“Your parents, relatives, and friends would be very proud of what you have achieved. At your age, to have completed your studies is your personal accomplishment. Your knowledge and capabilities are a great asset for the nation. I congratulate you for your achievements.

Finally, your capabilities and predisposition towards hard work will invariably shape the future of Bhutan. You must work with integrity, you must keep learning, keep working hard, and you must have the audacity to dream big.”

- His Majesty Jigme Khesar Namgyel Wangchuck

ADVANCED
GEOGRAPHY
CLASS XII

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

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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

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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!

Karma Galay
Director General

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Chapter 1

The Origin of the Universe

Learning Objective (s):

- Explain the origin of the Universe with reference to Gaseous Mass hypothesis and Electromagnetic Theory.

1.1 Introduction

The evolution of the Universe is among the puzzles of cosmology. There are several theories that describe the origin of the Universe. The Gaseous Mass Hypothesis is one of the earliest theories describing the origin of the Earth based on the Newton's law of gravitation and rotatory motion while the Electromagnetic Theory highlights the Electro- magnetic fields and its influence on the formation of the universe.

1.2 Gaseous Mass Hypothesis

Gaseous Mass Hypothesis is a theory based on a monistic concept explaining the origin of the Earth. Emmanuel Kant, Prussian philosopher in 1755 presented the Gaseous Mass Hypothesis. This theory is developed based on the principles of Newton's law of Gravitation and Rotary Motion.

Kant assumed that primordial matter (supernaturally created) was scattered in the universe. The matter which was small, hard and cold motionless particles attracted towards each other under the influence of gravitational force.

The attraction and collision between the particles generated random motion in the primordial matter. The friction between these particles produced heat and raised the temperature of the primordial matter gradually. The rise in temperature also changed the state of primordial matter from solid to gas. The collision of the particles propagated random motion resulting in the formation of angular velocity. Due to the angular velocity, the original cold and motionless cloud of primordial matter became Hot Nebula. The Hot Nebula started expanding due to continuous rise in the temperature and high rate of rotary motion. It became vast that it extended from the Sun in the centre to as far away as the orbit of the outermost planet.

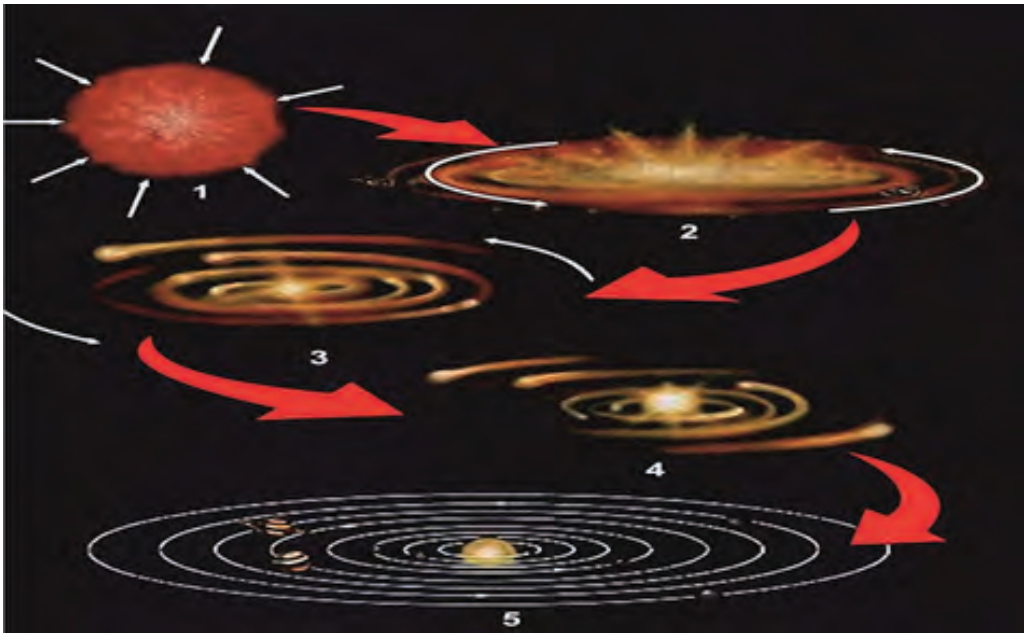

Fig. 1.1 Stages of Gaseous Mass

The repeated collisions of the particles increased the pace of random motion and angular velocity. This process made the Nebula to rotate and stimulated centrifugal force. The centrifugal force was larger than the centripetal force that developed irregular rings. The rings were thrown away from the center of the Nebula to outside because of the centrifugal force. The process repeated for NINE times subsequently forming NINE planets.

The Earth is one of the rings thrown away from the centre of the Nebula. By small scale repetition of the same process, the gaseous mass of the planets threw away rings which became their satellites. The remaining portion of the gaseous mass or the hot nebula is the Sun. Thus, the entire solar system comprising the sun, planets and their satellites came into existence.

The Universe was formed due to aggregation of all the matter of the rings which were separated from the nebula due to centrifugal force. Kant was so confident about his hypothesis that he proclaimed, “Give me matter, and I will show you how to make a world of it.”

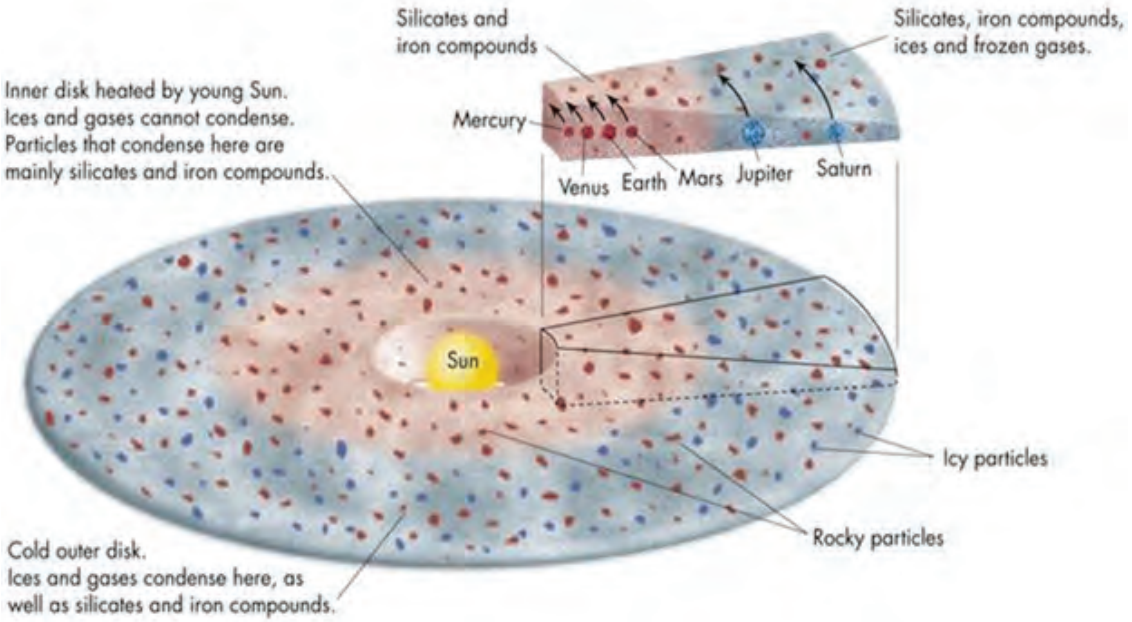

Fig. 1.2 Expanding disc of primordial matter

1.3 Merits of Kant's Theory

1. **First theory based on gravity and motion** - The fundamental scientific facts, such as Newton's Laws of gravity and motion were the basis for Kant's theory.
2. **Simple** - Kant's hypothesis appears to be simple and sounds more logical.
3. **Trend setter** -This theory provided the basis for development of future ideas on the origin of the Earth. Nebular theory of Laplace was influenced by Kant's theory that paved the way for hypothesizing Laplace's theory.

Demerits of Kant's Theory

Although this theory was held in high esteem for about half a century, it has been criticized on the following grounds:

1. **Origin of primordial matter not explained**

   Primordial matter is assumed to be created supernaturally and did not explain its source.

2. **Problem of Gravitational Pull**

   Kant was of the view that the collision between the particles of the primordial matter was due to gravitational pull.

3. **Generation of angular momentum not explained**

   Generating angular momentum requires external force and Kant did not mention any such force to support his theory. The generation of angular momentum in the primordial matter after collision of its particles is not explained in Kant's theory.

4. **Against the Law of Conservation of Angular Momentum**

   Kant's assumption of angular momentum being produced in the nebula by the collision of its particles was against the well-known law of conservation of angular momentum.

Learning Activity

1. Watch the video https://youtu.be/dFjYjbQ86A and discuss the relation between temperature of the primordial matter and rate of collision. Share your findings.
2. Describe the role of the components in the development of the gaseous mass theory. Complete the task in Table 1.1.

Table 1.1 components in the development of gaseous mass hypothesis

a. Primordial Matter	b. The rise in the temperature	c. Motion of the particles	d. Gravity	e. Time period

1.4 Electromagnetic Theory

Electromagnetism is a branch of physics involving the study of the electromagnetic force. It is transmitted by electromagnetic fields composed of electric and magnetic fields. It is responsible for electromagnetic radiation, such as light and chemical bonds between atoms which create molecules, and intermolecular forces. It governs all chemical processes, which arise from interactions between the electrons of neighbouring atoms. The electromagnetic force plays a major role in determining the internal properties of most objects encountered in daily life and is widely used in modern technologies.

Electromagnetic theory is the basis of electric power engineering and electronics including digital technology. Electromagnetic theory was developed by Dr. Hannes Alfven, Swedish electrical engineer in 1942 based on electromagnetic force.

As per the theory, a strong electro-magnetic field surrounds the Sun like it surrounds the planets. The Electro-magnetic field was stronger than the gravitational field. Dr. Alfven mentioned it in the ratio of 60,000 :1.

Electro-magnetic Force = 60,000/Gravitational force = 1

The Sun was revolving at a high velocity and during the course of its journey, it entered a mass of dust clouds. The dust particles were attracted by the magnetic field of the Sun and they started revolving around the Sun.

In the beginning, the clouds of dust were not ionized and were scattered over the entire space. In due course of time, the particles received sufficient energy and were ionized as protons, neutrons and electrons. The ionised particles collided due to the electromagnetic forces and the planets were formed.

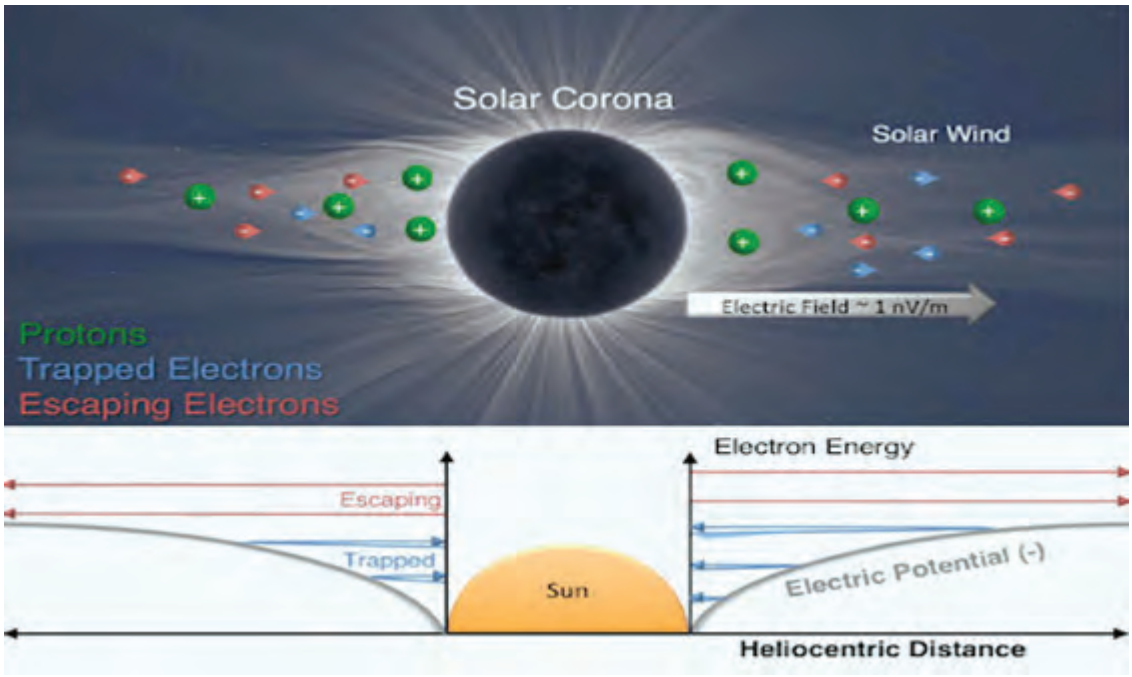

Fig. 1.3 Electromagnetic Force- Ionized Particles

When the planets grew bigger in size, they developed their own electromagnetic field. Consequently, they became capable of attracting dust particles and satellites were formed in the same manner. In this manner, the Solar system was created.

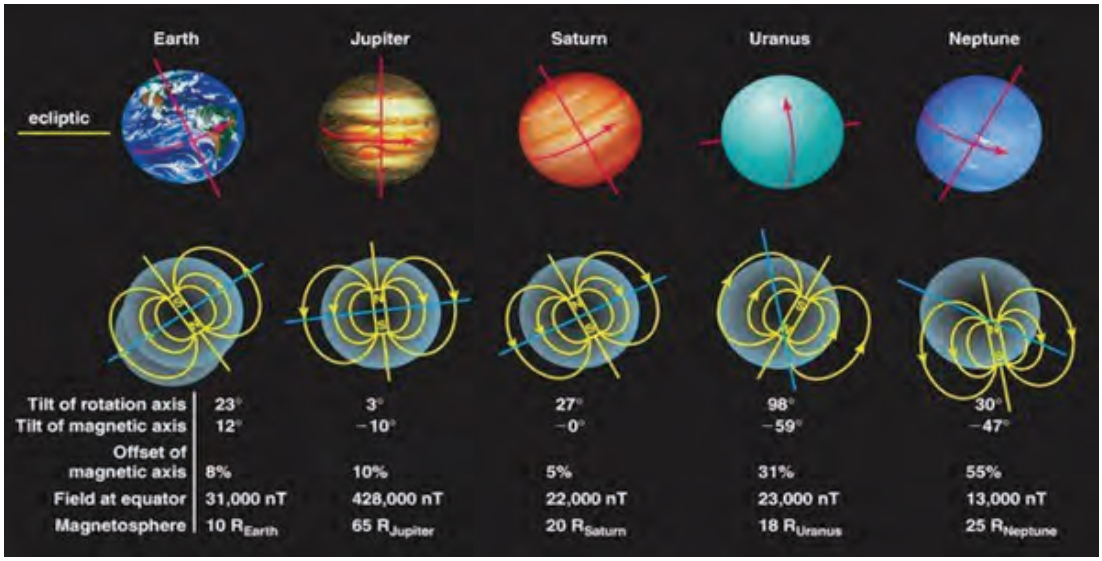

Fig 1.4 Planets and their electromagnetic fields

This hypothesis is simple and explains the origin of the universe in a reliable way. However, it has limitations.

1. The presence of magnetic fields in all the planets have not been proved.
2. The angular momentum of the planets has not been explained in a scientific manner.
3. Formation of four inner terrestrial planets that are rocky is not explained by this theory.

The understanding on the genesis and evolution of the universe is one of the greatest achievements of 20th century. This knowledge is generated from decades of research and experiments. Modern technologies, such as telescopes and satellites detect the light from galaxies billions of light years away, providing an image for better understanding of the universe. String theory, cosmic ego-trip and simulation theory are some of the emerging theories.

Learning Activity

Watch the video https://www.youtube.com/watch?v=9FCYGbOWk4w, and share your understanding about electromagnetism.

Test Yourself

1. Compare and contrast Gaseous Mass Hypothesis and Electro-magnetic theory.
2. Why do you think that Gaseous Mass Hypothesis was not widely accepted by the scientific world? Suggest possible ways to make the theory more reliable.
3. Do you think all celestial bodies have an electro-magnetic field? Justify.
4. What are some of the reasons for wide acceptance of Electromagnetic theory?
5. State whether the following statements are True or False. Correct the false statement (s).
    a. Gaseous mass hypothesis was the first ever theory about the origin of the Earth.
    b. Angular velocity is the cause of centrifugal force.
    c. The gravitational force is higher than electro-magnetic force that resulted in the formation of planets.

6. Write differences between primordial matter and Nebula.

7. Fill in the blanks

   i. The temperature of the primordial matter was increased due to_____.

   ii. The Electromagnetic field was stronger than the gravitational field, in the ratio of_____.

   iii. The rings were thrown away from the centre of the nebula and formed the planets, the remaining portion of the hot Nebula became _____.

Chapter 2

Survey and Mapping

Learning Objective (s):

- Explain cartography and its uses.
- Discuss Surveying.
- Conduct Plane Table Survey.
- Discuss uses of Total Station for survey.

2.1 Introduction

Cartography is an art and science of representing geographical features through maps, charts and graphics. The basis for the art of map making is survey. Surveying is the measurement of relative positions of natural and human-made features on the Earth's surface.

Maps are an important element of geographical studies. Geospatial technology and digital tools, such as Total Station, GPS, Remote Sensing, GIS and Google Earth enhance the accuracy of maps and map making skills.

2.2 Cartography

Cartography, the art of mapmaking, dates back to 7th BCE. It links art and science to embrace the principles and practical standards of maps and mapmaking. Cartographic technique helps in creating and studying maps. The art of map making involves the use of data on political, cultural and non-geographical phenomena. Cartography helps to understand the location, analysing positional relationships and reflecting on geography's influence on daily lives.

The development of geo-spatial technology and digital tools like GPS, GIS, Remote Sensing and Google Earth have revolutionised cartographic techniques enhancing accuracy of map making.

Know more

Abraham Ortelius (1527-1598) is called the father of Modern Cartography for producing the First Modern Atlas.

Anaximander, an ancient Greek scientist and geographer, is said to be the first scientist to publish the world map.

Cartographic Process

The first step in map making involves evaluating the viewer and using diagrams to decide the map size, text features and map scale. This is an essential step for showing colour schemes of the map and deciding the projection to be used. This makes the map simple and transparent for the readers to interpret.

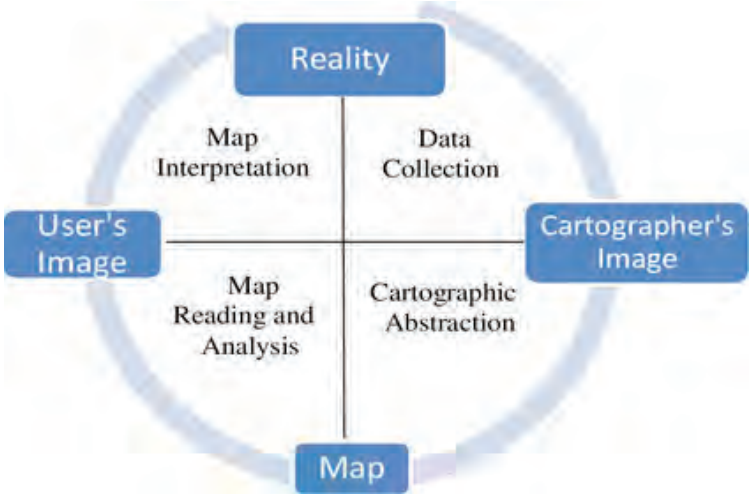

Fig. 2.1 Cartographic Process

Identification and selection of colour, size and projection are important processes to create maps. The use of geo-spatial technology and tools help in collecting and uploading information. This enables the cartographers to modify and design maps as per the requirements of the users.

Uses of Cartography

Cartographic tools and map features help people to locate various features on the surface of the Earth. There is an increase in the number of people using maps.

1. Helps us understand our place in world, analyse positional relationships and reflect on geography's effect on people.
2. Cartography deals with method expression and communication of the facts and phenomena with symbols and graphs.
3. Cartographic skills are used for planning and decision making in areas of socio-economic, population trends, urbanisation, security, defense and environment management.

2.3 Surveying

Surveying is an art of making measurements of the relative positions of natural and human-made features on the earth surface and presenting this information graphically or numerically. Surveying has been an essential element in the development of peoples' environment for many centuries. It is important for planning and execution of developmental activities. Surveying involves measuring and recording distances, angles, height and size of the earth surface features and drawing them on the plan, section or map.

Surveying in the present day influences all spheres of life. It is used to map the earth above and in the marine sites, prepare navigational maps (land, air, sea), establish databases for natural resources management, development of engineering data for huge building and constructions, land development roads, railways, settlements, and bridges.

i. Purpose of surveying

Surveying is carried out for the following purpose:

- Collecting field data and preparing a plan or map of the area surveyed.
- Preparing various maps for different users.

ii. Phases of surveying

1. Decision Making - selecting method, equipment and final point locations.
2. Fieldwork and Data Collection - making measurements and recording data in the field.
3. Computing and Data Processing - preparing calculations based upon the recorded data to determine locations in a usable form.
4. Mapping or Data Representation – plotting data to produce a map or chart in the proper form.

2.4 Types of surveying

Surveying is categorised primarily into geodetic surveying and plane surveying.

1. Geodetic surveying

It takes into account large areas of the earth's surface (greater than 300 square miles/ approximately 500 square Km) and considers curvature of the earth. It aims to establish a network of horizontal and vertical features that goes beyond angles, size as well as latitude and longitude. It is carried out at national and international level.

2. Plane surveying

Plane surveying is commonly used surveying for small areas like schools, villages and townships. Plane surveying measures and considers the surface of earth as flat and neglects the curvature. The areas covered are generally less than 300 square miles or less than 500 square kms and surfaces of earth are projected onto horizontal planes.

Branches of surveying

1. Topographic surveying

In this branch of surveying, natural and human-made maps and plans are produced.

2. Engineering surveying

The survey work is done before, during and after any engineering works.

3. Cadastral surveying

It is done to produce plans of property boundaries for legal purposes. In many countries, the registration of ownership of land is based on such plans.

Learning Activity

1. Explore the differences between geodetic and plane surveying using internet sources and share it in the class.
2. Referring relevant sources, explain the different branches of surveying.
   a. Geographical Information System
   b. Archaeological survey
   c. As-built survey
   d. Bathymetric survey
   e. Hydrological survey
   f. Measured survey

Plane Table Survey

Plane table surveying is a method of gathering and recording field observations on a sheet fixed on the plane table. It is also called plane tabling. Plane tabling is used for small and medium scale mapping of large areas where accuracy is not the main consideration.

The main instrument used in plane table surveying includes a table top similar to a drawing board fitted onto a tripod. The observations are made for the objects by fixing the drawing sheet on the table top. Scaling down the distances and plotting of objects are carried out on the field. The accuracy achieved in this type of surveying is less, though there is no chance of omitting any necessary measurement in this surveying. Therefore, this type of surveying is used to fill the details between the survey stations fixed by other methods. The equipment required to carry out plane table survey includes:

a. Alidade

Alidade is used for drawing line of sight. It has a straight edge with a sighting device. The other edge of the ruler is bevelled and graduated. The two types of alidade are plain alidade and telescopic alidade

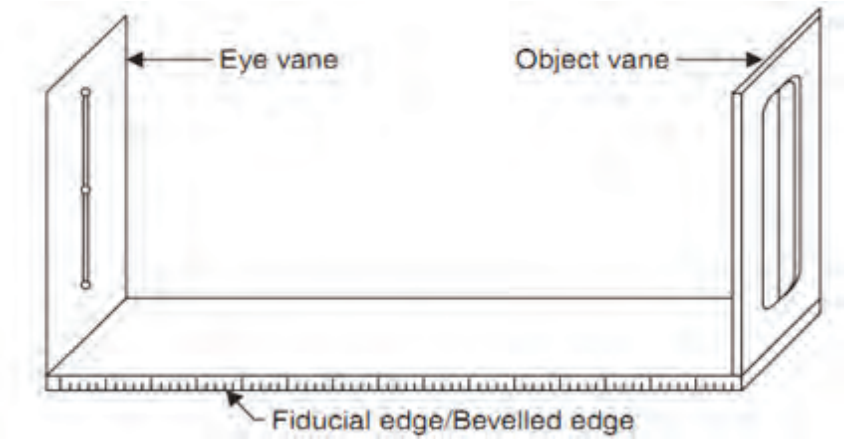

Fig. 2.3 Alidade

b. Plumbing fork with plumb bob

Plumbing fork is a U-shaped metal frame with a lower inclined arm and upper horizontal arm. Lower arm has a hook to suspend the plumb bob and the upper arm has a pointer at the end. Vertical line (line of plumb bob) passes through the pointed edge of the upper arm when the plumbing fork is kept on the plane table. Plumb bob transfers the ground point to the drawing sheet.

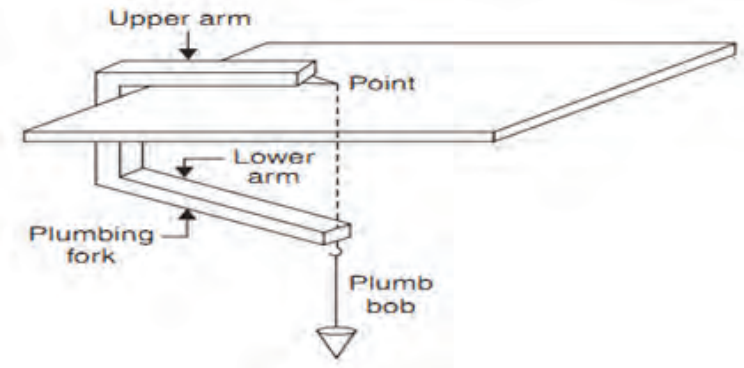

Fig. 2.4 Plumbing fork with plumb bob

c. Spirit Level

The position for the bubble tube in a spirit level should be at central level. This can be checked by positioning the spirit level in any two mutually perpendicular directions.

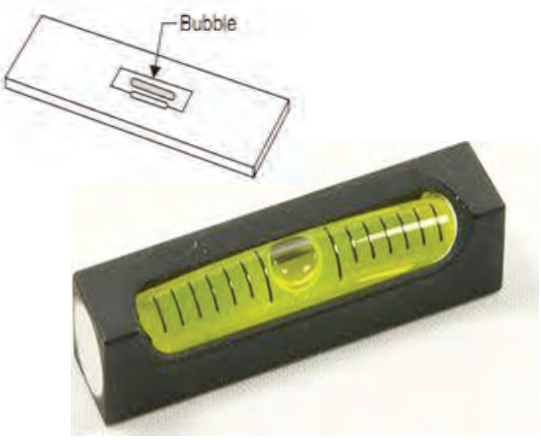

Fig. 2.5 Spirit Level

d. Trough Compass

Trough compass is a magnetic compass used to accurately align instruments, such as the plane table and theodolite to the magnetic north. It consists of a box 80 to 150mm long and 30mm wide with freely suspended needle at the centre. The needle ends on the box are marked with 0 to 5 degrees on either side of the centre

Fig 2.6 Trough Compass

a. Tripod

Drawing board is fixed on the tripod to conduct a plane table survey. Tripod consists of a screw at the bottom to set and level the drawing board on it.

Fig. 2.7 Tripod

b. Ranging Rods and Measuring Tape

Ranging rods are used to mark the position of different surveying stations. It is also used for aligning and taking straight sights from a plane table. Measuring tapes are used to measure the distance between the plane table and the object being studied.

Fig. 2.8 Ranging Rods and Measuring Tape

Learning Activity

1. Explore and present the differences of plain alidade from telescopic alidade.
2. Refer internet sources and discuss the uses of plane table survey equipment.

Procedures of Plane Table Surveying

1. Fixing of Plane Table

Plane table is properly fixed on the tripod stand and a drawing sheet is placed on the table. Drawing sheet is fixed with thumb screws or clips while conducting the survey.

2. Leveling of Plane Table using spirit level

Plane tables are placed parallel to the ground surface and are levelled by placing using spirit level on the four corners of the plane table.

3. Centering of Plane Table

Plane table is centered using a plumbing fork similar to a plumb bob. The point on the ground is marked using a plumb bob to represent the point on the drawing sheet.

4. Orientation of Plane Table

The orientation aligns the plane table towards magnetic north with the use of a trough compass. Plane table is fixed parallel to the direction on the ground.

Methods of Surveying

There are four methods of plane table surveying. The first two methods are used for finding the location details of various objects. The other two methods are employed for establishing the plane table station.

