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PRACTICAL GEOGRAPHY

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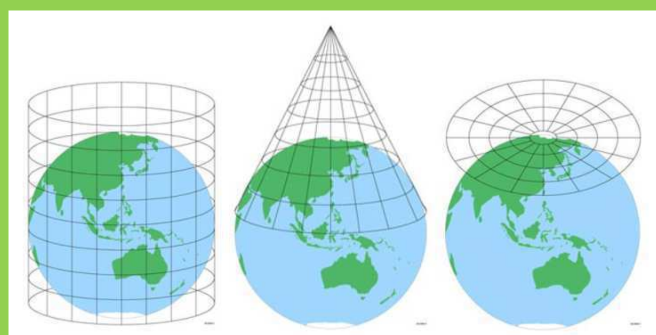

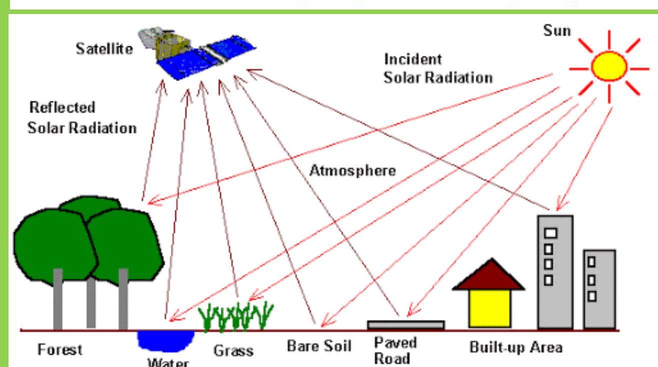

DEPARTMENT OF GEOGRAPHY

AND NATURAL RESOURCE MANAGEMENT

SCHOOL OF EARTH AND ENVIRONMENT SCIENCES

UTTARAKHAND OPEN UNIVERSITY

(Teenpani Bypass, Behind Transport Nagar, Haldwani (Nainital), Uttarakhand, India)

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PRACTICAL GEOGRAPHY

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Title	:	Practical Geography
ISBN No.	:	
Copyright	:	Uttarakhand Open University
Edition	:	First (2020)

Published By : Uttarakhand Open University, Haldwani, Nainital-263139
Printed By : Shivalik Press, Haridwar

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BLOCK 1: MAP PROJECTIONS

UNIT 1: DEFINITION AND PRINCIPLES OF MAP PROJECTION

1.1 OBJECTIVES

After reading this unit, you should be able to:

- Understanding the definition of Map Projection.
- Gaining knowledge about principals of Map Projection.

1.2 INTRODUCTION

A map or interpolation of a grid of longitudinal lines created by light or geometric methods to map a spherical earth or a large surface on a flat surface is called a map projection. The meaning of interpolation is to show a transparent film or figure made on paper with the help of light on a wall or cloth screen. Although not all map interpolations are drawn by the above method, the term interpolation has become so prevalent that the completely modified lines drawn by geometric methods are also called map interpolations. Different scholars have defined map interpolation in different words, but all definitions have almost the same meaning. This is well explained by studying some of the definitions written below.

According to (Erwin Raisz)1 - A Projection can be defined as any orderly system of parallis and meridians on which a map can be drawn.

(John Bygotu)2 - A map projection is some method of representing on a sheet of paper the lines of latitude and longitude of the globe.
(EJ Monkhouse)3 - " A map projection is the representation of the earth's parallels and meridians as a net or graticule on a plane surface.

(JA. Steers)4 - A map projection is a means of representing the lines of latitude and longitude of the globe on a flat sheet of paper.

1.3 DEFINITION AND PRINCIPLES OF MAP-PROJECTION

In Cartography, a map projection is a way to flatten a globe's surface into a plane in order to make a map. This requires a systematic transformation of the latitudes and longitudes of locations from the surface of the globe into locations on a plane.[1]

