshomo.

Besides other varieties of vegetables, Sherub Nima has been cultivating mushrooms for three years. "Last year I harvested around 160 kilograms of mushroom and earned Nu 50,000. And this year, the returns were more. I have put up 500 new kinds of wood for mushroom plantation," he added.

Taking his inspiration, locals in the village have also taken up commercial vegetable cultivation.

"I earn Nu 70,000-80,000 from vegetable annually. But we lose most of our vegetables to wild animals. We would be grateful if we are provided with electric fencing." said Kelzang Dema, a local in the village.

Jiri-Lemi Primary School used to purchase the vegetables from the farmers. But with school closure amid the pandemic, they have started selling it to Khaling, Kanglung and Trashigang.

Sonam Darjay

Source : http://www.bbs.bt/news/?p=141122

In the past few years, agriculture became very challenging. Factors like lack of labour due to rural -urban migration, lack of market place and not being able to adopt technological package were hindrance to the development of agriculture. However, with adequate technical and financial support, profitable and sustainable farming can be made attractive to youth entrepreneurs. Retaining and encouraging youths to promote agriculture in rural areas can substantially enhance food security in Bhutan. The shift in production to value added products has also provided a scope for wide range of entrepreneurship. The Covid-19 pandemic in 2020, has provided opportunity for Bhutan to realize its huge potential for sustainable agriculture. It has given farmers the opportunity to substitute a large portion of the country's vegetable and meat requirement that are imported from India.

Sustainable development of agriculture in Bhutan faces several challenges. However, sustainable farming models and vibrant processing businesses have provided opportunities for private sector development in Bhutan.

Test Yourself

1. Multiple cropping is a common farming practice in Bhutan. Give reasons.
2. 'Bhutan is an agrarian country, however, few products are being exported to other countries'. Support this statement.
3. Refer relevant source to explore the scope of Smart Agriculture and Analyze.
4. "If we can give agriculture one earnest push today, we will see that many of our biggest problems have gone away. We will wake up to see that suddenly unemployment is no longer a national issue. And we have enough to feed ourselves."-The Prime Minster of Bhutan, 2020.

   Critically analyse the statement.
5. Shade agro ecological zones on an outline map of Bhutan with proper legend.
6. Referring articles or by watching videos of the recent agricultural development taking place in other countries, suggest any one development that you think would bring revolution to Bhutanese agriculture. Support your answer with relevant reasons.

CHAPTER SEVEN

Insolation, Temperature and Atmospheric Pressure

Learning Objectives:

- Discuss temperature and pressure
- Explain the causes and consequences of a shift in world pressure and wind belts

7.1 Introduction

The Sun is the primary source of solar energy to the Earth. The Sun provides heat and light energy to the Earth which is known as solar radiation. The amount of solar radiation received by the surface of the Earth over a given area in a given time is called insolation. It is expressed in kilowatt-hours per square meter per day (kWh/m^2/day). The insolation is not uniform on the Earth and varies spatially and temporally. The amount of insolation determines the temperature and pressure of a place, affecting the wind systems.

7.2 Factors affecting the distribution of insolation

The amount of solar radiation that reaches any particular point on the ground depends on several factors:

7.2.1 Angle of incidence

Sun rays are almost vertical (high angle of incidence) at the equator, receiving more insolation. The angle of incidence decreases with an increase in latitude.

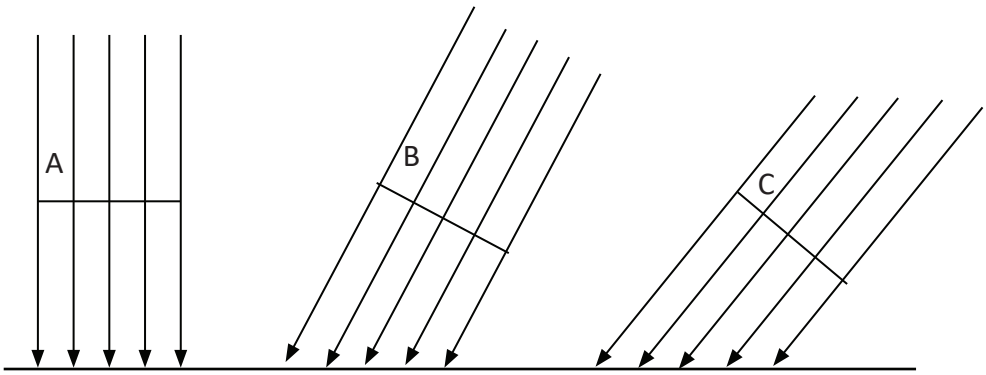


Figure 7.1: Angle of incidence

7.2.2 Distance between the Earth and Sun

Earth receives maximum and minimum insolation at the time of perihelion and aphelion, respectively.

7.2.3 Transparency of the atmosphere

The presence of atmospheric gases and aerosols determine the transparency of the atmosphere. An area receives maximum insolation when the atmosphere is transparent.

7.2.4 Length of the day

The duration of daylight determines the length of the day. The longer the duration of the day, the greater is the amount of insolation received. The length of the day varies with Earth's position on its orbit during the revolution around the Sun.

7.3 Distribution of Insolation

Generally, daily average insolation decreases with an increase in latitude. However, the insolation in high latitudes is more significant at the summer solstice than near the equator. The distribution of insolation also varies depending on the season. For instance, during summer solstices, daily average insolation is higher in the months of May, June, July, and August (*Fig. 7.1)*.

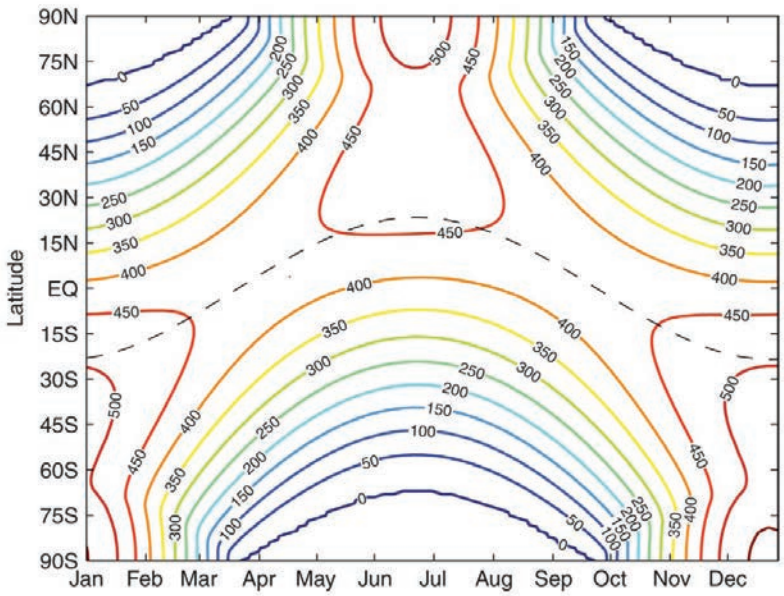


Figure 7.2: Isotherm of the daily average insolation. Adapted from The Global Energy Balance by Hartmann (2016).

Learning activity

1. Explain the factors affecting the distribution of insolation, referring to *Figure 7.2.*

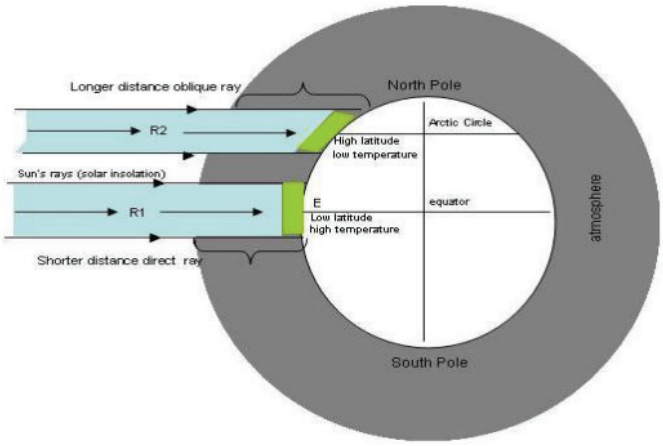


Figure 7.3. Factors affecting the distribution of insolation.

7.3.1 Temperature

Temperature is the degree of hotness or coldness of an object expressed in the Fahrenheit scale, Celsius scale, and Kelvin scale. The daily mean temperature is an average of the maximum temperature and minimum temperature recorded during a day.

7.3.2 Factors affecting temperature distribution

The factors affecting the distribution of temperature are:

i. Insolation

The temperature of any particular place depends primarily on the amount of insolation. The higherr the angle of incidence,the higher is the temperature.

ii. Latitude

Regions of lower latitudes experience high temperatures because of vertical sun rays. Low latitude areas in the equatorial region record higher temperature than the higher latitude areas in the polar region.

iii. Altitude

Temperature decreases with increasing height from the earth surface. Low lying areas record higher temperatures than the mountains.

iv. Nature of Surface

Different surfaces have varying degrees to absorb and release heat. For example, snow-covered surfaces record low temperatures as it reflects a significant amount of solar radiation.

v. Prevailing winds

Wind transports the heat and thermal energy on Earth. The wind blowing from the low latitudes raises the temperature of the higher regions.

vi. Local relief

South-facing slopes in the northern hemisphere receive more heat than north-facing slopes.

7.4 Horizontal distribution of temperature

Earth experiences a wide variation in the horizontal temperature gradient. The maximum mean temperature is recorded in the equatorial regions. The temperaturevariation is more pronounced in the northern hemisphere because of the presence of large landmasses (Fig. 11.2). The changing of the seasons also influences temperature distribution. During summer, regions in the northern hemisphere record higher temperatures.

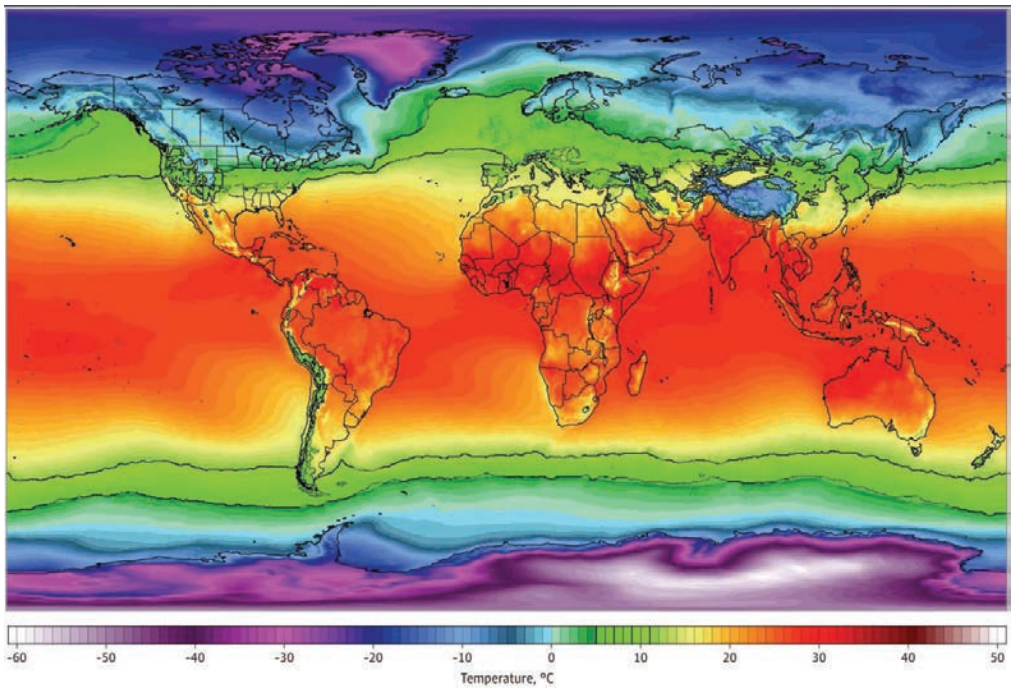


Figure 7.4. World 2-m Mean Temperature Map, March to April 2019. Adapted from Sajadi et al. (2020).

7.5 Vertical distribution of temperature

The decrease of temperature with increasing altitude in the atmosphere is called the vertical temperature gradient. On average, the rate of decrease of temperature with increasing altitudes in a stationary column of air with an absence of any vertical motion is 6.5°C/1000 meters. However, temperature increases with elevation in certain layers of the atmosphere.

Learning activity

1. 'We get more sun burn during the winter than summer season'. Discuss and share your views with the class.
2. Discuss the distribution of temperature in the Southern Hemisphere when it is summer in Bhutan. Share your findings with the class.

7.6 Atmospheric Pressure

Air is held to the Earth by gravity giving air molecules weight. The weight of air molecules exerts a force upon everything on the Earth. The amount of force exerted on a unit surface area is known as atmospheric pressure or air pressure. On average, at sea level, the standard value of the atmospheric pressure is 1013.25 millibars, 29.92 inches of mercury, and 14.7 lbs/sq in. Atmospheric pressure is an indicator of weather. For instance, low-pressure systems usually lead to stormy weather.

7.7 Pressure belts

There are seven pressure belts on the globe, high and low alternate pressure belts in the northern and southern hemispheres and one common equatorial low-pressure belt (Fig. 7.5).

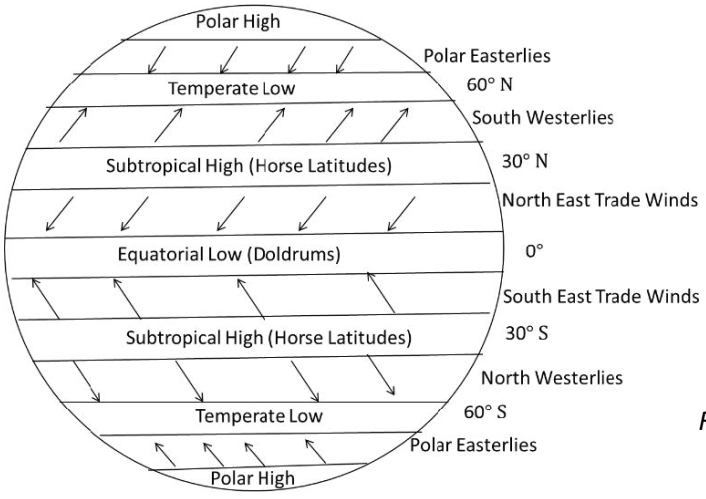


Figure 7.5: World pressure belt.

i. Equatorial low-pressure belt

It is located on either side of the equator between 10°N and 10°S latitudes. The equator receives the most intense heat from the Sun. An equatorial low-pressure belt is a thermally induced belt due to intense heat leading to low pressure. The equatorial low-pressure belt is also known as doldrums because of the presence of variable light winds. The equatorial low-pressure belt represents the zone of convergence of northeast and southeast trade winds.

ii. Subtropical high-pressure belt

It extends from near the tropics to about 35°N and 35°S latitudes. The air that rises at the equator spread outwards towards the poles, gradually cooling and sinking back down to the surface at about 30°N and 30°S latitudes, making a high-pressure zone. It is a dynamically induced belt. The sailing ships were often becalmed due to calm air in the subtropical highs in the ancient days. As food supplies dwindled, horses were either thrown overboard. Consequently, these regions were called the horse latitudes.

iii. Subpolar low-pressure belt

It extends between the latitude of 60° to 65° in both the hemisphere. The convergence of westerlies and polar easterlies characterise the subtropical low-pressure belt. The surface air spreads outward from this zone due to the Earth's rotation (Coriolis Force) and causes low pressure. Therefore, it is a dynamically induced belt.

iv. Polar high-pressure belt

It extends between the latitude of 80° to 90° in both the hemisphere. High pressure persists at the poles throughout the year because of low temperature, usually below the freezing point. It is a thermally induced belt.

7.8 Factors affecting atmospheric pressure

Factors affecting atmospheric pressure are:

i. Altitude

Air pressure always decreases with increasing height above the ground. This is because fewer air molecules are pressing down from above in the higher atmosphere.

ii. Temperature

Warm air is less dense than cold air. Therefore, it weighs less and tends to rise, thereby exerting less pressure.

iii. Water vapour

Moist air exerts less pressure than dry air since water has a lower molecular weight than nitrogen and oxygen.

iv. Shifting of pressure belts

Pressure belts usually are shifted along with the position of the overhead Sun. Except for the polar high-pressure belt, all the pressure belt moves northward with the Sun's northward movement. On the contrary, except for the polar high-pressure belt, all the belts move southward due to the southward movements of the Sun. The pressure belts occupy their normal ideal position at the vernal and autumnal equinoxes when the Sun is vertical at the equator.

The shifting of the pressure belts causes seasonal changes in the climate, especially between latitudes 30° and 40° in both hemispheres. Mediterranean climate prevails in this region since westerlies bring much rain to the region during winter while trade winds blow offshore and bring less rain during summer.

Learning activity

Discuss how Bhutan is affected by the shifting of subtropical high-pressure belts and share your findings with the class.

Test yourself

1. Afternoon hours receive maximum insolation than morning and evening hours. Justify.
2. Why is the equatorial region not the hottest despite vertical sun rays?
3. Moist air exerts less pressure than dry air. Explain.
4. Why do people experience shortness of breath while ascending the mountain?
5. Why is it possible to have two or more cropping seasons in the low latitude areas?

Chapter Eight

Global Climatic Zones

Learning Objectives:

- Discuss the concept of climate zone
- Explain the purpose of climate classification
- Explain climatic zones based on the genetic classification

8.1 Introduction

The major factors that influence climate determine the different climate zones. Climate zones are areas with distinct climates, which occur in the east-west direction around the Earth. The Earth is divided into different regions based on climatic conditions. In general, the same type of climate zone is found at similar latitudes on both hemispheres. The climatic zones are based on genetic and empirical approaches. The genetic classification includes Flohn and Strahler's climatic zones.

8.2 Classification of the climatic zones

Classification of the climate is an attempt to systematize volumes of meteorological data. It aims to define climatic types and patterns. According to Ward, a broad division of the Earth's surface into zones is necessary as the first step into any systematic study of climate. Many classifying schemes that use spatial variations of meteorological variables such as temperature, precipitation, and energy budget to differentiate the climatic zones. Broadly, the genetic approach and empirical approach are used to classify climatic zones.

8.3 The genetic approach

The genetic method classifies climate based on the climatic controls or based on its causal elements, the activity and characteristics of all factors such as air masses, circulation patterns, fronts, jet streams, net radiation, and topographic effects. The most extensively used genetic approach to classifying climates are those that employ air mass concepts. Classifications based on this concept take into account the main features of general circulation, heat transfer by sea and air currents, and the position of continents and oceans.

8.3.1 Flohn's classification scheme

Flohn has classified climatic types based on global wind belts and precipitation characteristics.