1. Radiation
2. Intersection
3. Traverse
4. Resection

1. Radiation

Plane table is set at a single point from where the details are plotted on the sheet. The rays are drawn from the instrument station to the points on the plane table and are measured using tape or chain. The distance is marked on the drawing sheet with scale along with their respective rays.

This method is only effective if the whole surveying is to be done from one single station i.e. the table will be in such a position from where all the other points of the field are easily visible.

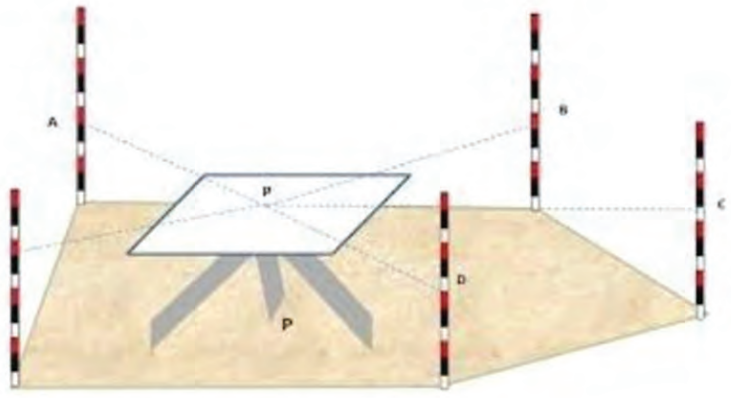

Fig. 2.9 Radiation Method Survey

Learning Activity

1. Discuss the errors and precautions in surveying and present it to the class.
2. Conduct a plane table survey following the radiation and intersection method. Discuss the challenges and benefits of conducting the survey.

Total station

The modern surveying instrument provides faster and more precise measurements than conventional instruments like chain and plane table survey. Total Station is a modern optical surveying instrument that uses electronics to calculate angles and distances. It combines the functions of a theodolite with that of a transit level and electronic distance meter (EDM). A theodolite uses a movable telescope to measure angles in both the horizontal and vertical plane. It has an integrated microprocessor, electronic data collector, and storage system that allows measurement to be stored on the device which can be uploaded to a computer for further processing

Fig. 2.10 Total Station

Measuring Distance

Total stations measure distance by using a modulated infrared carrier signal which is generated by a small solid-state emitter inside the instrument's optical path. This beam is reflected off a prism or an object that the user wants to survey, while the modulated pattern of returning signal is read and interpreted by a computer inside the instrument.

Most stations can measure distance with an accuracy of 1.5 mm plus two parts per million over the distances of up to 1500 metres. This is much more accurate than a GPS or any type of based station. The development of Total Stations has increased efficiency and accuracy in surveying:

1. Improved accuracy: The coordinate measurements by the theodolite are done in the traditional way – trigonometry and triangulation – the angles are measured by means of electro-optical scanning to a high degree of accuracy – up to 0.5 arc-seconds. Line

of sight between the two points is now measured by GPS technology in a Total Station to include unseen points in the survey.

2. Better productivity due to efficiency and functionality

3. Total Stations also include up-to-date image capture technology, which can record any image or screen-view from the surveying site, eliminating the need for costly revisits, and producing high-resolution images of site conditions.

4. A Total Station has electronic documentation and sketching functions, which reduces the need for paper field notes.

5. Data processed and stored in the Total Station can be downloaded to other computer systems, for archiving or distribution, or to be used with other applications such as mapping software.

Fig. 2.11 Labelled Total Station

Uses of total station

i. Distance measurement - It is used for distance estimations by using a regulated transporter infrared signal.

ii. Angular measurement - The electronic theodolite part of the total station is used for measuring vertical and horizontal angle.

iii. Data Processing - The microprocessor computes the horizontal distance and X, Y, Z coordinates.

iv. Digital display of point details - Points are stored in an electronic notebook (like a compact disc). Surveyors can download the data stored in the notebook to the computer and reuse the notebook.

Learning Activity

1. Use the link https://youtu.be/Br5yG_mwT2E and discuss the differences in conducting surveys using plane table and total station.

Test Yourself

1. Why do you think surveying is important?

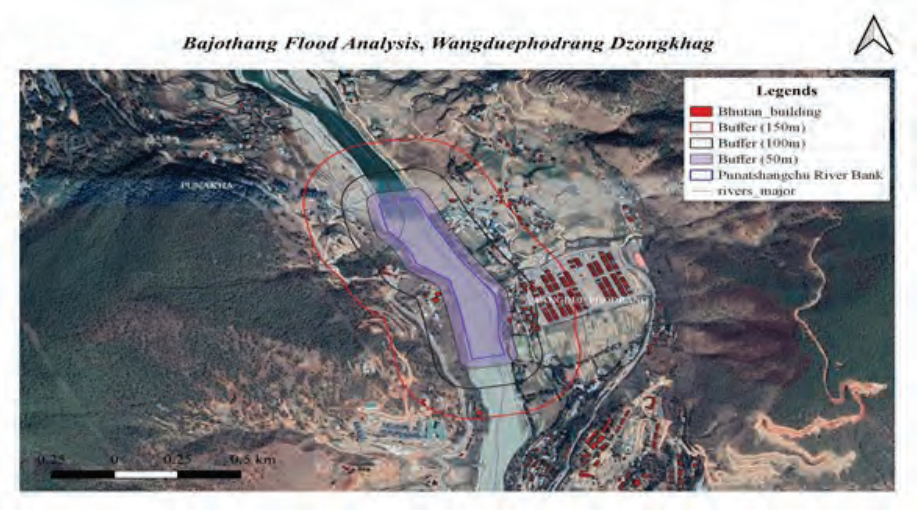

Fig. 2.12 Google Earth Image

2. Interpret Google Earth map using essential skills of cartography.
   a. Analyze the image on the basis of Land Use Land Cover including vegetation, farming and water bodies.
   b. Synthesize flood mitigation process in case of floods measuring 50m and 150m.

3. You work as a survey engineer in the National Land Commission Secretariat of Bhutan. As a surveyor, which method of surveying would you prefer the most? Why?
4. What are the differences between plane table surveying and geodetic surveying?
5. Discuss the advantages and disadvantages of conventional and modern surveying techniques.
6. Study the figures and answer the questions.

Fig. 2.13 Anaximander's World Map

Fig. 2.14 Present Day World Map

a. Analyse the differences between the two maps.
b. Discuss different modes of basis for the development of the two maps.

Practical Components

1. Conduct a plane table survey for two different areas in your school using radiation and intersection method.

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Chapter 3

Geospatial Technologies

Learning Objective (s):

- Explain global positioning system and its importance.
- Describe remote sensing and its application.
- Discuss GIS and its application.
- Demonstrate the use of GIS for spatial and non-spatial data.

3.1 Introduction

The development of geo-spatial technologies and scientific advancement enhance peoples' understanding about the earth. Geospatial technologies like Global Positioning System, Remote Sensing and Geographic Information System are important tools that support research, planning and decision making. The geographic space is made more accessible and affordable to a larger audience.

3.2 Global Positioning System (GPS)

GPS is a positioning system based on a network of satellites that continuously transmit coded information. The information transmitted from the satellites are interpreted by receivers to identify locations on the earth. It allows accurate determination of geographical locations by different users. GPS requires signals from three or more satellites to determine the accuracy of location.

GPS components

The components are satellites, GPS receivers, and computer software to decode the signals and compute the geographical position. These are categorised into three segments.

1. Space Segment

The satellites orbit the earth and transmit signals at regular interval. The nominal GPS

operational constellation consists of 24 satellites arranged in six orbital planes. These satellites have a number on the GPS screen. Satellites complete one orbit in a day and passes over the same location. This orbital configuration and number of satellites allow a user at any location on Earth to view at least four satellites every day.

Fig. 3.1 GPS satellites

Control Segment

It monitors the health and position of the satellites in the space segment and transmits information to the satellites. GPS control segment consists of a global network of ground facilities that track the GPS satellites, monitor their transmissions, perform analyses, and send commands and data to the constellation.

Monitor Stations track GPS satellites as they pass overhead and collect signals and feed information to the Master control station. The Master Control station controls the whole constellation of GPS satellites and generates navigation messages to the satellites. It also performs satellite maintenance and monitors the health and accuracy of the satellites. Ground antennas send signals, navigate data and upload programs to the processor.

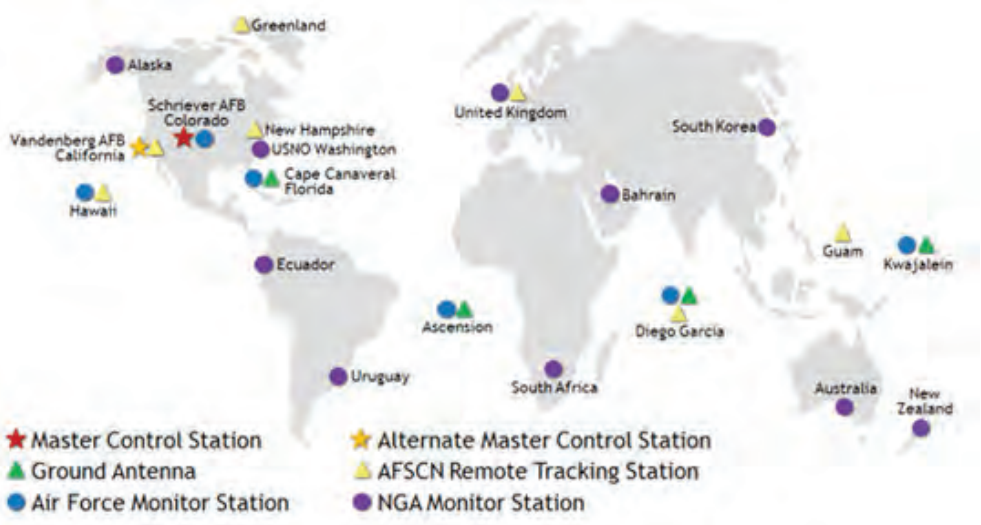


Fig. 3.2 Control Stations around the world

User Segment

The users segment consists of L-band radio receiver/ processors and antennas that receive GPS signals, determine pseudo ranges and solve the navigation equations in order to obtain their coordinates and provide accurate time. The device interprets the messages broadcast or received from the satellites.

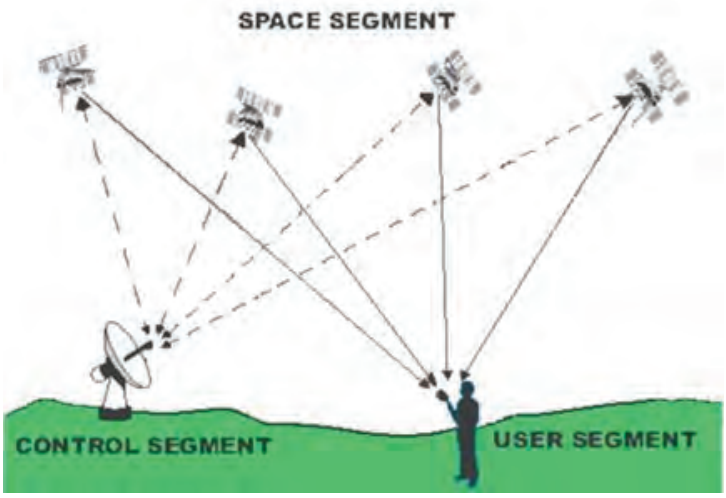


Fig. 3.3. Segments of GPS satellites

Components of GPS devices are an antenna, a receiver-processor and display unit.

Antenna and receiver-processor unit converts the radio signal to a usable navigational solution and a display unit displays the position.

Importance of GPS

- Emergency Response: During an emergency and natural disaster, first responders use

GPS for mapping, following and predicting weather, and keeping track of emergency personnel.

- Entertainment: GPS is incorporated into games like Pokémon Go and Geocaching,
- Health and fitness: Smart watches and wearable technology can track fitness activity (such as running distance, steps).
- Construction and mining: From locating equipment, to measuring and improving asset allocations.
- Transportation: Logistic companies implement telematics systems to improve driver productivity and safety. It supports route optimization, fuel efficiency, driver safety and compliance.
- Military: GPS is used for navigation of military aircraft, vehicles, vessels and personnel. It has changed the nature of command and control, guidance of unmanned systems and weapons targeting.
- Telemedicine: Tele-examination of patients through telemedicine requires GPS. It monitors patients' health without having to involve physicians and doctors.

Learning Activity

1. Download GPS Location application and Google map, using smartphone, find the location using coordinates.

3.3 Remote Sensing

Remote sensing detects reflected electromagnetic radiation from the Earth's atmosphere, terrestrial and aquatic ecosystems and monitors physical characteristics of an area without making physical contact. Aircraft and satellite-based sensors are classified as passive and active sensors. Passive sensors gather radiation emitted or reflected by an object or the surrounding space through reflected sunlight. It includes infrared, radiometers and film photography. Active sensors emit radiation to scan objects and measure the energy reflected from the target. It includes Radio Detection and Radiometer (RADAR) and Light Detection and Radiometer (LiDAR).

The data collected through Remote Sensing is processed and analysed using hardware and computer software. The work of remote sensing satellites depends on orbits, resolution, electromagnetic waves and electromagnetic spectrum for image interpretation and analysis.

Orbits

Satellites are stationed at different orbits around the Earth. Geosynchronous and Geostationary are two types of orbits. The speed of the geosynchronous orbit matches with the rotation of the earth that is positioned at an altitude of 35,786 km. The satellites are positioned directly over the equator on Earth's surface in geostationary orbit.

a. Low-Earth orbit (approximately 160 to 2000 km above Earth's surface)

b. Medium-Earth orbit (approximately 2000 to 35,500 km above Earth's surface)

c. High-Earth orbit (above 35,500 km above Earth's surface)

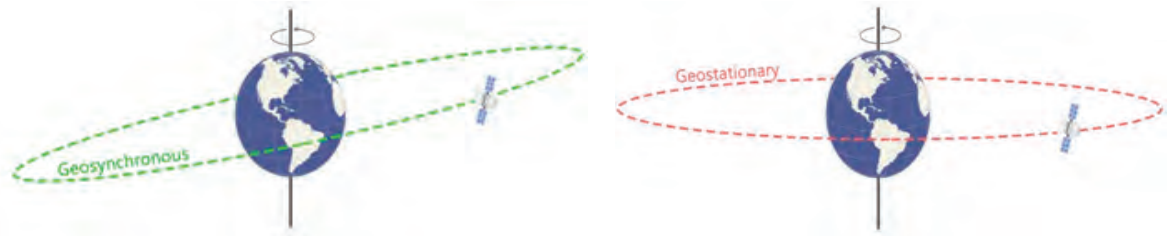


Fig. 3.4. Geosynchronous and Geostationary Orbits

Resolution

Resolution depends on the satellite's orbit and sensor design. Radiometric, Spatial, Spectral and Temporal are four types of resolution.

a. Radiometric Resolution

The information stored in each pixel represents the energy recorded and is represented in bits. A single bit records an exponent of power 2. For example, 8-bit resolution is 28 and it indicates that the sensor has 256 potential digital values to store information. Higher the radiometric resolution, more values are available for storing information.

Fig. 3.5 Radiometric Resolution

b. Spatial Resolution

A digital image has a different pixel size and the area on Earth's surface is represented by pixels. Majority of the bands captured by Moderate Resolution Imaging Spectroradiometer (MODIS) have spatial resolution of 1 km (each pixel represents 1 km x 1 km area on the ground). Finer the spatial resolution, the more precise the image.

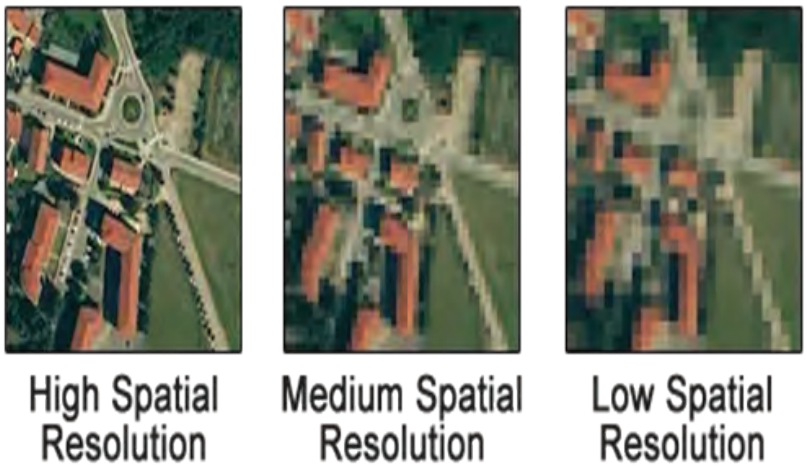


Fig. 3.6 Spatial Resolution

Learning Activity

1. Using internet, discuss Spectral and Temporal resolution providing suitable examples.
2. Study the image and explain remote sensing platforms. Prepare a power point presentation and share it to the class.

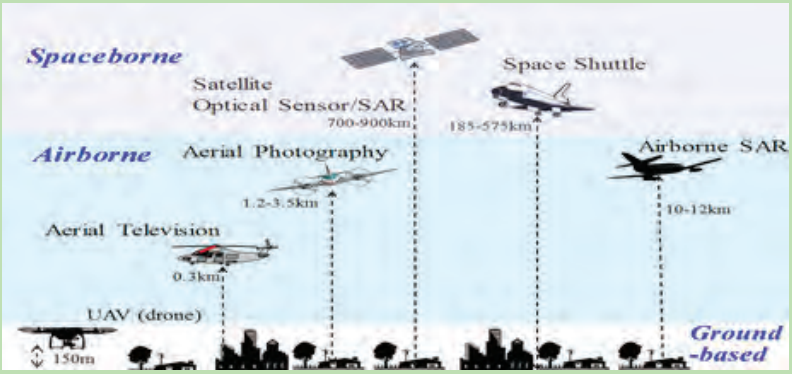


Fig. 3.7 Remote Sensing Platforms

Electromagnetic Waves and Electromagnetic Spectrum

Energy transported through space in the form of periodic disturbances of magnetic and electric fields are called electromagnetic waves. Electromagnetic waves are characterized by frequency and wavelength that travels at the speed of light. It is represented by the equation:

Speed of light = Frequency x Wavelength

$c = 2.99792458 \times 10^8$ m/s

Electromagnetic waves depend on its source and have a wide range of frequencies. It ranges from high frequency of gamma rays originating from atomic nuclei to low frequency of electric waves generated by power transmission lines. This frequency of electromagnetic waves constitutes the Electromagnetic Spectrum.

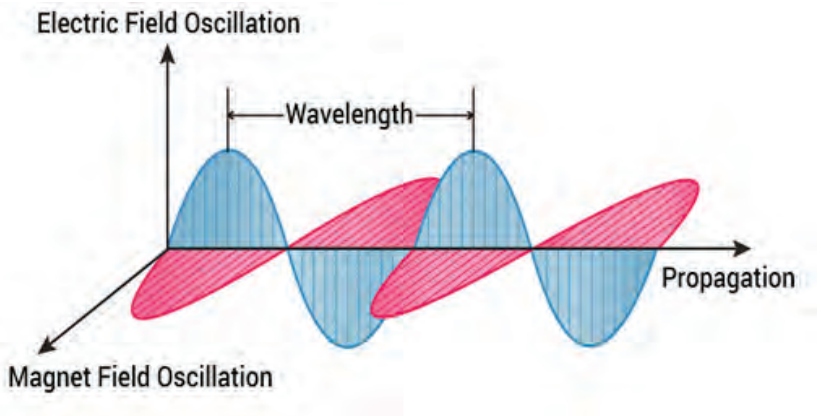


Fig. 3.8 Electromagnetic Waves

Electromagnetic spectrum is divided into several wavelength (frequency) regions. It comprises electromagnetic radiation consisting of subranges, commonly referred to as portions. Portions include visible light and ultraviolet radiation. These portions are named based on differences in emission, transmission and absorption of waves. There are no precise boundaries between these portions and the ranges tend to overlap.

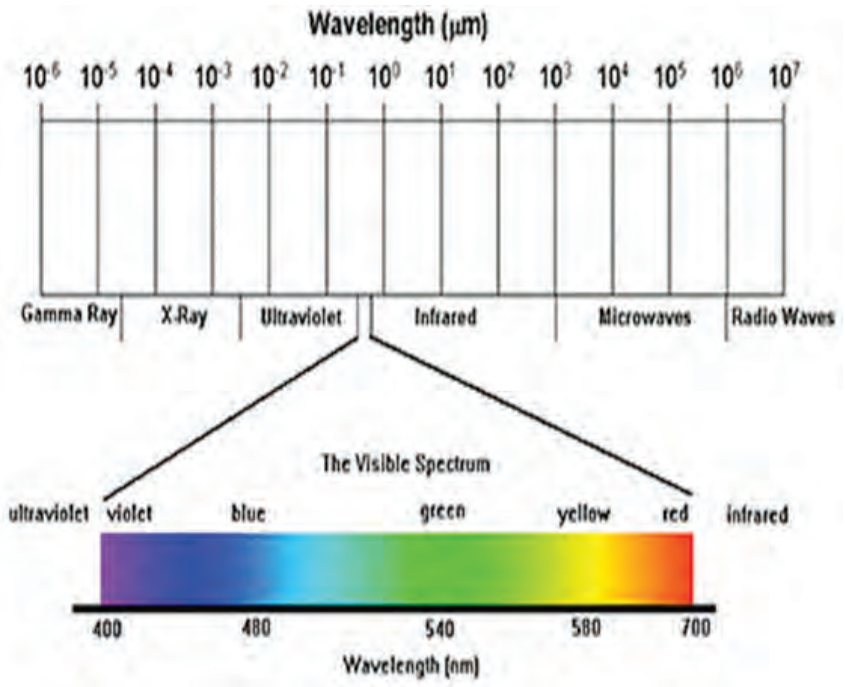


Fig. 3.9 Electromagnetic Spectrum

Remote Sensing Applications

Remote sensing is used for various purposes, such as disaster response, defense and natural resource management.

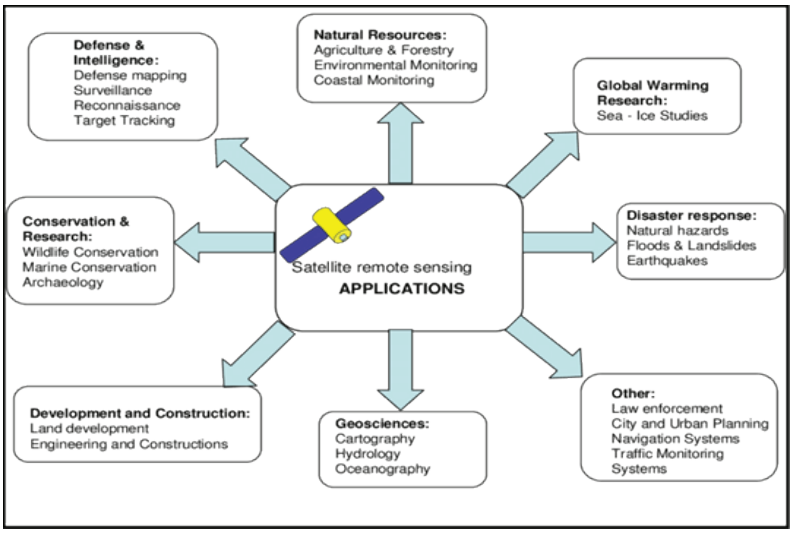


Fig. 3.10 Applications

Learning Activity

1. Access the link https://earthengine.google.com/timelapse/ and complete the activity.

Steps:

i. Click on the link and type 'Jomolhari, Bhutan' in the search button.

ii. Let the timelapse play completely and gather a general idea of the changes that occurred each year.

iii. Click on the pause button for 1991, 2005 and 2020.

   a. What are the environmental changes that are observed in 1990, 2005 and 2020?

   b. Discuss reasons for the changes.

3.4 Geographic Information System (GIS)

Geographic Information system is a digital-based tool for gathering information of data sources to map for various purposes. It captures, stores, manages, analyses, and visualises geographic data. GIS integrates and collects analysis of geospatial data from multiple data sources including satellite imagery, GPS recordings and textual attributes.

GIS data

Facts and statistics collected for reference or analysis in mapping is known as GIS data. Two types of GIS data are:

1. Spatial data: It is geo-spatial data or geographic information identifying the geographic location of features and boundaries on earth, such as natural and human-made features. It is stored as coordinates and topology that are mapped.
2. Non-spatial data: It is called attribute or characteristic data and is independent of all geometric considerations. For example, a person's height, mass and age are non-spatial data as they are independent of the person's location.

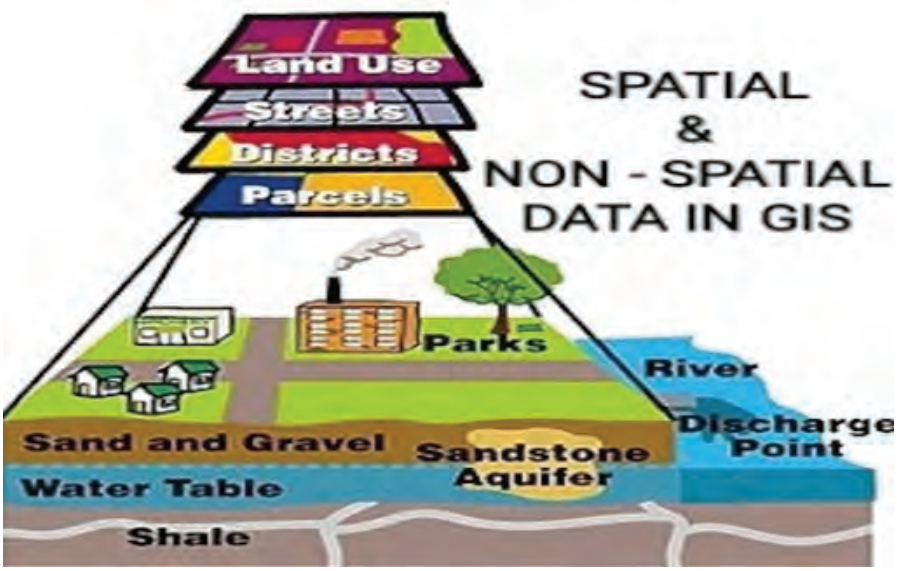


Fig. 3.11 Spatial and Non-spatial data in GIS

3. GIS process

1. Capture

Geospatial data are remotely sensed data created through the digitization process. GIS data uses spatial coordinates (latitude and longitude) to represent the location of features. Multidimensional data are used to cover depth, elevation and time.

Fig. 3.12 Capturing GIS data

2. Store

Multidimensional data and metadata are stored in scientific data formats. The formats are Network Common Data form (net CDF), Hierarchical Data Format (HDF) and Gridded Binary (GRIB). Cloud-ready formats include Cloud Optimized Geo TIFF (COG), Meta Raster Format (MRF) and Cloud Raster Format.

Fig. 3.13 Cloud Ready formats

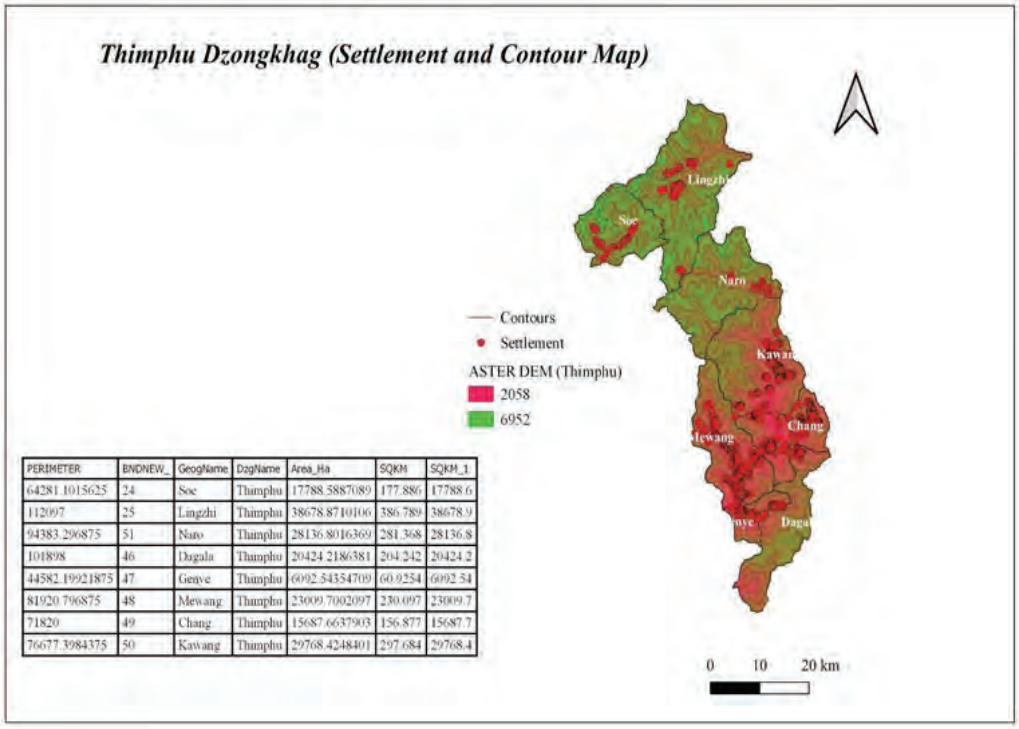
3. Display

GIS tools use coordinate systems as well as the projections to display.