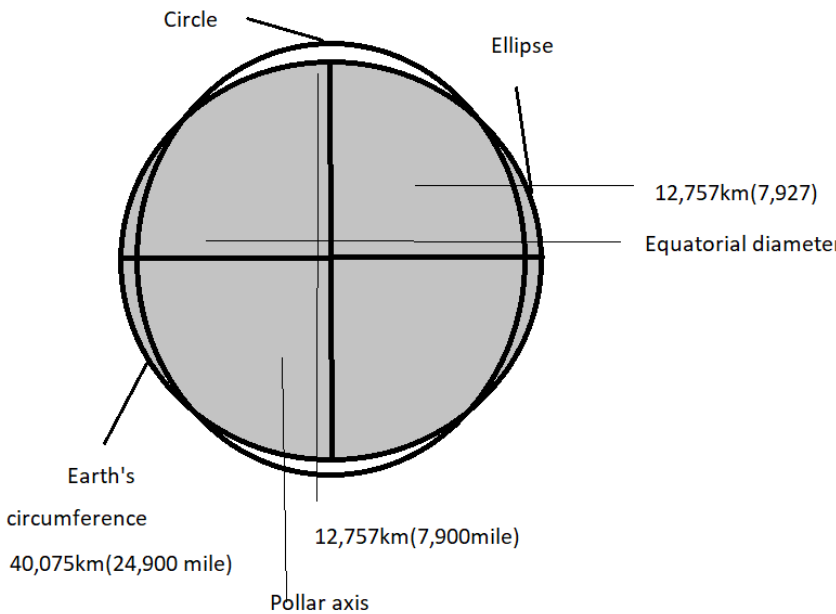
(John Bygotu)2 - A map projection is some method of representing on a sheet of paper the lines of latitude and longitude of the globe.
(EJ Monkhouse)3 - A map projection is the representation of the earth's parallels and meridians as a net or graticule on a plane surface.
(JA. Steers)4 - A map projection is a means of representing the lines of latitude and longitude of the globe on a flat sheet of paper.
"A.N.Strawles"5 - A map projection is an orderly system of Parallels and meridians used as a/ basis for drawing a map on a surface

Principles of Map-Projection:

Map - Necessity of Map Projection The shape of the Earth is similar to an oblate ellipsoid of revolution 492 TETY (oblate spheroid). The polar radius of the Earth is about 215 km shorter than its equatorial economy due to the slightly flattened polar regions (Fig 1). But this difference is so small in front of the huge size of the earth that the flat spherical form of the earth is considered almost spherical in order to fulfill the common objectives. An accurate depiction of this shape of the Earth is possible only through the globe. But the globe is less used than maps, due to the following reasons:

(1) The entire part of the globe cannot be seen in a single sense, ie less than half of the surface of the globe is visible at a time.
(2) Due to the large size, it is difficult to move the globe from one place to another and it is not possible to bend it like a map made on paper etc.
(3) The distance between two places on the globe is difficult to measure.
(4) To make a small part of the earth visible on a large scale, the size of the globe will have to increase so much that the use of the globe itself will be impossible.
(5) More money is spent in the creation of globes than maps.

Due to the above difficulties, maps on the flat surface are more useful than on the globe. Some interpolation is required to draw a map on a flat surface. In each projection, a network of latitudinal circles and Yamyotras is formed and in the mines of this graticule, the trajectories of the graticule and the meridian formed on the globe are transferred. In this connection, it is noteworthy that no map made on a flat surface gives an accurate representation of the shape of the Earth. Just as the orange peel cannot be spread flat on the flat surface without cutting it - it is not possible to depict the spherical earth without distortion on the flat surface. A map like this the larger the area it displays, the greater the distortion. Although no map interpolation is complete, but it is possible to make interpolation of any one of the properties of the area, natural or pure direction. The appropriate interpolation is selected keeping in mind the purpose of making the atom map. No interpolation is required for maps of very small areas such as villages or cities etc. because the effect of the spherical shape of the earth on the area displayed in such maps is negligible.



Earth's shape and size (fig. 1)

1.4 CONCLUSION

Map Conclusion and projection projections and co-ordinate system in mapping are important for positions specification on the earth which is transferred to flat map. This type of projection is used in UTM coordinates map and base map is all around the World the coordinates system enables us to know materials. And positions of the earth through meditation line dividing the earth into two parts based on Angular distances on meditation call Geographic coordinates. The popular map projection is universal transverse Mercator (UTM) this type of projection is used in (UTM) coordinate system in making geographic map and base map in all around. The world map scale is another variable causes.

Map scale is another variable causing different types of uses of Calculation and be processed by comparing distance between two points in the real Geography with distance on the map scale is also divided into vertical and horizontal skills which are differently calculated in including different features such as wording or line scales reading map depends on symbol interpretations since the symbols are represent its of real completed Geography characteristics the intersection using map to find locate position of to landmarks while the Reactions find the position of map uses following references from the land marks. There are two types of tools compass and protractor and lines or graphics matchmaking aims to present Geographic data through appropriate symbols map designs must then emphasize accurate data in communicating spatial data that is well matched with real Geography characteristics then selecting map scale and projection analyzing map contact finding out appropriate symbols to serve the objectives and organizing map elements such as map contract measure name. My name direction based on making designs criteria, when the design is complete it is finally printed for checking moreover. It should be presented to the map users to cooperatively check.

1.5 SUMMARY

Through the definition of what the map is, the projection has been informed to tell and make the projection. An attempt has been made to explain the definition of different geography leaders to map interpolation so that the students studying it can understand it completely.