Table 8.1. Flohn's classification scheme

Sl.No.	Types	Characteristics
1	Equatorial westerly zone	Constantly wet
2	Tropical zone winter trades	Summer rainfall
3	Subtropical dry zones (Trades or subtropical high pressure)	Dry conditions prevail throughout the year
4	Subtropical winter rain zone (Mediterranean type)	Winter rainfall
5	Extra-tropical westerly zone	Precipitation throughout the year
6	Subpolar zone	Limited precipitation throughout the year
	Boreal continental type	Summer rainfall limited, winter snowfall
7	High polar zone	Meagre precipitation summer rainfall, early winter snowfall

Adapted from Physical Geography by Obando & Makokha (2005).

8.3.2 Strahler's classification scheme

This classification divides the global climates into three major divisions, the low latitude, the mid-latitude and the high latitude climates. These three divisions are further classified into 14 climatic regions. The dominant air masses and the precipitation parameters are criteria for classification.

i. Low latitude climates

Low latitude climates are controlled by equatorial and tropical air masses. The sub-classifications are:

(a) Wet equatorial climate
(b) Monsoon and trade wind coastal climate
(c) Wet-dry tropical climate
(d) Dry tropical climate

iii. Middle latitude climates

Middle latitude climates are controlled by tropical and polar air masses. The sub-classifications are:

(a) Dry subtropical climate
(b) Wet subtropical climate

(c) Mediterranean climate
(d) Marine west coast climate
(e) Dry mid-latitude climate
(f) Moist mid-latitude climate

iii. High latitude climates

High latitude climates are controlled by polar and Arctic air masses. The sub-classifications are:

(a) Boreal forest climate
(b) Marine subArtic
(c) Tundra climate
(d) Ice sheet climate

Note: **H–**Highland climates are found in major highland areas of the world where the altitude is the dormant control of climates.

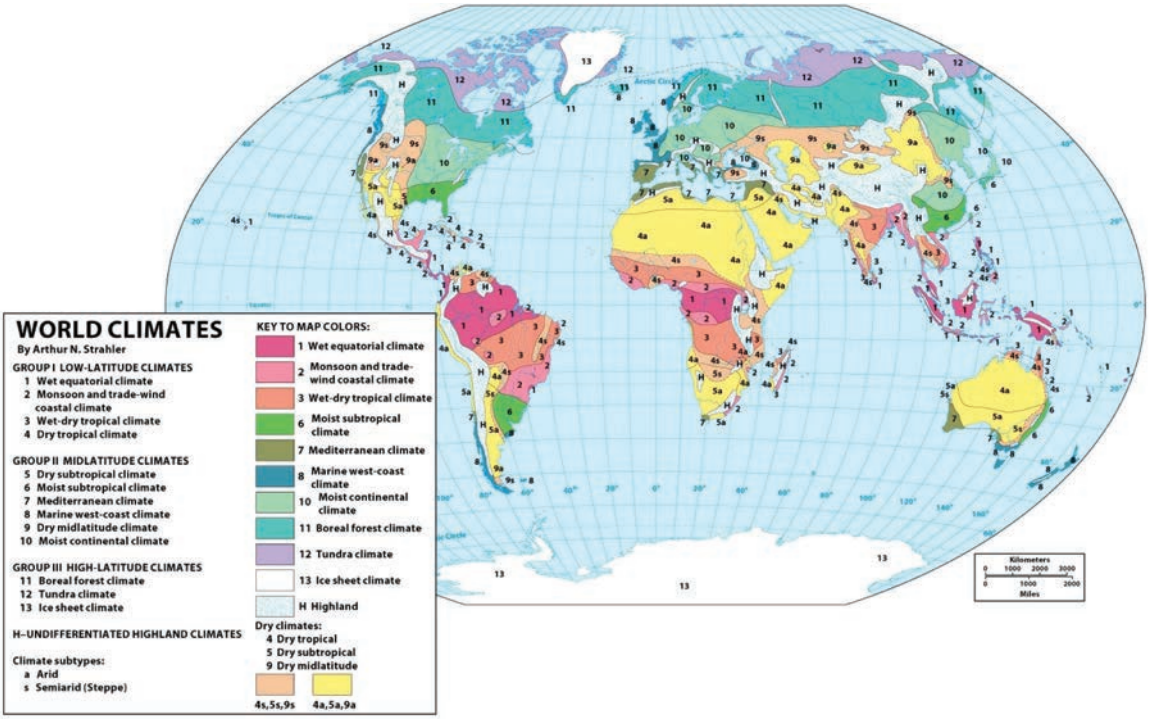


Figure 8.1: Strahler's classification scheme. Adapted from

https://www.pinterest.pt/pin/739857045015080307/

Learning Activity

1. Discuss and find out why genetic classification is not suitable for the classification of climate.
2. On the world map (Web GIS), shade Flohn's types of climate using legend and compare it with Strahler's types of climate.

8.4 Empirical approach

The empirical method makes use of observed climatic data such as temperature, humidity, and precipitation, or simple quantities derived from the data. Koeppen's classification scheme is based on this approach (Koeppen's classification will be discussed in Class XII).

Test yourself

1. Discuss climatic types that prevail in our country based on Flohn's classification scheme.
2. Explain the sub-climatic zones that prevail in your locality from Strahler's classification scheme.
3. Prepare a map of world climates based on Flohn's classification scheme using QGIS.

Chapter Nine

Global Warming and Climate Change

Learning Objectives:

- Analyse the relationship between global warming and climate change.
- Discuss the evidences for climate change.
- Analyse the consequences of climate change and suggest measures to minimise the impact.

9.1 Introduction

Global warming is a condition in which the Earth and its atmosphere experience a gradual increase in the average global temperature. It is caused due to an increased amount of solar energy trapped in the atmosphere by greenhouse gases. The greenhouse gases such as water vapour, carbon dioxide, methane and nitrous oxide trap the terrestrial radiation and make the Earth warmer. Global warming is accelerated by human-produced greenhouse gases.

Climate change is the variation in temperature, precipitation and pressure. These variations cause extreme climatic events such as floods, wildfires and droughts. Such events have recurred on most of the Earth's surfaces affecting lives and properties. Therefore, it has become a global concern requiring immediate measures to minimise the impacts.

Know More

President Biden convened 40 world leaders in a virtual Leaders Summit on Climate in April 2021 to rally the world in tackling the climate crisis and meeting the demands of science. The world leaders announced ambitious new climate targets ensuring that nations accounting for half of the world's economy have now committed to the emission reductions needed globally to keep the goal of limiting global warming to 1.5° C within reach.

9.2 Causes of climate change

Both natural and anthropogenic factors are responsible for global warming, leading to abrupt and erratic climatic conditions. Natural causes are events like an forest fires, volcanic eruptions and methane released from the thawing of permafrost on the ocean floor. Anthropogenic causes are exhausts from all kinds of combustion, industrial production of greenhouse gases, agricultural waterlogging and deforestation. Anthropogenic activities are more prominent causes of climate change.

Know More

Earth's climate has changed throughout geologic history, and most of the changes have occurred due to natural factors. The concentration of atmospheric greenhouse gases can increase or decrease due to natural phenomena and human activity.

9.3 Evidences of climate change

Scientists have found various evidences of climate change. Some of the evidences are:

i. Temperature rise

The rise in the global temperature is one of the evidences of climate change (Figure 13.1). According to the National Oceanic and Atmospheric Administration (NOAA), the average global temperature has increased by about 0.8°C over the past 100 years. A global mean temperature of 1.2 ± 0.1°C in (January to October) 2020 is one of the three warmest years on record (World Meteorological Organization, 2020).

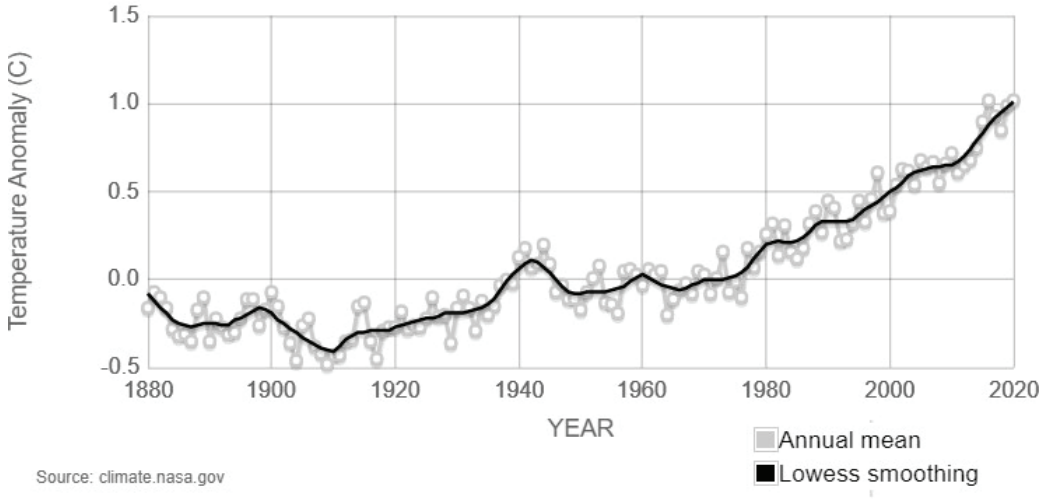


Figure 9.1. Global land-ocean temperature index. Adapted from Climate.nasa.gov

ii. Seasonal rainfall variability

Global warming increases the rate of evaporation of soil moisture. This triggers the potential incidences and harshness of droughts in some places, while other places experience heavy downpours causing flash floods and storm waters. This phenomenon leads to drought conditions in some areas while other areas experience more frequent cyclonic conditions.

iii. Desertification

Global warming is one of the major causes of desertification. Climate change has intensified the rate of desertification due to the increasing scarcity of water resources besides deforestation. Desertification leads to the loss of biodiversity and ecosy

Global warming increases evaporation on land, worsening droughts. Droughts are more prone to wildfire and a longer wildfire season. A warming atmosphere is also associated with heavier precipitation events through an increase in the air's capacity to hold moisture. For example, the prolonged drought condition in 2020 caused a major heatwave in Brazil with temperatures as high as 44.6 ° C on fifth October. Consequently, significant wildfires occurred in Pantanal wetlands in western Brazil, intensifying desertification (World Meteorological Organization, 2020).

iv. Melting of sea ice and glacier

The decline in sea ice both in extent and thickness over the last decades is further evidence for rapid climate change. Glaciers and ice sheets in the polar and mountainous regions are increasingly receding over the years. For example, the Arctic is warming twice as fast as anywhere on Earth, and the sea ice is declining by more than 10% every 10 years.

Figure 9.2: Retreating glaciers

v. Sea level rise

The world is phasing increased rates of sea-level rise. The rise is due to the shrinkage of sea ice and glaciers due to global warming. Global sea-level rose about 8 inches (20 cm) in the last century. The rate in the last two decades, however, is nearly double that of the last century and is slightly accelerating every year.

Figure 9.3: Rising sea levels pose threats to humans.

9.4 Effects of climate change

Climate change has adverse and devastating impacts on the global population. The effects of climate change are:

a. Decline in agricultural productivity

The effect of climate change on agricultural productivity is related to variability in local climates rather than in global climate patterns. The study conducted by scientists from Cornell, Maryland, and Stanford universities have found that global agricultural production has declined by about 21% in the last 60 years. They analysed annual official records of agricultural productivity in 172 countries along with the climate parameters from 1960-2020. The findings indicate that climate change has impacted the equivalent of seven years of stagnation in agricultural productivity. The impact was more pronounced in warmer regions of Africa, Latin America and the Caribbean.

b. Impacts on human health

Climate change increases the risk of illness. Women, children and elderly people are at greater risks. Climate-sensitive diseases and health impacts are higher in poor countries that have minimal resources to treat and prevent illness. Vector-borne diseases like malaria and dengue occur in areas with warm temperatures and prolonged flooding. The earlier onset of warmer seasons favours the parasites and pathogens to survive and spread over large areas. Extreme weather events and storm surges threaten the water storage infrastructures, and people are exposed to contaminants. Moreover, the rise in temperature causes increasing bacteria-related food poisoning.

c. Impacts on ecosystems

Climate change has led to changes in freshwater and marine ecosystems in the world. Some species of flora and fauna have become vulnerable to the extreme climatic conditions, while others have extinct. The migration patterns, geographic range, and seasonal activity of many terrestrial and marine species have changed in response to climate change. The plant and animal species that thrive in the mountainous and coastal areas are at greater risks of getting extinct due to climate change.

d. Climate change impact on human rights

Climate change poses an enormous threat to the lives and well-being of individuals and communities across the world. Millions of people and ecosystems are predicted to be adversely affected by climate change as per the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC). The abrupt-onset of natural hazards and disasters pose direct threats to human lives and properties and undermine access to basic amenities that support life.

Some of the regions are hit harder than others. For instance, sea-level rise has adverse effects on the livelihood of many coastal inhabitants, and soaring temperature accelerates the retreating glaciers in the Arctic region and disrupts the livelihood of the indigenous communities.

Learning activity

Discuss the evidence of climate change in your area and suggest measures to minimise the impact of climate change.

9.5 Mitigations to combat climate change

Mitigation is a human intervention to adapt to climate change to minimise the impact. The strategies to mitigate the impact of climate change are actions such as reduction of greenhouse gas emissions, adopting the efficient use of renewable energy and promotion of sustainable use of resources.

i. Lifestyles

A sustainable lifestyle is one of the ways to mitigate climate change. It includes sustainable production and consumption of resources. Saying no to non-renewable energy sources, growing your organic food, or wearing warmer clothes to keep warm instead of burning fossil fuels are examples of sustainable lifestyles.

ii. Consumption of efficient energy

The usage of renewable over non-renewable energy resources decelerates the impact of climate change. Switching off the light when leaving the room, unplugging the devices when not in use, and opting for LED bulbs for lighting reduces the power consumption.

iii. Fuel efficient transportation

The usage of fuel efficient vehicles, rail, public and non-motorised transport will minimise the GHG emission. The investment in attractive public transport facilities and non-motorised forms of transportation, and car-pooling are examples of efficient transportation.

iv. Forest management

Afforestation, reforestation and forest management practices will increase biomass productivity and carbon sequestration.The establishment of Community Forest and protected areas are examples of forest management in Bhutan.

v. Agricultural practices

Climate-smart agriculture helps to mitigate climate change. Improving crop, livestock, and manure management practices are some of the measures to minimise methane emissions. The preference of high-bred animals and high-yielding varieties of seed over indigenous animals and seeds are examples of sustainable agricultural practices.

Learning Activity

1. If you were living in a down-stream where there is a risk of GLOF, what measures will you adopt?
2. Discuss some of the traditional forest management techniques in your locality and share the findings.

Test yourself

1. Explain evidences of climate change that are observed in your locality.
2. What would you suggest to minimise the threats of climate change?
3. What are the causes of climate change?
4. Distinguish the impacts of climate change in mountainous and plain regions of Bhutan.
5. 'There is minimal decrease in the Antarctic glaciers'. Justify.
6. What would happen if all the glaciers on the mountains melt?
7. In your opinion, is global warming a huge task to tackle? Give reasons.

CHAPTER 10

Population

Learning Objectives

- Analyse the significance of conducting population census.
- Examine the spatial distribution of population.
- Discuss population dynamics.
- Explain the trends of population.
- Draw population pyramid using a given population data and interpret it.

10.1 Introduction

Human population is not static; it exist and change in both time and space, and population changes underlie all population "problems". The description of all these changes constitute unique discipline of population studies. Population study is concerned with the size, composition and distribution of population; their patterns of change over time through births, deaths, and migration; and are the determinants and consequences of such change.

Population studies helps to understand the nature of population changes over time. Population size, age and sex, distribution, mortality and fertility and other characteristics of human population are the results of past events, and these characteristics of the existing population will partly determine the future changes.

Population is not evenly distributed over the earth's landmass. Physical environments vary from place to place. Hence, it is necessary to understand the spatial distribution of populations. Present spatial distribution as well as projections for the future are integral for proper planning and development activities. The distribution of the world population is expected to change significantly over the 21st century.

10.2 Population Census

The United Nations defines a population census as the total process of collecting, compiling, and publishing demographic, economic, and social data pertaining to a specific time to all persons in a country or delimited part of a country. As part of a census count, most countries also include a census of housing. Population Censuses are generally conducted every 10 years. In Bhutan, the National Statistical Bureau (NSB) conducted the first Population and Housing Census of Bhutan (PHCB) in 2005 and the second census in 2017.

Reprint 2024

10.2.1 Purpose of Population Census

Population census gives a comprehensive picture of social and living conditions of the people in a city, country or a continent. It provides essential tools for effective policy, planning and decision making purposes. This enables to track developments over a long period with considerable accuracy.

The population census forms an integral part of a country's National Statistical System. It provides valuable benchmark data on a wide range of characteristics, a frame for statistical survey and data to compile a variety of social and economic indicators. Census provides the demographic, housing, social and economic data not provided by population registers. Most importantly a census provides data at the smallest area level like a village.

At the national level, it provides population statistics which are essential for planning in the provision of health care, education and employment. Census also measures the exact extent of migration.

For Bhutan, PHCB is carried out to:

- acquire an up-to date count of the population size, by age and sex,
- obtain geographic distribution of the population by demographic and socio-economic characteristics,
- provide frames for surveys and other statistical activities, and
- gather information about migration and fertility.

Learning Activity

Explore the challenges in carrying out population and housing census in a country. You may like to focus on PHCB. Share your finding

10.3 Spatial Distributions of Population.

Spatial distribution describes where a population is located. Population distribution is the spatial pattern of the dispersal of population, formation of agglomerations, and linear spreads of population. In most countries, a wide regional variations in the geographic distribution of the population exist.

Figure 10.1: World population distribution (Source: https://ourworldindata.org/world-population-cartogram)

The global population is highly dispersed over the seven continents. Most of the world's population (about 60 per cent) lives in Asia (4.4 billion), 16 per cent in Africa (1.2 billion), 10 per cent in Europe (738 million), 9 per cent in Latin America and the Caribbean (634 million), and the remaining 5 per cent in Northern America (358 million) and Oceania (39 million).

It is estimated that 50.4 per cent of the world's population is male and 49.6 per cent, female. About one-quarter (26 per cent) of the world's population is below 15 years of age, 62 per cent are aged 15-59 years, and 12 per cent are 60 years or over.

Table 10.1: The ten most populous countries in the world, 2020

Sl.No.	Country	Population
1	China	1.439 billion
2	India	1.380 billion
3	United States of America	331 million
4	Indonesia	224 million
5	Pakistan	221 million
6	Brazil	213 million
7	Nigeria	206 million
8	Bangladesh	165 million
9	Russia	146 million
10	Mexico	129 million

Source https://myfunkytravel.com/most-populated-countries.html

Know More

India's population is expected to continue growing for several decades. It is projected to reach 1.5 billion in 2030 and 1.7 billion in 2050, while that of China is likely to remain constant and then decrease slightly. Therefore, it is projected that India's population will surpass China in the future.