Fig. 3.14 Data visualization

4. Analyse

Spatial analyses are performed to determine patterns or trends across space. It is used to detect change, extract features, identify relationships, interpolate data, perform statistical analysis, determine view sheds and find optimal routes.



PERIMETER	BNDNEW_	GeogName	DzgName	Area_Ha	SQKM	SQKM_1
64281.1015625	24	Soe	Thimphu	17788.5887089	177.886	17788.6
112097	25	Lingzhi	Thimphu	38678.8710106	386.789	38678.9
94383.296875	51	Naro	Thimphu	28136.8016369	281.368	28136.8
101898	46	Dagala	Thimphu	20424.2186381	204.242	20424.2
44582.19921875	47	Genye	Thimphu	6092.54354709	60.9254	6092.54
81920.796875	48	Mewang	Thimphu	23009.7002097	230.097	23009.7
71820	49	Chang	Thimphu	15687.6637903	156.877	15687.7
76677.3984375	50	Kawang	Thimphu	29768.4248401	297.684	29768.4

Fig. 3.15 Analysed data

5. Share

GIS users create and publish web mapping services, develop powerful user-intuitive applications and create interactive dashboards. These methods allow content to be distributed to broad audiences that are easy to borrow, explore, utilize and integrate with content of the users. It increases awareness and exposure within new communities and helps in using data science.

Fig. 3.16 Web mapping

3.5 Types of GIS

1. Web GIS

It is an advanced form of Geospatial Information System available on the web platform. Information is exchanged between the Geospatial Information System and a web browser. Web GIS enables analysis of spatial or geographic data which was not possible in the past.

2. Desktop GIS

It is a mapping software on a personal computer that enables users to display, query, update and analyze data about geographic locations.

Learning Activity

1. Explore the differences between server GIS and image classification GIS using internet. Share your findings.
2. Using the data on percentage of Rural-Urban Migrants, develop a QGIS map following the instructions.
   i. Double click on Dzongkhag layer
   ii. Right click and open attribute table
   iii. Click on Toggle Editing Mode (Ctrl+E)
   iv. Click on New Field (Ctrl+W) and fill Name as 'Migrant', Type as 'Decimal number (real)', Length '5', Precision '1' and Click OK
   v. Add data for 20 Dzongkhags
   vi. Click on Save edits (Ctrl+S) and Click on Toggle Editing Mode to stop editing
   vii. Click on Classify
   viii. Click OK
   ix. Double click on Dzongkhag layer
   x. Click on Symbology
   xi. Change to Graduated
   xii. Change value to Migrants
   xiii. Change colour ramp (as you wish but DO NOT choose Random Colour)
   xiv. Make classes into 3
   xv. Click on Classify
   xvi. Click OK

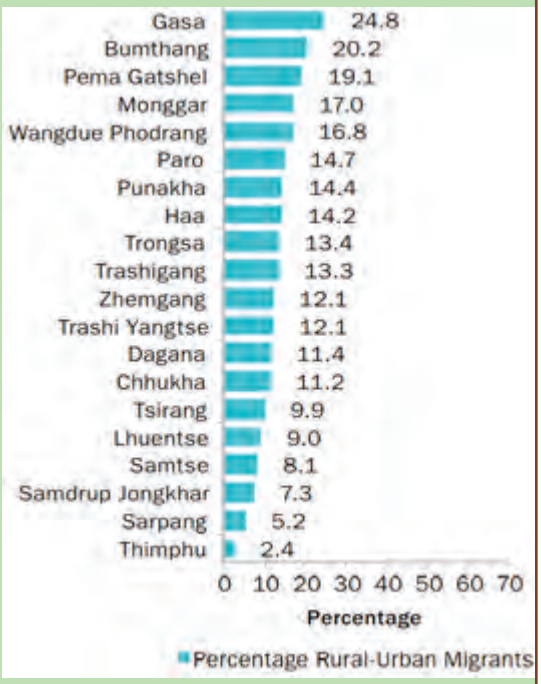


Fig. 3.17 R-U migration data (2017)

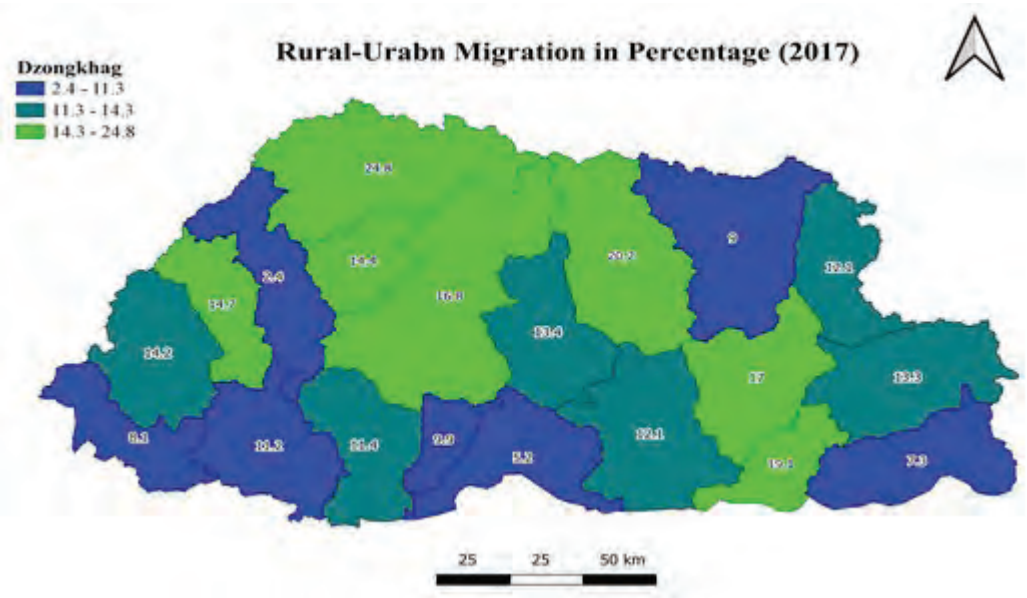


Fig. 3.18 R-U Migration map (2017)

3.6 Application of GIS

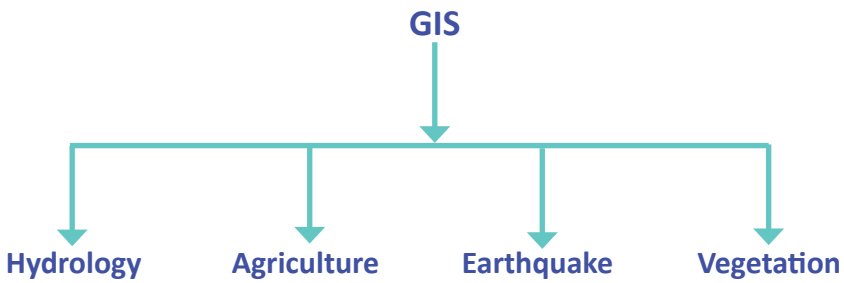


Fig. 3.19 GIS application

Learning Activity

1. Discuss and prepare a Power Point presentation on the applications of GIS and make a presentation.
2. Prepare a choropleth map using QGIS following the instructions. Make sure that Dzongkhag and population shapefiles are saved in the computer.

   Use the data to create a choropleth map of the population for different Dzongkhags using the quantile classification method.

Use the data to create a choropleth map of the population for different Dzongkhags using the quantile classification method.

i. Double click on Dzongkhag layer

ii. Click on Symbology

iii. Change to Graduated

iv. Change value to total-pop-1

v. Change colour ramp (as you wish but DO NOT choose Random Colour)

vi. Make classes into 3

vii. Click on Classify

viii. Click OK

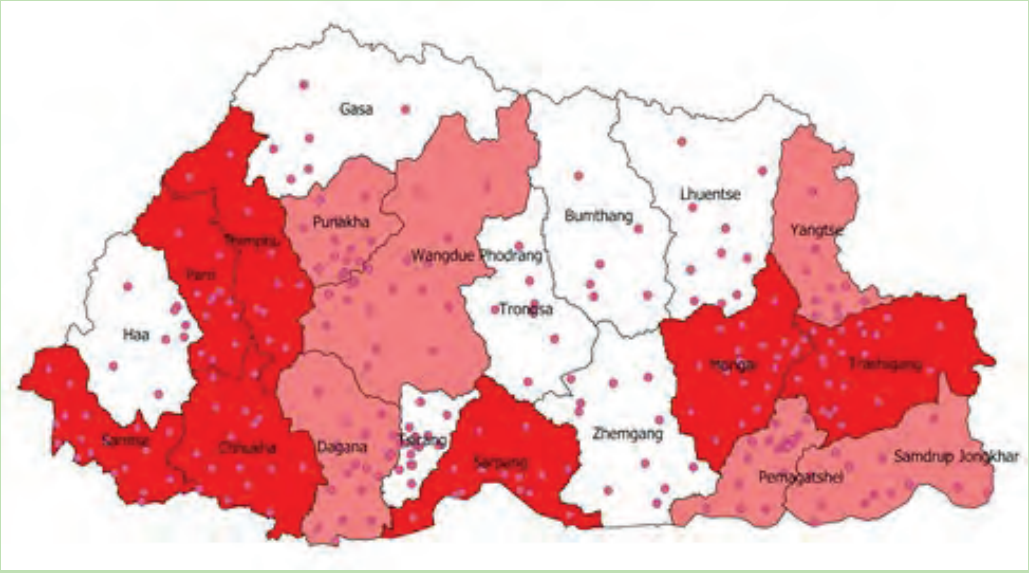


Fig. 3.20 Choropleth Map

i. Double click on Population layer

ii. Click on Symbology

iii. Change to Graduated

iv. Change value to Total-population

v. Click on size

vi. Make classes into 3

vii. Click on Classify and OK

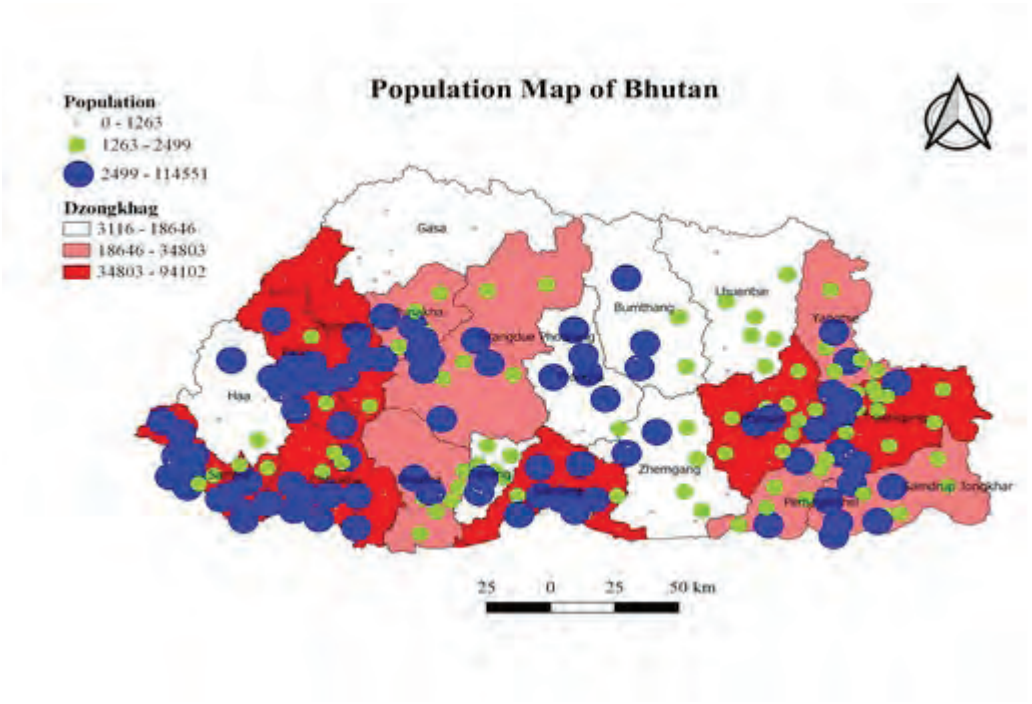


Fig. 3.21 Population map of Bhutan

Test Yourself

1. Sensors play an important role in capturing information from the object. Justify.
2. Advancements in Geo-spatial technologies made an impact on the world. Discuss the impacts of Geo-spatial technologies.
3. Discuss the future prospects of GIS and its impact on the country's economy.
4. Write the differences between spatial and non-spatial data in GIS.
5. Sonam graduated from Sherubtse College and plans to take up farming rather than public services but he is not familiar with geo-spatial technology. How will you help him make his business lucrative with the help of remote sensing and GIS? Support your answer with justifications.

Practicals

Prepare three maps using QGIS.

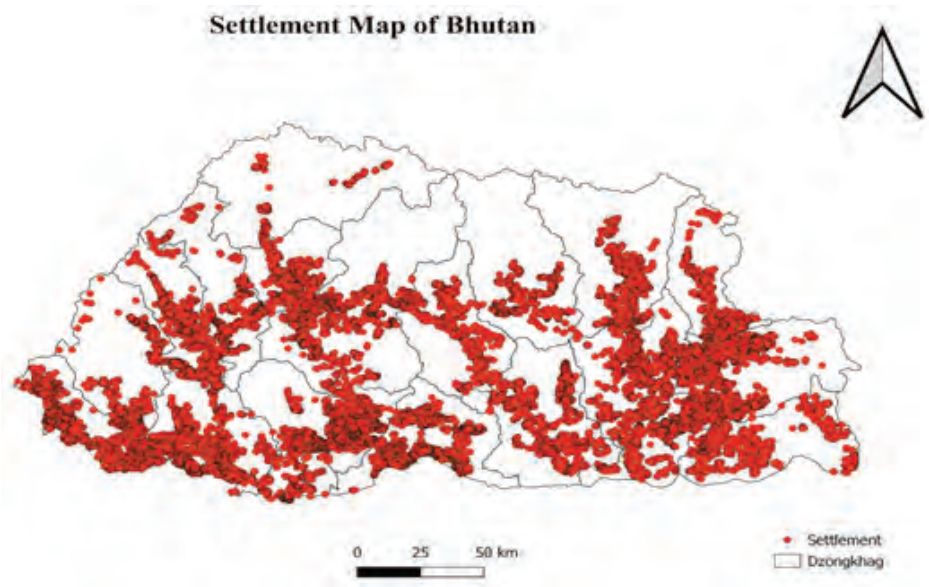


Fig. 3.22 Settlement Map of Bhutan

1. Open QGIS and access the folder where you have saved the population data> Double click on the Dzongkhag.shp file>Right click on Dzongkhag under layers and click on properties
2. Layer properties > Symbology > Simple Fill > Click on drop down menu of Fill Style > select No brush > Apply > OK
3. Access the folder where you have saved the settlement data under Browser > Double click on the Settlement.shp file>Right click on Settlement under layers and click on properties.
4. Layer properties > Symbology > Simple Marker > Click on drop down menu of Fill color > select the color of your choice > Apply > OK
5. Click on Project > New Print Layout > Type 'Settlement Map' in Create Print Layout Title dialog box > Click OK
6. Click on Add Item > Add Map and drag the cursor on the empty page > Add label, drag cursor and write the title of Map as Settlement Map of Bhutan > Add Legend and drag cursor on the bottom right corner > Add Scale Bar and drag cursor below the map > Add North Arrow and drag cursor on top right corner
7. Click on Layout > Export as Image > Save Layout box appears > Select Desktop or any other folder > Save as type JPEG format (*.jpeg*.JPEG) > Click on Save
8. Image Export Options dialog box appears > Click on Save and the final product will be exported.

Chapter 4

Classification of Rocks

Learning Objective (s):

- Explain rock cycle
- Classify rocks
- Discuss the scope of studying rocks

4.1 Introduction

The most important part of outer crust of the earth is Lithosphere. It is composed of solid material known as rock. Rock consists of different minerals. It is formed by physical and chemical changes such as melting, cooling, eroding, compacting and recrystallizing. Igneous, sedimentary and metamorphic are the major types of rocks. Rocks are source of minerals, metals, food nutrients and fuel besides being used for construction and soil formation.

4.2 Rock Cycle

Rocks change as a result of natural processes that are taking place all the time. Most changes happen slowly. The rock cycle is a geological process that involves transitions among the three types of rocks. Igneous rocks are formed as a result of solidification of lava or magma. Sedimentary rocks are formed when igneous and metamorphic rocks are exposed to the forces of weathering and denudation. Igneous and sedimentary rocks are transformed into metamorphic rocks under the influence of temperature and pressure. The sedimentary and metamorphic rocks are buried deep as a result of denudation and leads to the formation of igneous rocks and the cycle is repeated.

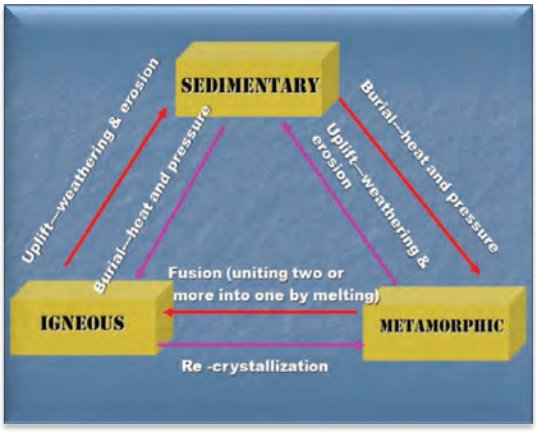


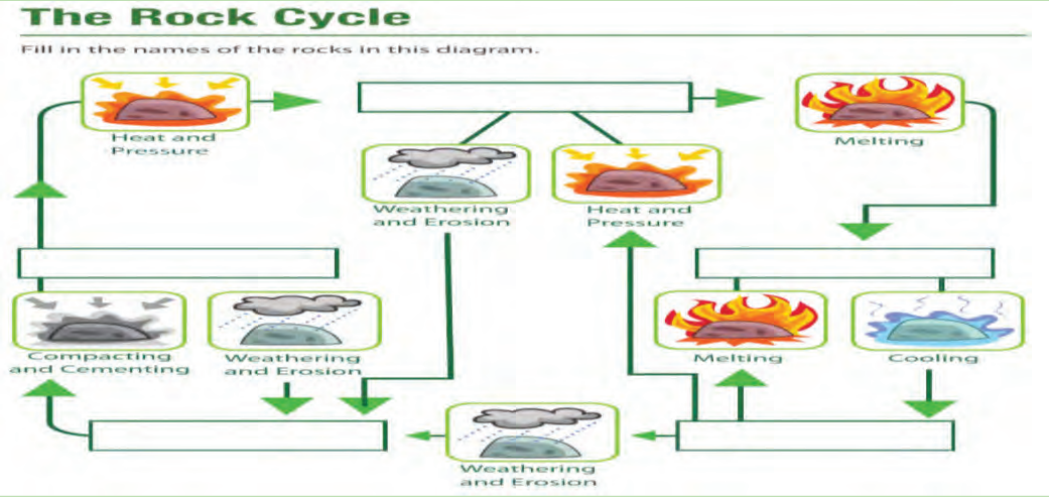
Fig. 4.1. Rock cycle

Know more

Orogeny - orogeny is a process in which a section of the earth's crust is folded and deformed by lateral compression to form a mountain range

Learning Activity

1. Complete the flow chart



2. Identify an area in your locality where you can observe transformation of rocks due to weathering and erosion and prepare a brief journal.

4.3 Classification of rocks

Rocks are classified as igneous, sedimentary and metamorphic based on the process of formation. These rocks are further classified based on chemistry and environment of formation.

Morphic

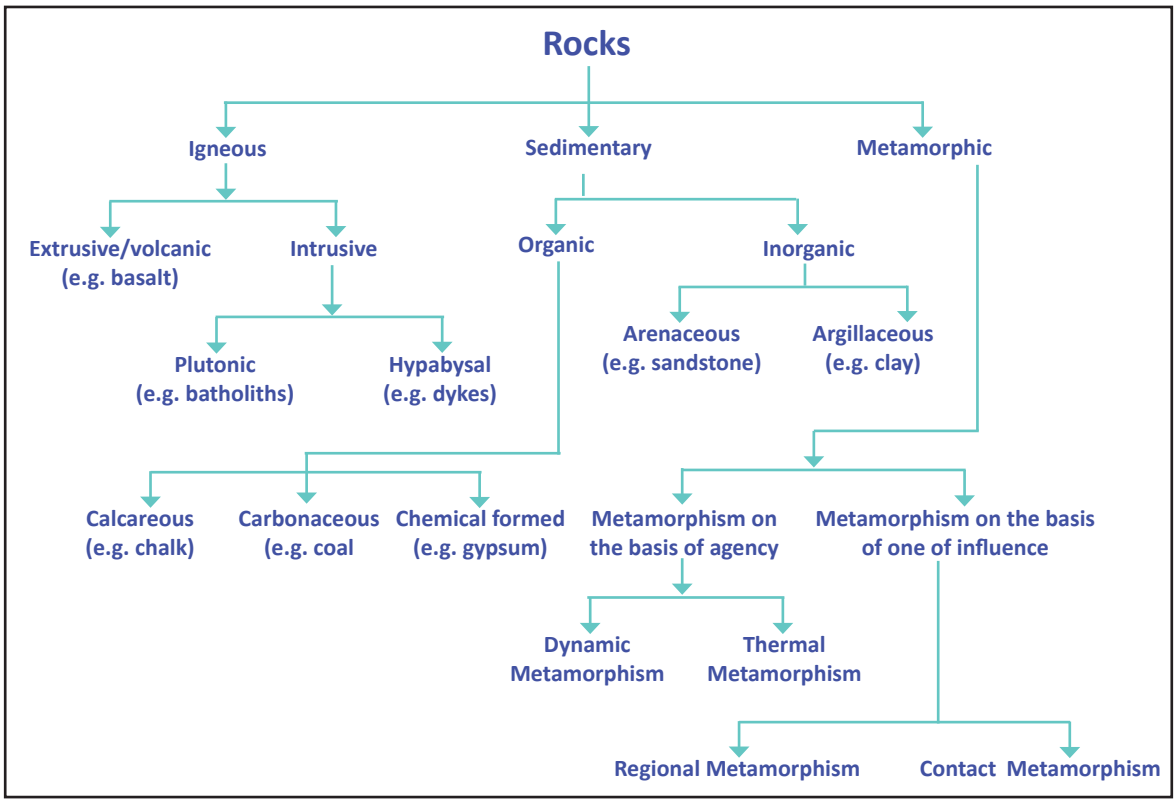


Fig. 4.2 Classification of Rocks

Learning Activity

1. Explore and browse a relevant video source and compare the following:
   i. Plutonic and hypabyssal
   ii. Arenaceous and argillaceous
   iii. Calcareous and carbonaceous
   iv. Dynamic and thermal metamorphism
   v. Regional and contact metamorphism

i. Igneous rock

Igneous rocks are formed as a result of solidification of molten materials. It is classified as extrusive and intrusive rock based on the location of magma solidification. Intrusive rocks are formed from magma that cools and solidifies within the crust of the planet. Extrusive rocks are formed on the surface of the earth by cooling of lava

Igneous rocks are further classified as felsic, intermediate, mafic and ultramafic based on the chemical compositions.

Examples of intrusive rocks are granite, peridotite and batholith

Examples of extrusive are pumice, andesite and basalt

Common examples of igneous rocks

ii. Sedimentary rock

Sedimentary rocks are formed as a result of deposition, sedimentation, cementation and compaction of materials by the agents of denudation. Sediments are deposited in layers or strata and the rocks thus formed are known as stratified rocks. Sedimentary rock is classified into organic and inorganic rocks.

Organic sedimentary rocks are formed from the accumulation and lithification of organic debris such as leaves, roots, other plants and animals. Inorganic sedimentary rocks are formed when minerals precipitate out of an acute solution due to water evaporation.

Sedimentary rocks are further classified as marine or aqueous rock, riverine rock, lacustrine rock, aeolian rock, and glacial rock according to its place of origin.

Organic		Inorganic	
Name	**Chemical Composition**	**Name**	**Chemical Composition**
Coal	$C_{240}H_{90}O_4NS$	Rock salt	NaCl
Limestone	$CaCo_3$	Chert	SiO_2
Gypsum	$CaSO_4.2H_2O$	Dolomite	$MgCO_3.CaCO_3$

Common examples of sedimentary rocks

iii. Metamorphic rock

Metamorphic rocks are formed due to the transformation of igneous and sedimentary rocks as a result of process of metamorphism. Metamorphisms on the basis of agency are dynamic and thermal. Metamorphisms on the basis of zone of influence are regional

and contact metamorphism. Metamorphic rocks are classified as slate, phyletic, schist and gneiss based on texture.

Common examples of metamorphic rocks

Learning Activity

1. Collect a few rock samples available in your locality. Using rock and mineral identifier apps classify the rock sample into different types and list the characteristics.

Fig. 4.4 Rocks and Geology

Geology is a science that deals with history of the earth and its life, especially as recorded in rocks. Studying geology helps in understanding present geological formations and predicts future changes. The study of geology determines a timeline of geologic events. Geology is important for mineral and hydrocarbon exploration and exploitation, evaluating water resources, understanding of natural hazards, and remediation of environmental problems and providing insights into past climate change.

Geologists play an important role in the advancement of alternative energies by studying and searching for minerals to be used in batteries and solar panels, finding and harnessing geothermal, tidal and hydro-electric power. Therefore, rocks are valuable resources that contribute greatly to the economic development of a country.

Know more

James Hutton is known as the father of Geology. He attempted to formulate geological principles based on observation of rocks. He played a key role in establishing geology as modern science

Test Yourself

1. A class was observing samples of rock and recorded their observations as:
   a. Hard, massive and compact
   b. No layers and fossils
   c. Identify the rock based on the observations.
      A. Igneous
      B. Argillaceous
      C. Sedimentary
      D. Metamorphic
2. Rocks are the basis of our civilization. How has rock contributed to socio-economic development of Bhutan?
3. Rocks are used for various purposes since the beginning of human civilization till date. Each rock has different uses. Which rock is shown below? Mention any other two uses of such rock.

4. Using GIS map making software produce mineral map and locate marble, coal, slate, dolomite, gypsum, quartzite and graphite.
5. Geological changes occur slowly, as in the formation of sedimentary rock or the weathering of exposed rocks. Changes occur suddenly as in erupting volcano or landslides. How does geological change affect biodiversity of a place?

Chapter 5

Classification of Soil

Learning Objective (s):

- Classify soil.
- Discuss the major classification of soil in the world.
- Suggest measures of soil conservation.

5.1 Introduction

Soil is a thin surface layer of the earth. It is a mixture of weathered rock particles, decaying organic matter, living organisms, mineral salts and soil water. It is also called as pedosphere in which lithosphere, atmosphere, hydrosphere and biosphere interact.

Soil is formed as a result of biological, chemical, physical, and climatic factors. The evolution of soil and its properties is called soil formation. Soils are formed by disintegration and decomposition of rocks, plants and animal fossils. Soil properties change under certain factors such as parent material, climate, organisms, relief and time.

The vertical section of the soil showing the various layers from the surface to the unaffected parent material is known as soil profile. A study of soil profile is important as it is basis for the study in pedagogical investigations. Soil is categorized into different types based on distinct characteristics.

The growth of industrial agriculture and increasing use of fertilizers poses threat to the health of the soil. The problem of soil loss is a global issue. So, it has become pertinent to put effort to restore the productivity of the soil.

5.2 Factors affecting soil formation

Soils are formed through the interaction of five major factors; parent material, climate, organisms, relief and time. The influence of each factor varies from place to place but the combination of all factors determines the kind of soil developing in any place. Soil

formation is a slow and continuous process, and generally takes thousands of years. Climate, particularly temperature, precipitation and frost action have dominant influence on the soil forming process.