The entire part of the globe cannot be seen in a single sense, i.e. less than half of the surface of the globe is visible at a time. Due to the large size, it is difficult to move the globe from one place to other.

The flat maps that are drawn through this scale and direction, rather than the globe, are pure maps, and map projections are used to create them through a network of latitude and longitude lines, including grids. Importance or grid time changes by stating the weather. With this type of map projections it is possible to construct a pure map.

Another and it is not possible to bend it like a map made on paper etc. The distance between two places on the globe is difficult to measure. To make a small part of the earth visible on a large scale, the size of the globe will have to increase so much that the use of the globe itself will be impossible. More money is spent in the creation of globes than maps.

Although no map interpolation is complete, but it is possible to make interpolation of any one of the properties of the area, natural or pure direction. The appropriate interpolation is selected keeping in mind the purpose of making the atom map. No interpolation is required for maps of very small areas such as villages or cities etc. because the effect of the spherical shape of the earth on the area displayed in such maps is negligible.

1.6 GLOSSARY

- UTM - Universal Transverse Mercator.
- GRID - A pattern of straight lines that cross each other to form squares.
- COORDINATE SYSTEM - In geometry, a coordinate system is a system that uses one or more numbers, or coordinate, to uniquely determine the position of the points or other geometric elements on a manifold such as Euclidean space.
- VERTICAL - Erect, Perpendicular, Vertical, Upright, Steep, Direct.
- HORIZONTAL - Going from side to side, not up and down, flat or level.

1.7 ANSWER TO CHECK YOUR PROGRESS

Q. What is a map interpolation?

Ans. Launching the line trap of the latitude and longitude limes of the globe on a flat paper is called map projection.

Q. What is a line trap?

Ans. The line sequence formed by projecting the latitude and longitude lines of the entire globe or any part of it on a flat paper is called a line mesh.

Q. How many longitude lines?

Ans. The longitude lines are drawn 1800 west from 00 longitude.

Q. What is the net work of latitude and longitude lines called?

Ans. A grid of latitude and longitude lines is called a gred.

True and false:

1. The longitude lines are 3600. True/False

2. The line drawn parallel to the globe at latitude $22\left(\frac{1}{2}\right)^0$ north of the equator is called the tropic of cancer. True/False
3. Launching the line trap of the latitude and longitude limes of the globe on a flat paper is called map projection. True/False

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1.10 TERMINAL QUESTIONS

Q. Why map Projection is required?

Ans. A map projection is a way of showing the surface of a three-dimensional sphere on a flat surface. Such projections are necessary to create maps. The problem with projections is that they change the surface in some way; this is called distortion. Depending on the purpose of the map, some distortions may be less bad. This is why cartographers uses different mathematical projections for different maps.

Carl Friedrich Gauss showed that is not possible to project the surface of a sphere to a plane, without distorting it. This theorem is known as Theorema egregium today.
To understand the projections, it is easier to imagine a light source, a globe, and another geometric object. The light source shines "a shadow" of each point of the globe onto the geometric object. At the end the surface of the geometric object is unrolled, this yields the map. It is possible to tell the projections apart by the type of helper object used:

- Using a plane gives azimuthal projections.
- Using a cone gives conical projections.
- Using a cylinder gives cylindrical ones.

Cylindrical projections "put the sphere into a cylinder, and then unroll its surface".
Examples of these are Equirectangular projection, Mercator projection
Psedocylindrincal: Same as cylindrical, but only applies to the main meridian and parallels.

Q. Why is a map less accurate than a globe?
Ans. Maps are less accurate than globe because map is a flat presentation of our earth but globe is the spherical presentation of the earth and globe are more accurate than maps because globe is a model of earth and we can imagine how our earth looks like by the globe. globe helps us to understand about the structure of our earth, orbit, path etc... So these are more accurate and maps are less accurate.

Q. What is the map projection?
Ans. In cartography, a map projection is a way to flatten a globe's surface into a plane in order to make a map. This requires a systematic transformation of the latitudes and longitudes of locations from the surface of the globe into locations on a plane. ... There is no limit to the number of possible map.

UNIT 2: THE EARTH: SHAPE, SIZE, AREAS AND GREAT CIRCLES-COORDINATE SYSTEM

2.1 OBJECTIVES

After reading this unit, you should be able to understand that:

- Essential elements of map-projection.
- Shape and size of the Earth.
- Areas and great circles-coordinate system.