Learning Activity

- Refer Population and Housing Census of Bhutan 2017 and prepare a choropleth map manually or using QGIS based on the total population of each dzongkhag to show the spatial distribution of population in the county.

10.3.1 Density of Population in the World

Population density is the number of people living in a unit area of the earth's surface. It is normally expressed as persons per square km. Population densities vary in different parts of the world. The average density of population in the world is 51 persons per square km. South Central Asia has the highest density of population followed by East and South East Asia.

Population density is useful in describing the location, growth, and migration people. It is often discussed in relation to urbanization, immigration, and population demographics.

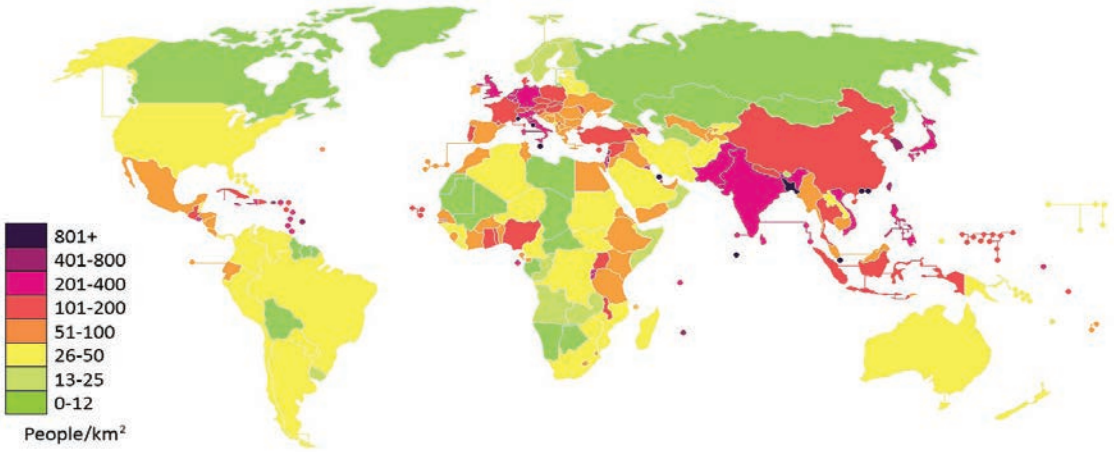


Figure 10.2: World population density map

Table 10.2: Countries with the highest population density worldwide in 2019

Sl No	Country	Population Density
1	Macau	21,055/km²
2	Monaco	19,150/km²
3	Singapore	8,109/km²
4	Hong Kong	6,677/km²
5	Gibraltar	5,620/km²
6	Bahrain	2,052/km²
7	Vatican City	1,820/km²
8	Maldives	1,719/km²
9	Malta	1,390/km²
10	Sint Maarten	1,234/km²

(Source: https://worldpopulationreview.com/country-rankings/countries-by-density)

Learning Activity

- Using the total population of 20 dzongkhags from PHCP 2017, prepare a population density map of Bhutan using QGIS or manually

10.4 Factors affecting spatial distribution of population

The factors affecting distribution of population may broadly be grouped into the following major categories:

1. Physical factors
2. Socio-economic factors
3. Demographic factors and
4. Political factors

10.4.1 Physical Factors

The physical factors include climatic conditions, topography or terrain, availability of water, fertility of soil, location of a place and natural disasters. Humans seek favorable climatic conditions in the places they want to settle. Plain areas are more populated than rough ones while mountains are less preferred because of lack of arable land. Similarly water is essential for human survival. The ancient civilizations of the world flourished near rivers and the coastal areas.

Soil quality influences density and distribution of the population. A substantial proportion of populations earn their livelihood from agriculture which depends on the quality of soil. Further location of a place near to the energy or mineral resources attract more people. Proximity to major towns and cities favours concentration of population. On the other hand frequent storms, earthquakes, and floods, wild fires discourage formation of settlements as people migrate to safer places.

10.4.2 Socio-economic Factors

The factors influencing the choice of a place for settling no longer depends entirely on natural conditions. With time, people have been able to adjust and control the natural processes to some extent. Thus, as needs changed with the evolution of human society, social and economic perspectives importance also change. Some of the socio-economic factors include cultural characteristics, types of economic activities, technology used (including the type of farming), and social organization.

Economic activity is an indicator of employment opportunities. Concentration of population in urban areas is an outcome of diverse economic activities and livelihood options offered by cities. Population density in the towns and cities are higher than in rural areas, and will continue to increase. For example, hydroelectric power stations in largely uninhabited areas attract migrants to these places, resulting in increase in population.

Social organization of communities in new areas encourages the movement of people and settling in newer lands. People are social animal and it becomes essential for them to form a community, creating a familiar environment in the place they live.

10.4.3 Demographic factors

The demographic factors are the characteristics of the population that have considerable influence on population distribution and settlement patterns. These include fertility and mortality trends, and migration. Fertility and mortality together influence the natural increase in a region.

On the other hand migration has deep influence on population distribution. The push factors, or negative circumstances, at the place of origin tend to motivate people to leave their native places to newer areas. Better opportunities in distant lands also encourage migration.

The migration process allows redistribution of population, but it also puts pressure on the place of destination and increases the population density in this place.

10.4.4 Political factors

Factors such as political boundaries, political stability (or unrest), disturbances, controls on migration and trade, government policies and transportation facilities are considered as political factors. War, political disturbance, conflict, and weak administration negatively affect population distribution.

Clashes between different political parties or people with different religious beliefs have often resulted in a reduction of population in the affected area. Discrimination faced by migrants because of race, language, food, culture etc., discourages in-migration. This has reduced the population growth on one hand and newer settlements on the other.

Policies encouraging migration have often led to population growth in the destination region. International labour movements take place where rules governing cross-border migration are lenient. Migration helps in the redistribution of population. Policies that promote reduction in fertility levels, banning of infanticide, etc. also influence the population growth in a place.

No single factor can be considered as solely responsible for concentrated or scanty populations, or their distribution and growth. Most of the factors are interrelated and often act collectively. The tremendous population growth in the world population has forced many to settle in uninhabitable regions where there is a shortage of adequate natural resources. Earlier, physical factors determined population distribution; however the industrial revolution and accompanying urbanization increased transport and communication networks. These developments influenced population distribution.

Learning Activity

- Why the world population is so unevenly distributed? Discuss and share your findings.

10.5 Population Dynamics

Until the 1800s, the world's population grew slowly for thousands of years. In 1820, the world's population reached one billion. The global rate of population growth is now one billion every 15 years. Such changes in a population over time is called population dynamics. Birth, death and migration are the causes of change in population. The difference between the birth rate and the death rate of a country or place is called the natural increase.

The natural increase is calculated by subtracting the death rate from the birth rate. The population increase in the world is mainly due to rapid increase in natural growth rate.

Population growth rates vary across the world. Although the world's total population is rising rapidly, not all countries are experiencing this growth. In the United Kingdom, for example, population growth is slowing, while in Germany the population has started to decline. More economically developed countries have low population growth rates, with low death rates and low birth rates.

10.6 The Demographic Transition Model

The demographic transition model (DTM) shows population change over time. It takes into account the birth rate and death rate and how this affects the overall population of a country.

The relationship between birth and death rates changes with economic development and a country has to pass through different stages of population growth. C.P. Blacker divided population into five types as high, stationary, early expanding, low stationary and diminishing. According to the demographic transition model, population growth will have to pass through these different stages during the course of economic development.

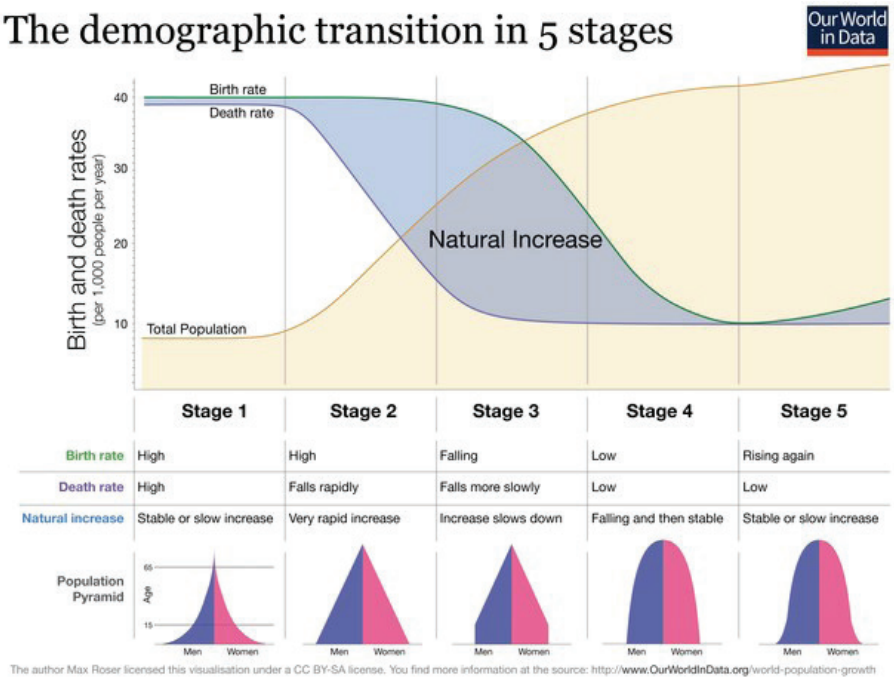


Figure 10.3: Five Stages of the Transition Model.

First Stage

This stage has been called high population growth potential stage. It is characterised by high and fluctuating birth and death rates which will almost neutralize each other. People mostly live in rural areas and their main occupation is agriculture which is in the stage of backwardness. The tertiary sector consisting of transport, commerce banking and insurance is underdeveloped.

People have very low income and there is existence of poverty of the masses. The mortality rate is highest among the poor. Thus, high birth rates and death rates remain approximately equal over time so that a static equilibrium with zero population growth prevails.

Second Stage

In this stage the death rate decreases while the birth rate remains constant at a high level. It is called the stage of population explosion. Agricultural and industrial productivity increases, means of transport and communication develops. Education expands and income level of people also increases.

Due to the widening gap between the birth and death rates, population grows at an exceptionally high rate and that is why it has been called the population explosion stage. This is an "Expanding" stage in population development where population grows at an increasing rate.

Third Stage

The population continues to grow at a fast rate in this stage. Birth rate as compared to the death rate declines more rapidly. As a result, population grows at a diminishing rate. This stage witnesses a fall in the birth rate while the death rate stays constant because it has already declined to the lowest minimum.

Birth rate declines due to the impact of economic development and facilities for family planning. Population continues to grow fast because death rate stops falling whereas birth rate though declining but remains higher than death rate.

Fourth Stage

It is called the stage of stationary population. Both birth rate and death rate are at a low level and they are almost equal. Birth rates may drop to well below replacement level as leading to a shrinking population. Death rates may remain consistently low or increase slightly due to increases in lifestyle diseases due to low exercise levels and high obesity and an aging population in developed countries.

Fifth Stage

This stage includes countries in which fertility rates have fallen significantly below replacement level (2 children) and the elderly population is greater than the youthful population. Aging population and decline in population may eventually occur, assuming that the fertility rate does not change and sustained mass immigration does not occur.

The Demographic Transition Model helps to understand the population dynamics but it cannot reveal the impact of other demographic variables, such as migration and it cannot predict how long a country will be in each stage.

Learning Activity

- In which stage of Demographic Transition Model does Bhutan fit in? Justify.
- How does Demographic Transition Model help in understanding the population dynamic of a country?

10.7 Trends of Population Growth

The world population was estimated to be around 8 million at the advent of agriculture around 8000 B.C. Consequently, improvement in in food supply permitted the births to exceed the deaths by modest margin. The population continued to grow slowly for pretty long time. The world population reached 800 million by the dawn of the modern era. Since then the population has started recording spectacular increase partly due to human's increasing control over nature and partly due to industrial revolution which enhanced the supporting capacity of the areas manifold.

Two hundred years ago, the world population was just over one billion. Since, then the number of people on the planet grew more than 7 times to 7.7 billion in 2019. Most of the people always live in Asian continent.

The fastest doubling of the world population happened between 1950 and 1987, a doubling from 2.5 to 5 billion people in just 37 years. The population doubled within a little more than one generation. This period was marked by a peak population growth of 2.1% in 1962.

The fastest population growth over last two centuries was in North America. The population grew by 31fold. Latin America saw the second largest increase (28-fold). Over the same period the population of Europe increased 3-fold, Africa by 14-fold, and in Asia by 6-fold.

The huge growth in the world population over the past two centuries is largely the result of advances in modern medicines and improvements in living standards. These have

significantly reduced infant, child and maternal mortality, contributing to an increase in life expectancy. Although fertility levels have declined, they have not fallen at the same pace as mortality levels.

The world population will continue to grow for decades to come. This is the result of 'population momentum'. There are more women of reproductive age today, because of improved survival rates and past high fertility levels. This will contribute to a relatively large number of births, even if those women have fewer children on average. Although population growth is, today, largely attributable to population momentum, after 2060 it will almost exclusively be driven by fertility levels in the world's least developed countries.

Learning Activity:

- What are the impacts of rapid growth of population in the world? Suggest at least three measures to control the rapid growth of population at a global scale.

Case study on Trends of Population in the World

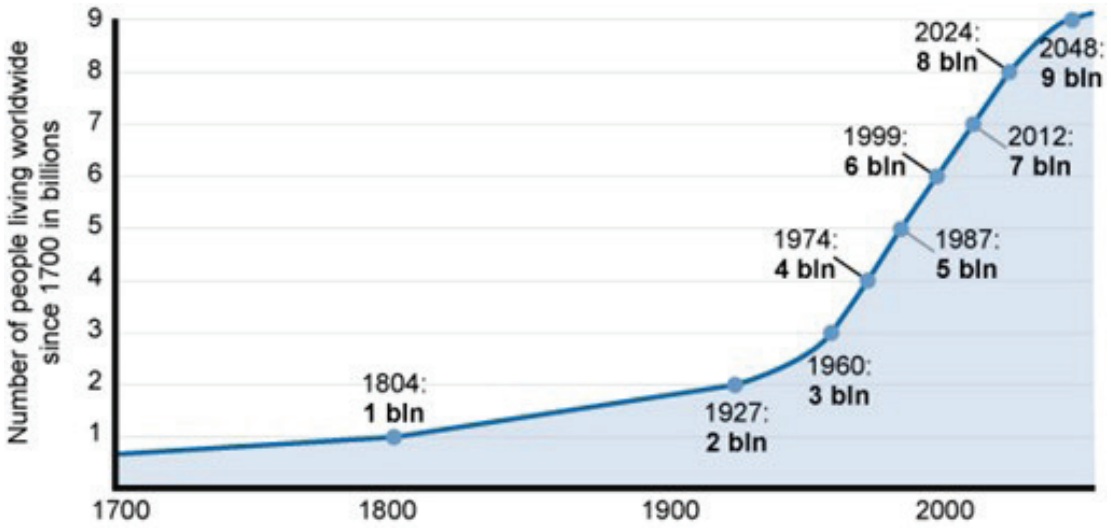
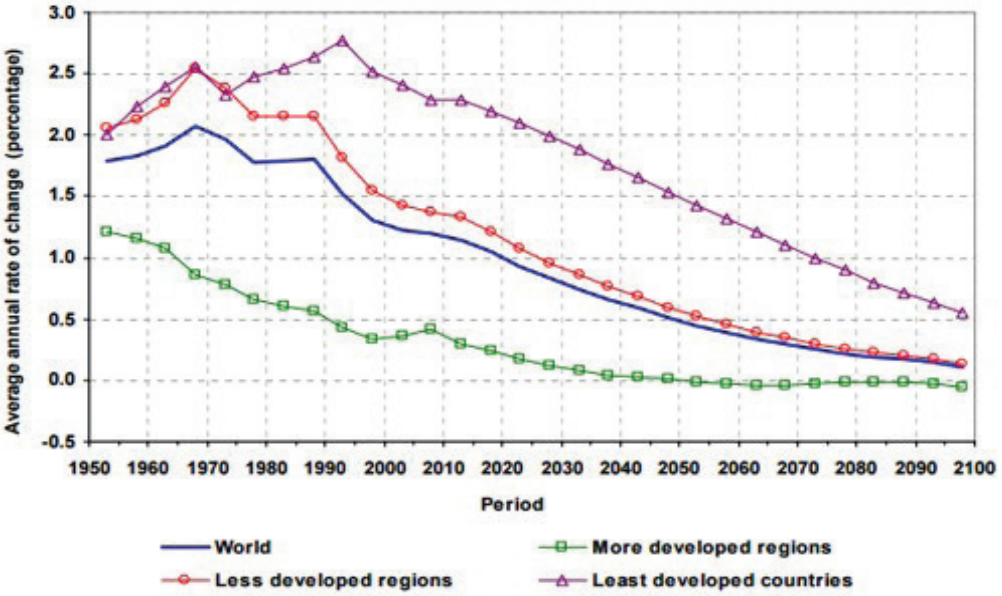


Figure 10.4: Population growth globally

In 1950, about 8% of the world's population was above 60 years of age. In 2013, this proportion had increased to 12% and it is expected to reach 21% in 2050 (UNDESA, 2013). The rates of change in population vary in different regions of the world and can be categorized into groups based on the socio-economic development status of different countries.



Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2013). *World Population Prospects: The 2012 Revision*. New York: United Nations.

Figure 10.5: Average annual rate of population change for the world and development groups, 1950–2100.

The least developed countries continue to have a higher rate of population increase for several reasons. Significant among these is the fact that the benefits from advances in health and agriculture are not spread evenly across the world. Medical technologies, for example vaccines and antibiotics, reduce the death rate by protecting people against diseases like influenza, measles, polio and rubella. However, vaccines are still not available for many diseases like malaria that are common in less developed countries, particularly in sub-Saharan Africa.

Other public health measures, like water and sanitation, waste management and nutritional education are very important in preventing disease and in reducing the death rate. These measures are well developed in industrialised countries but less so in developing countries.

Similarly, in agricultural science and technology, advances such as new kinds of seed, fertilisers, pesticides and mechanisation in farming have transformed food production. These have increased the quantity of food produced, which has helped to improve nutrition and decrease death rates. However, advanced food production and distribution are still developing in many countries.

The trend in population should not be viewed in isolation from other aspect of development. The demographic variables and the socio economics variables interact upon each other.

The determinants of fertility, mortality and migration are interwoven in the social system and are influenced by the people's perception and public policies. The social and economic conditions affect mortality, fertility and propensity move. The population growth on the other hand modifies the social fabrics and the natural environment.