Parent material is the unconsolidated mineral and organic deposit in which soils are developing. It determines the mineral composition and contributes to the physical and chemical characteristics of the soil. The shape of the land surface, its slope and position on the landscape influence the kinds of soil formed. All living organism such as bacteria, fungi, vegetation and animals also influence the soil forming processes.

Learning Activity

1. Soil profile is an important tool in nutrient management. Discuss how the study of soil profile helps in understanding soil nutrient management and share it to the class.
2. Interpret s = (cl, or, r, p and t) where 's' is soil.

5.3 Classification of soil

Soil is classified into various types based on its texture, proportions and forms of organic and mineral composition. Sand, silt, clay and loam are types of soil classified based on texture.

i. Sandy Soil

Sandy soil is formed as a result of breaking down of rocks like granite, limestone and quartz. It consists of small particles of weathered rock. Sandy soils are mostly found in arid and semi-arid regions. The addition of organic matter improves the nutrients and water holding capacity of sandy soil.

ii. Silty Soil

It is made up of rock and other mineral particles, which are smaller than sand and larger than clay. It is smooth and fine quality of the soil that holds water well. Silty soil is found near the rivers, lakes and other water bodies. The silty soil is mixed with other soils to improve soil fertility fertile for agricultural practices.

iii. Clay Soil

The particles in this soil are tightly packed together with little or no airspace. This soil has good water storage qualities and makes it hard for moisture and air to penetrate into it. Clay is the densest and heaviest type of soil which does not drain well or provide space for plant roots to flourish.

iv. Loamy Soil

Loamy soil is a combination of sand, silt and clay. It has the ability to retain moisture and nutrients. It also has higher calcium and pH levels because of its inorganic origins. Loamy soil supports all types of plant growth.

Learning Activity

1. Examine the acidity and alkalinity of the soil in and around your school campus using soil testing kit and share. OR watch the video http://youtube.com/watch?v=LWonFocBHAQ and write process of soil testing.
2. Explore the economic value of soil besides agriculture.

Know more

5.4 Major classification of soil in the world

The major soil types of the world are:

i. Tundra soil

This type of soil contains high proportion of humus in which the parent rock contents are prominently seen. It is found in cold climatic conditions. The common vegetation found in tundra soil is mosses and lichens.

ii. Podzolic soils

It is ash-grey in colour and found in the broadleaf coniferous belt. It is a mixture of clay and iron. Podzolic soil has limited agricultural value as bacterial activity is low. It is used for grazing, forestry and recreation.

iii. Red and yellow soil

It is found in hot and humid climatic zones. It normally appears reddish due to iron content. Red and yellow soil lacks calcium and is acidic in nature. Nutrients are added to make it favourable for cultivation.

iv. Laterite soil

Generally found in hot and humid climatic regions (equatorial & savannah). The presence of oxides of iron, aluminum and manganese deposited in upper layer gives them red-brown colour. Laterite soil has low agriculture value.

v. Prairie soil

Mostly found in moist part of temperate grassland. The prairie soil is a mixture of Silt and sand. It has good crumby soil structure which makes it fertile for agriculture.

vi. Chernozem soil

It is also known as black soil and found in semi-arid lands. Chernozem soil is rich in humus and calcium and is one of the most fertile soils of the world. It is used continuously for years without adding fertilizer.

vii. Chestnut soil

It is dark-brown in colour and found in semi-arid regions. Chestnut soil contains less humus. Cultivation is possible with irrigation and addition of fertilizer.

viii. Tropical Black soil

It is black in colour and formed as a result of volcanic activity. It is found in tropical region and has moisture holding capacity. It contains a variety of minerals and is good for agriculture.

ix. Desert soil

It is commonly found in the temperate and tropical deserts. High rate of evaporation makes it alkaline. Thin vegetation cover makes the soil to appear grey or red and has less humus. Agriculture is possible in desert soil when the texture is fine and irrigation facilities are available.

Know more

Every year December 5 is observed as the World Soil Day to create awareness on the importance of healthy soil and advocate sustainable management of soil resources.

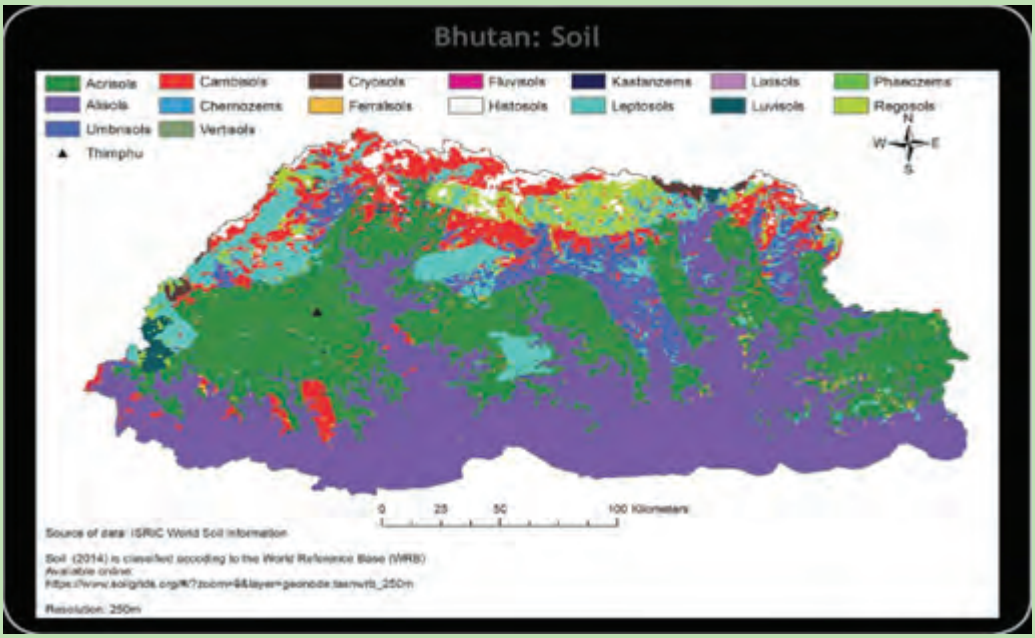
5.5 Soil conservation

Soil is a valuable natural resource and is indispensable for life. Majority of people in the world depend on agriculture for their livelihood. The increasing demand for food production exerts pressure on soil, making it vulnerable to unsustainable exploitation and pollution. Therefore, soil conservation is necessary for sustainable use.

Soil conservation helps to control pest, mitigate erosion, prevent soil degradation, and minimize nature pollution to contribute sustainability of environment and resources. Mulching, contour barriers, terrace farming and contour ploughing are some measures to conserve soil.

Learning Activity

1. Explore relevant resources to find out the additional measures of soil conservation.
2. Interpret the soil map of Bhutan and share your findings



Test Yourself

1. A class was observing samples of soil and recorded their observations as:

   a. Rough and hard

   b. Gritty and bumpy

   c. Smooth and soft. Identify the characteristics of the soil based on the observations.

A. Size

B. Color

C. Shape

D. Texture

2. Human civilizations have flourished near the river valleys since ancient times. How are soil and human civilization interdependent? Explain with an example.

3. Healthy soils are basis for healthy food production. Discuss the importance of soil for an agrarian country like ours.
4. Using Geospatial technologies, explore the types of soil in Bhutan.
5. The process by which earthworms are used to convert organic materials into humus like material is called vermi compost. What is the difference between vermi compost and other compost?

Chapter 6

Condensation and Precipitation

Learning Objective (s):

- Explain humidity and air temperature.
- Describe different forms of condensation.
- Discuss types of precipitation.

6.1 ntroduction

Weather and climate affect the growth and survival of plants and animals. Elements of weather and climate are atmospheric variables that work together to create different weather conditions and establish climate patterns. The primary elements of climate are temperature, precipitation, air pressure, wind, humidity and clouds.

6.2 Temperature

Temperature is the intensity of heat. It is measured in degree Celsius, Fahrenheit or Kelvin. Temperature is an important factor in determining the weather.

The average of the maximum and minimum temperature recorded in a day is known as daily mean temperature. Mean monthly temperature is the average temperature of a month.

The mean annual temperature refers to the average of the maximum and minimum temperatures of a year.

Temperature calculation	Definition	Formula
Mean daily temperature	Sum of hourly temperatures divided by 24 hours	$\frac{\textit{sum of hourly temperatures}}{24}$
Diurnal temperature range	Differences between the maximum and minimum temperatures recorded in a day	Max. daily temperature – min. daily temperature
Mean monthly temperature	Average daily temperatures recorded in a month	$\frac{\text{Sum of mean daily temperatures in the year}}{\textit{Number of days in a month}}$
Mean annual temperature	Average temperature recorded in a year	$\frac{\text{Sum of mean daily temperatures in the year}}{12}$
Annual temperature range	Difference between the maximum and minimum mean monthly temperature recorded in a year	Maximum mean monthly temperatures – minimum mean monthly temperature.

Learning Activity

1. Using reliable app, record the temperature of your locality at noon on daily basis for a week and interpret the weather condition.

6.3 Humidity

Humidity is the amount of moisture present in the air. It is a natural part of atmosphere that is formed from the amount of water vapour. Water vapour enters the atmosphere by evaporating from the large bodies of water on the Earth's surface. It is an integral part of the water cycle, as water vapour is continuously generated by evaporation and removed by condensation. Air with higher temperature can hold more water vapour.

Colder climates have lower humidity levels than warmer climates as colder air holds less moisture than warm air. In winter, humidity is low whereas in summer, humidity is high.

i. Absolute and relative humidity

Absolute humidity is the amount of water vapour in a unit volume of air which is expressed in kilograms per cubic metre (kg/m3). Absolute humidity is directly proportional to the amount of water vapour in the air.

Relative humidity is the amount of water in the air in relation to the maximum amount of water vapour air can hold at that temperature. It is also expressed as the percentage of the moisture against the highest possible level of moisture in the air at a specific temperature.

It is expressed in percentage:

$$RH = \frac{\text{Actual vapour pressure(Absolute humidity)}}{\text{Saturated vapour pressure(vapour holding capacity)}} \times 100$$

Relative humidity is also influenced by air moisture content and saturated vapour pressure. Hygrometer is used to measure relative humidity. A simple hygrometer also known as psychrometer/sling psychrometre consists of a dry bulb and a wet bulb thermometer. Evaporation from the wet bulb lowers its temperature thus reads lower than the dry bulb.

Variety of digital and analog model exists. Most modern dehumidifiers use a built in humidistat to measure relative humidity.

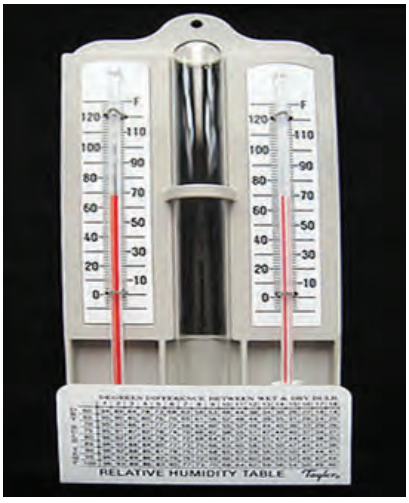


Fig. 6.1 Dry and wet bulb Thermometer

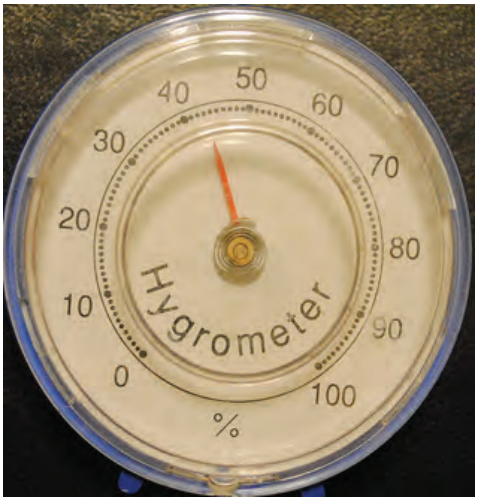


Fig. 6.2 Hygrometer

Learning Activity

1. Explain the working procedure of hygrometer for measuring humidity by watching the video in the link.

   https://www.google.com/search?q=working+principle+of+using+hygrometer +for+measuring+hygrometer&source=lnms&tbm=vid&sa=X&ved=2ahUKEwiHzNPZ94_1AhUW9XMBHZzTD 9YQ_AUoAnoECAEQBA&biw=1366&bih=657&dpr=1

The capacity of the air is 10 grams per kilogram at 15° c. If the air is at 15°c temperatures contains 5 grams of water vapour per Kilogram. Calculate relative humidity?

$$RH = \frac{\text{Actual vapour pressure(Absolute humidity)}}{\text{Saturated vapour pressure(vapour holding capacity)}} \text{ X } 100$$

Vapour pressure = 5 grams of water vapour per kilograms. Saturation vapour pressure =10 grams per kilogram at 15°c

$$RH = \frac{\text{5 grams per kilogram}}{\text{10 grams per kilogram}} \text{ X } 100$$

$$= 50$$

Learning Activity

1. The moisture holding capacity of the air is 15 grams per kilogram at 15°C. If the air at 15°C temperature contain 10 grams of water vapour per kilogram. Calculate relative humidity.

6.4 Condensation

The process of change of state from gaseous to liquid or solid is known as condensation. With decrease in temperature, moisture content in the air becomes more than its holding capacity. The temperature at which saturation occurs or water vapour begins to change into water is known as dew point. In free air, condensation results from cooling around very small particles termed as hygroscopic nuclei.

The condensation depends on amount of cooling and relative humidity of the air. These two factors are associated with volume, temperature, pressure and humidity of the air.

The condensation takes place under the following conditions:

- The temperature of the air falls below dew point but its volume remains constant.
- The volume of the air is increased without any addition of heat.
- The change in temperature and volume reduces the moisture holding capacity of the air below its existing moisture content.
- Additional moisture is added to air by evaporation.

6.4. Forms of Condensation

Water vapour or moisture in the atmosphere takes the following forms – dew, frost, fog and clouds after condensation.

i. Dew

The cooling of earth's surface at night is so much that the temperature of the air touching earth's surface falls below dew point. Water vapour present in the air condenses and is deposited in the form of droplets on cooler surface of solid objects. This is known as dew.

Favourable conditions for the formation of dew are long night, clear sky, calm air and high relative humidity.

Long night

It gives sufficient time for cooling the earth surface and the air touching it. This results in fall of temperature below dew point.

Clear sky

Cloud obstructs the incoming solar radiation and outgoing radiation. Clear sky permits sufficient heating and large scale evaporation during the day. Similarly clear nights favour more terrestrial radiation and cooling resulting in more condensation.

Calm air

If the air is calm, it will remain in contact with the earth's surface for a long time and cool down to dew point.

High relative humidity

High relative humidity is essential for formation of dew. Dew formation does not take place in low humidity even if temperature falls below dew points.

Learning Activity

1. Explore the spiritual and health benefits of dew and share the findings.

ii. Frost

Frost is formed when the dew point is below freezing point. Water vapour accumulates on the earth surface in the form of small white ice particles called frost.

iii. Fog

Fog is similar to cloud with its base at or near the ground. It is formed due to sudden drop in temperature of moist air mass resulting in condensation around hygroscopic nuclei. The atmosphere appears smoky and visibility is poor. It is formed during winter nights and disappears after sunrise.

Types of fog

On the basis of formation, fogs are classified as radiation, advection and frontal or precipitation fog.

a. Radiation fog

It occurs during the night due to terrestrial radiation. It is thin and normally varies from 10 – 30 metres.

b. Advection fog

It is formed when moist warm air moves over a cold surface. Advection fog is often thick ranging from 300 to 600 metres and continues for a longer period.

c. Frontal or precipitation fog

It is formed along the front separating the cold and warm air masses. Due to convergence, warm air is forced to rise over the cold air and condensation is caused due to cooling. If the temperature reaches dew point, frontal fog is formed.

d. Frontal fog

Is more prevalent in the temperate zone due to large scale formation of fronts.

iv. Mist

Mist is tiny droplets of water suspended in the air. These droplets are formed when warmer water in the air is rapidly cooled, causing it to change from invisible gas to tiny visible water droplets.

Mist often forms when warmer air over water suddenly encounters the cooler surface of land. It is also formed when warm air from land suddenly encounters cooler air over the ocean.

v. Cloud

Cloud is a mass of minute droplet of water or tiny crystals of ice formed by the condensation of the water vapour at considerable elevations. Clouds are caused mainly by the adiabatic cooling of air below its dew point.

Clouds usually appear white because the tiny water droplets inside them are tightly packed, reflecting most of the sunlight.

Dark clouds are formed due to clumping of water vapour into raindrops creating larger spaces between drops of water.

Clouds are classified as high, middle and low clouds based on the height.

a. High clouds appear above 6km.

Cirrus

Cirrus clouds are short, detached, hair-like clouds found at higher altitudes. It indicates fair weather. Halos and other optical effects are produced. Cirrus clouds are formed at

temperatures below -40oC and consist entirely of ice particles.

b. Cirrocumulus

It is found in a similar altitude range to cirrus and does not produce precipitation. Cirrocumulus clouds are small broken rounded puffs appearing like a scaly skin of fish.

c. Cirrostratus

A thin high level layer cloud, which produce halos and through which the outline of the sun is visible. These clouds are first indication of an approaching weather front.

b. Medium clouds (2 to 6km)

i. Altocumulus clouds are small mid-level layers of patches of clouds. It is generally broken in appearance and occasionally produces precipitation. It is thick enough to obstruct the sun light.

ii. Altostratus clouds are large mid-level sheets of thin cloud. It is composed of mixture of water droplets and ice crystals. Thicker forms of these clouds often produce continuous light precipitation and obstruct the sun light.

iii. Nimbostratus cloud is dark, grey, featureless layers of cloud. These clouds always obstruct sunlight and normally produce continuous precipitation

c. Low clouds (below 2km)

Stratocumulus clouds are low level clumps or patches of clouds varying in colour from bright white to dark grey. These clouds produce drizzle, particularly in hilly or coastal areas, and are thick enough to obscure the sun or moon.

Stratus clouds are low level layers with fairly uniform grey or white colour. Thick stratus produces considerable precipitation, particularly in hilly or coastal regions. Thick stratus clouds obscure the sun or moon but are clearly visible through thin stratus.

Cumulus clouds are the white fluffy clouds. It indicates fair weather and brings light rain for short duration.

Cumulonimbus clouds are dense, towering vertical clouds formed by powerful upward air current. These clouds produce heavy showers, thunderstorms and hail, often also producing squally winds. A fully developed cumulonimbus cloud has a classic anvil appearance as the upper levels of the cloud spread out on reaching the tropopause.

Know more

Cloud seeding is a weather modification technique that improves the cloud's ability to produce rain or snow by artificially adding condensation nuclei to the atmosphere

Learning Activity

1. Refer relevant sources and discuss the benefits and limitations of cloud seeding.

6.5 Precipitation

Precipitation is water released from clouds in the form of rain, snow, sleet and hail stones.

i. Snowfall

Snow forms when tiny ice crystals in clouds stick together to become snowflakes. These crystals stick together heavy enough to fall on the ground. It takes place at a temperature below freezing point.

ii. Sleet

Sleet is frozen rain drops and refrozen melted snow water. It is a mixture of snow and rain or partially melted snow. It is formed as a result of cool air overlying the sub-freezing layer.

iii. Hail stone

Hail is solid precipitation made of balls or irregular lumps of ice. It occurs during severe thunderstorms. Hailstones are formed when rain drops are carried upward by the thunder storms updrafts into extremely cold areas of atmosphere and freeze.

Learning Activity

1. Explore relevant sources and write the characteristics of haze and smog. Display in the class.

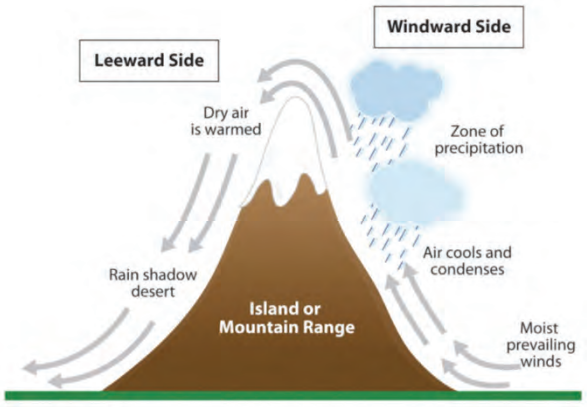
iv. Types of Rainfall

Raindrops are formed when the cloud droplets grow big enough to fall on the ground. Based on formation rainfall is classified as orographic, convectional and cyclonic.

a. Orographic Rainfall

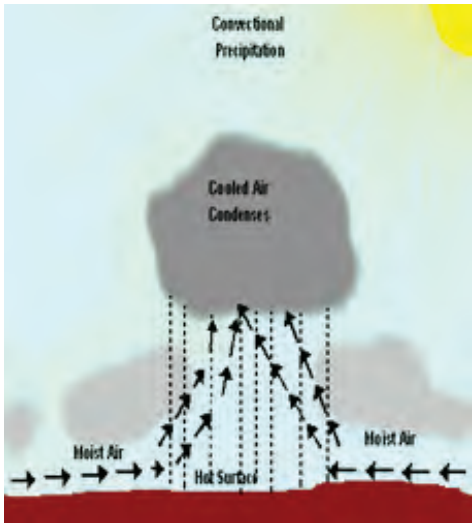
This is the most wide-spread form of rainfall. It occurs when mountains stands in the path of the moisture-laden winds and force them to rise. As the air rises, it expands cools and rains.

Relief rainfall is heavy where high mountain stretches close to a coast that obstructs rain bearing winds. Windward side experiences heavy rainfall. As the wind crosses over to the other side it loses most of the moisture. The wind becomes warm and dry while descending and there is less rain. The leeward side of the mountain is called as rain shadow area.



b. Convectional Rainfall

Due to conduction, the moisture laden air near the surface becomes warmer than the surrounding, and it begins to rise in the form of convection currents. As the air reaches the upper layer of atmosphere, it cools and rains.

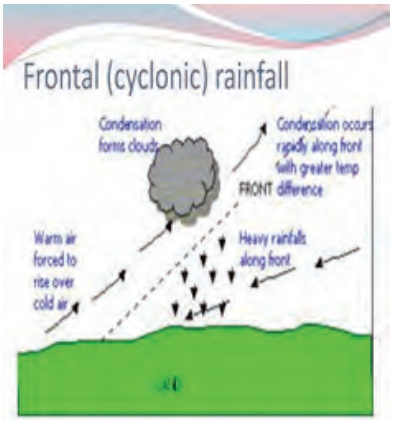


The convection currents are normally set up in the atmosphere as a result of local heating. The currents rise up in the centre and are drawn up at the sides. The rapid rising of the warm moist air results in the formation of clouds which give rise to heavy rain for a short duration. Convectional rainfall is common within the Tropics in the Equatorial belt.

c. Cyclonic Rainfall

Cyclonic rainfall is associated with cyclones and depressions.

Warm air and cold air are of different densities, and do not mix well. The warm air, being less dense, rises over the mass of cold air, expands further, cools and rains.



Sometimes dense cumuliform cloud form accompanied by thunder and hailstones. Cyclonic rainfall is common in temperate zones where the air from the polar high pressure zones converge the air from the sub-tropical high pressure zones.

Learning Activity

1. Explain the type of rainfall common in Bhutan with the help of a diagram.
2. Cloud is my mother, my father the wind. Lake is my son and land is my bed. Who am I?

Test Yourself

1. Explain the importance of relative humidity for plants and animals.
2. The holding capacity of the air is in Chamkhar town of Bumthang during Autumn season is 5 grams per kilogram at 5oC. Assuming the air at that place at 15°C temperatures contain 3 grams of water vapour per Kilogram, calculate relative humidity of the place.
3. Which is the most common form of condensation that takes place in your locality? Explain its characteristics.
4. During winter, we see vapour coming out of our mouth, while talking and breathing. Why is it so? Give reasons.
5. Among the cloud types, which cloud brings more rain? Justify.
6. Why do we feel excessive sweating on a cloudy day? Explain.
7. What is the impact of cloud cover on geospatial technology?

Chapter 7

Glaciers

Learning Objective (s):

- Classify glaciers.
- Discuss glaciers as an agent of gradation.
- Explain the importance of the Third Pole.

7.1 Introduction

In areas of high altitude and latitudes, temperature is normally below freezing point and precipitation is in the form of snow. Snow accumulates into mass of ice when the rate of snowfall is greater than the snow melt. The ice that moves slowly down slope due to pressure and gravity is known as glacier. Glacier is the most important agent of gradation in high-altitude areas. Gradation is the process of erosion, transportation and deposition of eroded materials.

Mountains ranges of Asia have the world's highest mountains peaks and thousands of square kilometres of glaciers. The region encompassing Tibetan plateau, the Himalayas, the Hindu Kush, the Pamirs and the Tien Shan Mountains is referred to as the 'Third Pole'. The melting glaciers from the Third Pole is source of many lakes and rivers in Asia and is also known as 'water tower of Asia'.

7.2 Classification of glaciers

Glaciers are classified into three types:

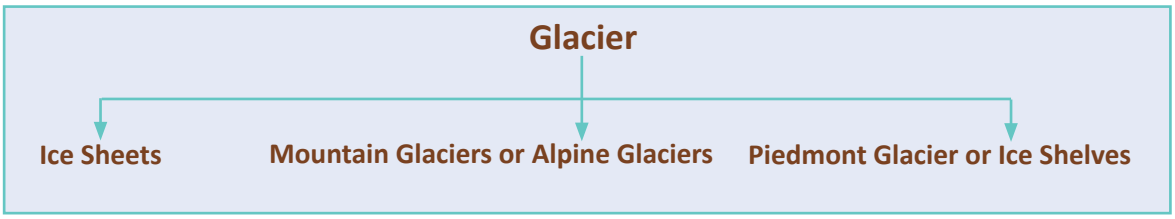


Fig.7.1 Classification of glacier

Glacier that extends in continuous sheets, moving outwards in all directions is called ice sheet. Mountain or Alpine Glaciers are glaciers that are confined within a path that directs the movement of ice. Glacier that spreads out on levelled ground or on the oceans at the foot of glaciated regions is called piedmont glacier or ice shelves.

7.3 Glacier as an agent of erosion

Glacier causes erosion in two main ways; plucking and abrasion. Plucking is a process of erosion and transportation of large pieces of rocks. The bottom part of the glacier melts and seeps into cracks within the underlying bedrock as it moves over the landscape. This water freezes and melts, weakening the bonds holding pieces of bedrock in place. These pieces of rocks are picked up or plucked from their rocky base and carried along with the moving glacier.

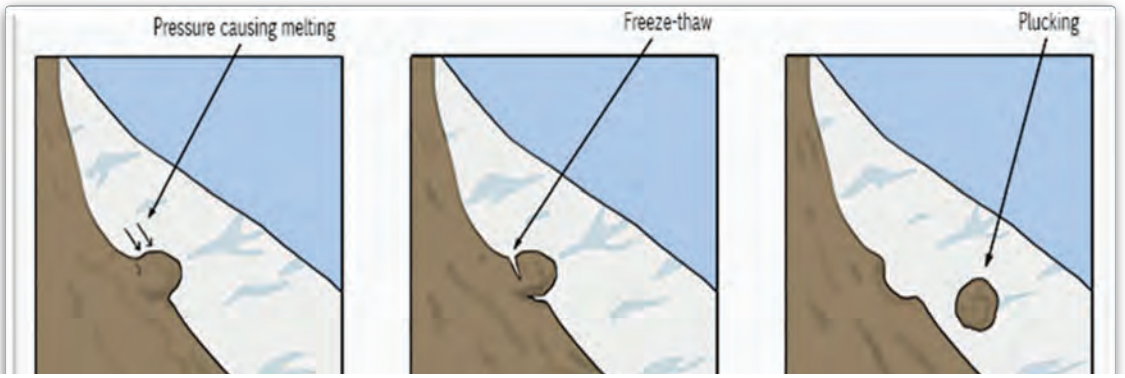


Fig. 7.2 Glacial Erosion

i. Abrasion is the process of scraping or wearing of materials from land surface. Abrasion occurs when rocks and stones become embedded in the base and sides of the glacier. These are then rubbed against the bedrock at the bottom of the glacier and rock faces as the glacier moves. This causes the wearing away of the landscape as the glacier behaves like sandpaper.

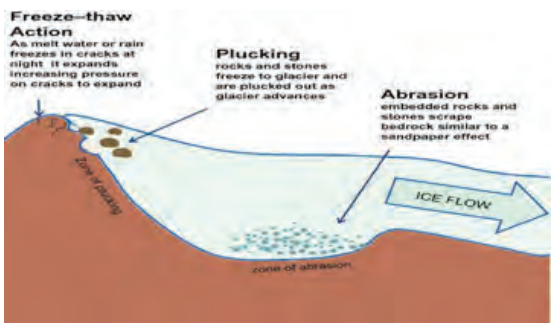


Fig. 7.3 Free - Thaw Action

Learning Activity

1. Explore and describe landforms formed by glacial erosion.
2. Bhutan has about 2674 high altitude glacial lakes, out of which some lakes pose a risk of Glacial Lake Outburst Floods (GLOFs). Using Google Earth, find out major high risk glacial lakes and suggest some mitigation measures downstream.

ii. Depositional features

Glacier deposition is the settling of sediments left behind by a moving glacier. Glacial drift, till, glacial fluvial sediments, snout, terminal moraine, recessional moraine, ground moraine and drumlins are some of the depositional landforms.

a. Glacial drift is a material transported by a glacier and deposited directly by it or from the ice, or by running water emanating from a glacier. Glacial till and stratified drift are types of glacial drifts. Glacial till is unsorted material deposited directly by glacial ice. It is called as boulder clay as it contains mixture of clay and boulders. Stratified drift is sorted and stratified debris deposited from glacial meltwater.

b. Glacial-fluvial sediments are deposited by glacial meltwater in a floodplain. These deposits consist of coarse to medium grained sand and gravel, poorly to well sorted and bedded with numerous cobbles, boulders, and lenses of till.

c. Glacial Snout is the lowest end of the glacier where melting occurs. It is also called glacier terminus or toe.

d. Moraines are the deposited sediments by the melting glaciers. It consists of heterogeneous rock materials such as glacier flour, angular stones and boulders of different sizes and shapes.

Materials deposited at the end of a valley glacier in the form of ridge are called terminal moraines. The glacier keeps on retreating after small intervals of time and series of terminal moraines are formed. This succession of terminal moraines is called recessional moraine. The excessive load that the glacier cannot carry forward is deposited on its own bed or at the base is known as ground moraines.

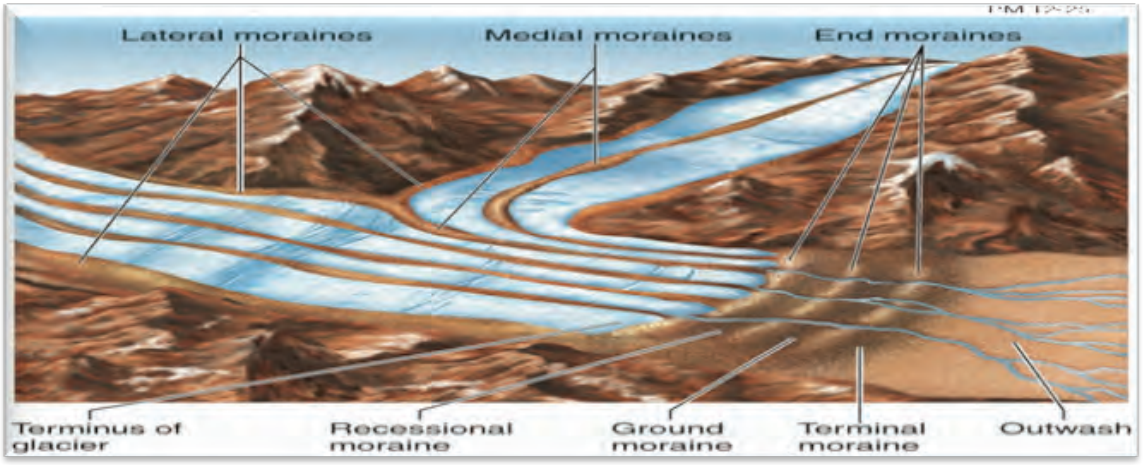


Fig. 7.4 Moraine

Drumlins are smooth and elongated hillocks of boulder clay, with its long axis parallel to the direction of moving ice. Drumlins are often found in group and are known as "basket of eggs topography".

Fig. 7.5 Drumlin

Alpine glaciers and landforms

Alpine glaciers are formed in high mountains and flows through valleys. Glacial erosion is prominent in Alpine glaciers. Alpine glaciers have characteristics of rivers and solid rock flowing fastest at the top from centre and slowest around the sides and bottom. Some of the major landforms produced by Alpine glaciers are:

Fig.7.6 Alpine glacier

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a. Erosional

Cirque, Tarn, Horn, Glacial trough, Hanging valleys and Fjords are some of the erosional landforms.

Cirque (corrie) is a steep-walled rock basin on the side of a mountain resembling an armchair. It is open at one end, has a flat bottom and very steep slopes on three sides. It is separated from the main valley by a slightly higher ground.

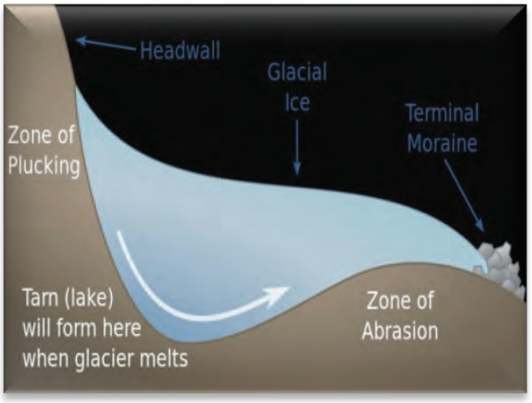


Fig. 7.7 cirque glacier

Fig. 7.8 Tarn glacier

Tarn is a small steep banked mountain lake or pool formed as a result of melting ice in the cirque.

Horn is a pyramidal peak formed by erosion of cirques due to multiple glaciers diverging from central point.

Fig. 7.9 Horn glacier

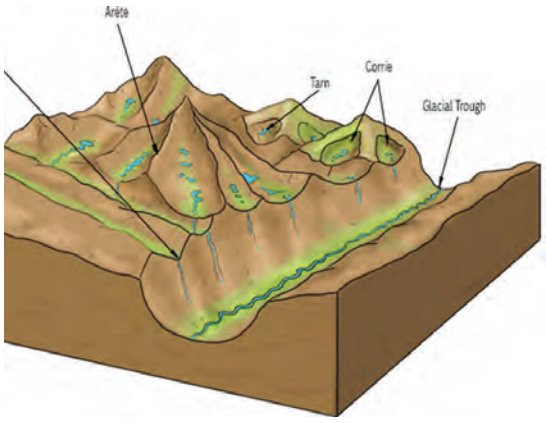


Fig. 7.10 Glacial Trough

Glacial troughs, or glaciated valleys, are long, U-shaped valleys that are carved by glaciers that have receded or disappeared. Troughs have flat valley floors and steep, straight sides

Hanging valleys are formed as a result of the main glacier eroding faster and deeper compared to tributary glacier. A steep slope develops at the confluence of the tributary glacier. The water of the tributary glacier forms a waterfall that enters the main valley after the snow melts. Tributary glacier turns into a valley hanging over the main valley.

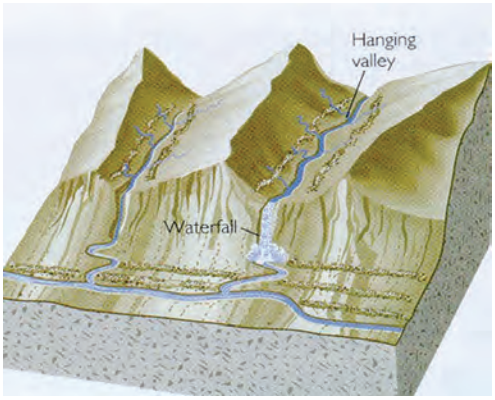


Fig. 7.11 Hanging valley

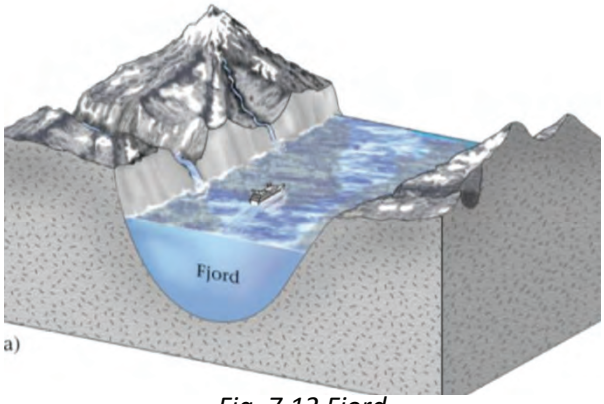
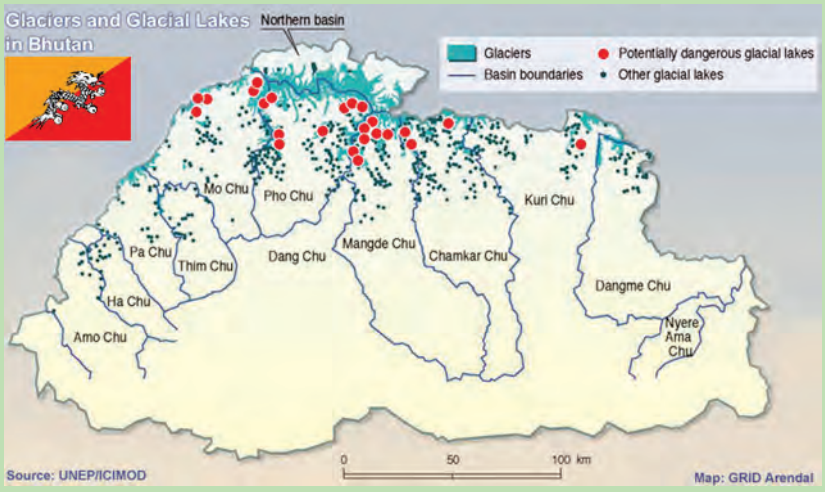


Fig. 7.12 Fjord

A fjord is a long, deep, narrow body of water that reaches far inland. Fjords are glaciated U-shaped valley with steep walls of rock on either side. Fjords are usually deepest farther inland, where the glacial force is strongest.

Learning Activity



1. Refer the map of Bhutan to interpret and discuss the dzongkhags which may face the future consequences of glacial lake outburst flood

b. Depositional

A cirque glacier is glacier formed in a bowl-shaped depression on the side of the mountains. Snow and ice accumulation in cirques often occurs as a result of avalanching from surrounding slopes. The snow persists in cirque throughout the year and becomes glacier ice.

Fig. 7.13 Cirque glacier

Fig. 7.14 Valley glacier

Valley glacier is found in valley in which the ice moves down the slope in pre-existing valley from a broad reservoir of ice in the higher mountains. It is also known as Alpine glacier.

Material deposited on either side of the glacier is known as lateral moraine. Medial moraines are formed where two tributary glaciers come together.

Learning Activity

1. Using locally available materials, prepare a model of major depositional landforms produced by glacier.

7.4 The Third Pole

The Third Pole stretches from Pamir and Karakoram Mountain region in the west to Hengduan Mountains in the east, Kunlun and Qilian mountains in the north to Himalayas in the south. It covers over five million square kilometres with an average elevation of over 4,000 meters above the sea level.

The region has more snow and ice than any region in the world apart from the Arctic and Antarctic. Therefore, it is known as the 'Third Pole'. It is also known as Hindu Kush Himalayan (HKH) region.

The third pole region comprises of the countries such as Afghanistan, Bangladesh, Bhutan, China, Kyrgyzstan, Mongolia, Myanmar, Nepal, Pakistan, Tajikistan and Uzbekistan. This region has vast cryospheric zones.

Know more

The Cryosphere contains the frozen parts of the planet. It includes snow and ice on land and sea. This sphere helps to maintain the Earth's climate by reflecting incoming solar radiation back into space.

Five major river systems of Asia: Indus, Brahmaputra, Mekong, Yangtze, Hwang Ho (Yellow) rivers originate from HKH. This region is endowed with rich natural resources and provides a wide range of ecosystem services and livelihood to over 21 million people.

The cryospheric processes at the Third Pole is prone to global environmental changes. A slight change in climate results in large-scale melting of glacier, permafrost and snow cover altering the land-surface energy balance and water cycle in the region and beyond.

International organizations, associations and agencies working for environmental protection and climate change have initiated various measures to protect Third Pole Environment. One of the initiatives is the Third Pole Environment (TPE), an international program for interdisciplinary study of the relationships amongst water, ice, air, ecology and humankind.

Learning Activity

1. Watch the TED talk: An urgent call to protect world's 'Third Pole', and prepare a PPT.
2. Using Geospatial technology, explore the extent of glacial retreat in Bhutan and share your findings.

Test Yourself

1. What are the processes involved in the erosional work of a glacier? Explain the role of each process in the formation of different land features.
2. What is the significance of Third pole to Bhutan? Explain with examples.
3. Suggest measures to prevent glacial retreat in Bhutan.
4. Discuss the economic importance of glaciers.
5. Disturbance on Thorthomi Lake could result in glacial lake outburst flood (GLOF), potentially with huge cost of life and property. Suggest measures to conserve Third Pole Environment in the context of "Think Globally and Act Locally".

Chapter 8

Koppen Climate Classification

Learning Objective (s):

- Explain Koppen climate classification
- Discuss merits and limitations of Koppen climate classification

8.1 Introduction

Climate classification is a way of categorizing the climate of the world. There are three principal approaches to climate classification; generic classification based on levels of temperature and aridity in relation to vegetation boundaries, classification based on the moisture budget and potential evapotranspiration and genetic classification based on atmospheric circulation of winds and air masses. Climatologists have classified climate into various types.

Wladimir Koppen, a German botanist and climatologist developed the popular climate classification based on vegetation. His classification is based on quantitative data as numerical values of temperature and precipitation is used in describing boundaries of different climates. Koppen published his first climate classification in 1918 and has undergone numerous refinements.

8.2 Koppen climate classification

Koppen classified world climate based on vegetation zones. Five major climates zones are designated with capital letters, A, B, C, D and E. H is another alphabet used to describe the Highland areas proposed by his followers.

Koppen designated alphabets: A- Tropical climate, B-Dry climate, C- Temperate climate, D-Continental climate and E-Polar climate.

A: Tropical climate

It covers tropical or equatorial zone and is called humid tropical climate. In general, tropical climate is warm and moist throughout the year with mean temperature above 18°C. A

Climate is also known as Tropical Rainy Climate.

It is further divided into four sub-types according to the periodicity and regime of precipitation.

Af - Equatorial Rainforest Climate.

Aw - Savanna Climate.

Am - Monsoon Climate.

As - Dry Summers.

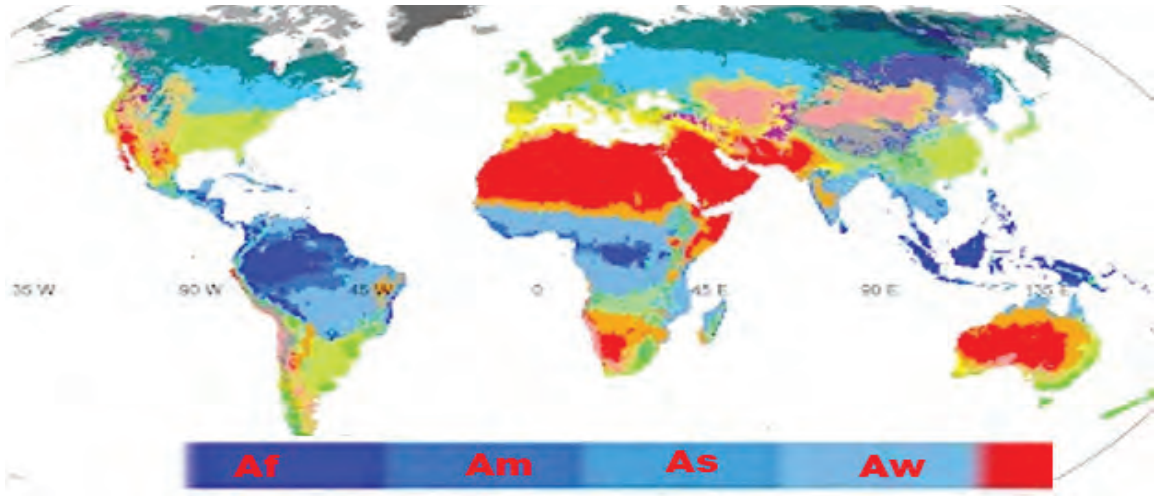


Fig. 8.1 A climate region

B: Dry climate

It covers arid or dry zones of the world. Considering the annual temperature and the rainiest month of the year, B climate is divided into two types as BW and BS.

BW and BS Climates are further divided into four categories as:

BWh- Tropical Desert Climate with average annual temperature above 18°C.

Bsh- Tropical Steppe Climate with average annual temperature above 18°C.

BWk- Mid Latitude Cold Desert Climate with mean annual temperature below 18°C.

BSk- Mid Latitude Cold Steppe Climate with mean annual temperature below 18°C.

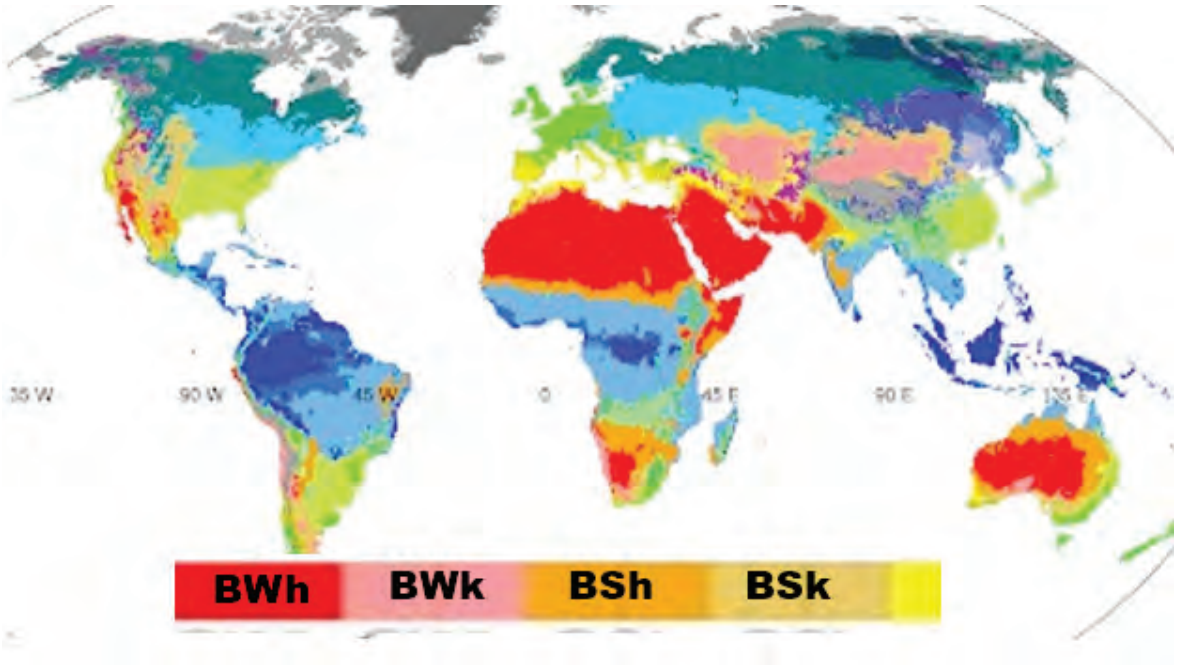


Fig. 8.2 B climate

C: Temperate climate

It covers warm or mild temperate zones and characterized by humid mid-latitude warm temperate climate with mild winters. The average temperature of the coldest and the warmest months ranges between 8°C and 18°C. C climate is called Humid Mesothermal or Warm Temperate Rainy climate.

Depending on seasonal distribution of precipitation, this climate is classified into three types:

Cf - Western Europe Type with precipitation throughout the year.

Cw- China Type with precipitation more in the wettest month of summer than the driest month of the winter.

Cs- Mediterranean Type with precipitation more in the wettest month of the winter than the driest summer.

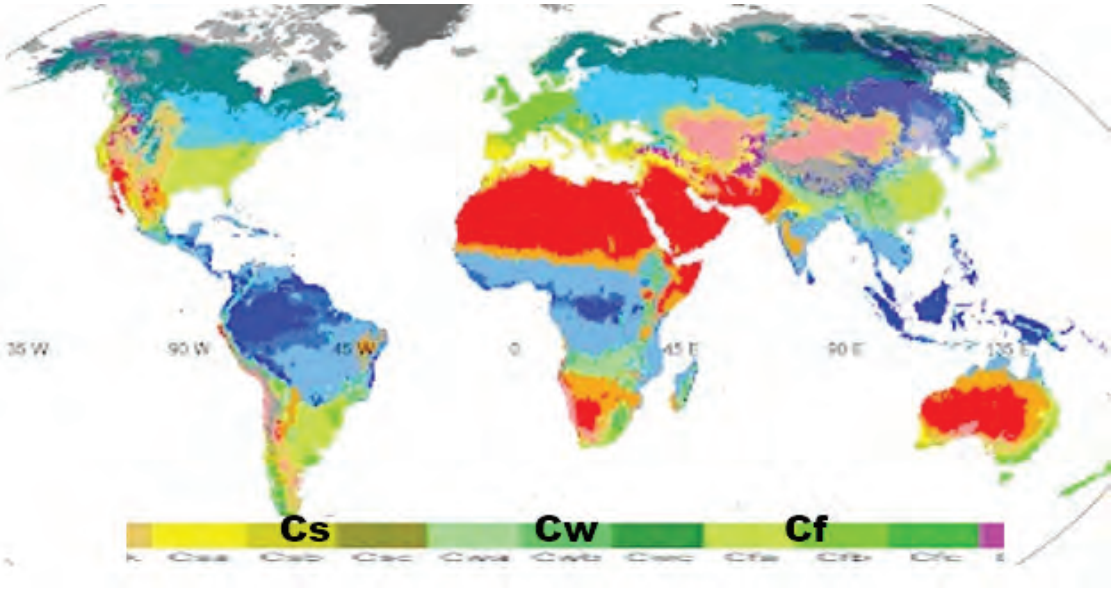


Fig. 8.3 C climate

D: Continental climate

It covers continental zone characterized by humid or cold forest climate with severe winters. The average temperature of the coldest and the warmest months is below 3°C and above 10°C respectively. The ground remains snow covered for several months of the year. This climate is also termed as humid microthermal or Cold Snow Forest Climate.

It is divided into:

Df - Humid cold climate, wet throughout the year.

Ds - Dry summer.

Dw - Humid cold climate with dry winters.

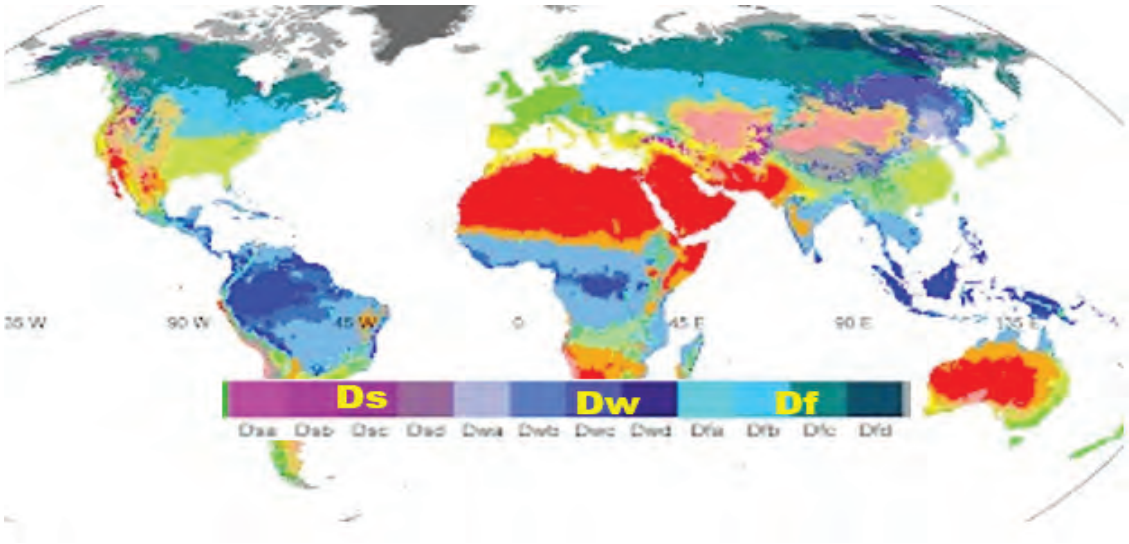


Fig. 8.4 D climate

E: Polar climate

In polar climate, temperatures are low all year round. The temperature of the warmest month is less than 10°C. This climate is divided into:

ET - Tundra climate with temperature ranging from 0° to 10°C.

EF - Perpetual snow with temperature below 0°C.

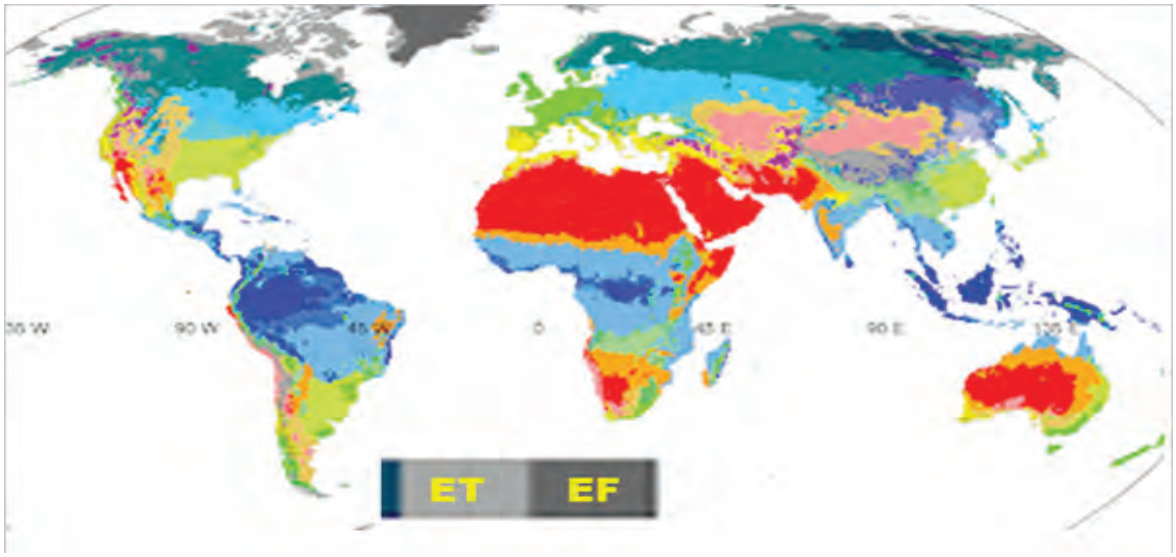


Fig. 8.5 E climate

F: Highland climate

Regions above 1500 metres experience H climate. The air temperature decreases with increasing elevation in the mountains. This classification can encompass any of the previous five.

Learning Activity

1. Discuss the significance of learning Koppen climate classification with reference to Bhutan.
2. Refer figure 8.6 and explain the location and characteristics of Am, As, BWh, Dsb, Cw, Cs, Df, Ds, ET and EF climate.