Learning Activity

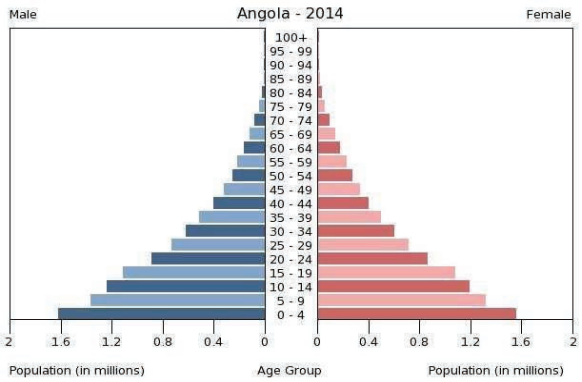
Study figure 10.5 about global population growth and average annual change in population and answer the questions:

- How would you describe the predicted trend in world population for the middle of the 21st century?
- How does the trend in population change correspond with the predicted trend for the middle of the 21st century?
- Which development group is expected to have zero population growth and highest annual rate of population change by 2050?

10.8 Population pyramid

Population pyramid is a graph that shows the distribution of ages across a population divided down the center between male and female members of the population. The graphic starts from youngest at the bottom to oldest at the top. A population pyramid can be used to compare differences between male and female populations of an area. It also show the number of dependents (children and, sometime, elderly people) and general structure of the population at any given moment.

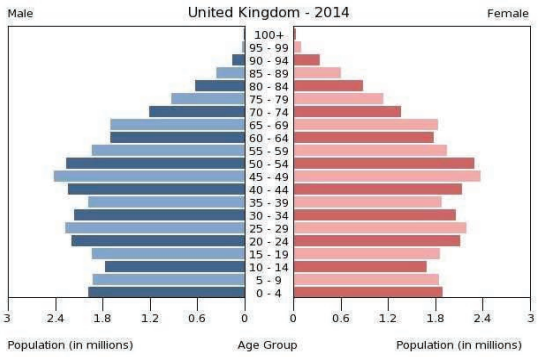
There are three main trends in populations that affect the shape of a population pyramid. The first type, known as "expansive," creates a sharp triangle shape in the graph. Expansive pyramids mean that the population does not increase much in total number and has many young people. The second trend, known as "constrictive," is when there is a lower mortality rate with the fertility rate remaining constant. This population pyramid is wider in the middle of the graph as the population has high numbers of middle aged and elderly people, but fewer young people. The third trend is "stationary", which is a population with low mortality and low fertility rates. This graphs has a square or "pillar" shape rather than a pyramid. It represent a stable population that will not change significantly barring any sudden changes to fertility or mortality rates.



Angola Population Pyramid - 2014

Central Intelligence Agency

- Wide base = higher birth rate
- Narrow top = shorter life expectancy and fewer people living to an older age
- Youthful population



UK Population Pyramid – 2014

Central Intelligence Agency

- Narrow base = low birth rate
- Similar numbers in each age group = low death rate
- Wide top = long life expectancy
- Ageing population

Figure 10.6: Population pyramid for Angola and United Kingdom 2014

Learning Activity:

Using internet, identify one county each for expansive, constrictive and stationary population pyramid. Give reasons for each type of pyramid.

Test Yourself

1. Which factors play a dominant role in the spatial distribution of population in the 21st century?
2. The high population growth rate is the main enemy of the poor and developing countries. Do you agree? Justify you answer with suitable reasons
3. Refer the data in PHCB 2017 on total population, female and male for 20 dzongkhags. Using QGIS prepare a population distribution map and overlay bar graph layer to show female and male population in each dzongkhag.
4. Is there a need to control population growth in our country? Support your answer with suitable reasons.
5. What are some of the issues related to population planning in the country? Suggest a few measures to overcome these issues.
6. Why is it important to understand different types of population pyramid?

Chapter 11

Energy Resources

Learning Objective (s):

- Discuss Energy Resources
- Differentiate between conventional and non-conventional energy sources
- Discuss geothermal energy
- Discuss the sustainable development
- Explain importance and approaches of resource management
- Examine the dichotomy between resource utilization and sustainable development
- Discuss the concept of biomes

11.1 Introduction

Energy is the main source of input in the production of goods and services. The energy plays significant role to sustain the economic growth of a nation. The source of energy vary as the conventional sources of energy are limited in quantity unlike non-conventional source of energy. Sustainable energy efficiency is a strategic step to reduce our impact on climate change and maintain current operations without risking the energy needs. Natural resources and the way in which we manage them hold the key to our future. An important holistic approach for resource management helps to identify the necessary actions to overcome the barriers of sustainable development.

A biome is a large naturally occurring community of flora and fauna occupying a major habitat. It plays a vital role in understanding of ecology about the interaction among plants and animals and the characteristics that it has developed to live in its environment.

11.2 Energy Resources

Energy resources are all forms of fuels used in a society to light, heat, move objects and to run industrial machines. In the early days, the main source of energy was the sun as it provides heat and light during the day. People relied on wood, bamboo and dung burning for heating and lighting. Humans and animals were the main sources of power to run pre-modern industrial activities.

Energy may also be classified as ***conventional*** and ***non-conventional*** depending upon its nature.

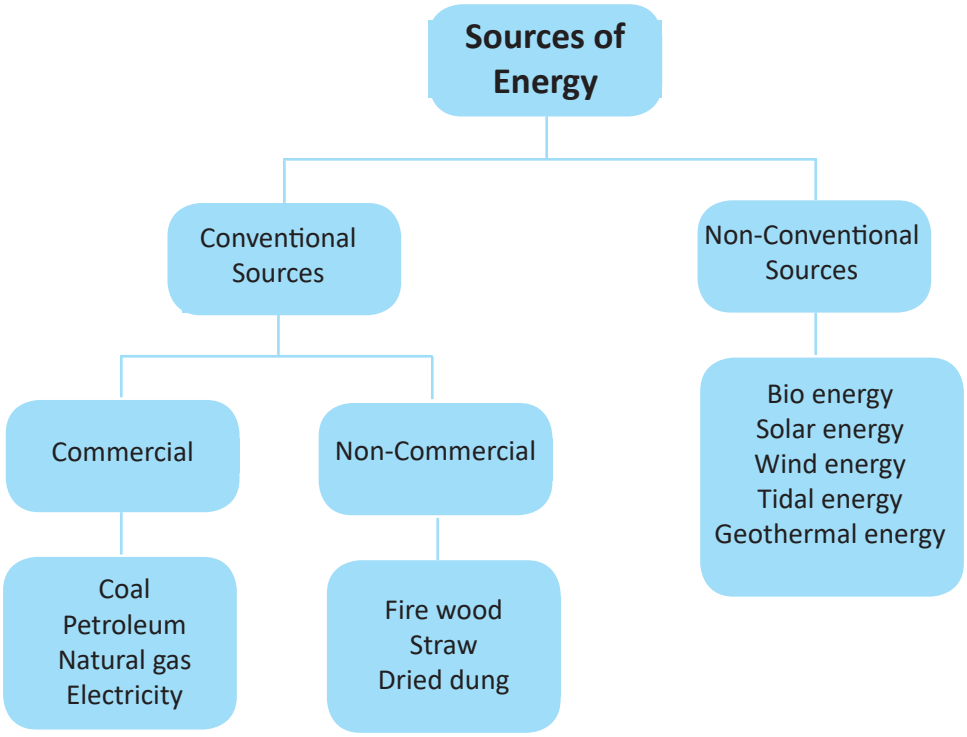


Figure 11.1: Source of energy

11.2.1 Conventional Source of Energy

Conventional sources of energy are also known as non-renewable sources of energy. The energy resources which once used cannot be easily replenished by nature means. These resources have been depleted due to continuous exploitation to meet the major source of power for growing industries. The common examples are coal, electricity, petroleum and natural gas.

These resources get exhausted quickly and their formation of same resources will take millions of years. They are available in limited quantity apart from hydro-electric power. There are three main types of conventional hydropower technologies: dam, diversion and pumped storage. The production capacity of a dam is dependent on the water supply available. Since water cycle is an endless process, constantly recharging system, the hydropower is considered as a renewable energy.

a. Coal

Coal is an inflammable organic substance composed mainly of hydrocarbons. It is found in the form of sedimentary rocks and capable of being used as fuel to heat or light. It contains volatile matter, moisture and ash in varying proportions. Combustible matter in coal consists of carbon and hydrogen. Anthracite, Bituminous, lignite and peat coal are verities of coal graded based on the carbon contain. The State Mining Corporation Limited (SMCL) is the first state owned company in the Bhutan. It was incorporated in 2014.

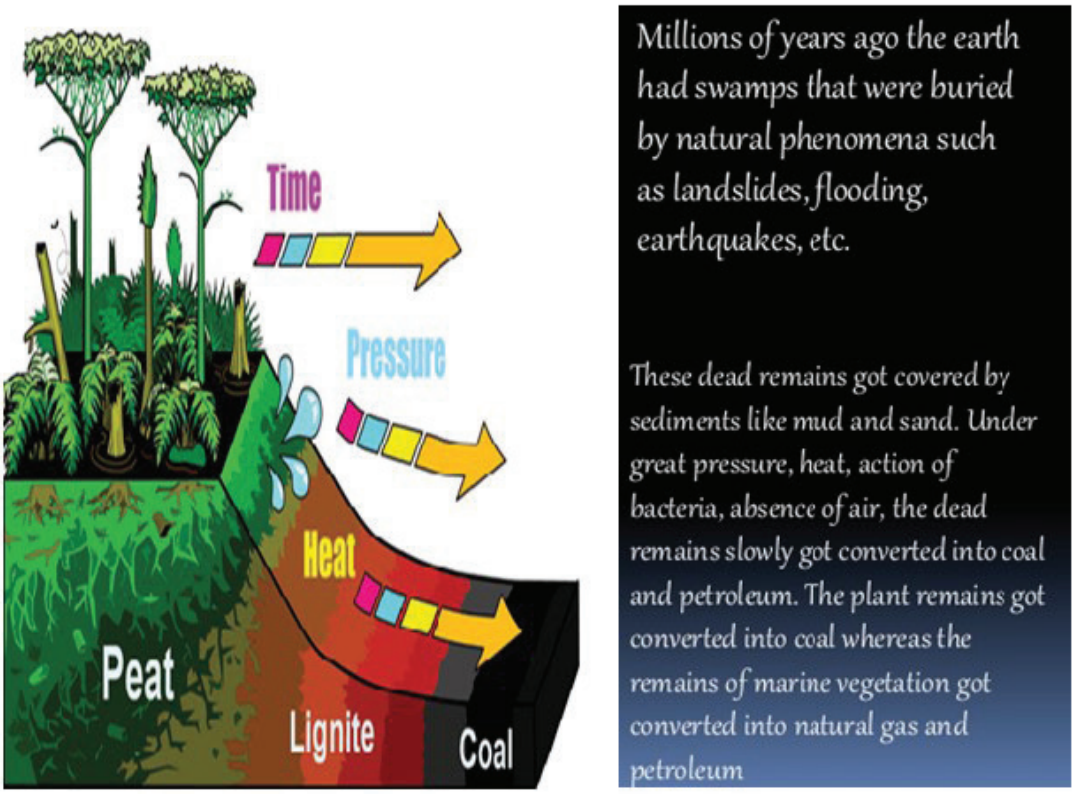


Figure 11.2: Occurrence of coal

b. Hydroelectricity

Hydropower remains the chief resource for renewable energy in Bhutan. The energy represents a significant share of the national economy in Bhutan. About 75% of the total hydroelectric energy generation was exported to India annually.

Know More

Although Bhutan has achieved near universal electricity access, households continue to depend on fuel wood and kerosene to meet cooking an heating energy needs.

The favorable geographical location on the southern slope, altitudinal varying land mass with good vegetation cover, perennial swift flowing rivers provides Bhutan a great potential source of energy. Lhuntse, Mongar and Wangdue dzongkhags are considered to have excellent hydropower power potential in the country. The country's potential to generate hydroelectric power is estimated at 30,000 MW. Bhutan has ambitious plan to harness a large scale hydropower plants, which have greater potential to cause adverse effect to biodiversity. Moreover, these hydro plants are subject to climate threat which is a serious concern for Bhutan. The sustainability of hydropower is dependent on the snow mass, since all the runoff rivers are formed by the glaciers.

Figure 11.3: Tala Hydropower

Learning Activity I

Hydro power is the backbone of the Bhutanese economy. Discuss in teams and suggest different ways to enhance the development of hydro power sector on a sustainable basis to maintain continued contribution to the government's revenue.

Learning Activity II

Describe the origin, types and occurrence of petroleum with necessary diagram. Share the information in the class.

11.2.2 Non-conventional Source of Energy

Non-conventional sources are also known as renewable sources of energy. These energy resources which can be renewed or replenished by physical, mechanical or chemical processes. These sources of energy do not pollute the environment and do not require heavy expenditure. With rising demand for electricity, it is crucial to explore other alternative renewable energy source such as solar, wind, modern bio energy and geo-thermal to create a sustainable energy system.

Learning Activity III

Hydropower is likely to remain an important component of the energy sector in Bhutan. Renewable energy technologies such as solar, wind, bio-energy and small hydropower could offer opportunities for diversifying the country's energy mix and to address rising energy demand. This is according to Renewable readiness assessment launched in the country. ***Source: Kuensel dated 17, December 2019***

1. Discuss the ways how solar, wind, bio-energy and small hydropower could offer opportunities for diversifying the country's energy mix and to address rising energy demand in the country?
2. Create and design a biomass cycle to show the process of working. Include different types of raw materials used and ways of using bio-energy. Explain the process of working.

11.2.3 Geothermal Energy

Geothermal energy is heat produced within the sub-surface of the earth. Water or steam carry the geothermal energy to the Earth's surface. The energy can be used for heating or cooling purposes. In the countries like Iceland and New Zealand, the energy is used to heat the house or the heat can be used to produce electricity. Besides being the clean energy, the generation of electricity does not depend on weather condition unlike solar and wind energy. However, geothermal energy also causes a risk of triggering earthquakes. This is due to the modifications in the Earth's structure as result of digging to enhance geothermal power plant.

The underground heated water which eventually rises up to the surface of the earth through small cracks in the earth's crust to form a pool of water is called hot spring. In Bhutan, hot springs are known as Tshachu. The water contains different minerals which are of great medicinal values. Bhutanese people use hot spring for bathing.

Learning Activity IV

1. Using google earth, locate hot springs of Bhutan.
2. Study the figure about Geothermal power plant. Explain how Geothermal Energy works. Discuss the procedure in your team.

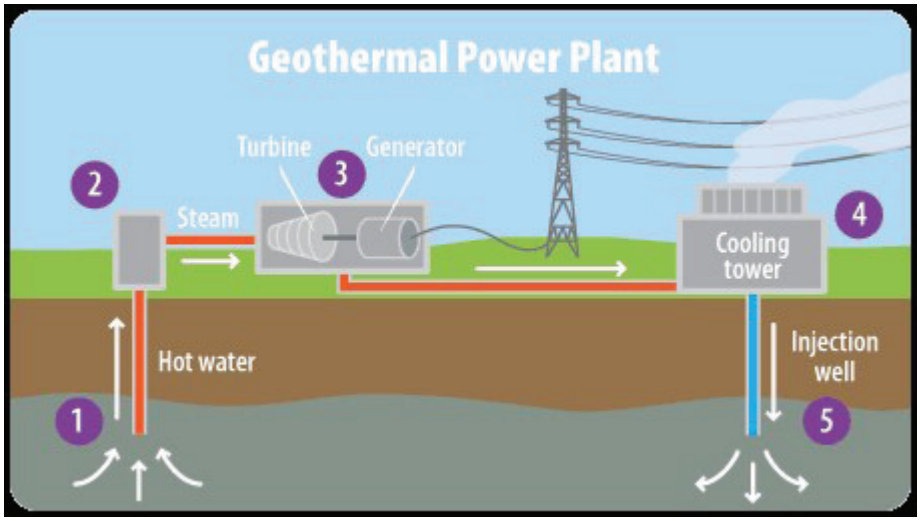


Figure 11.4: Geothermal power plant

11.4 Sustainable Development

The source of energy must be sustainable to meets our present demand without putting them in risk of getting depleted. Hydropower is a clean and sustainable climate-friendly energy source, generating power in Bhutan.

Sustainable and equitable socio-economic development is one of the main pillars of Gross National Happiness (GNH). Bhutan has long aspired to grow in a sustainable manner. Sustainable development is defined as the development that meets the needs of the present without compromising the ability of future generation to meet their own needs. This concept of sustainable development aims to maintain economic advancement and progress while protecting the long-term value of the environment.

Sustainable development has three main pillars. These three pillars are economic viability, environmental protection and social equity. The three pillars of sustainability explain that economic, environmental, and social dimensions should be treated equally. An interaction between the social, economic and environmental aspects of human activity needs to maintain a healthy environment, promote investment in sustainable livelihoods and support economic growth.

Figure 11.5: The Model for Sustainable Development

The development of renewable and energy efficiency plan is guided by the philosophy of Gross National Happiness. Bhutan's hydropower are mainly run-of-the river schemes with no impact or minimal impact to the environment. The rates of harvest should not exceed the rate of regeneration to ensure sustainable yield of this renewable resources. The rate of waste generation from any project should not exceed the capacity of the environment. This kind of energy generation aims to minimize our impact on the environment to preserve it for future generations.

Economic sustainability aims to maintain the capital intact. The Royal Government decided to exploit available water resources for production of electricity, which has transformed the economic scenario for Bhutan. Maintaining high and steady levels of economic progress is one the main objective of sustainable development. Such sustainability of economic progression enables human society to exist. Human society creates the condition, rules and relation to support sustainable economic activity.

11.5 Approaches to Resources Management

Resources management refers to an effectual and judicious utilization of natural resources as necessary. The ultimate aim is to maximize the efficiency of the resources to achieve sustainable socio-economic development and to prevent adverse effect on the resources. Resource management is important as it involves the study of classification, evaluation, utilization and management of natural resources.

The two important approaches to resources management are classified as holistic and monistic approach. Holistic Approach consider all the ecological problem coming out of resource utilization together and all these issues are address together, not one by one. This approach aims at long-term solution of problems and ecological balance and technological infrastructure. For instance, the 2011 Water Act of Bhutan identified Integrated Water Resources Management (IWRM), which is a holistic approach to water management. This approach placed to harness the country's abundant water resources and follow a long-term plan for their sustainable use. It follows the basic principles of efficient use, equitable access, balanced approach to extraction, and use of appropriate technologies.

Monistic Approach advocates for narrow solution or short solution for specific problem at a time rather than attempting all the issues together at the same time. For example, climate change has serious impacts on Bhutan. Glacial lake outburst flood has impact on our life and resources. It affects the flow of our river with serious consequences on water resources. The country must participate in international forums on climate change to negotiate on mitigation measure for important resources.

Learning Activity V

1. Many non-government organizations in Bhutan focus on sustainable use of natural resource through community participation and capacity building. Discuss the activities carried out by the projects. Use the given link given or other similar source to obtain information.

   http://www.rspnbhutan.org/community-based-natural-resource-management/

2. List the types of the things available in your classroom or at home. Classify each thing as efficient use and inefficient use. Use the table shown to collect the data.