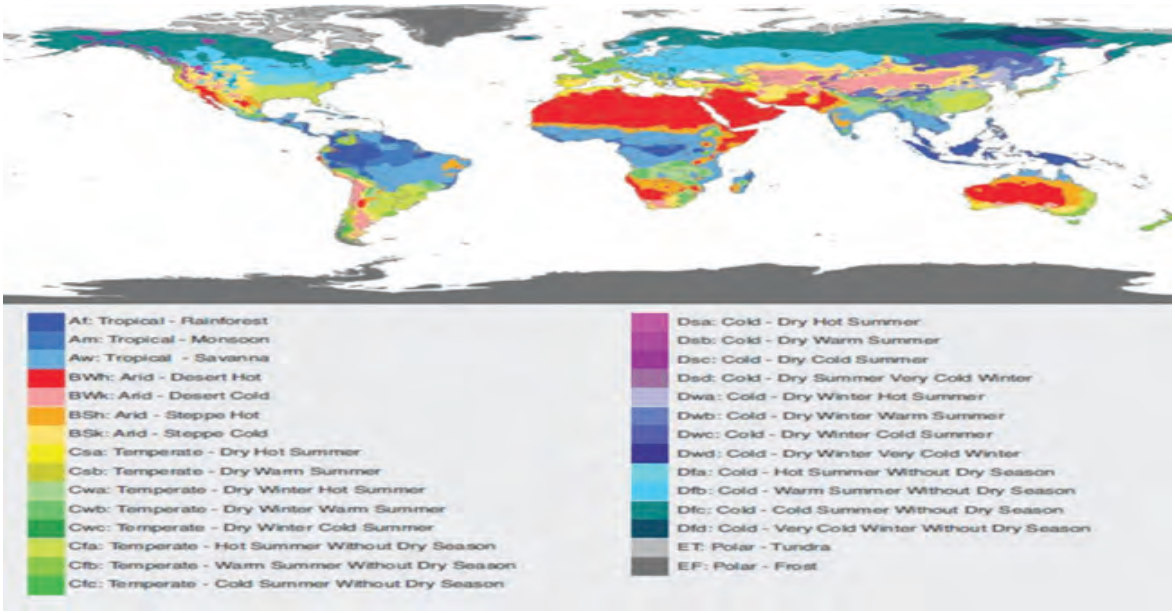


Fig. 8.6 Koppen Climate Classification

Merits of Koppen climate classification

Koppen climate classification is widely used compared to other classifications. He used temperature and precipitation statistics in his climate classification. Since the classification is based on statistical parameters, each region is precisely defined.

He introduced the concept of effective precipitation which depends on the rate of potential evapotranspiration. Potential evapotranspiration is mainly controlled by temperature. It also explains more on relation between heat and moisture factors. The classification is appealing to geographers because of the visible association of vegetation with climate types. This system of climatic classification is descriptive and generalised so is useful to geographers. Thus, Koppen climate classification is simple, comprehensive, detailed and used at different educational levels.

Learning Activity

1. Precipitation and temperature are the two important elements of Koppen climate classification. Explore other elements that influence climate and share your findings.

Limitations of Koppen Classification of Climate

Koppen climate classification is widely used in the world however many climatologists has criticized his classification. It is based on the mean monthly values of temperature and precipitation. By such statistic, potent factor of precipitation is estimated rather than measured accurately making it difficult to compare climate of one locality with another.

Another draw back is that he did not take into account of other weather elements like wind, amount of cloudiness, daily temperature extremes which are equally important to study details of the climate.

Further his classification is based on facts and observation, not on theory. The causative factors of climate have been ignored. Lastly, use of alphabets provides short form so is difficult to characterise in words. However, Koppen's classification maps are still used by scientist and climatologist to this day.

Test Yourself

1. Complete the table with appropriate characteristics and sub divisions.

Major climate Type	Characteristics	Sub-Division
1. A Climate		1.
		2.
		3.
2. B Climate		1.
		2.
		3.
3. C Climate		1.
		2.
		3.
4. D Climate		1.
		2.
		3.
5. E Climate	Polar climate wuth no summer season, but characterized by avarage temperatiure of the warmest month below 10^{0}c.	1. ET Climate(tundra climate with temperature ofthe warmest month below10^{0}c but above 0^{0}c
		2. EF Climate (perpetual snow covered climate with temperature below 0^{0}c all the year round).

2. Study Koppen climate classification map and answer the following questions.

   i. What type of climate is experienced in the shaded areas?

   ii. Write the climate characteristics of these areas.

3. One of the limitations of Koppen climatic classification is based on the mean monthly values of temperature and precipitation without accurate measure. As a future climatologist, how would you improve the classification?

4. Given an option to settle in one of the climatic zones of Koppen climate classification, which zone would you prefer? Give reasons.

5. Place A and B are located at the same latitude, but there is difference in climatic conditions. Justify.

Chapter 9

Fluvial Processes

Learning Objective (s):

- Discuss fluvial processes and landforms
- Discuss Cycle of Erosion

9.1 Introduction

The word "fluvius" is derived from the Latin word meaning "river". Fluvial refers to running water like streams and rivers. Fluvial processes consist of erosion, transportation, and deposition of earth's materials by running water.

The cycle of erosion is an idealized model for stream erosion which explains the development of relief in landscapes to a minimum erosion. The Davisian and Penck's model is developed based on the idealized concept of cycle of erosion.

Learning Activity

1. Watch the video https://www.youtube.com/watch?v=06zTFc5_Ra8 and discuss various processes and features formed by the river.

9.2 Fluvial Erosion

It is the removal of weathered materials, such as soil, sediment, and regolith from the landscape. Streams and rivers are active agents for transforming and shaping the physical landforms. The geomorphic activity of running water, known as fluvial processes produce landforms through erosion. Head ward, vertical and lateral erosion are three types of erosion.

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i. Erosional processes

1. Hydraulic action

It is the process of dragging of sediments at the bottom and sides of the stream by the force of running water.

2. Abrasion

It is the process of chipping and grinding the valley bottom by large rock fragments. This mechanical process is called abrasion or corrasion.

3. Attrition

It is the process of breaking larger rock particles into smaller pieces by hydraulic action and abrasion.

4. Corrosion

It is the chemical process of removing and transporting the soluble materials by the running water.

Learning Activity

1. Explore types and factors affecting the erosional work of rivers. Share your findings.

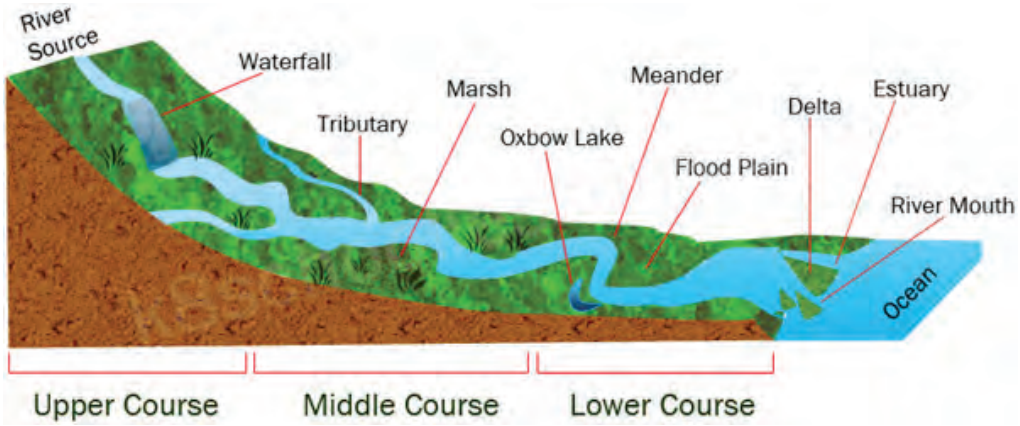


Fig. 9.1 Stages of River

Erosional Landforms

1. Gorges and Canyons

Gorge is a French word meaning throat or neck. A narrow valley with steep and rocky walls located between hills and mountains is called gorge. Canyons are larger than gorge and it comprises of deep narrow valleys with rivers flowing along the valley.

Types of Canyons

a. Box Canyon

It has cliffs on the three sides of the canyon.

b. Slot Canyon

It has narrow canyons developed by water.

c. Submarine Canyons

It has wide canyons cut by rivers and are found on the ocean floor.

Fig. 9.2 Gorge and Canyon

2. Rapids

The areas of shallow and fast flowing water are called rapids. Rapids are found in younger streams where the river flows straight and faster. Soft rocks on the river bed are eroded faster compared to harder rocks on the river bed. This breaks the flow of the river and tiny waterfalls are formed creating rapids.

Rapids are important for the health of a river system. Water splashing on rocks captures air in bubbles and it dissolves oxygen in the water. The oxygen maintains the river ecosystem.

Fig. 9.3 Rapids

Learning Activity

1. Using internet sources, explain interlocking spurs and V-shaped valley.
2. Explain the process of formation of waterfall referring figure no 9.4.

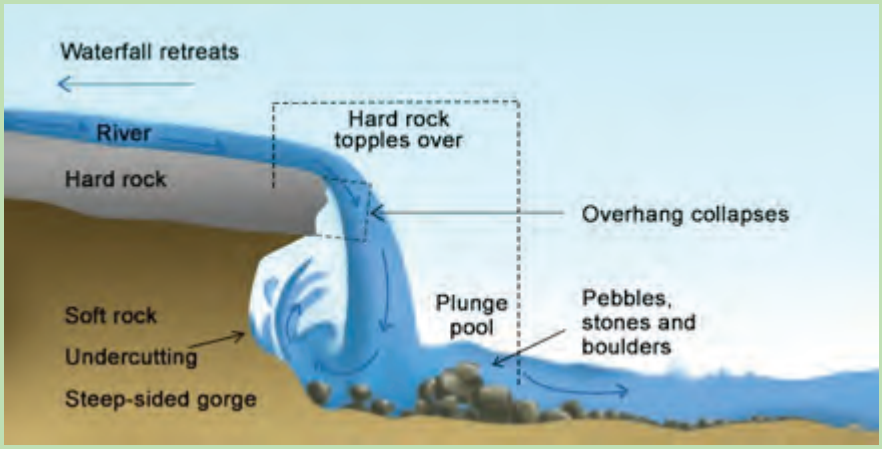


Fig. 9.4 Waterfall

ii. Fluvial Transportation

The process of carrying eroded materials downstream by running water is known as fluvial transportation. River load is the eroded materials that include large boulders in the upper course and suspended sediments in the lower course.

River load is distinguished into three components and includes:

1. Dissolved load- Ions, molecules and atoms originating from the soluble substances.
2. Suspended load- Small and light solid particles held in suspension.
3. Bed load- solid particles on the river bed transported through traction and saltation.

Transportational Landforms

The volume and velocity of the water is high in the transportational stage of the river. In this stage, the rivers flow through a gentle gradient with a wide and deep river channel. Large river channels have less friction and the water flows faster. Lateral erosion is dominant in this stage.

a. Meander

Meanders, named from the Menderes (historically known as the Maeander) river in Turkey. Rivers flow through gentle slopes and begin to curve back and forth forming meanders. Meandering river channels are asymmetrical. The deepest channels are formed at the outer end and shallow channels at the inner end of river bend. Water flows faster and erodes materials from the river bank in deeper channels, whereas the river flows slowly and deposits sediments on a series of shallow channels known as point bars.

Fig. 9.5 River Meander

b. Alluvial Fan

Triangle-shaped deposits of gravel, sand and silt form an alluvial fan. Alluvial fans are formed by rivers near hills and steep walls of canyons. The river transports and deposits sediments to a flat plain. The velocity of the river decreases and river channels spread out forming triangle-shaped features. Narrow point of the alluvial fan is the apex and a wide triangle base forms the fan's apron.

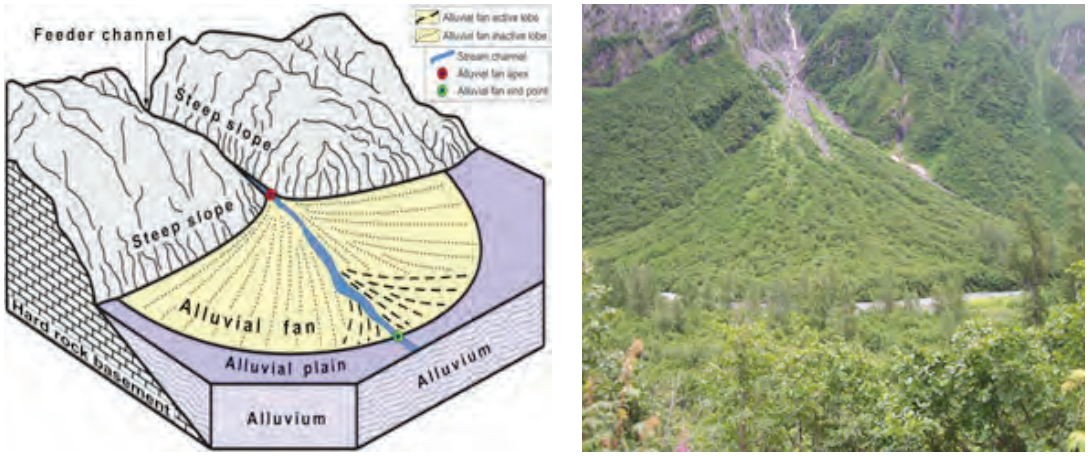


Fig. 9.6 Alluvial fan

Types of Alluvial Fan

i. Bajada

The convergence of multiple alluvial fans forms bajada. It is found in both deserts and wet climatic regions.

ii. Subaqueous fan

It is formed by sediments deposited by water currents from a hill or mountain and are found underwater.

Learning Activity

1. Use the link https://www.youtube.com/watch?v=Dth6DP3HZ9U and explain how the river transports its load (Traction, saltation, suspension and solution). Prepare a power point presentation and share it.
2. Discuss the formation of alluvial cones and U-shaped valleys using relevant sources.
3. Access Google Earth and complete the activity.
   a. Open Google Earth Application and type 'Paro, Bhutan' in the search button.
   b. Zoom near Paro International Airport and click 'Add Path'.
   c. Type 'U-shaped valley' in name column, draw a line connecting two sides of the valley and click OK
   d. Right click on U-shaped valley and click on Show Elevation Profile in Places layer.

iii. Fluvial Deposition

Deposition is the process of dropping the eroded materials by river. The river loses its force due to decrease in gradient and velocity. It occurs in areas of low gradient, at the confluence and at the mouth of the river.

Depositional Landforms

a. Flood Plains

Flood plains are found along major rivers and large tributary valleys. It is a relatively flat surface adjacent to river channels and occupies valley bottoms. It has its surface covered with alluvial deposits and are inundated during floods. Flood plains are categorized into two types:

i. Lateral Accretion Deposits

It is formed within the river channel as the river flows back and forth across the valley bottom.

ii. Vertical Accretion Deposits

It is formed as a result of rivers overflowing its channel banks and accumulation of sediments on the floodplain surface.

Fig. 9.7a Flood Plain

Fig. 9.7b Delta

a. Delta

Delta is a fan-shaped alluvium tract of land formed at the mouth of a river. It is formed by the deposition of sediments at the mouth of a river.

Types of Delta

The different types of delta are:

i. Bird foot delta

The fluvial force dominates the marine force resulting in deposition of sediments. The delta grows faster into the sea along the distributary channels while it is slow between coastline distributaries. This type of delta appears as digits of a bird's foot and is named digitate delta.

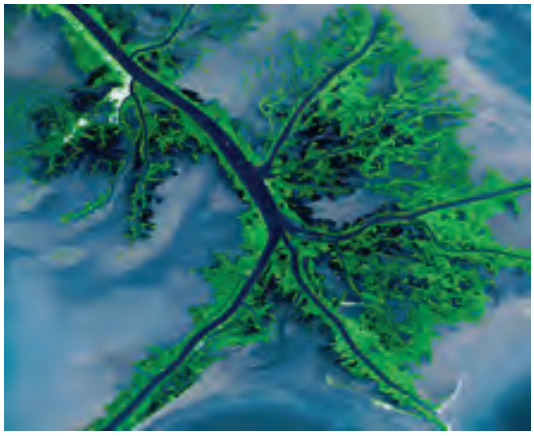


Fig. 9.8 Digitate delta appears like bird's foot

ii. Arcuate delta

The sediment deposited at the mouth of the river is reshaped when the fluvial and marine forces are almost equal. Sediments are redistributed along the shore giving rise to a curved, or bowed delta with its outer convex margin facing the sea. This type of delta is called an arcuate or lobate delta.

Fig. 9.9: Arcuate Delta

iii. Braided Stream

The main channel of the river is divided into a complex network of shallow converging and diverging streams, separated by bars of sand and islands. This branching characteristic is called anastomosis (Greek) and the channels are called anastomosing. Braided streams develop where there are no lateral confining banks, such as large alluvial piedmont fans and confined valleys.

Fig. 9.10 Braided Stream

iv. Ox-bow Lake

Ox-bow lakes are found in flat, low-lying plains where the river changes its course and flows into another river channel. Rivers have wide meanders in plain areas. The meander becomes an ox-bow lake along the side of the river. Meanders that form into ox-bow lakes have two sets of curves:

a. Concave Banks

The curve of the river banks that are close to each other forms concave banks. The force of river water wears away the concave banks of meanders.

b. Convex Banks

River banks that lie on opposite sides of concave banks are called convex banks. Silts and sediments are deposited on convex banks.

Ox-bow lakes are still water lakes with no natural inlet and outlet. It often becomes swamps or bogs and dries out as water evaporates. Ox-bow lakes are also called a horseshoe lake, a loop lake and a cutoff lake.

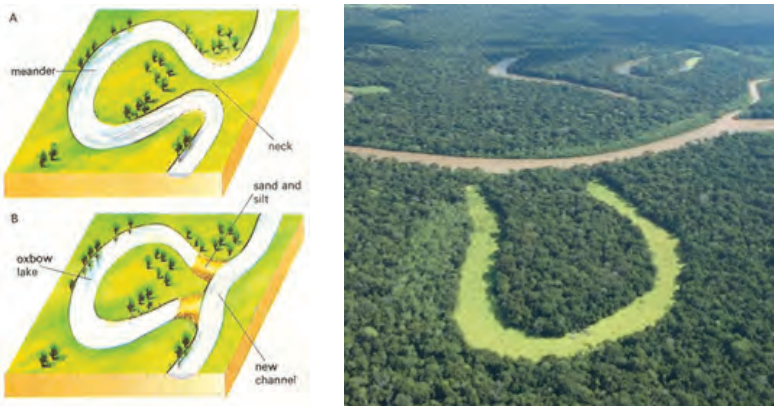


Fig. 9.11 Ox-bow Lake

Learning Activity

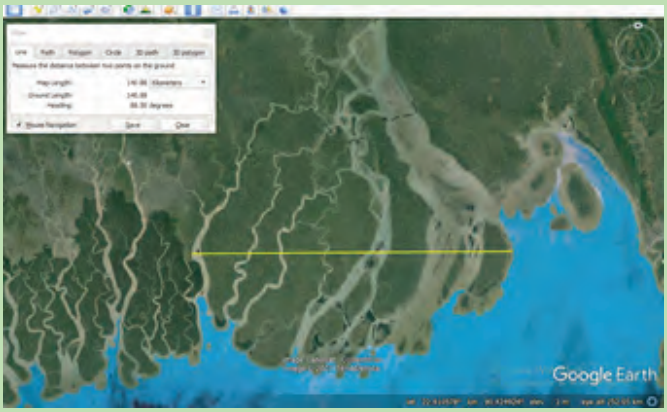
1. Watch the video https://www.youtube.com/watch?v=h_47JRsHNkk and discuss the formation of levees.
2. Access Google Earth and complete the activity.

a. Open Google Earth Application and type 'Brahmaputra River' in the search button.

b. Zoom near the mouth of river Brahmaputra where deltas are seen.

c. Click on 'Show ruler' and change map length to kilometres in the ruler panel.

d. Draw a line connecting two ends of the delta and record the distance.



i. Analyse how these delta basins are used for agricultural purposes.

ii. What would happen to the people living in delta regions if it submerges under the sea or ocean?

9.3 Cycle of Erosion

Davis and Penck cycle of erosion are two geographic cycle models explaining relief in landscapes and its development.

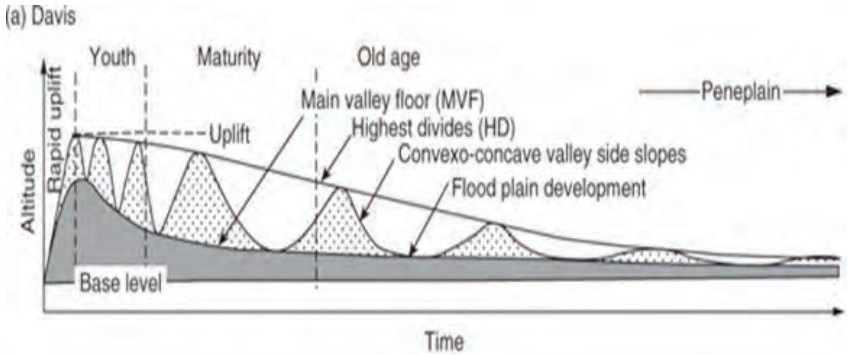


Fig. 9.12 Davisian Cycle of Erosion

i. Davies cycle of erosion

The cycle of erosion is a model of stream erosion and landscape development by William Morris Davis. Davis stages in the fluvial process define a youth, mature and old sequences in the development of the river valleys.

The basic goal of the Davisian model of geographical cycle and general theory of landform development was to provide a basis for a systematic description and genetic classification of landforms. The Davisian theory explains that landforms change in an orderly and sequential manner as processes operate through time and uniform external environmental conditions. The sequential changes in landforms pass through youth, mature and old stages leading to a formation of peneplain.

Structure, time and process are important factors in the origin and development of landforms of a particular place. These three factors are called 'Trio of Davis' and his concept is expressed as:

a. Structure means lithological (rock types) and structural characteristics (folding, faulting, joints) of rocks.

b. Time was not only used in temporal context by Davis but it was also used as a process itself leading to an inevitable progression of change of landforms.

c. Process means the agents of denudation including both weathering and erosion (running water in the case of geographical cycle).

The basic premises of Davisian model of 'geographical cycle' includes assumptions:

1. Landforms are the evolved products of the interactions of endogenetic and exogenetic forces.
2. The evolution of landforms takes place in an orderly manner and systematic sequence. Landforms are developed through time in response to an environmental change.
3. Streams erode valleys rapidly downward until the graded condition is achieved.
4. There is a short-period of rapid rate of upliftment in land mass.
5. Erosion occurs after the upliftment is completed.

The cycle of erosion has its initial stage at a time when the landmass is rapidly elevated by internal earth forces, followed by a long period of tectonic quiescence. Once uplifted, erosion by streams begin to operate on the uplifted landmass which is gradually worn down to a plain. The landmass may be rejuvenated and the cycle begins again and remnants

of the earlier cycle of erosion are preserved. Three stages of cycle of erosion are youth, mature and old stage.

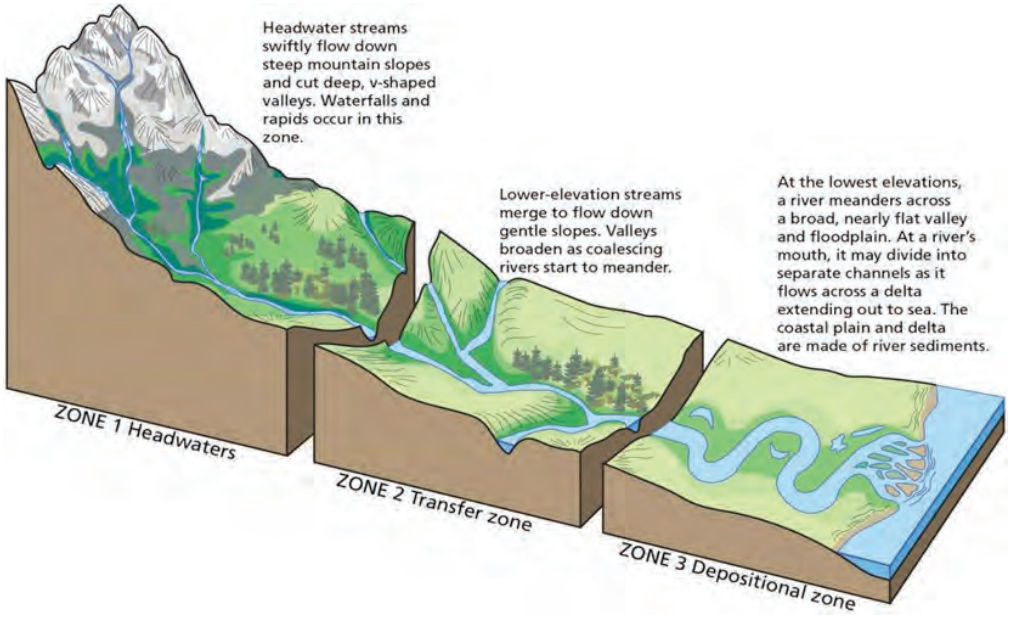


Fig. 9.13 Erosional Stages

Youth Stage

In this stage, the river flows along an uneven surface and there is intensive bottom erosion. This results in the formation of V-shaped valleys, lakes, rapids, waterfalls, steep-sided valleys and gorges.

Mature Stage

The river stage attains a profile of equilibrium with a dissected and integrated drainage system. The topography consists of features, such as hogbacks, cuestas, mesa and butte.

Old Stage

The river loses its erosive power and flow in a sluggish manner. In this stage, the work of the river is deposition with minimal erosion. The topography consists of features like peneplains, natural levees and deltas.

Cycle of erosion, arid cycle of erosion, glacial cycle of erosion, and marine cycle of erosion were developed on the basis of Davies cycle of erosion.

Learning Activity

1. Debate on the Davisian cycle of erosion is not a 'geographical cycle'.
2. Some cycles of erosion do not reach the final stage. Discuss the causes of an incomplete cycle.

ii. Penck cycle of erosion

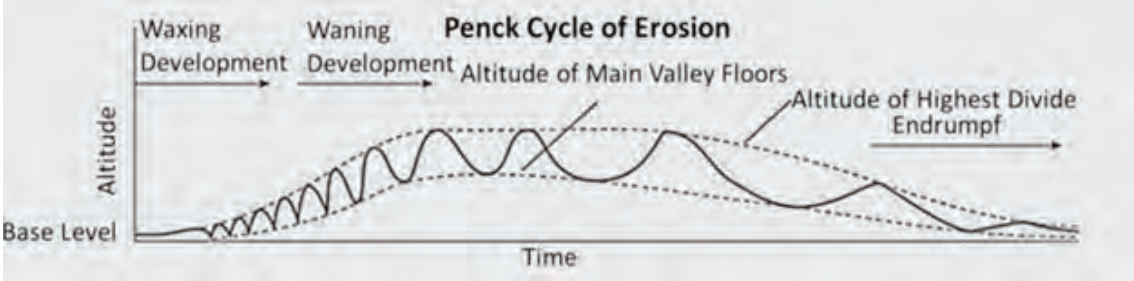


Fig. 9.14 Penck's Cycle of Erosion

Walter Penck studied the Davis erosional cycle model and agreed with most of Davis's theory. However, Penck disagreed on the process and stages of the Davis model as there were no sequential stages and may be interrupted by rejuvenation.

The endogenic force interferes with the cycle of erosion through rejuvenation. This process of rejuvenation returns the cycle from the old stage to the young stage through the processes of:

a. Lowering the base level
b. Upliftment of landforms

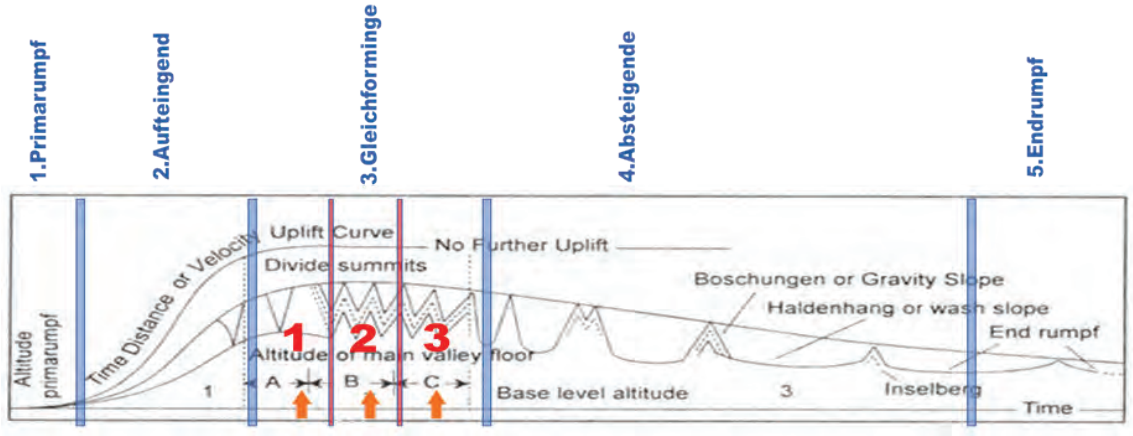
Penck's 'Trippen' concept has three parts: zone of erosion, transportation and deposition. He emphasised the zone of erosion on a convex and free face. The zone of transportation is on a rectilinear slope and the zone of deposition is on a concave slope.