Things use efficiently	Things used inefficiently	Give reasons

   Develop a guideline to use the available resources efficiently in the classroom.

3. Use the link https://www.youtube.com/watch?v=Q38pL8KewOY or any other sources from library and internet. Explain the significances of following approaches to resources management:
   a. Maximum Sustainable Yield Approach
   b. Natural Resources Scarcity Approach
   c. Ecological Approach

11.6 Resource utilization and sustainable development

The sustainable utilization of resources depends on the type of resources. Non-renewable resources are limited in quantity as it does not regenerate, and therefore it gets exhausted by use. In contrast, renewable resources can regenerate and may be managed to maintain or increase their productivity. People must employ smart techniques that allow efficient and sustainable use of available resource on earth.

According to the World Bank, the world population is estimated to rise from 7.2 billion today to around 9 billion by 2050. The rise in population reduces the level of sustainable development. This change in population will have adverse effect and pressure on utilization of resources. However, the impact of population growth on sustainable development varies according to level of development of the countries. The developing countries affect sustainable development negatively and developed countries affect sustainable development positively. The expansion of trade, global production pattern and investment flows are affected as the sustainable development is a long term solution. Sustainable development based upon the exploitation of resources is feasible, provided there are practical substitutes for the depleting natural resources. Therefore, the interrelationship

between economic progress, environmental management and individual wellbeing is a complicated process, affecting the both quality and sustainability of the society.

Effective watershed management is crucial for water resources conservation and sustainable utilization. However, due to the rapid pace of socio-economic development, there is increased pressure on the watersheds. Although harvesting of forest produce is based on sustainable management plan but increasing demand for timber, firewood and non-timber forest produce is starting to have negative impact on watersheds. Therefore, watershed management as the reservoir of water and other related resources is a challenge that must be solved collectively in the interest of all the resource users.

Learning Activity VI

Community forest is gearing up in many parts of Bhutan. People are happy and blessed to use the resources available in their community forest.

Visit a nearby community forest member or Gewog office if you can. Or, you may use any other source from internet, YouTube, Kuensel or library books. Collect the data on the following points:

i. Community's roles and responsibilities
ii. Government's supports
iii. Resources management and utilization
iv. Benefits and challenges

Use the data and analyze the sustainability of resources utilization in the community. Share your findings in the class.

11.7 Biomes

Biomes have changed many times during the history of life on Earth. Different biomes have different effect on the resources. It is important understand the inter-relationship between each these element in a biome.

Biome is a collection of plants, animals and soils of all those regions that have common characteristics of the environment they live in. The region of a biome is characterized by more or less uniform environmental conditions. Based on the relationships between the distribution patterns of plants, animals and world climates, the world has been divided into different biome types. The vegetation is the most dominant component of biomes. Since vegetation and climate are very closely related, the world is divided into different biome types on the basis of major world climate.

Figure 11.6: Terrestrial Biomes

Figure 11.7: Aquatic Biomes

Our Earth is classified into terrestrial and aquatic biomes. Both plants and animals depend on each other to survive. The animals in a biome rely upon plants for food and similarly plants in a biome also depend upon the animals for spreading pollen and seeds for new plant to grow. The area where plants, animals and other organism work together under same environmental conditions give rise to an ecosystem.

Learning Activity VII

On the outline map of the world, identify major types of biomes. Shade the types of biomes with different colours and label them accordingly. Compare and contrast the unique characteristics of major biomes.

Test yourself

1. Which type of energy in the figure would you recommend to use for sustainable power generation in the future? Why do you think so? Support your view with valid points.

Reprint 2024

2. “If coal is a black gold for India, then water is a white gold for Bhutan.” Justify the statement.

3. How would you suggest about generating electricity from geothermal energy in Bhutan?

4. Do you think sustainability will affect the pace of economic development in a country? Explain your ideas.

5. Use the figure to elaborate your ideas on “reducing our environmental footprint through sustainable practices.”

6. Glacial Lake Outburst Floods (GLOF) is a serious impact of climate change. It will result in reducing the natural flow regulating capacity of the glaciers for our rivers. Discuss the ways to combat the challenges for sustainable hydropower generation in Bhutan.

Chapter 12

Industries

Learning Objective (s):

- Discuss the history of industrial development
- Explain type of manufacturing industries
- Discuss the development of tourism industry in Bhutan
- Explain the factors affecting tourism

12.1 Introduction

Industries are considered the backbone of economic development. The economic strength of any country depends on the development of industries. The growth of industries is not uniform in the world. The development countries are highly industrialized, whereas developing countries are industrially backward. With the industrial activity urbanization follows. Sometimes, industries are located in or near the cities. Thus, industrialization and urbanization go hand in hand.

The development of tourism industries has become major contributing factor to the Bhutanese economy. The numbers of tourists visiting a country depend on various factors. A minimum daily tariff was fixed for tourists visiting Bhutan to avoid mass tourism. Industries and tourism sector helps in the eradication of unemployment and poverty of country.

Know More

Many industries tend to come together to make use of the advantages offered by the urban centres known as agglomeration economies. Gradually, a large industrial agglomeration take place.

12.2 Development of Industries

Ever since people begin to live a settled life, the industries grew up to provide the necessities such as furniture, textiles, leather goods, agriculture implements and luxury goods.

Figure 12.1: Causes of Industrial Revolution

The transformation of industry and the economy in Britain between the 1780s and the 1850s is called 'Industrial Revolution'. This marks the transition from domestic to factory inventions. These made goods to produce on a massive scale compared to handicraft and handloom industries. The development of steel-making has added impetus to the industrial revolution. Later, similar changes occurred in European countries and the USA. The industrial development has spread to Japan, the U.S.S.R., China and other countries.

Industries are divided into four categories known as primary secondary, tertiary and quaternary industries.

12.3 Manufacturing Industries

Manufacturing is the production of goods in large quantities after processing the raw materials into more valuable finished products. The nature of activity vary slightly from primary industries that produce raw materials and service industries that produce intangible value. The most important manufacturing industries are shipbuilding, automobiles, aircrafts, chemicals, textile and food processing.

Technological innovations are an important aspect of modern industries for quality control, efficiency, eliminating waste and combating pollution. High-tech industries are the latest

generation of manufacturing activities to improve the quality of goods. For instance, airplane and automobile manufacturing are technological backbones of the U.S. manufacturing base.

Manufacturing industry is divided into cottage industry, small, medium and large scale industry based on their size of investment, production capacity and employment. Cottage Industry is the smallest manufacturing industry usually operated by family members at home. The workers use local raw materials and simple hand-made tools to produce the goods. Finished produce such as foodstuffs, fabrics, mats and furniture can be used for consumption, sale in the market and used for barter system. It is easy to start this kind of manufacturing industry though it has low economic significance.

Manufacturing, production and providing services are done on a micro scale in small industries. The locally available raw materials, easy operating machines and semi-skilled workers are involved in such production. It provides employment and promotes regional purchasing power. The countries like India, China, Brazil and Indonesia, have developed labour-intensive small scale manufacturing to employ their population.

Large scale industries are capital intensive industry. It requires large market, tremendous energy, specialized operators, superior technology, huge infrastructure and mass production. Iron and steel industry, textile industry, heavy machinery, automobiles, shipbuilding, are some examples of large scale industries.

The development of Cottage, Small and Medium Industries (CSMI) in Bhutan is playing a vital role in creating employment opportunities, income generation and in bringing regional balanced development. The requirement in terms of capital, technology, management and utilities are not demanding in CSMIs unlike large scale industries. In 2010, the RGoB established the Department of Cottage and Small Industry (DCSI) under the ministry of economic Affairs (MoEA) to support the national cottage and small industry development.

Learning Activity I

The cottage and small industry (CSI) has grown by about 20 percent between June 2017 and June 2018. According to the CSI annual report published by Department of Cottage and Small Industry (DCSI), there are 20,195 licensed and operational CSIs in the country as of June 15, 2018.

However, close to 79 percent of CSI in Bhutan is dominated by the service sector, while Production and Manufacturing sector accounts for only about 10 percent. The

remaining about 10 percent is comprised of contract sector. "Nonetheless, production and manufacturing sector recorded an impressive growth of 27 percent in the 12-month period," the report stated. The service sector also recorded growth of 19 percent followed by the contract sector with 16 percent, in terms of growth.

Source: Kuensel dated 17 July, 2018

Study the article and prepare a power point presentation based on the given questions:

i. Explain the concept and classification of Cottage and Small Scale Industry (CSI). Use necessary smart graphic such as flow chart and insert table if required.
ii. Use a pie-chart to show the comparison between service sector, production and Manufacturing sector and Contract sector. Provide justifications.
iii. Examine what would happen, if production and manufacturing sector is not promoted as equally as service sectors industry.
iv. Suggest ways to promote cottage and small scale industry in the country.

Learning Activity II

Dhamdum Industrial Park (DIP) in Samtse, which has remained idle for some years, is gradually taking shape with some factory construction almost complete. Of nine industries that initially agreed to start construction at the DIP, Samtse in December 2020, only three- a textile factory, a furniture house, and a fruit juice factory have started to work.

Source: Kuensel dated 15 March, 2021

i. Discuss the factors favoring DIP as industrial zone in the country.
ii. Why do you think Samtse has remained idle for some years which has delayed the construction of factories? Give reasons.
iii. If you were one of the proponents to start business activity at DIP, do you think it will benefit Samtse Dzongkhag? Justify.

12.4 Manufacturing Industries in Bhutan

Manufacturing industries are the secondary sector of the economy. The manufacturing sector in Bhutan is mainly dependent on agro, forest and mineral based industries. Agro-based industries include processing of raw materials from agricultural field and farms into finished products. Major agro-based industries are food processing, fruit juice, pickles and beverages.

Forest based industry is a fast growing industry in Bhutan. This kind of production includes the particle boards, furniture and wood craft. The stable and increased forest coverage in Bhutan has made the raw materials easily available. The majority of forest based industries are small swami

Figure 12.2: Bhutan Agro Industry

Figure 12.3: Mineral-based Industry

Mineral based industries in Bhutan are characterized by production of cement, coal, dolomite, ferrosilicon, graphite, marble and limestone. Most of the mineral based industries in Bhutan are related to cement. Penden Cement Authority Ltd. in Gomtu and Dungsam Cement Corporation Ltd in Nganglam are examples of mineral based industries.

Learning Activity III

1. In the outline map of Bhutan, mark with thick dot and name the types of manufacturing industries.

   (Bhutan Fruit Product Pvt. Ltd, Bhutan Centennial Distillery, Tashi Beverages Ltd, Bhutan Brewery Pvt. Ltd, Bhutan Board Product Ltd, Wood Craft Centre, Penden Cement Authority Ltd, Lhaki Cement, Yangzom Cement Industry Pvt. Ltd, Druk Cement Pvt. Ltd, Dungsam Cement Corporation Ltd, Druk Satair Corporation Ltd, Eastern Bhutan Coal Company, Bhutan Ferro Alloys Ltd, Bhutan Chemicals & Industries Pvt. Ltd, Druk Plaster & Chemical Ltd, Bhutan Gypsum Product, Bhutan Polymer Company Ltd, Dungsam Polymer Ltd, Barma Chemical Industry)

2. Select any manufacturing or cottage industries and complete the following activity:

   a. Describe their location, type and scale, and raw materials.

   b. Explain the steps and method of production process.

12.5 Tourism

Tourism is one of the service industries, which thrives the biggest revenue earners after the hydropower in Bhutan. It was first introduced in Bhutan in 1974. Bhutan's tourism industry is regarded as one of the most exclusive travel destinations in the world. The country enjoys a reputation for authenticity, remoteness and a rich culture and pristine natural heritage. Initially, Bhutan Tourism Corporation (BTC) was operated by the Royal Government. It was privatized to become a public company as the Bhutan Tourism Corporation Ltd. after 1991. It is a vibrant business with a high potential for growth and further development.

Tourism industry in Bhutan is based on the principle of sustainability. The tourism must be environmentally and ecofriendly, socially and culturally acceptable and economically viable. Bhutan adheres strongly to a policy of 'High Value, Low Impact' tourism, to attract most discerning visitors with minimum daily tariff of USD 250 per person per night.

12.5.1 Growth of Tourism

The tourism has become one of the fastest growing and most important economic sector in Bhutan. The country received a total of 274,097 visitor arrivals in 2018 which is an increase of 7.61% comparing to 2017, according to Bhutan Tourism Monitor 2018.The continuous growth in tourism has contributed significantly towards economic growth and social development through revenue generation and creation of employment opportunities.

Tourist in Bhutan is broadly categorized as International, Domestic and Regional. When people visit from foreign country, it is referred to as International Tourist and if tourism activity take place within the country, it is known as Domestic. Regional Tourist refers to the people visiting from Bangladesh, India and Maldives. In 2018, 71,807 international and 202,290 regional tourists arrived in the country.

Learning Activity IV

1. Domestic tourism is an emerging industry in Bhutan. How would you promote domestic tourism and make it more attractive?
2. Study the table 1.1 and answer the questions.

Table 12.1

Purpose of visit	International		Regional		Total	% Share
	Air	Land	Air	Land		
Leisure	58843	4524	68060	109244	240671	
Official	4498	91	3443	1043	9075	
Business	1005	48	2337	2716	6106	
Others	2642	156	1597	13850	8245	
Total	66988	4819	75437	126853	274097	
	24.44	1.76	27.52	46.28	100.00	

Source: Bhutan Tourism Monitor 2018

I. In teams, construct a bar graph showing the differences between international and regional tourist's mode of arrival based on purpose of visit.

II. Study the graph and discuss the questions. Each team presents the discussion in the form of a report.

   i. Identify the types of tourist that visits the most in Bhutan. Give reasons.

   ii. Why majority of regional tourist arrivals to Bhutan has used land as mode of transport and international tourists by an air.

   iii. Which type of tourist would you prefer to visit our country? Why?

The types of travelers are classified based on the purpose of their visit. Bhutan is well known to the world for its Gross National Happiness Index, pristine natural beauty, forest conservation, great culture and heritage and for being only carbon negative country in the world. Eco-tourists, cultural tourist and adventure tourist are most common travelers in the country.

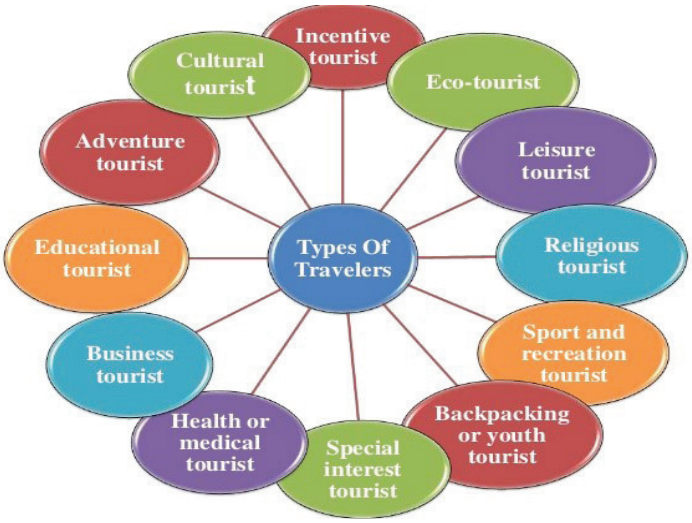


Figure 12.4: Types of travelers

12.5.2 Factors affecting the tourism

The development of tourism mainly depends on factors such as attraction, accessibility and adequate service infrastructure. A tourist attraction is a place of interest where the tourists visit, typically to exhibit natural or cultural values, historical significance, natural or built beauty, offering leisure and amusement. These attractions are widely advertised so that people come to know about them. Different things attract different people. Some tourists visit Bhutan for bird watching, botanical tours and photography while others either want different activities such as rock climbing, hiking, rafting, mountain biking and trekking.

Figure 12.5: Royal Bhutan Flower Exhibition

Accessibility is another important component of tourism. Accessibility is the means of travel to the destination. Tourists must be able to travel easily from their home country to their destination. Usually most tourists have very limited holidays in a year. Druk Air provides a quick and efficient travelling services by connecting to some of the important international airport such as Calcutta, New Delhi, Dacca, Kathmandu and Bangkok. Tourists are able to access the places they wish to visit on time.

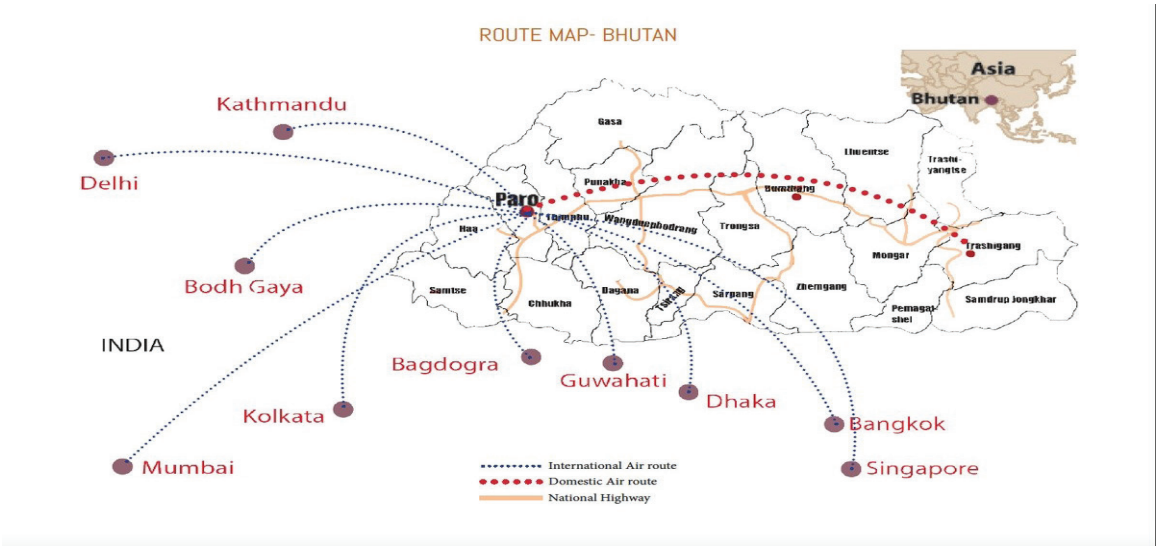


Figure 12.6: Air Route

Table 12.2 Tourist Accommodation

Dzongkhag	Accommodation Type				Total Accommo-dation	Total Rooms	Total Beds
	3* Hotel	4* Hotel	5* Hotel	Home stay			
Bumthang	18	-	1	17	36	483	956
Chhukha	8	-	-	-	8	253	498
Haa	3	-		23	26	117	234
Mongar	2	-		1	3	47	94
Paro	21	3	5	14	43	886	1766
Punakha	10	3	2	10	25	444	863
Sandrup-Jongkhar	1	-	-	-	1	8	16
Thimphu	36	5	3	3	47	1386	2558
Trashigang	3	-	-	2	5	96	192
Tsirang	1	-	-	-	1	13	26
Trongsa	1	-	-	-	1	21	42
Wangdue Phodrang	8		2	30	40	267	522
Gasa	-	-	-	7	7	21	42
Lhuentse	-	-	-	21	21	63	126
Trashi Yangtse	-	-	-	7	7	21	42
Total	112	11	13	135	271	4126	7977

Source: Bhutan Tourism Monitor 2018

Tourism infrastructure is the basis of tourism development and utilization of existing destination. It plays a distinctive role in the development of expanding this industry. Tourism is dependent on the range and type of infrastructure available at destination. Tourism infrastructure includes a large number of necessary services to meet the needs of tourists and increase satisfaction during their stay at the destination. Adequate and comfortable accommodation, varieties of good food and luxury transportation are necessary services required during their stay.