Five stages in the erosional cycle are:

a. Primarampf: It is featureless and developed as Pediplain
b. Aufsteigend: The gap between the upper curve and lower curve is increasing with the development of landforms, mountains, valleys and slopes.
c. Gleichforminge: Upliftment with great erosion. Upliftment and erosion are the same. Upliftment decreases gradually in both valley and mountain.

d. Absteigende: The rate of erosion is faster with formation of conical shape and slopes.

e. Endruff: The landform development stops and pediplain are developed with erosion in the upper surface of deposition.



Learning Activity

1. Differentiate Davis cycle of erosion from Penck's erosion cycle and share your findings.

Test Yourself

1. Rivers in Bhutan are the source of income generation. Climate change is posing a threat to the source of our income. Suggest measures to sustain our rivers.
2. Differentiate Cuspate delta from Estuarine delta.
3. Refer the link https://www.thethirdpole.net/en/climate/flash-floods-are-burying-the-lands-on-the-india-bhutan-border-in-silt/ and complete the activities.

a. Construction activity and flash floods are changing the nature of the land downstream of the Bhutan-India border, fundamentally changing the lives of the people that live there. Explain how change in landforms has led to change in the lives of people.

b. Suggest measures to mitigate the impact of natural hazards on Hindu-Kush Himalayan regions and its river sources.

4. Which cycle of erosion best describes the river systems of Bhutan. Why?

5. How do rivers contribute to the development of land features on the surface of the Earth?

   Explain with examples. Discuss the economic importance of the river in context to Bhutan's economy.

7. Identify the stages of the rivers according to the land features formed in your locality. Explain the land features.

8. Is the fluvial process constructive or destructive to the natural environment? Justify.

Chapter 10

Population Dynamics

Learning Objective (s):

- Explain measures of fertility and mortality
- Analyse the trends of fertility and mortality
- Examine the causes and consequences of migration
- Suggest measures to mitigate migration
- Discuss the impact of working population on the economy
- Suggest ways to overcome unemployment problem in Bhutan

10.1 Introduction

Population is dynamic as it changes over time. The change in the number of people living in a particular area between any two points of time is termed as growth of population. Population increases, decreases or remains same depending on fertility, mortality and migration.

The role of working population and its impact on the economy is one vital part of population study. The working age population and the dependency ratio determine the economic status of a country. As the population of a country increases, the issue of unemployment generally surfaces adversely impacting the economic conditions of population.

10.2 Fertility

Fertility is the actual number of children born to a woman in her entire life time. It is different from fecundity as fecundity refers to the reproductive capacity of woman during her entire reproductive period (15 - 49 years). Some important measures of fertility are:

i. Crude Birth Rate

Crude Birth Rate (CBR) is the number of live births in a year per 1,000 population. It is the simplest and commonly used measure of fertility.

$$CBR = \frac{\text{Total number of live births in a year}}{\text{Total number of population in the same year}} \times 1{,}000$$

ii. General Fertility Rate

General Fertility Rate (GFR) is the number of births in a year per 1,000 women of reproductive age.

$$GFR = \frac{\text{Total number of births in a year}}{\text{Total number of women in reproductive age group in the same year}} \times 1{,}000$$

iii. General Marital Fertility Rate

General Marital Fertility Rate (GMFR) is the number of births during a year for every 1,000 women of reproductive age who are married or living together.

$$GMRF = \frac{\text{Total number of births in a year}}{\text{Total number of women married or living together in reproductive age group in the same year}} \times 1{,}000$$

iv. Age - Specific Fertility Rate

Age-Specific Fertility Rate (ASFR) is the number of live births in a year by age of mother per 1,000 women of reproductive age classified in specific age groups. The highest ASFR in 2017was observed in the age group 25–29 years, while the lowest was in the age group 45-49 years.

$$ASFR = \frac{\text{Total number of live births occurred to mothers in specific age group in a year}}{\text{Total number of mothers in the same age group in the same year}} \times 1{,}000$$

Learning Activity

1. The ASFR was the highest in age group 25 - 29 years in both 2005 and 2017. What could be some possible reasons? Share your reasons.

v. Total Fertility Rate

Total Fertility Rate (TFR) refers to the average number of children a woman would bear during her entire reproductive life, at the prevailing age-specific fertility rate.

$$TFR = 5 \times \sum ASFR$$

Where, 5 is the age interval and ∑ASFR is the sum of age-specific fertility rate

Table 10.1: Measures of mortality in Bhutan, 2005 & 2017

Measures of Fertility	Year	
	2005	2017
CBR	20.0	15.5
GFR	79.0	57.3
GMFR	126.5	92.0
TFR	2.6	1.7

Source: PHCB 2017 & PHCB 2005

For the population in a given area to remain stable, an overall total fertility rate of 2.1 is needed. So, how would decrease in TFR from 2.6 in 2005 to 1.7 in 2017 affect the Bhutanese economy in the long run?

Learning Activity

1. Discuss some possible reasons that have caused a decrease in TFR in the country. What does this fall in TFR indicate for Bhutan?

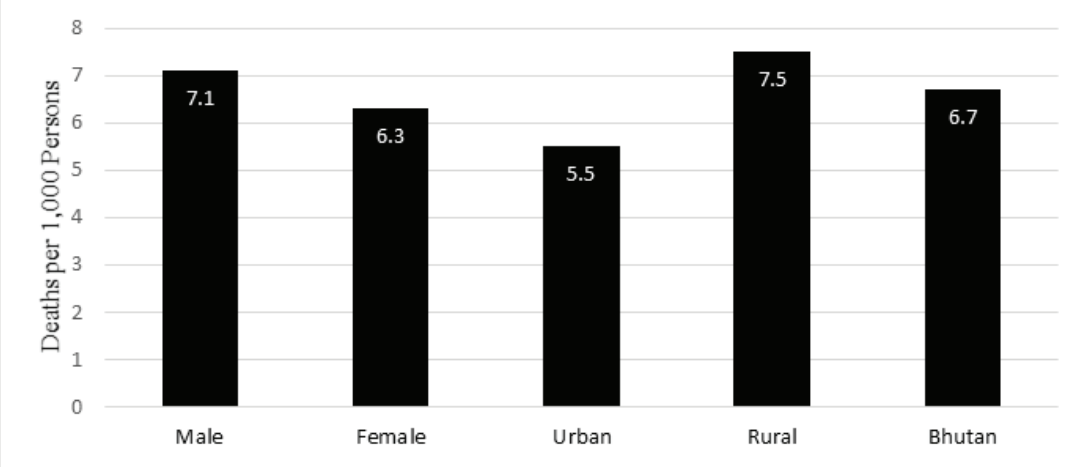
10.3 Mortality

Mortality is defined as the number of deaths in the population in a given period of time. It contributes to the decrease of population density. Mortality rate is expressed in unit of deaths per thousand individuals per year. Some important measures of mortality are:

1. Crude Death Rate (CDR)

The crude death rate (CDR) is defined as the number of deaths in a year per 1,000 population. It is the simplest and most commonly used measure of mortality.

$$CDR = \frac{\text{Total number of death per year}}{\text{Total population}} \text{ X } 1{,}000$$



Source: PHCB 2017

Fig. 10.1 Levels of Crude Death Rate by Sex and Area,Bhutan, 2017

2. Infant Mortality Rate (IMR)

Infant Mortality Rate (IMR) is defined as the number of babies died below the age of one year per 1,000 live births in a year.

$$IMR = \frac{\text{Total number of infant deaths in a year}}{\text{Total number of live births in a year}} \text{ X } 1{,}000$$

3. Child Mortality Rate (CMR)

Child Mortality Rate (CMR) refers to the number of deaths of children between 1-4 years per 1,000 live births in a year.

$$CMR = \frac{\text{Total number of deaths of children (aged 1-4) in a year}}{\text{Total population of children (aged 1-4) in a same year}} \text{ X } 1{,}000$$

Learning Activity

1. Visit a nearby health centre and collect the following demographic data for recent three years.

Year	Total live births	No. of deaths below 1 year	No. of deaths between age 1-5 years

   a. Calculate infant mortality rate, child mortality rate and under-five mortality rate.

   b. Prepare a line graph and share the findings.

2. "Although Bhutan has achieved the Millennium Development Goal (MDG) target for infant and under-five mortality rate, the number of babies dying within their first 28 days after birth still remains a concern in most Dzongkhags" (Bhutan's Daily Newspaper, 2016).

   a. Why do you think the target to achieve zero infant mortality rate in all the dzongkhags stands at risk?

   b. Suggest way to achieve zero infant mortality rate in the country.

4. Maternal Mortality Ratio

The maternal mortality ratio (MMR) refers to the number of women who die from pregnancy-related causes while pregnant or within 42 days of pregnancy termination per 100,000 live births. It depicts the risk of maternal death relative to the number of live births and essentially captures the risk of death in a single pregnancy or a single live birth.

$$CMR = \frac{\textit{Total number of maternal deaths of children in a year}}{\textit{Total population of live births in a same year}} \textit{ X 1,000}$$

5. Age Specific Death Rate

Age Specific Death Rate (ASDR) refers to the number of deaths per 1,000 population in a specific age interval. Most age groupings for age-specific mortality rates are 5 or 10 year groups.

$$ASDR = \frac{\textit{Total number of deaths in an age - specific group in a year}}{\textit{Total population in the same age - specific group in a same year}} \textit{ X 1,000}$$

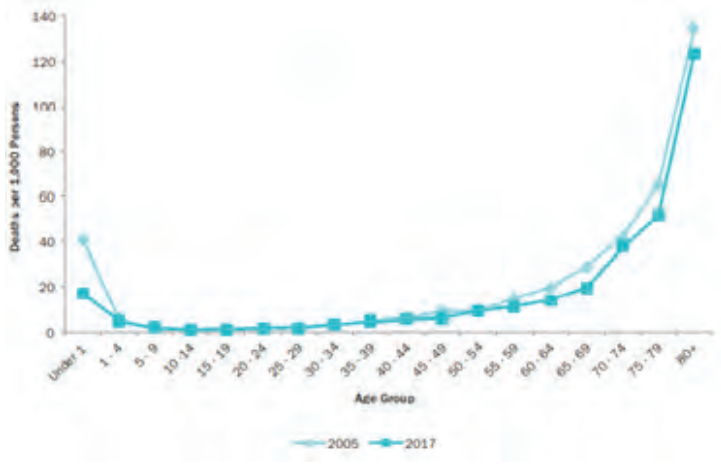


Fig. 10.2 Age Specific Death Rate by Age Group, Bhutan 2005 and 2017

Learning Activity

1. Refer figure 10.2 and discuss the factors that caused higher death rate at infancy and the lowest in the age group of 10-14 years. Suggest measures to improve this situation.

6. Life Expectancy at Birth

The life expectancy at birth is the average number of years new-born children would live if they were subjected to the mortality risk prevailing for the cross section of population at the time of their births. Life expectancy at birth reflects the overall mortality level of a population.

Table 10.2: Measures of mortality in Bhutan, 2005 & 2017

Measures of Mortality	Year	
	2005	2017
CDR	7.0	6.7
IMR	40.1	15.1
CMR	21.4	19.0
GMFR	126.5	92.4
MMR	310.0	89.0
U5MR	61.6	34.1
Life expectancy (in years)	66.5	70.2

Source: PHCB 2017, 2005& UNFPA

Learning Activity

1. Compare MMR of 2005 and 2017 and discuss the causes of change in MMR. Present the findings.
2. Generally, female life expectancy is higher than male. Why do men often die earlier than women?

10.4 Fertility and Mortality Trends in Bhutan

Bhutan has seen a decline in the number of children born to a woman in her entire lifetime over the last three decades. As per the 1991 survey of National Statistics Bureau (NSB), an average number of children born to a woman was about six babies, which has decreased to about two babies in 2017. While the death rate for Bhutan in 2019 was 6.3 per 1,000 population. Over the last 50 years, the death rate of Bhutan was 23.3 per 1,000 people in 1971 and 6.3 per 1,000 people in 2020.

Table 10.3: Fertility & Mortality Trends in Bhutan

Year	Crude Birth Rate	Crude Death Rate
2014	17.97	6.27
2015	17.78	6.26
2016	17.62	6.25
2017	17.46	6.24
2018	17.23	6.25
2019	17.01	6.25

Source: The World Bank Data

10.5 Migration

Migration is the process where people move from one place to another to settle permanently or temporarily. It is not a natural phenomenon in the change of population like fertility or mortality as migration depends on individual choice. Migration impacts the population size, composition and structure. Sequential and step migration are few examples of migration. There are numerous causes of migration which are grouped as political, social and economic. Sometimes a combination of these causes may be responsible for migration.

Fig. 10.3 Causes of migration

Learning Activity

1. Read the extract given and answer the questions. Prepare a power point slide to present your work.

   "In Bhutan, major thromdes and western dzongkhags saw the increase in population, the eastern and central dzongkhags suffered huge population loss over the years. Of the total 334,185 migrants, 39.8 percent migrated from one dzongkhag to another, out of which 40.8 percent were male and 38.9 percent female according to PHCB 2017. Thimphu thromde saw the highest population gain of 48,214 while Trashigang experienced the highest population loss of 23,612. In 2005, 32.7 percent of the population migrated between dzongkhags. Employment dominated the reason for migration with 18.7 percent, and family move for females, 6.2 percent. Education was the second biggest reason for migration for male and female, 8.9 percent and 7.6 percent respectively. The age group of 25 to 29 migrated the most at 66 percent, followed by the age group 20 to 24 at 65 percent." (Bhutan's Daily Newspaper, 2018).

a. Draw a migration bar graph using MS Excel. displaying the reasons of migration.

b. Since all the causes of migration can be classified under push and pull factors, discuss push and pull factors that contributed highest population gain in Thimphu and highest population loss in Trashigang.

c. Family move is one of the main reasons for sequential migration. Explore and explain the term sequential migration. How is it different from step migration?

10.6 Consequence of Migration

As people migrate from one place to another, the impact is felt on both the place of destination as well as place of origin. The resources can be explored and exploited as the

labourforce in the receiving place increases, cultural diffusion will also take place, and areas can develop faster. However, it results in increase in crime rate and social evils, increase pressure on land and other resources and may even invite tensions and political problems. It also helps in redistribution of population.

The increasing rural to urban migration has resulted in increase in barren land and decline in agricultural production due to labour shortage. Elderly people are left behind without attendants in the rural areas. Further in most of the rural areas empty households (gungtongs) are increasing.

On the other hand, urban areas are over populated leading to innumerable problems like unemployment problem, housing shortage, urban spraw land increasing crime rates.

Learning Activity

With the increase in the number of educated people, rural to urban migration is also increasing. This has caused more adverse impacts than positive impacts in the society. Discuss and suggest measures to mitigate these problems. Share your findings.

10.7 Migration Trend

Migration rate in Bhutan has been increasing yearly. In 2005, the migration rate was 32.7% out of which 34.3% male and 31.0% female. While in 2017, it has increased to 39.8% of which 40.8% male and 38.9% female.

Sex	2005	2017
Male	34.3%	40.8%
Female	31.0%	38.9%
Total	32.7%	39.8%

10.8 Working-age Population

The working-age population consists of people between 15 -64 years. This group of peopleare categorised as labour force or economically active population and economically inactive population. Labour force or economically active population comprise of all persons in the working-age population who are employed or unemployed. The economically active population represents the current supply of labour for the production of goods and services in the country. In contrast, economically inactive population include all persons who are

neither working nor seeking or available for work.The working population of Bhutan in 2005 was 380,704 and 537,728 in 2017.

Table 10.4: Working -Age Population by Sex and Area, Bhutan 2017

Sex	Urban		Rural		Total
	Number	Percent (%)	Number	Percent (%)	
Male	108,694	52.8	175,886	53.0	284,580
Female	97,317	47.2	155,831	46.0	253,148
Both Sex	206,011	100.0	331,717	100.0	537,728

Source: PHCB 2017

Labour force participation rate (LFPR) refers to number of persons in labour force per 100 persons under working-age population. Bhutan's LFPR has increased from 60.4percent in 2005 to 63.3% in 2017.According to PHCB 2017, employed population comprise of people who work as paid employees, employers, own account workers or contributing family workers.

Table 10.5: Currently Employed Persons by Sectors of Employment, Bhutan 2017

		Sex		Area		
Industry Type	Total (Numbers)	Male	Female	Urban	Rural	Total
Agriculture	145,691	34.2	59.3	4.4	62.7	43.9
Mining/Quarrying	2,184	0.8	0.4	1.0	0.5	0,7
Manufacturing	13,559	4.5	3.5	8.9	1.8	4.1
Electricity/Gas/Water	14,126	6.0	1.4	3.9	4.4	4.3
Construction	36,167	16.2	2.5	13.5	9.6	10.9
Wholesale/Retail Trade	18,395	4.1	7.8	11.7	2.6	5.5
Accommodation/Food Service	11,316	2.3	5.2	6.9	1.7	3.4
Transport/Communication	11,998	5.0	1.5	6.8	2.1	3.6
Finance/Insurance	2,761	0.8	0.9	2.2	0.2	0.8
Public Administration	35,599	13.8	5.8	22.1	5.3	10.7
Education Services	16,029	4.4	5.5	6.6	4.0	4.8
Health Services	5,503	1.5	1.9	3.7	0.7	1.7
Others	18,771	6.4	4.4	8.3	4.4	5.7
Total	**332,099**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: PHCB 2017

Learning Activity

A large proportion of employed people in Bhutan are in agriculture sector followed by construction and public administration. How would this trend change in future? What are some opportunities and challenges that you foresee?

10.9 Unemployment

Unemployment is a situation when someone is willing and able to work but does not have a paid job. The unemployment rate is the most commonly used indicator of socio-economic development. It is the ratio between unemployed population to economically active population. The unemployment rate was 3.1% in 2005 and 2.4% in 2017. The female and male unemployment ratesin 2017 were 2.9% and 2.1% respectively. In urban areas the unemployment rate in 2017 was 4.6% and in rural areas it was1.3%.

Table 10.6: Unemployment Rate by Dzongkhag/Thromde

Sl. no	Dzongkhag/Thromde	Unemployment Rate		
		Male	Female	Both Sex
1	Bumthang	1.6	1.6	1.6
2	Chhukha	2.3	3.5	2.7
	PhuntshoglingThromde	3.1	6.3	4.0
	Other than PhuntshoglingThromde	1.6	2.2	1.9
3	Dagana	1.3	1.0	1.2
4	Gasa	0.6	0.8	0.7
5	Haa	1.2	2.3	1.5
6	Lhuentse	1.2	0.8	1.0
7	Monggar	1.3	1.2	1.2
8	Paro	1.8	2.3	2.0
9	PemaGatshel	1.4	1.4	1.4
10	Punakha	1.5	2.1	1.7
11	SamdrupJongkhar	1.4	2.1	1.7
	SamdrupJongkharThromde	2.2	6.0	3.2
	Other than SamdrupJongkharThromde	1.2	1.4	1.3
12	Samtse	1.3	1.4	1.3

13	Sarpang	2.0	3.0	2.3
	GelephuThromde	2.5	5.7	3.4
	Other than Gelephu Thromde	1.8	2.5	2.1
14	Thimphu	4.8	8.0	6.0
	Thimphu Thromde	5.1	8.7	6.4
	Other than Thimphu Thromde	3.6	4.4	3.9
15	Trashigang	1.0	1.0	1.0
16	Trashi Yangtse	1.2	1.2	1.2
17	Trongsa	0.7	1.9	1.1
18	Tsirang	1.1	1.1	1.1
19	Wangdue Phodrang	1.3	2.0	1.5
20	Zhemgang	1.1	1.2	1.1
	Bhutan	2.1	2.9	2.4

Source: PHCB 2017

Learning Activity

Using the data, prepare a map in QGIS to show unemployment rate in 20 dzongkhags. Insert bar graph to represent the male and female unemployment rate in each dzongkhag on the map.

i. Youth unemployment

The number of people in the age group 15-24 years who are willing and able to work but do not have a paid job are considered as unemployed youth. The youth unemployment rate is defined as the percentage of unemployed population in the age group 15-24 years to the labour force in the same age group.

Table 10.7: Youth Unemployment Rate by Area and Sex, Bhutan 2017

Age Group	Urban			Rural			Both Areas		
	Male	Female	Both Sex	Male	Female	Both Sex	Male	Female	Both Sex
15-24	14.0	20.6	16.7	6.1	7.7	6.7	9.2	12.9	10.6
25-34	3.3	4.3	3.6	1.1	1.1	1.1	2.0	2.4	2.1
35-44	0.4	0.8	0.5	0.3	0.2	0.3	0.3	0.4	0.4
45-54	0.2	0.7	0.3	0.1	0.2	0.1	0.2	0.3	0.2
55-64	0.5	0.8	0.6	0.1	0.1	0.1	0.1	0.1	0.1
65+	0.2	1.0	0.5	0.0	0.0	0.0	0.1	0.1	0.1
All Ages	3.6	6.6	4.6	1.2	1.4	1.3	2.1	2.9	2.4

Learning Activity

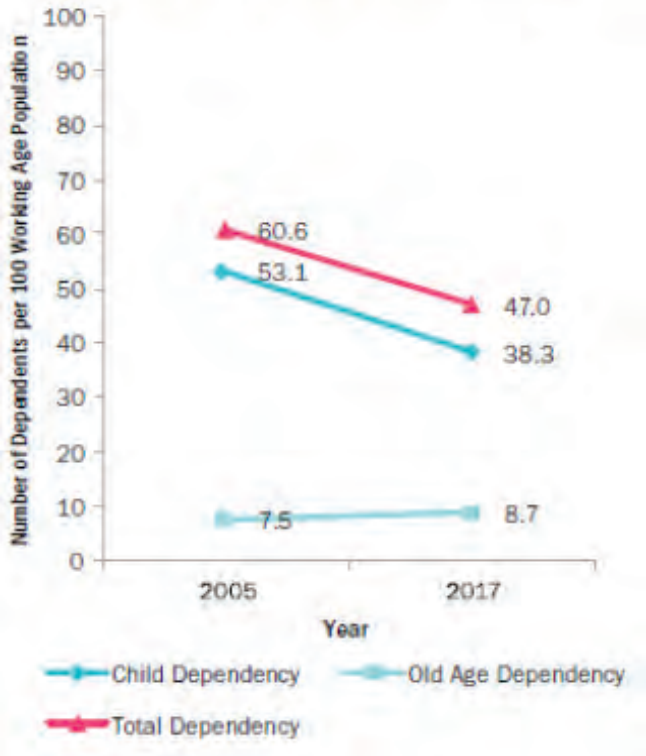
1. Why is unemployment rate higher for female?
2. Represent the data using a suitable graph and conduct a Gallery Walk.

10.10 Dependency Ratio

It is the ratio between the numberof dependents to the number of working-age population. Dependents include young people aged less than 15 years and the elderly people aged 65 years and above. The total dependency ratio is the sum of child and old age dependency ratios.

$$\text{Dependency Ratio} = \frac{\text{Population aged15 years and below+Population aged 65 years and above}}{\text{Population aged 15-64 years}} X\ 100$$

Figure 2.5 Dependency Ratios, Bhutan 2005 and 2017



Source: PHCB 2017

Learning Activity

1. The total dependency ratio has fallen from 60.6 in 2005 to 53.1 in 2017. The period when the dependency ratio declines is known as the 'window of opportunity' when a 'demographic dividend' may be reaped. Explore some potential opportunities and dividends, and share your findings.
2. Use old age dependency ratio of Bhutan for 2017 from the graph and calculate elderly population when the number of working population in the same year is 43,064.

Test Yourself

1. Explain the importance of studying fertility and mortality.
2. Calculate the Child Dependency Ratio from the given data.

Age-Group (in Years)	Percentage of population
0 – 14	33.1
15 – 64	62.2
65 and above	4.7

3. Amongst the different determinants of population growth, which do you think is playing a dominant role in population growth of our country? Justify.
4. The overall life expectancy of Bhutan has increased to 70.2 years in 2017 from 66.3 years in 2005. Explain with suitable reasons.
5. The unemployment problem has been a national issue for more than a decade. Suggest some strategies to reduce this problem.
6. Among child dependency ratio and old age dependency ratio, which do you think is going to dominate in the future? Justify your answer.
7. Close to 12,000 Bhutanese are staying in Australia. While some go for jobs, others go to become permanent residents, many go for studies and some go on vacations or visit there to be with family and friends (Thobchog, 2021). Suggest ways to reduce this trend.

Chapter 11

Energy Resources

Learning Objective (s):

- Discuss the development of the hydropower in Bhutan.
- Discuss alternative sources of energy.

11.1 Introduction

Energy resources are all forms of fuel or sources that produce heat, electricity and move objects. Most of the energy we use today come from fossil fuels. But in Bhutan, hydropower forms an integral source of energy.

Fossil fuels are non-renewable and cause potentially harmful effects on the environment. The future reliability of hydropower is also at stake as a result of climate change. All these have contributed to the exploration and development of renewable and alternative sources of energy such as solar, wind, and nuclear in the world today.

11.2 Hydropower in Bhutan

The hydropower potential in Bhutan is estimated at 30,000MW of which 23,760MW is considered technically feasible. Hydropower plays an important role in the socio-economic development of the country.

11.2.1 Development of Hydropower

The development of hydropower in Bhutan started with the commissioning of a 360 KW mini hydropower plant in 1967 in Thimphu. The first mega hydropower plant was established in Chukha with a production capacity of 360 MW which was then commissioned in 1986. The share of electricity to Gross Domestic Product rose to 19% increasing the growth rate of GDP to 25.4% in the following year. In 2006, with the commissioning of a 1020 MW Tala hydropower project, the power sector achieved another milestone. The share of electricity to GDP increased to 22% thereby increasing the growth rate of GDP to 19.7% in 2007.

Table 11.1: Hydropower generation in 2019 & 2020

Power Plant	Installed Capacity (MW)	2019 Annual generation (MUs)	2020 Annual generation (MUs)
Chukha HEP	336	1,689	1,858
Kurichhu HEP	60	395	391
Basochhu HEP	64	306	384
Tala HEP	1020	4,536	5,031
Dagachhu HEP	126	399	518
Mangdechu HEP	720	1,320	3,218

*Source: Bhutan Electricity Authority ***

The total tapped energy in Bhutan was 2,326 MW as of 2019. It aims to achieve a minimum of 5,000 MW by 2030. To achieve this goal, the country is exploring to develop more hydropower plants.

Learning Activity

1. Using QGIS, prepare a map to show commissioned hydropower plants of Bhutan.
2. Using information from Table 11.1, draw a suitable graph and interpret it.

11.2.2 Challenges of Hydropower

Hydropower has several advantages over other sources of energy but it has its own limitations. The development of hydropower plants is not feasible in all places. The amount of energy generated depends on the volume and velocity of a river. The riverine ecosystem is adversely impacted due to construction of dams. Other challenges of hydro power include lack of capital and human expertise

Learning Activity

1. Read the extract and answer the questions:

   "The 1,020MW Tala hydroelectric plant has been completely shut down since 6pm of July 19 with a daily revenue loss of around Nu 55 million (M). Large chunks of debris due to continuous rainfall during the past few days clogged the gates of the intake tunnels. At this time of the year, the Tala power plant with the monsoon rains would be generating the rated capacity of 1,020MW and an additional 10 percent overloading capacity, altogether amounting to 1,122 MW, according to the Druk Green Power Corporation (DGPC). This is equivalent to a daily generation of about 26 million units" (Bhutan's Daily Newspaper, 2021a).

   Identify the challenges and suggest measures to address it.

11.3 Alternative Sources of Energy

Alternative sources of energy refer to energy sources other than fossil fuels and hydropower. It is also known as renewable source of energy. Bhutan is in the process of harnessing alternative renewable energy. The current installed capacity for alternative renewable energy is nine megawatt. Some alternative sources of energy are:

i. Solar Energy

Solar radiation is light that is emitted by the sun. Solar technologies capture this radiation and convert it into useful forms of energy used for generating electricity, providing heat and light for domestic and commercial use. Solar photovoltaics (PV) and concentrated solar-thermal power (CSP) are two types of technologies used to harness solar energy.

Solar PV, often referred to as solar panels, is an electric power system which converts solar radiation into electricity. The solar panels in the solar PV system absorb the sunlight and convert it into electricity.

Fig. 11.1 Solar PV plant (180 kW) at Rubesa, Wangdue

Concentrated solar-thermal power generates electricity using mirrors. The mirrors reflect, concentrate and focus sunlight onto a specific point, which is then converted into heat. The heat is used to form steam, which turns a turbine to generate electricity. CSP technology stores the heat produced that can be used on days when there is no sunlight or at night.