Learning Activity V

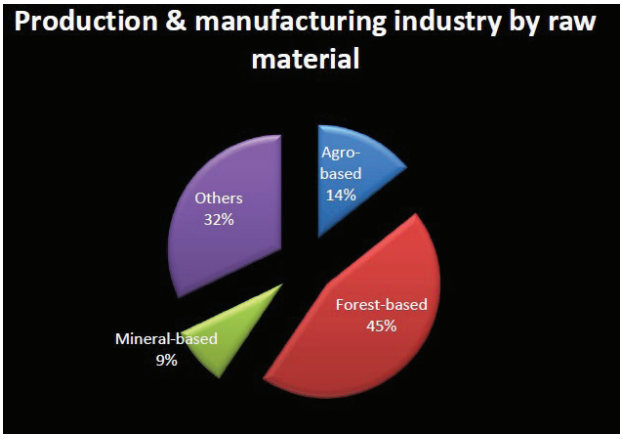
Dorji Dermo, a travel agent from Paro said, tourism in Bhutan lies at the heart of the people's economy and earning. Bhutan remains closed to international tourists, but COVID-19 has inspired in her a new found interest in domestic tourism. She is looking forward to expand her work. Glamping, eco-tourism and homestay are new ventures, she is hoping to offer for travelers.

i. How would you describe the role of 'Home Stay' accommodation services offered to tourists in Bhutan?

ii. Which dzongkhag would you recommend for the following tourism activity? Why?
   a. Eco-tourism
   b. Cultural tourism
   c. Business tourism
   d. Wellness tourism

Test yourself

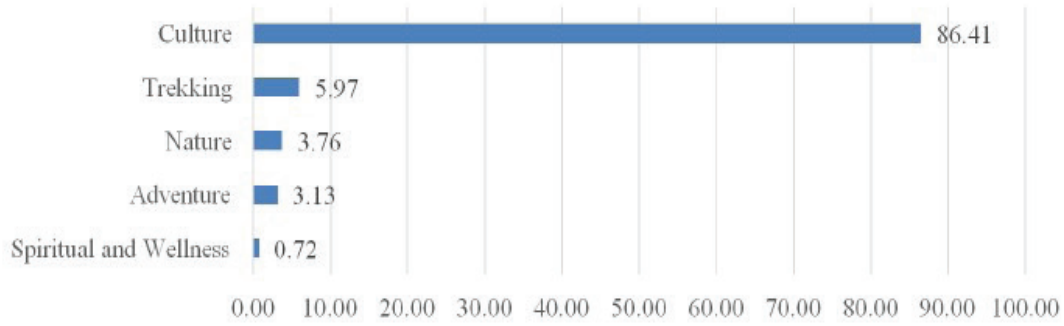
1. Discuss the benefits and challenges of cottage and small scale industry in the country.
2. Study the figure and complete the following questions.



i. Forest-based industries affect the environment conservation in the country? Justify.

ii. According to the pie-chart, which type of manufacturing industry do you think needs to promote in our country. Why?

3. The figure shows the percentage of tourists arrival by activity.



Source: Bhutan Tourism Monitor 2018

i. More than 86% of the visitors to Bhutan has been attracted by cultural activities. Identify and discuss the activities initiated by RGoB to attract those visitors.

ii. Which type of visitors are fond of Bhutan's pristine natural environment? Suggest significant activities you would like to promote for such tourists in the country.

4. Private sector industries contribute more economic growth than public sector in Bhutan. Give reasons.

CHAPTER 13

Urbanisation

Learning Objectives:

- Discuss urbanisation
- Analyse the cause of urbanisation
- Describe urbanisation trends in the world
- Classify the urban centres

13.1 Introduction

An urban settlement is a thickly populated area which consists of mostly human-made structures with different functional zones. These zones include administrative or central business, residential, industrial areas and religious functions. People in urban areas are mostly engaged in secondary, tertiary and quaternary activities. People from rural area shifts to urban centres due to better employment opportunities, better services and facilities. The shifting of population from rural to urban centres increasing the proportion of people living in urban areas is called urbanisation. The rapid growth of global urbanization not only leads to complex land cover changes but also affect the vegetation, hydrological and ecological systems.

The urban settlement may have classified as towns, cities and suburbs based on the various criteria such as population size, density, economic activity and level of infrastructure. It is almost universally accepted that a single criterion is not enough to define an urban settlement.

13.2 Urban Settlement

Urbanization is a recent phenomenon and is common in developing and developed worlds as more people move to towns and cities to acquire “privileged” social, economic services and other benefits. More than half of the world’s population lives in urban areas. The city of London was the first urban settlement to reach a population of one million in BCE 1810. About 2.5 billion people will be added to the urban population by 2050, mainly in Africa and Asia.

Know More

It is predicted that by 2050 about 64% of the developing world and 86% of the developed will be urbanized.

Urbanization in Bhutan is also a recent phenomenon. It began in 1961 with the introduction of the first five-year plan. Construction of roads, establishment of infrastructure, and educational facilities had contributed towards urbanisation. In 2002, Bhutan was one of the least urbanised countries of the world with only 21% of its total population living in the urban areas. However, it has been noticed that Bhutan's urban population is increasing at a rate of about 7% to 8% annually. According to Population and Housing Census of Bhutan (PHCB) 2017, more than half of urban population reside in Thimphu and Phuntsholing. It is projected that 50% of Bhutan's population will reside in urban areas by 2037.

The table 13.1 shows the urban areas of Bhutan according to its population size.

Table 13.1 Table showing Major urban centres of Bhutan

Urban Centre	Population
1. Thimphu Thromde	114,551
2. Phuntsholing Thromde	27,658
3. Gelephu Thromde	9,858
4. Samdrup Jongkhar Thromde	9,325
Total Urban Population	**161,392**

Source: PHCB 2017

13.2.2 Urbanisation trend in world

Urbanization trend is unique in the past few centuries comparing now. According to human history, most people across the world lived in small communities. With change of time, the mass of people started migrating to urban areas. The poor economic situations, lack of employment opportunities, poor agricultural condition and greater population pressure in villages are the main push factors that drift the rural population to the urban areas.

According to UN World Urbanization Prospects, it is estimated that more than half of the world's population now live in urban areas.

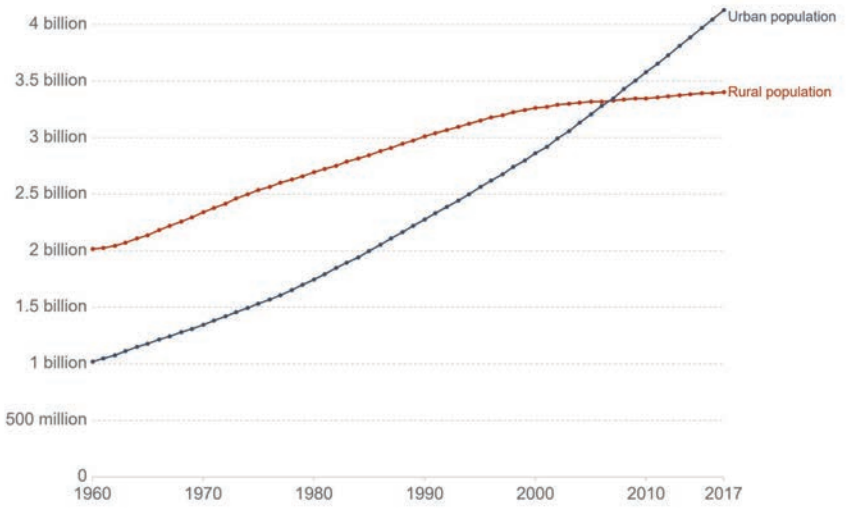


Figure 13.1: Urbanisation trend *Source: UN world Urbanisation Prospect 2018*

Know more

By 2050 it's projected that more than two-thirds of the world population will live in urban area.

Urban settings are relatively new phenomenon in human history. The transition has transformed the way we live, work, travel and build network.

Learning Activity I

Study the figure 1.2 and organize the debate in the class.

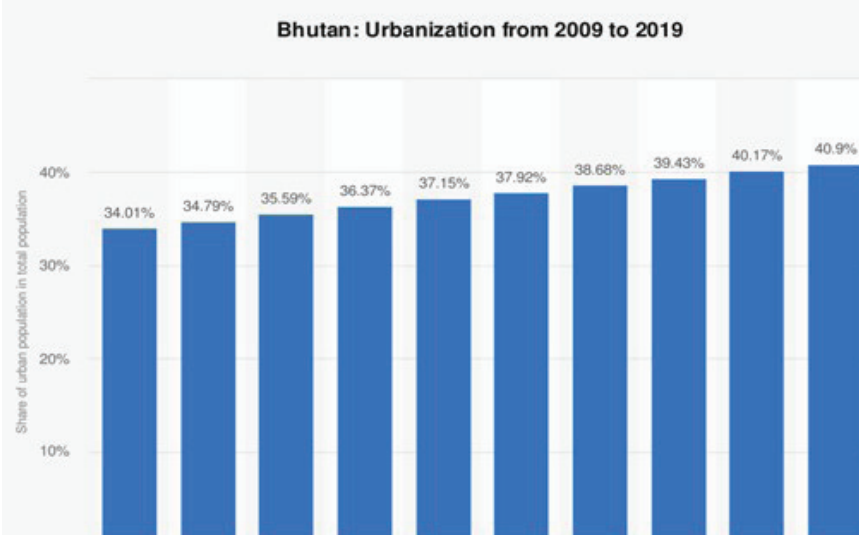


Figure 13.2: Urbanisation in Bhutan *Source: World Bank 2020*

Reprint 2024

The rate of urbanization has increased in past ten years in Bhutan. “Is this urbanization trend good or bad?”. Divide the class into two teams and debate on it.

13.3 Causes of Urbanisation

According to Mitchell urbanisation is a process of becoming urban, moving to cities, changing from agriculture to other pursuits common to cities. Urbanization occurs because people move from rural to urban areas and there is natural increase in population. Various reasons have led to the growth of cities. They are as follows:

i. Industrialization

Industrialization is a major cause of urbanization. It has expanded the employment opportunities. In rural sector people have to depend mainly on agriculture for their livelihood. The people migrate to cities on account of better employment opportunities. Industrialization is very closely related to urbanisation and one cannot survive without the other.

ii. Social Factors

Many social factors such as attraction of cities, better standard of living, better educational facilities, need for status also induce people to migrate to cities. The cities offered better facilities which are not found in rural areas. Since a variety of public facilities such as health and education are provided in the cities, people have more options to choose either to use public or private.

iii. Modernization

Urban areas are characterized by sophisticated technology better infrastructure, communication and medical facilities. People feel that they can lead a comfortable life in cities and migrate to cities.

iv. Proper Infrastructure and Utilities

Most countries all over the world are focusing on the development of major cities as the centre of government and business. As such, the cities will be definitely equipped with a better infrastructure and utilities such as roads and transportation, water, electricity and others.

Know More

The 'Break Transport' Theory: A break in transportation occurs at a place where one mode of transportation terminates and the other mode of transportation starts. Often towns come up at places where there is a break in transportation.

Learning Activity II

According to Population Projections Bhutan 2017-2047, by 2037 half the population of Bhutan will be living in urban areas.

Sources: Kuensel dated January 14th, 2019

1. What would be the main causes of such rapid urbanisation in the country? How would you address such issue?
2. Going by the Population Projections Bhutan, many towns are likely to encounter the problems of urbanisation. Discuss the kind of problems you foresee in the future. How would address such problems? Suggest measures.

13.4 Models of Urban Structure

Urban structure is the arrangement of land use in urban areas. Urban planners, economists, and geographers have developed several model that explain where different types of people and businesses tend to exist within the urban setting. Cities are not simply random collections of buildings and people. They exhibit functional structure: they are spatially organized to perform their functions as places of commerce, production, education, and much more.

i. Concentric Zone Model

The Concentric zone model, also known as the Burgess Model is one of the earliest theoretical models to explain urban social structures. It was first propound by sociologist Ernest Burgess in 1925.

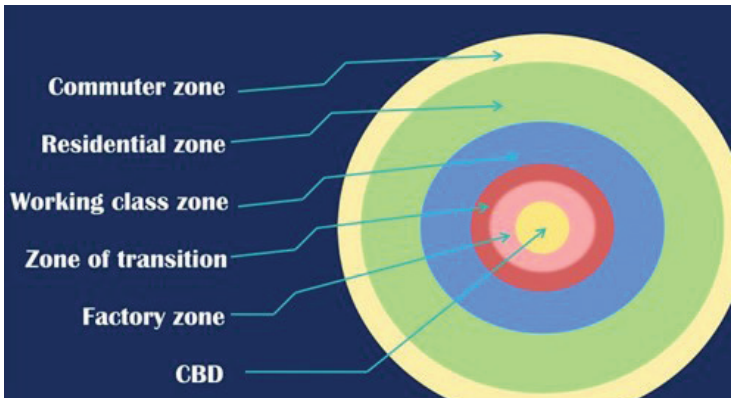


Figure 13.3: Concentric Zone Model

The Concentric zone model explains, why certain groups of people lived in certain areas of city. The towns expand outward evenly from an original core in a series of concentric circles so that each zone grows by gradual colonization into the next outer ring. The cost of land may decrease with increased distance from the city center. The commercial agents that can afford high land values will be concentrated in the city center. Series of concentric circles which can be recognized in five concentric zones expanding outward from the city core are:

Central Business District: Central Business District or CBD is the heart of a city, which can be described as commercial core. It has different types of shops, office buildings, banks, hotels, theatres, clubs etc. The area remains full of multi-story buildings where the daytime population is very high while at night the area is almost deserted. The CBD draws its business from all other areas of city.

Factory Zone & Zone in Transition: This zone surrounds the CBD, which supports business and light manufacturing industries. In this zone, we get maximum immigrants and have slums where poor people of economically weaker sections live.

Working Class Zone: Industrial workers mainly occupy this zone that have migrated out from the zone in transition but want to settle down near to their place of working i.e. factories and industries.

Residential Zone: In residential zone of town middle class groups mainly occupy the area for single-family settlement. The whole zone is full of residential buildings.

Commuter's Zone: This zone is the outer most part of town, which can be termed as rural – urban fringe. It has the residences of very high-class people separated from the city by a green belt.

Know More

Agricultural urbanism (AU) is an approach to settlement planning to that focuses on all elements of the food system across all parts of a city thereby creating more productive, cohesive and sustainable settlement. The concept of Agricultural Urbanism are considered in Bhutanese urban planning.

ii. Sector Model

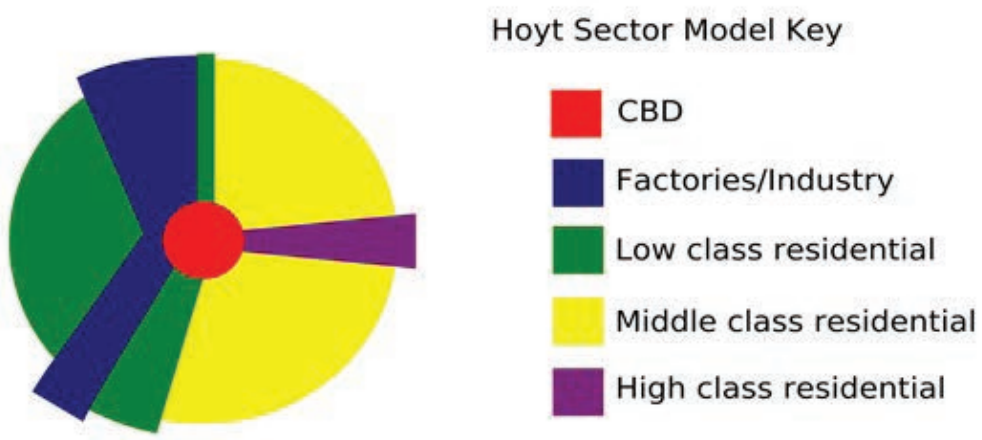


Figure 13.4: Sector Model

In the late 1930s, Homer Hoyt's sector model (B) was published, partly as an answer to the drawbacks of Burgess' concentric zone model. As technology dealing with transportation and communication was improving, growth alone created more of a pie-shaped urban structure. Hoyt discovered that land rent (for residential, commercial, or industrial) could remain consistent all the way from the CBD to the city's outer edge.

iii. Multiple Nuclei Model

In the 1940s, Chauncy Harris and Edward Ullman, arguing that neither of the earlier models adequately reflected city structure, proposed the multiple nuclei model (C). This model was based on the notion the CBD was losing its dominant position and primacy as the nucleus of the urban area. Several of the urban regions would have their own subsidiary but competing "nuclei." As manufacturing cities became modern cities and modern cities became increasingly complex, these models became less and less accurate.

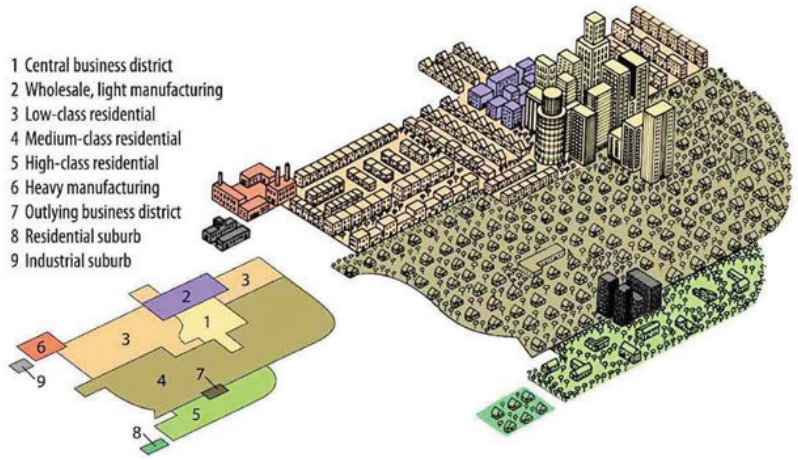


Figure 13.5: Multiple Nuclei Model

Learning Activity III

1. Make a comparative study of any urban centre and a rural area based on population, occupation and amenities. Share your findings.
2. Explore through the internet or any relevant source. Identify and explain draw backs of Burgess' concentric zone model.
3. Sketch and design the land use model of any towns in Bhutan. Use the relevant key to located its land use.

13.5 Classification of Urban Settlements

Urban settlement is classified based on population size and its functions. Settlements do not have to attain a particular size in order to become a town. However, it depends on country to country. The lower limit of the population size for a settlement to be classified as urban is 1,500 in Colombia, 2,000 in Argentina and Portugal, 2,500 in U.S.A and Thailand, 5,000 in India and 30,000 in Japan.

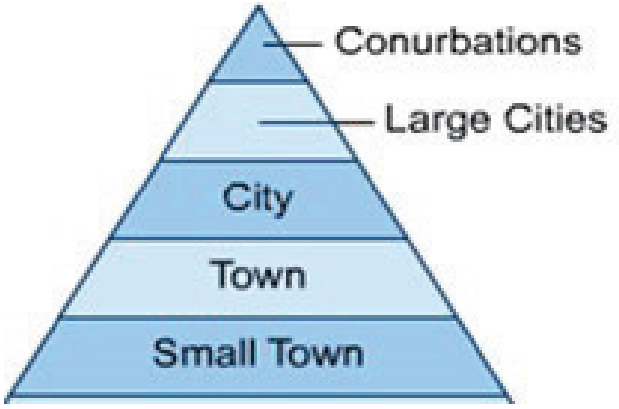


Figure 13.6: Hierarchy of urban settlement

Urban settlement is classified based on population size as town, city, metropolis, conurbation and mega city. Towns are of many different sizes, ranging from small country towns to enormous sprawling cities with several million inhabitants. An urban centre with less than one hundred thousand populations is called a town and more than hundred thousand is called a city. Cities have population varying from one to five million are called metropolitan cities while those with more than five million are known as mega cities. Majority of metropolitan and mega cities are urban agglomeration. An urban agglomeration may consist of any one the following three combinations:

i. A town and its adjoining urban outgrowths
ii. Town or more contiguous towns with or without their outgrowths and

iii. A city and one or more adjoining towns with their outgrowths together forming contiguous spread

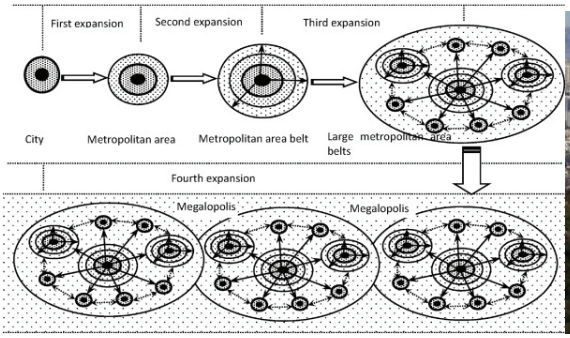


Figure 13.7: Urban Agglomeration

Figure 13.8: Conurbation

13.6 Types of urban settlement

Cities and town can be classified into various categories on the basis of their dominant functions. The structure and functions of any region varies in terms of function, history of development and age of the town. Town and cities fulfil various functions for their resident population as well as for their hinterland. Every town or city performs a number of function, one or a few of these functions become more important than others. For instance, towns and cities that develop as a result of administrative functions are called administrative town. If town which serves as a connecting point between the two countries and as such is an ideal place for promotion of trade is called trade town.

Functional Classification of Towns	
Educational Towns	Cantonment Towns
Industrial Towns	Mining Towns
Transport Towns	Tourist Towns
Cultural Towns	Religious Towns

In Bhutan, hierarchy of urban system are categorised based on population size and major function. The hierarchy of national urban system are as follows:

Sl. No.	Types of Urban Area	Population Size	Major Function
1	Gyelong Thromde (National/ Regional City)	More than 10,000	National/Regional economic drivers
2	Dzongkhag Thromde (Dzongkhag Centres)	5,000 to 9,999	Dzongkhag Administration/ Service centre
3	Yenlag Throm (Medium Towns)	1,500 to 4,999	Service centre for nodes
4	Geog Throm (Small Towns or Geog Centres)	100 to 1,499	RNR service, market, Geog centre (IGC)

Learning Activity IV

1. Identify a town that you would like to study. Write a descriptive account about it. Present your work in the class.

You may collect the information using given format:

Name of town	Site and situation	Type of town	Major function of town	Population size	Service facilities

2. Use the link – https://youtube/D9R5xSv7gZY or watch any other related clips from YouTube or internet. Write the process for the formation of urban agglomeration and conurbation.

Test yourself

1. How would you define urban agglomeration? Explain its characteristics.
2. During the last thirty years, the rate of urbanization in Bhutan has been rapid. Give three reasons.
3. Study the figure 13.9, identify and differentiate the following towns:
    a. Town A and Town B
    b. Town C and Town D

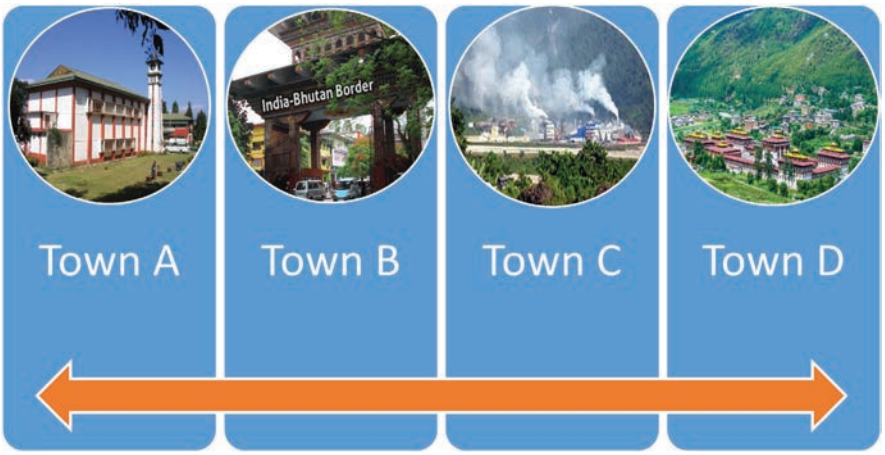


Figure 13.9: Types of towns

4. "Urbanisation and industries go hand in-hand with each other." Do you agree with this statement? Give reasons.

Reprint 2024

Chapter 14

Hazards and Disasters

Learning Objectives:

- Identify types of hazards and disasters
- Discuss hazard vulnerability and its types
- Explain risk assessment
- Discuss the impacts of hazards and disasters
- Explain human response to hazard and disasters
- Discuss role of technology in disaster management

14.1 Introduction

The world's most deadly menacing disasters range from earthquakes to plagues famines and floods. Drought conditions in Africa and India have resulted in huge loses of population and livestock. Flu pandemics took the lives of over a hundred million people in 1918 and 1919. Torrential rains and floods on the Yangtse River in China in 1931 claimed the lives of 51 million people. Similarly the covid 19 pandemic affected 223 countries and took lives of over 4.189 million from 2020 to 2021 (WHO).

Bhutan is also vulnerable to a wide range of hazards, particularly earthquakes, flashfloods, windstorm, drought, landslides, wildfire, and glacial lake outburst floods. As a result of climate change, the intensity, duration and frequency of weather-related shocks are likely to increase.

14.2 Hazard and Disaster

Any phenomena that has the potential to cause destruction to life and property is termed as hazard. A hazard become a disaster when the potential to cause destruction is fulfilled. In other words hazards are extreme geophysical events and major technological accidents characterized by concentrated release of energy or material which pose or cause an unexpected threat to human life and can cause significant damage to goods and environment.

Disaster is an event that occurs suddenly or unexpectedly in most cases and disrupts the normal course of life in affected area. It occurs with great intensity and scale and results in loss or damage to life, property or environment. This loss is beyond the coping capacity of local affected population and society. It generate emergency response.

Hazards and disaster are very closely related and are sometimes used as synonym. Yet they are quite distinct from each other, and distinction has to be made between hazard and disaster.

A hazard is a situation where there is a threat to life, health, environment or property. Hazards are elements of circumstance in the environment that have the potential to cause harm to people and property.

These hazards are termed as disasters when they cause widespread destruction of property and human lives. Once a hazard becomes active and is no longer just a threat, it becomes a disaster. As compared to hazards, disasters are relatively sudden and cause large scale, wide spread death, loss of property and disturbance to social system and life over which people have little or no control. Hazard is a threat while disaster is an event.

Earthquake is a hazard if it occurs in an open desert as it does not cause any damage. So, it does not become disaster but remains as a hazard. However, if the earthquake occurs in a city, and buildings collapse, people die or are injured, normal life is disrupted, and then it becomes disaster.

Know More

- Natural disasters kill on average 60,000 people per year, globally.
- Globally, disasters were responsible for 0.1% of deaths over the past decade. This was highly variable, ranging from 0.01% to 0.4%
- Disasters affect those in poverty most heavily: high death tolls tend to be centered in low-to-middle income countries without the infrastructure to protect and respond to events
- The most deadly disaster today tend to be earthquakes.

Learning Activity

- Complete table – on characteristics of hazards and disasters

Table 14.1: Characteristics of hazards and disasters

Sl	Characteristic of Hazards	Characteristics of Disasters
1		
2		
3		

14.3 Types of Hazards and Disasters

Hazard is a threat of a naturally occurring event which will have a negative effect on humans. This negative effect is what we call a natural disaster. In other words when the hazardous threat actually happens and harms humans, we call the event a natural disaster. These hazards and disasters are normally dived into natural hazards and disasters and people induced hazards and disasters on the basis of main causative factors.

Natural Hazards can also be divided into ***catastrophic hazards***, which have devastating consequences to huge numbers of people, or have a worldwide effect, such as impacts with large space objects, huge volcanic eruptions, world-wide disease epidemics, and world-wide droughts. Such catastrophic hazards only have a small chance of occurring, but can have devastating results if they do occur. Natural Hazards (and the resulting disasters) are the result of naturally occurring processes that have operated throughout Earth's history.

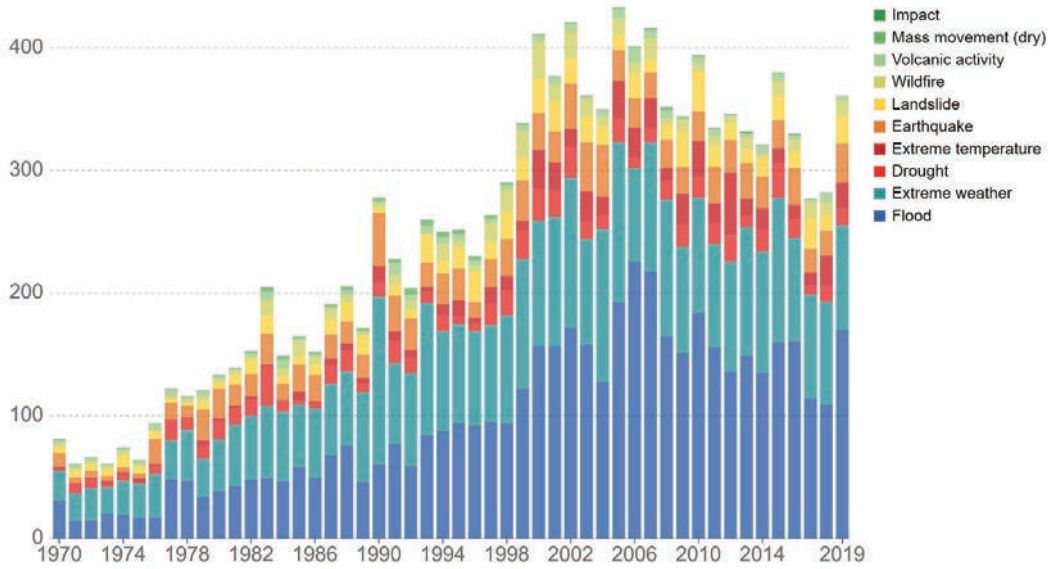


Figure 14.1: Global reported natural disasters by type, 1970 to 2019

Natural hazards and disasters can be further divided into - Planetary hazards and disaster and Extra-planetary or extra-terrestrial natural hazards and disasters.

i. Planetary hazards and disaster

Planetary hazards and disasters include the most disastrous events of our planet earth. On the basis of the origin of the extreme events, planetary natural hazards and disasters are divided into two broad categories viz.

(1) Terrestrial or Endogenous hazards caused by forces within the earth and

(2) Atmospheric or Exogenous hazards caused by atmospheric processes.

a. Terrestrial hazards and disasters

Terrestrial hazards or disasters normally include those extreme tectonic events which are caused by endogenic forces from within the earth. The causative factors of terrestrial extreme events and hazards lie deep within the earth and are not observable by human beings. Only their effects are experienced, rather badly by people. Such extreme events include earthquakes, volcanic eruptions, major natural landslides, and avalanches. Most of the terrestrial events are caused by tectonic movement of the lithospheric and oceanic plates relative to each other cause by thermal condition of the interior of the earth.

b. Atmospheric or exogenous

The atmospheric hazard are related to weather and climate events. The atmospheric environmental natural hazards are caused by atmospheric processes which originates from within the atmosphere and hence these natural hazards are called as Exogenous Natural Hazards. The extreme weather and climatic events are divided two groups namely abnormal and infrequent events that last for very short period of time such as tropical cyclones, typhoons, tornados and hurricanes and the events which prevail for prolonged period of time. Such events becomes hazard through cumulative effects such as drought and floods, heat waves and cold waves.

ii. Extra-planetary hazards and disasters

The catastrophic disasters caused by the collision between the earth and foreign bodies such as asteroids, meteorites and comets are called extra-planetary or extra-terrestrial hazards and disasters. Some scientist also consider the shift in the earth's axis of rotation as possible cause of catastrophic disaster affecting the earth, though this has not been scientifically approved. The geoidal shift have been assigned to extraterrestrial and terrestrial reasons. The rapid melting of polar ice caps may upset the rotation of earth and produce instability. The primary effects of collision between the earth and foreign bodies include emission of enormous volume of dusts, tidal waves in the oceans, shock waves, hurricanes, crater on the earth surface, rapid change in the sea level. The secondary effect may include climate change, biological extinction, volcanism and cataclysmic landform changes.

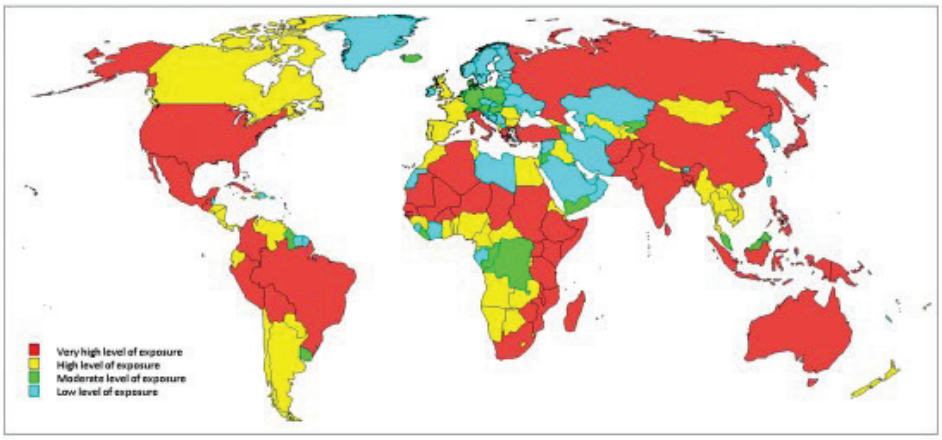


Figure 14.2: Map estimating the level of exposure of exposure of different countries to natural hazards
(Source: https://journals.openedition.org/cybergeo/25297)

iii. Human-induces hazards and disasters

Any environmental degradation induced by human beings becomes hazard and disaster when it assumes alarming proportion and causes irreparable loss to human society. The human-induced hazards and disasters may be caused by variety of human activities both intentional and unintentional characters. The human-induced hazards and disasters fall in three broad categories.

a. Human-induced physical hazards and disasters such as earthquakes, landslides and accelerated rate of soil erosion.
b. Human-induced chemical hazard such as release of toxic chemical and dumping off and exposure to toxic chemical, nuclear explosion, leakage of crude oil from oil tankers into the ocean water.
c. Human-induced biological hazards such as population explosion and eutrophication.

Figure 14.3: Human induced disaster

Though earthquakes are natural phenomena and are caused by endogenetic forces within the earth but certain human activities such as pumping of water and oil, deep underground mining, blasting of rocks by dynamites for construction purposes, nuclear explosion, and storage of huge volume of water in big reservoirs also causes earth tremors of serious consequences.

The other way to categorise hazards and disasters are such as geologic, meteorological, hydrological, climatological, biological, and extraterrestrial.

Geological hazards originate from solid earth. This term is used interchangeably with the term geological hazard. Earthquakes, volcanic eruptions, tsunami, landslides, floods, subsidence and impacts with space objects are some example of Geologic hazards.

Figure --: Destruction caused by Geological disaster (earthquake)

Meteorological hazards are caused by short-lived, micro- to meso-scale extreme weather and atmospheric conditions that last from minutes to days. Extreme temperature, fog and storm are some examples of meteorological hazards.

Hydrological hazard are caused by the occurrence, movement, and distribution of surface and subsurface freshwater and saltwater. Some example of hydrological hazards include flood, land slide and wave action.

Figure 14.4: Hydrological hazard (flood)

Climatological hazards are caused by long-lived, meso to macro-scale atmospheric processes ranging from intra-seasonal to multi-decadal climate variability. Some example of climatological hazards are tropical cyclones, tornadoes, droughts, severe thunderstorms and lightening.

Biological hazards are caused by the exposure to living organisms and their toxic substances (e.g. venom, mold) or vector-borne diseases that they may carry. Examples are venomous wildlife and insects, poisonous plants, and mosquitoes carrying disease-causing agents such as parasites, bacteria, or viruses. Epidemic, insect infestation and animal accident are some examples.

Extraterrestrial hazards are caused by asteroids, meteoroids, and comets as they pass near-earth, enter the Earth's atmosphere, and/or strike the Earth, and by changes in interplanetary conditions that effect the Earth's magnetosphere, ionosphere, and thermosphere.

Technological or human-made hazards are events that are caused by human beings and occur in or close to human settlements. This can include environmental degradation, pollution and accidents. Some of the human- made hazards or technological hazards consist of industrial and transport accidents. Chemical spill, explosion, fire, gas leakage, oil spill, rail road and air accident are some examples of technological or human made hazards.

Figure 14.5: Technological disasters

Learning Activity

- Identify hazards and disaster that have occurred in your locality and categorise them into different types of hazards and disasters

14.4 Vulnerability to Hazards and Disasters

Vulnerability refers to a human condition or process resulting from physical, social, economic and environmental factors, which determine the likelihood and scale of damage from the impact of a given hazard. It is the way a hazard or disaster will affect human life and property.