Fig. 11.2 Concentrated solar-thermal power

According to Bhutan's Renewable Energy Management Master Plan (2016), it is technically feasible to produce 12 gigawatts (GW) of solar energy.

Learning Activity

1. Read the extract and answer the question.

   Bhutan launches its first 180 kW grid-tied solar power plant at Rubesa, Wangduephodrang. It is expected to generate 263,000 units of energy a year.

2. Discuss the viability of harnessing large scale solar power in Bhutan.

ii. Wind Energy

Wind energy is harnessed using wind turbines. The wind blows over the blades and turns the blades. The blades are connected to a drive shaft that turns an electric generator and produces electricity. Bhutan is technically feasible to produce 760 megawatts (MW) of wind energy.

Fig. 11.3 Wind mills at Rubesa

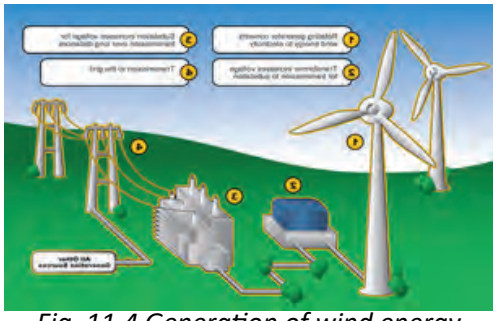


Fig. 11.4 Generation of wind energy

Learning Activity

1. Read the article in the link and discuss the future prospects of harnessing wind energy. Share the findings.

   https://www.energy.gov/eere/wind/next-generation-wind-technology

iii. Biomass Energy

Bio energy is generated from different forms of biomass such as wood, agriculture, animal wastes, sewage and other organic wastes. These materials are used to produce heat and electricity through a variety of processes. Biomass is also used to produce gaseous, liquid or solid fuel.

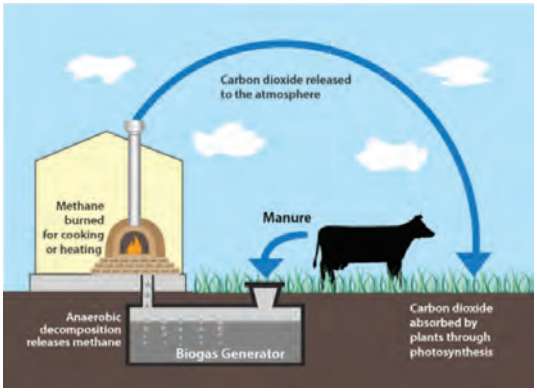


Fig. 11.5 Production of biogas

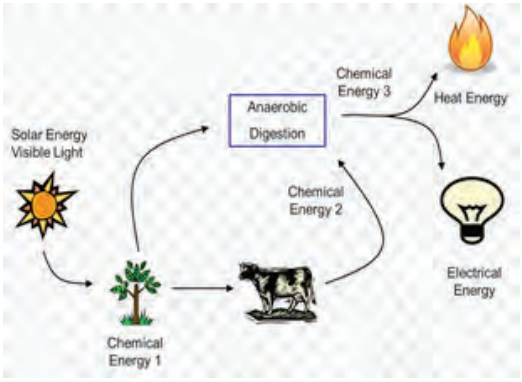


Fig. 11.6 Production of biomass energy

In Bhutan, the use of biomass is confined to cooking and heating, and is still at the traditional level. The use of biogas is gaining popularity in the country, thus reducing the dependence on imported LPG.

Learning Activity

1. Read the extract and answer the question.

   'Unlike other renewable energy sources, biomass can be converted directly into liquid fuels, called "biofuels," to help meet transportation fuel needs. The two most common types of biofuels in use today are ethanol and biodiesel, both of which represent the first generation of biofuel technology.' (Biofuel Basics, n.d.)

   Explore the production process and uses of ethanol and biodiesel. Share your findings.

iv. Nuclear Energy

Nuclear energy is generated through nuclear fusion and fission. However, nuclear fission is the most common method used in harnessing nuclear energy in the world. The process of nuclear fission involves splitting of uranium or plutonium atoms that produce an enormous heat energy in a reactor. The heat is used to convert water into steam that turns a turbine and generates electricity. (Sources of nuclear energy).

Fig. 11.7 Nuclear Plant

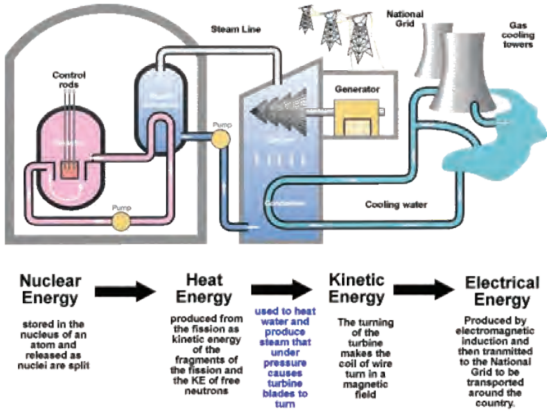


Fig. 11.8 Production of nuclear energy

Learning Activity

Watch the video https://youtu.be/AMXxXoHtM-o and discuss the process of producing nuclear power. Share the findings

v. Tidal Energy

Tidal energy is harnessed from kinetic energy generated by the rise and fall of tides. The turbines used for the generation of tidal energy are placed underwater. The two main ways to extract tidal power are tidal streams and tidal range.

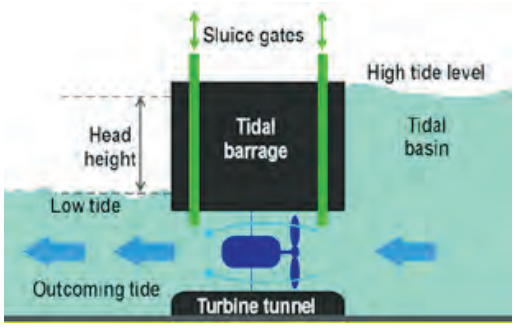


Fig. 11.9 Tidal energy through tidal barrage

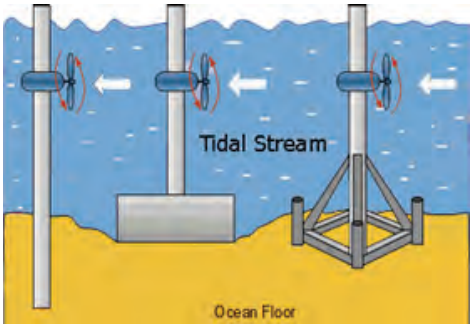


Fig. 11.10 Tidal energy through tidal stream

Learning Activity

Watch the video in the link https://youtu.be/1-2TyKqP84o and discuss the advantages and disadvantages of using tidal power. Share your findings.

Test Yourself

1. Besides revenue generation, how does a hydropower development help in the diversification of an economy?
2. Which alternative renewable energy resources do you think is most feasible in Bhutan? Justify.
3. If the use of biofuels becomes popular, what possible risks do you anticipate in the world? Explain.
4. Heavy investment in hydropower project by the country will guarantee sustainable growth of the economy. Do you agree? Justify.
5. Development of hydropower is perceived as 'putting all eggs in one basket'. What is your view on the statement? Explain.
6. Although nuclear power is a hope of future energy security, it has some serious problems of its own. Explain.
7. Explain the feasibility of geothermal energy as an alternative source of energy in Bhutan.

Chapter 12

Creative Industries

Learning Objective (s):

- Discuss the concept of creative industries.
- Explain sub-sectors of creative industries.
- Identify and explain the challenges of creative industries.

12.1 Introduction

Creative industries are gaining popularity in terms of employment and income generation. There is an increasing number of people with talent and skills joining the world of creative industries due to increasing demand for originality and creativity in work.

The digital world has facilitated and diversified opportunities in creative industries. There are different sub-sectors of creative industries where each one differs from other in the area of creativity and line of work. The diverse nature of creative industries provides good scope for anyone interested in the line of creative work. However, there are challenges faced by creative industries.

12.2 Creative Industries

Creative sector is gaining popularity in recent years. Creative industries refer to those industries which have their origin in individual creativity, skills and talent and which have a potential for wealth and job creation through the generation and use of intellectual property. The terms cultural industries and creative industries are interchangeable. The concept of cultural industries is related to cultural heritage and traditional forms of creation, while creative industries include the applied arts practices, innovations and generating profit and creation of jobs by creating intellectual property.

Creative industries is also termed as the “creative economy” and recently as the “Orange Economy”. The creative economy is creating added value based on creativity that is protected

by copyright and originated from cultural heritage, knowledge and technology. Creative industries are becoming increasingly important to economic well-being as human creativity is the ultimate economic resource. Further, the industries of the twenty-first century depend increasingly on the generation of knowledge through creativity and innovation.

Learning Activity

Explore and discuss the concept of "Orange Economy". How do you think this is different from "Green Economy"? Which one do you think is suitable for Bhutan? Justify your answer.

12.1 Sub-sectors of Creative Industries

The development in technology has led to diversification of opportunitiesin creative industries. The examples of creative industries are:

Arts and Crafts

Arts and crafts include a variety of activities involving making things with an individual's own skills. Most of the traditional arts and crafts in the world are evolving to meet the needs of the people. Besides, a plethora of arts and crafts are also inventions of with the integration of science and technology. People learn skills such as woodworking, paper working, sewing, or making things with all sorts of materials.

Fig. 12.1 Bhutanese contemporary painting

Fig. 12.2 Wood craft

Learning Activity

The sale of arts and crafts products is limited within Bhutan and to a few countries of the world despite having a mosaic of products. Suggest ways to make Bhutanese arts and crafts products competitive in the international market.

Film and Entertainment

Film and entertainment industry includes production of movies, documentaries, songs and dances, musical videos and television. Established film industries such as Hollywood and Bollywood play a significant role in the growth of their countries' economy.

Film production in Bhutan started only in the 1980s and it has evolved over the years. Strengthening the film sector develops other art forms such as drama, music, visual design, script writing among the people.

Fig. 12.3 Bhutanese films

Music in Bhutan includes a spectrum of subgenres, ranging from folk to religious song and music. Bhutan's traditional music like *Zhungdra* and *Boedra* are increasingly fading away. Even *Rigsar* is losing its popularity to rappers and rock bands. In the first annual event 'The Hidden Kingdom

World Music Festival' nine Bhutanese bands and 24 international bands from 18 countries participated. The festival has promoted a rich tradition of folk arts, music and dance and showcased its talents to viewers in Bhutan and outside. It has provided a platform to create and extend professional opportunities for the Bhutanese folk and traditional artists. The rappers and rock bands have created their place in the Bhutanese music and during the celebration of important occasions.

Learning Activity

Raising the visibility of Bhutanese films in the international platform, a Bhutanese film, Lunana: A Yak in the Classroom has been shortlisted in the International Feature Film Category for the 2022 Oscars. (Bhutan Broadcasting service, 2021.)

Discuss why this film was nominated for the Oscar Awards amongst many other Bhutanese films?

Fig. 12.4 Advertisement and Marketing

Publishing and Media

Publishing and media include publishing books, research and media like videos. Publishing research is a systematic investigation and study of materials in order to establish facts and reach new conclusions. There is a demand for this crucial information which is made available through reliable data generated through good research. This kind of research helps to conduct crucial decision-making.

Media plays an important role in the development of creative industries. The digital technology used in media communication promotes mutual combination of communications, broadcasting and computer information systems, the digital interactive media consolidation and industry convergence.

Fig. 12.5 Publishing and media

Learning Activity

With over 100,000 subscribers on YouTube, Yeshi Lhendup Films becomes the country's first YouTube channel to receive the Silver Creator Award or Play Button from YouTube.

Drawing the brand name from his own name, Yeshi Lhendup Films is the highest viewed and popular entertainment account in the country today. Since he dropped his first official music video in 2017, his YouTube channel has more than 80 videos today. The music videos are popular and successful because of photography and visual quality. Through his films and music videos, viewers are also introduced to young talents. (Bhutan Broadcasting service, 2021)

With reference to the extract, discuss the opportunities derived from such digital platforms.

Software and Apps

Software is used to design and create visual and audio assets for business. Creative software is now widely available and simpler to use. It is used in all kinds of things from creating leaflets and editing photos to recording a podcast or creating a promotional video.

The benefits of software systems are their speed and accuracy. Information is retrieved more quickly and accurately. This improves the productivity of employees. It also improves the movement of goods and the supply of goods to customers.

Software developers need to know the programming language. Even to work on design aspects of software, one should have some familiarity with coding and be able to create basic prototypes. The demand for software developers remains robust in a variety of industries.

App	Downloads (million) 2020
TikTok	850
WhatApp	600
Facebook	540
Instagram	503
Zoom	477

Table 12.6: Most Popular Apps in the World

Fig. 12.7 Apps developed in Bhutan

Gaming

Gaming is one of the largest segments of the entertainment industry and is considered the hottest profession across the world. It is a demanding career in the present world. The wide access to the internet has created a huge demand for online games. This has created plenty of career options available for aspiring artists, musicians, sound engineers, and programmers in this field.

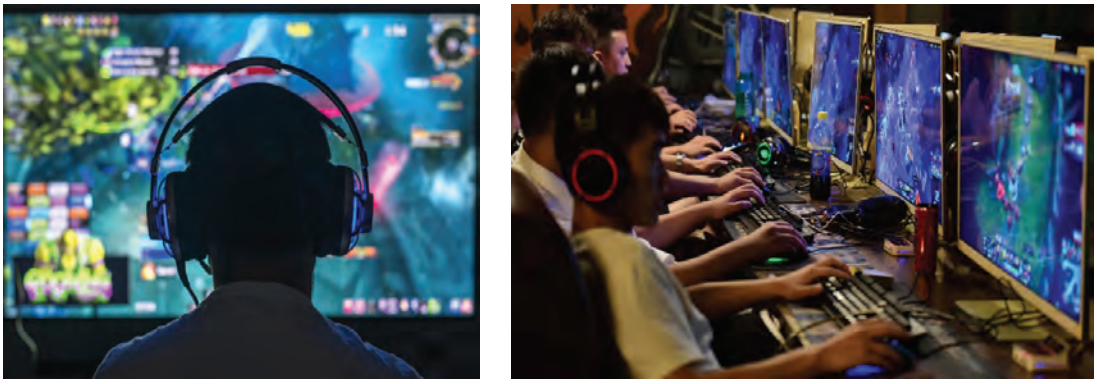


Fig. 12.8 Online games

Learning Activity

Watch the video in the link https://youtu.be/pbRzyfg0FgU and discuss how the gamer in the video established herself as the only professional gamer from Bhutan.

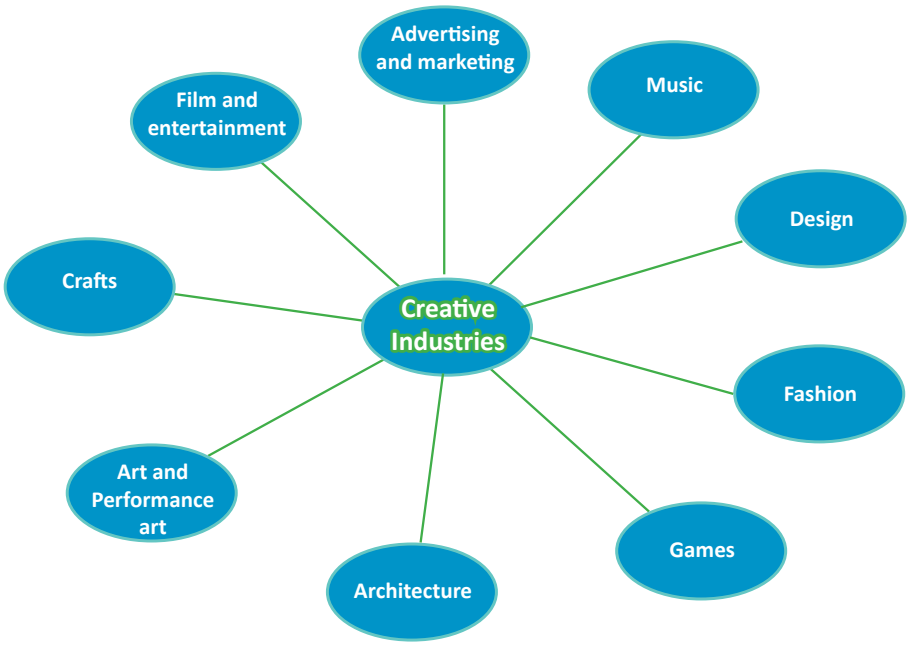


Fig. 12.9 Creative Industry and its sub-sectors.

12.4 Challenges of Creative Industries

There are numerous strategic issues and challenges in the development of the creative industry. The creative sector struggles to access funding which results in deprivation of opportunities to explore new projects and risks those important creatives. The industry is also constrained due to lack of integration of creativity skills in the school curriculum. The other challenges include unavailability of quality, diverse and competitive natural resources.

Learning Activity

eSports is a competition using online video games. It is gaining popularity worldwide, but many parents in Bhutan discourage their children. Is this a wise decision? Discuss.

Test Yourself

1. The launch of Creative Industries Export Strategy will promote the social, cultural and economy of our country. However, it may also have an adverse impact on society. List the positive and negative impacts.
2. With the increasing cyber-crime rate in the world, our film industry seems vulnerable. Suggest strategies of protection.
3. Networking is important in the creative industries. Explain.
4. Do you think the innovation and creativity of the creative industry will undermine and replace traditional art and culture in Bhutan? Justify.
5. Creative sector is in its infancy. Recommend ways to promote this sector in Bhutan.
6. With limited cinema theaters across the country, screening movies has become a challenge. Suggest ways to address such challenges.

Chapter 13

Hazard and Disaster

Learning Objective (s):

- Discuss potential hazards
- Suggest measures to mitigate hazards and disasters.

13.1 1ntroduction

Disasters like earthquake, volcanic eruption, fire outbreak and windstorm have wreaked havoc in lives of humans and environment since the time immemorial. The world has become vulnerable to increasing disasters caused by use of science and technology in the field of agriculture, medicines, electronics, automobiles, construction and production of goods.

Hazards and disasters resulting from climate change, industry, cyber technology, artificial intelligence, military and bio-technology have adverse implications on the lives, properties, economy and environment. Therefore, mitigation and preparedness activities need to be carried out to reduce the impacts of disasters.

13.2 Potential Hazards and Disasters

Climate Change Hazards

Human activities like burning of fossil fuels and deforestation have accelerated the global temperature and changed the weather patterns. The world is experiencing a range of climate related hazards like retreating of glaciers, glacial lake outburst flood (GLOF), shrinking of water reservoirs, rising of sea level, occurrence of diseases, landslides and frequent floods.

Studies have shown that Blue Pine which is usually confined to the lower elevations in Bhutan are now found in the fir forest between 3,400 metres and the tree line. The evergreen broad-leaved species is also expected to shift upwards as the temperature increases. This shift in the ecosystem will have adverse impacts on humans and their economic activities.

Fig. 13.1 Climate Change Hazards

Learning Activity

The Glacial Lake Outburst Flood (GLOF) comes as a reminder of our vulnerability. As climate changes, GLOF are becoming more common. It is proven that global temperatures are rising and glaciers are melting, creating lakes that can burst violently, devastating communities and properties downstream. (Source: Kuensel, Feb 10th, 2021)

Locate any place near the river bank with the help of Google map. Export the map into QGIS

Cybercrime

Cybercrime is defined as criminal activities conducted in cyberspace by means of internet technology. It involves access to data illegally, commit fraud, traffic unauthorized pornography and intellectual property, stealing identities or violating privacy. Cybercriminal activities when managed by an organised group systematically and deliberately is termed as Cyber Terrorism.

With the development of information and communication technology and increasing access to the internet, information is exposed to cyber-attacks. The internet has become essential for commerce, entertainment and functioning of the government. These increase the vulnerability of people to cybercrime. Cybercriminals target unsecured websites and networks that are easy to hack. Therefore, developing the software to protect computer systems from hackers is one of the challenges.

Types of Cyber Attacks

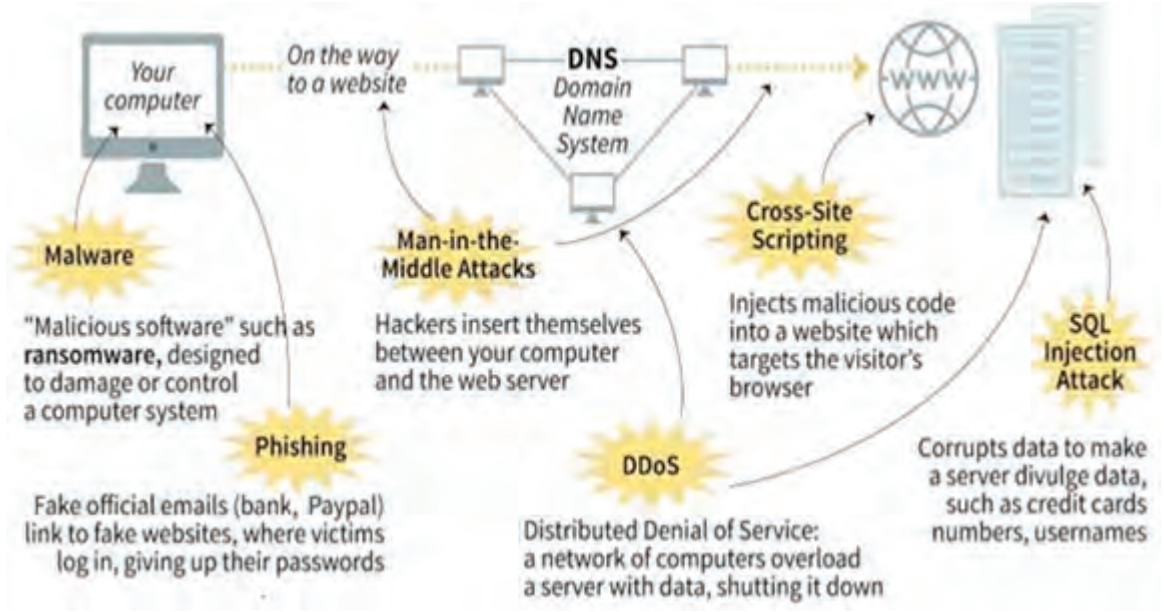


Fig. 13.2 Types of Cyber attacks

Most common modes of cybercrime are hacking, denial of service attack, software piracy, phishing and spoofing. Bhutan is experiencing cybercrimes like extortion, ransom ware, sound engineering, and release of internal emails of political parties, attacks against elections, phishing and fake news. One of the main reasons for cybercrime is the extensive use of pirated software.

It is a huge challenge for the government to combat cyber terrorism. Therefore, an integrated approach among stakeholders is necessary to prevent cybercrime.th

Learning Activity

Many countries are affected by cybercrimes and Bhutan is not an exception. Recommend ways to prevent such crimes.

Industrial Hazard

Industrial hazard refers to any condition produced by industries that cause injury, death and loss of property. Some of the industrial hazards are fire, explosion and toxic release. Industrial hazards are classified as physical, chemical and biological hazards.

Physical hazards are those hazards encountered by workers in the industry. It occurs in the workplace where workers are exposed to loud noise, radiation and extreme temperature. Continuous exposure to loud noises in the workplace causes permanent hearing impairment. Exposure to radiation from various sources harms the people. Working in extreme temperatures damages the thermoregulation systems of the human body.

Fig. 13.3 Physical Hazards

Chemical hazards are those sets of chemicals which have the potential to cause damage to humans or the environment when released into the environment. Chemicals exist either as solid, liquid or gas. Some commonly used hazardous chemicals in the workplace are acids, caustic substances, cleaning products, glues, heavy metals, paint, pesticides, petroleum products, solvents and photocopier toner. These harmful chemicals can enter the body through three major means such as ingestion through the mouth, absorption through the skin and inhalation through the nose.

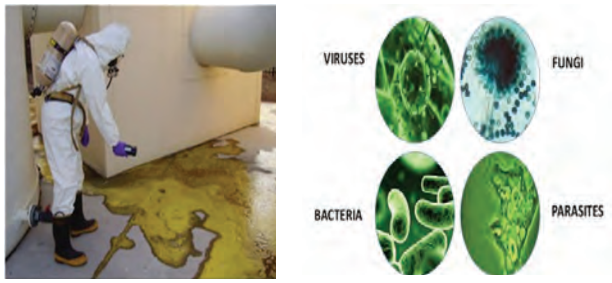


Fig. 13.4 Chemical and biological hazards

Biological hazards are organic substances that pose a threat to the people and other organisms. Diseases caused by bacteria, fungi and viruses, and exposure to poisonous plants and animal bites pose risks

Learning Activity

1. Study the physical condition of the industry.

2. Identify and discuss some of the challenges you observe in such a scenario. Design posters using safety signs and symbols to minimise such challenges. Do a Gallery Walk.

Artificial Intelligence Hazard

Artificial Intelligence (AI) is the effort to create computers capable of intelligent behaviour. It has tremendous potential to improve the wellbeing of both people and the natural world if used wisely. Various AI systems are used for the development of industry, health care and sophistication of weapons. However, it could eliminate human civilization if misused. Movies like Terminator, Transformer and Matrix display the threat resulting from the development of advanced technologies.

Fig. 13.5 Artificial Intelligence application

Learning Activity

Elon Musk said, "Unless we learn how to prepare for, and avoid, the potential risks, AI could be the worst event in the history of our civilization." Conduct a debate.

Bioterrorism

Bioterrorism is the intentional release of viruses, bacteria, or other germs that can sicken or kill people, livestock, or crops. Biological agents can be spread by spraying them into the air, person-to-person contact, infecting animals that carry the disease to humans and by contaminating food and water.

Biological weapons differ fundamentally from other weapons of mass destruction. Weapons of mass destruction like nuclear and chemical cause immediate casualties, while biological agents require hours, days, or even weeks of incubation before they cause fatalities.

Fig. 13.6 Bioterrorism

Many of the pathogens potentially used as agents of bioterrorism initially cause symptoms that are very similar to flu, making the detection of biological attack extremely difficult. Once news of the epidemic reaches the public, the resulting rush to hospitals and medical

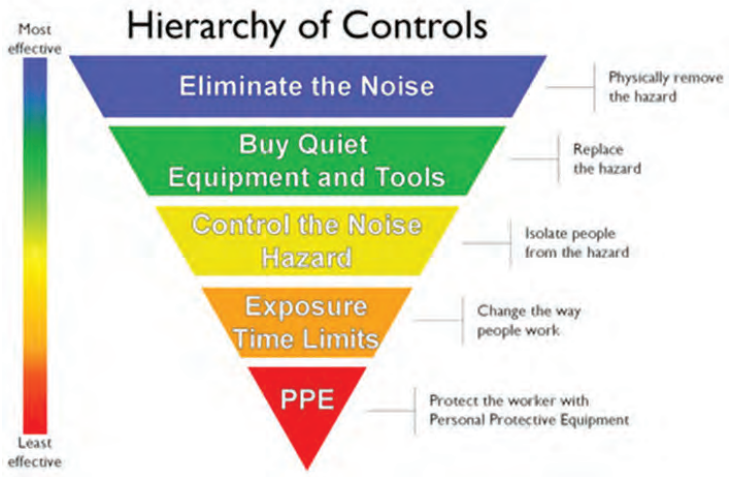
facilities is likely to be a major patient management disaster.

Biological weapons include the development of genetically-engineered pathogens and other bacteria and viruses which are used as bioweapons. Some diseases that are of potential interest to bioterrorists include anthrax, botulism, brucellosis and the plague. During the Cold War, the Soviet Union posed the greatest biological threat to the United States.

In the event of a biological attack, public health surveillance is critical to minimise deaths and casualties as well as economic costs.

Test Yourself

1. Every internet user is vulnerable to cybercrime. Suggest ways to protect you and your family from becoming victims of cybercrime.
2. Artificial Intelligence is a boon to human society. Do you agree? Justify.
3. Controlling exposures to occupational hazards is the fundamental method of protecting workers in the industry. Study the figure and answer the questions.



   a. Why do you think "eliminate the noise" is the most effective control measure?
   b. How does control PPE help in protecting workers from the hazards in the workplace?

4. *There are more outbreaks of bark beetles, crop pests, and diseases. Changing climate is affecting water balance, which in turn is affecting our agricultural productivity. Forest fire hazards show an increasing trend since 1999, which could have serious implications on rural livelihoods. Things are escalating out of control. Time is running out. (Bhutan's Daily Newspaper, 2021).* Suggest measures to mitigate such disasters.

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