Types of Vulnerability

There are four types of vulnerability viz:

i. Physical Vulnerability

It is the potential for physical impact of disaster on the built environment and population. It encompasses the structural and non-structural damage to buildings or building components or other infrastructure. Physical vulnerability includes difficulty in access to water resources, means of communications, hospitals, police stations, fire brigades, roads, bridges and exits of a building or/an area, in case of disasters.

ii. Economic vulnerability

It is the potential impacts of hazards on economic assets and processes. Some example of economic vulnerability may include business interruption, secondary effects such as increased poverty and loosing of jobs and poorer families living in huts because they cannot afford to live in a building.

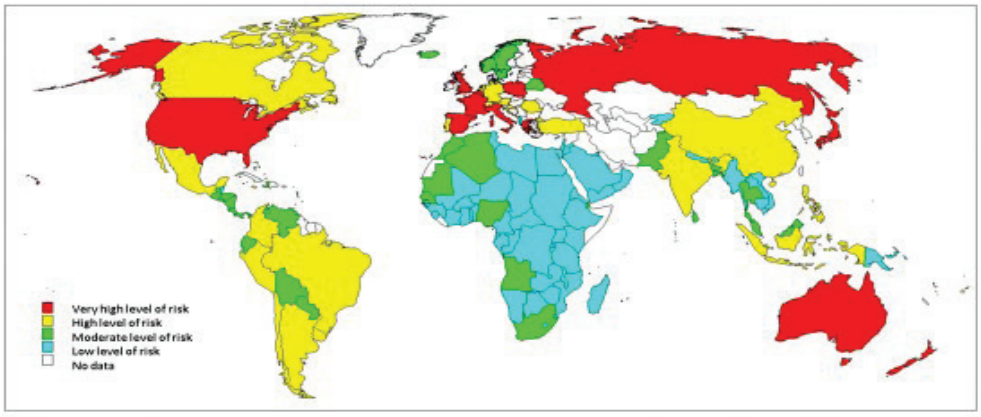


Figure 14.6: Level of risk per country according to economic approach to vulnerability (Source: https://journals.openedition.org/cybergeo/25297)

Figure 14.7: Conducting a vulnerability assessment. Photo: Royal Government of Bhutan
Social vulnerability

Social vulnerability refers to the resilience of communities when confronted by external stresses on human health, stresses such as natural or human-caused disasters, or disease outbreaks. Reducing social vulnerability can decrease both human suffering and economic loss.

iii. Environmental vulnerability

It is the potential impacts of disaster on the environment (flora, fauna, ecosystems, biodiversity). Land degradation, deforestation, desertification, loss of biodiversity, land, water and air pollution, climate change are some examples of environmental vulnerability.

Vulnerability is the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from impacts of a hazard and it depends on

- Proximity to a possible hazardous event
- Population density in the area proximal to the event
- Scientific understanding of the hazard
- Public education and awareness of the hazard
- Existence or non-existence of early-warning systems and lines of communication
- Availability and readiness of emergency infrastructure
- Construction styles and building codes
- Cultural factors that influence public response to warnings

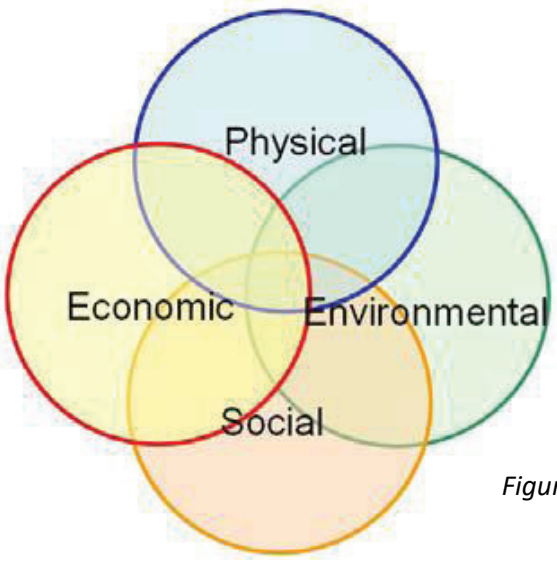


Figure 14.8: Factors, Influencing vulnerability (Source: UN-ISDR).

In general, developing counties are more vulnerable to natural hazards than are industrialized countries because of lack of understanding, education, infrastructure, building codes, etc. Poverty also plays a role as it leads to poor building structure, increased population density, and lack of communication and infrastructure.

Human intervention in natural processes can also increase vulnerability by:

- Development and habitation of lands susceptible to hazards. For example, building on floodplains subject to floods, sea cliffs subject to landslides, coastlines subject to hurricanes and floods, or volcanic slopes subject to volcanic eruptions.
- Increasing the severity or frequency of a natural disaster. For example: overgrazing or deforestation leading to more severe erosion (floods, landslides), mining groundwater leading to subsidence, construction of roads on unstable slopes leading to landslides, or even contributing to global warming, leading to more severe storms.

Learning Activity

- Discuss some of the factors that is responsible for making the Bhutanese population vulnerable to hazards and disasters.
- Developing countries are more vulnerable to hazards and disasters compared to developed countries. Discuss and share your findings.

14.5 Effects of natural disasters

The effects of natural disasters are many and varied. Some are short term effects that can be fixed with relative ease while others last for years. Natural disasters have three general types of effects: primary effects, secondary effects, and tertiary effects.

Primary effects are the direct result of the disaster. For example water damage during a flood or collapse of buildings during an earthquake, landslide, or hurricane.

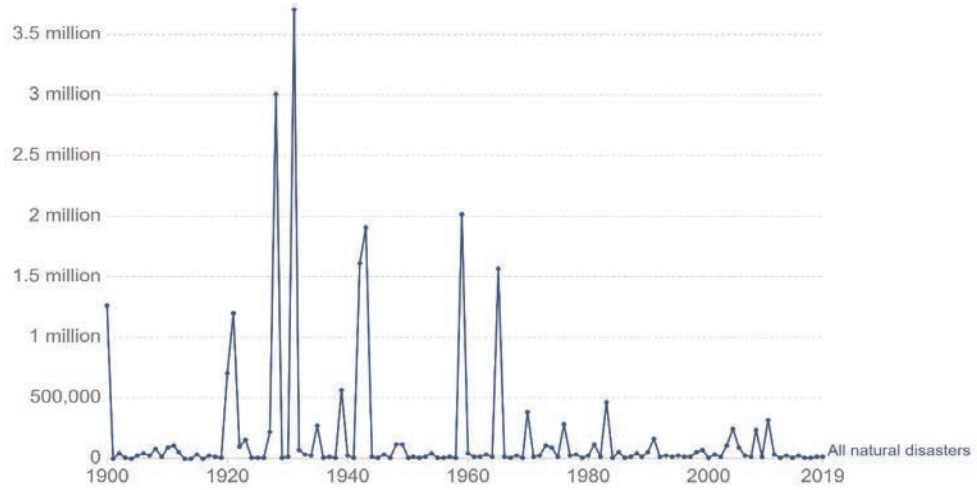


Figure 14.9: Global deaths from natural disasters, 1900 to 2019 (Source: https://ourworldindata.org/natural-disasters

Secondary effects are the result of primary effects. For example, fires ignited as a result of earthquakes, disruption of electrical power and water service as a result of an earthquake, flood, or hurricane, or flooding caused by a landslide into a lake or river. In these examples, the damaged building would be primary effects that caused the power outages and fires (secondary effects).

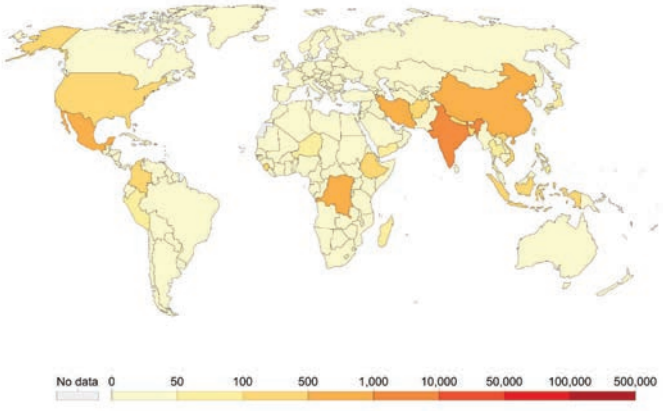


Figure 14.10: Number of deaths from natural disasters, 2017 (Source: https://ourworldindata.org/grapher/deaths-natural-disasters-ihme

Tertiary Effects are long-term effects that are set off as a result of a primary event. These include things like loss of habitat caused by a flood, permanent changes in the position of river channel caused by flood, crop failure caused by a volcanic eruption etc.

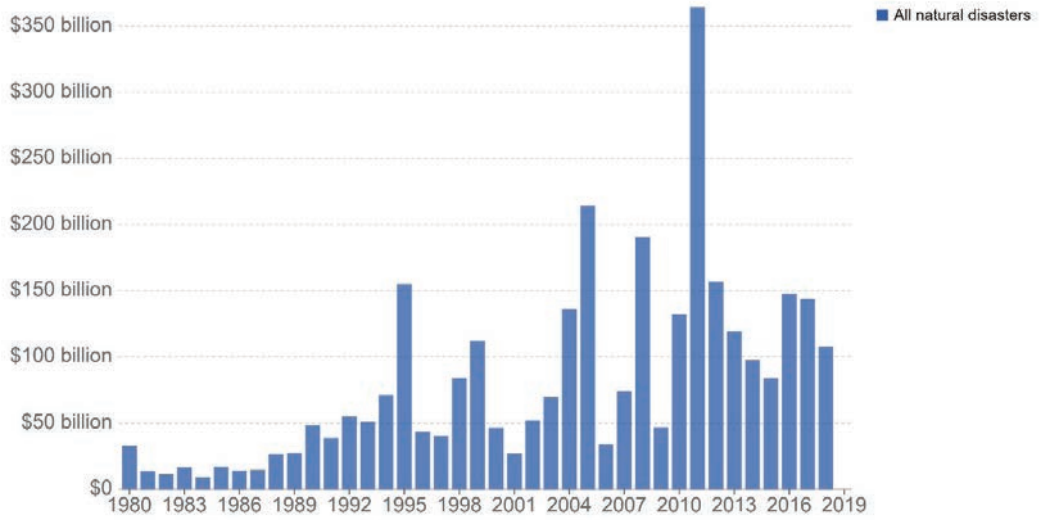


Figure 14.11: Global damage costs from natural disasters, All natural disasters, 1980 to 2019 (Source: https://ourworldindata.org/)

Learning Activity

- Disasters have caused huge economic impact in the world. Suggest at least three ways to reduce the impact of disasters in the world and share your findings.

14.6 Human Responses to Hazards and Disasters

Humans have always had to deal with natural hazards; whether through preparing for them or responding when a disaster occurs. One of the most important ways humans respond to natural hazards is by preparing for their occurrence. As technology has improved, so has the ability to prepare, predict, and forecast future natural disasters.

Hazard assessment

Hazard assessment is when scientists study hazards to determine characteristics of various hazards. A hazard assessment differs from a risk assessment primarily because and hazard assessment focuses mainly on the natural processes of a possible event while a risk assessment includes a hazard's possible effects on a society. Hazard assessment generally determines the location and timing of past hazardous processes, the severity and frequency of past hazardous processes, probable effects of different processes depending upon the

magnitude (severity) of a possible event, and organizing the information into a usable form for officials and policy makers.

Hazard Assessment consists of determining the following:

- When and where hazardous processes have occurred in the past.
- Severity of the physical effects of past hazardous processes (magnitude).
- Frequency of occurrence of hazardous processes.
- Likely effects of a process of a given magnitude if it were to occur now.

Risk assessment

It is the incorporation of information from a hazard assessment, but also includes possible socio-economic effects. A risk assessment includes locations of buildings and infrastructure in hazardous areas, the potential for exposure due to the physical effects of a hazard, community vulnerability in the event a hazard becomes a disaster, and a hazard assessment.

Figure14.12: Risk assessment model (Source: https://www.acamstoday.org/what-is-the-model-risk-in-a-risk-assessment/

Risk Assessment involves not only the assessment of hazards from a scientific point of view, but also the socio-economic impacts of a hazardous event. Risk is a statement of probability that an event will cause certain amount of damage, or a statement of the economic impact in monetary terms that an event will cause. Risk assessment involves

- hazard assessment,
- location of buildings, highways, and other infrastructure in the areas subject to hazards
- potential exposure to the physical effects of a hazardous situation
- Vulnerability of the community when subjected to the physical effects of the event.

Risk assessment aids decision makers and scientists to compare and evaluate potential hazards, set priorities on what kinds of mitigation are possible, and set priorities on where to focus resources and further study.

14.7 Hazard Prediction

Prediction is a statement of probability that an event will occur. In terms of natural hazards, predictions are made through various scientific observations. A common observation that could lead to a prediction is the identification of a precursor event. A precursor event is a smaller event that usually precedes a larger event, such as tropical depression leading to a tropical storm before becoming a hurricane or numerous small earthquakes around a volcano indicating an imminent eruption.

For example, the slow movement of the ground surface for a long period prior to landslides. Volcanoes have been noticed to swell or bulge before eruption and there is often a significant increase in the local seismic activity surrounding the volcano. Foreshock activity, unusual tilts and uplift of land and perhaps even strange animal activity may be a precursor activity for earthquakes.

Hazard Forecast and Warning

With some natural processes it is possible to accurately forecast when the event will occur and arrive at a place or area. For example flooding in the rainy season, cold wave in winter. The use of modern telecommunication technology can help to predict hazards and people could be informed. The spotting of hurricanes far out in the sea and tracing towards the shore helps to forecast when it will actually strike the land.

Figure 14.13: Flood monitoring station

Forecasting and prediction is often used synonymously; however, in certain instances a forecast can be slightly different from a prediction. The term forecast is usually used as a short-term prediction of the severity, location, and timing of weather related events. It can

also be used for long-term probabilities of an event occurring within a certain time frame. This long term forecasting is not as precise as a weather forecast.

These are much longer-term activities, which attempt to return an area to 'normality' after severe devastation. Such devastation can occur even in those areas apparently well prepared for disaster for example the Kobe area which suffered in the 1995 earthquake and 2011 Tsunami in Japan.

Disaster recovery and reconstruction involves the restoration of normal activities that were disrupted by the disaster impact. It is a phase in the emergency management cycle that begins with the stabilization of the disaster conditions and the community has returned to is normal conditions. It is a process by which the community achieves the goal of returning to normal routines. The recovery and reconstruction process involves both activities that were planned before the disasters impact and those that were improvised after the disaster impact.

Learning Activity

- Identify an elderly person in your locality and interview him or her to find out traditional ways of predicting and forecasting hazards and disasters. Share your findings.

Technology in hazard and disaster management

Information and Communication Technologies (ICTs) play a significant role in disaster prevention, mitigation response and recovery. Timely and effective information is required by government agencies and other humanitarian actors involved in rescue operations and decision-making processes. ICTs play a critical role in facilitating the flow of vital information in a timely manner.

Figure 14.14: Use of Technology in Disaster management (Source: https://www.itu.int/en/ITU-D/Emergency-Telecommunications/Pages/ICTs-4-DM.aspx)

In mitigating disastrous effects of hazards, technology promotes the use of different information and communication technologies and networks, including satellite,

radio, mobile networks and the Internet, that can contribute to enhance capacity and reduce vulnerability of people. Telecommunications are critical at all stages of disaster management: mitigation, preparedness, response and relief, recovery and rehabilitation.

Figure 14.15: Seismic station in Thimpu. Photo: Royal Government of Bhutan

Role of GIS and Remote Sensing in Disaster Management

Geographic Information System (GIS), Remote Sensing (RS) and Global Positioning System (GPS) are useful in the disaster management application and decision making. These technologies are useful for hazard zone mapping and preparation of mitigation strategies and preparedness plans. GIS technologies can be used in modeling the disaster risks and human adaptations to hazards. Accurate cataloging of GIS data provides useful information during emergency situations. GIS database include following information which is beneficial in disaster management:

- Use of different satellite imageries (Remote Sensing data) GIS data creation.
- Preparation of base map of different themes using satellite imageries.
- Thematic maps such as a hydro geomorphologic map, slope map, terrain map, and DEM generation in GIS which is used for disaster planning.
- Macro and micro-level maps used for identifying vulnerability and threat condition
- Identification of safe locations and zones for rehabilitation
- Road and location maps used for finding alternate routes, shelters, and locations

- Planning of evacuation and operation

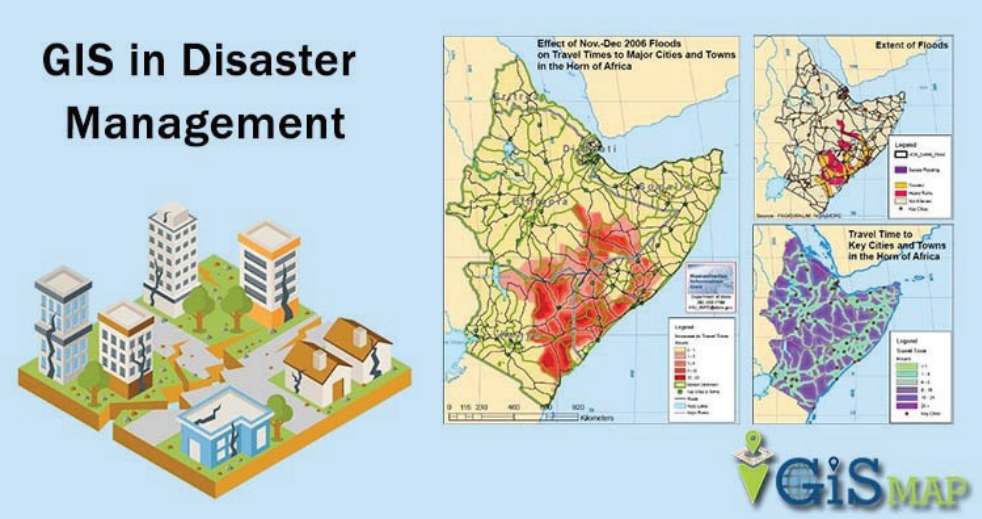


Figure14.16: GIS in Disaster management (Source https://www.igismap.com/gis-in-disaster-management-system)

Test Yourself

1. Why is it important to carry out risk assessment for hazard?
2. What are some of the current issues that our country need to focus on for effective and efficient disaster management?
3. Discuss the need for international cooperation in disaster management in the world.
4. "The world is becoming more hazardous". Do you agree with this statement? Justify your answer with reasons.
5. Imagine that you are the disaster focal person who is responsible for disaster management in your school. Develop a disaster management plan. Focus on one of the hazards like earthquake, flood or fire.
6. Collect dzongkhag wise data on COVID -19 cases from the Ministry of Health for the year 2021, and prepare a distribution map using QGIS.

Reprint 2024