2.2 INTRODUCTION

All the tropics of latitude and longitude lines are helpful in some way or the other in making the globe map. They make a detailed determination of the real shape of the Earth and its areas. In every way, weather and time depend on the grid projected by our latitude and longitude lines. No city in a grid is ever the same in village weather and time, and the state of each grid accurately states all the above facts. The inclination of the earth from its end of 220 and a half of 240 from its axis, which is believed to be between 230 and a half 00. North and South are based on special orientations and this determines our entire universe, how the Earth changes itself in which tropics and which seasons and which types of regions. Under this latitude, longitude zone lines, grid, core, Mediterranean line, location of northern and southern axes, map created by scale which is rf With the help of which we have information on the purest shape and size of the Earth and its coordinate, so that we can know how the Earth works by coordinating with these characteristics and interconnecting the surface into a Provides durability.

2.3 ESSENTIAL ELEMENTS OF MAP-PROJECTION

2.3.1 Latitude :

Latitude is the angular distance measured at a location on the globe and the equations of the arc of the meridian between the equator and the latitude of that location. In Fig. 2.2, the angular distance of the AC arc of the western pole of 85 ° between the A point and the equator is 28 °. Since point A is located north of the equator, its latitude value is 28 ° N. The equator has latitude 0 °, north-pole latitude 90 ° north and south-pole latitude 90 ° south. There are 60 minutes (') in a fraction and 60 seconds (') in a minute. In this way, if the latitude of a place is written as 40 ° 25130 " answer, then the latitude of that place will be read as 40 degrees, 25 minutes, 30 seconds north. Due to the flatness of the earth, the length in kilometers of 1 ° latitude increases slightly from the equator to the poles. The distance of 1 ° latitude is 110.569 km at the equator and 111.700 km at the poles.

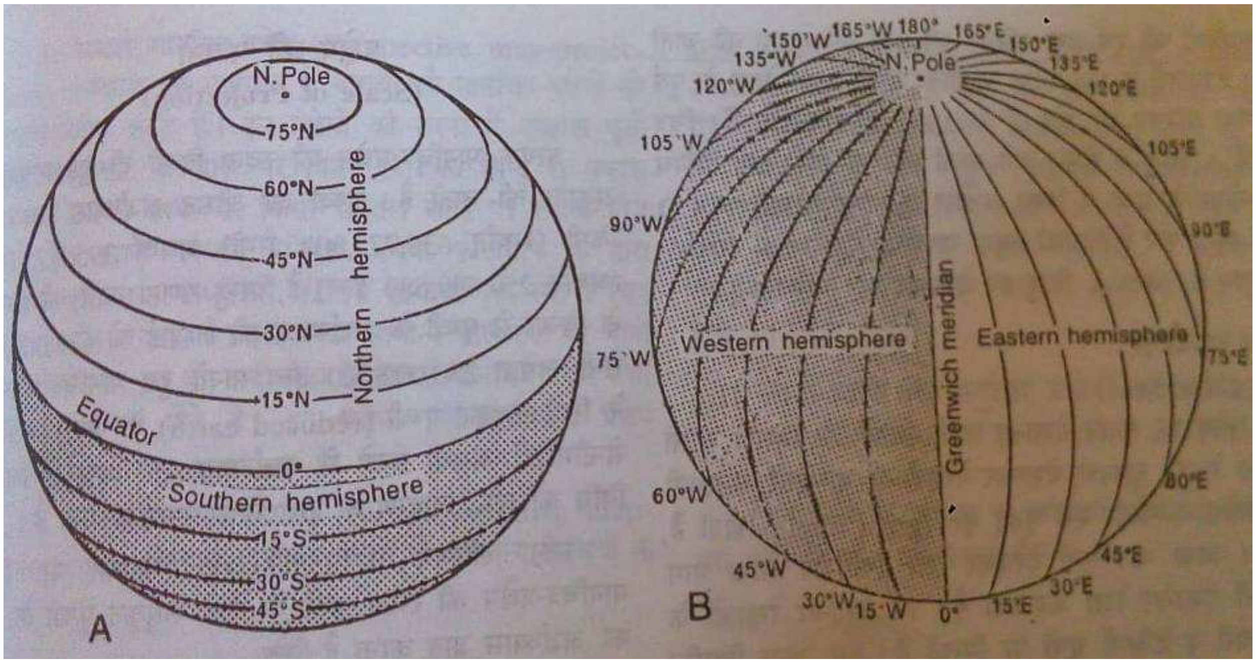

Fig. 2.1 (Source: Outlines of Practical Geography by J. P. Sharma)

2.3.2 Parallel of Latitude :

The line joining the equidistant points of the Parallel of latitude equator (meridians) on the globe is called the latitude line or latitude circle. The circles are called latitude circles. A latitudinal circle of any value between 0 and 90 can be formed in the north or south of the equator, but with the idea of simplicity, all possible latitudinal circles are not made on the globe, but rather. Necessary latitude circles are formed at the interval of a number that divides 90 ° completely, such as 5, 10 and 15 etc. The latitude circles north of the equator are called the northern latitude circle and the latitude circles in the south are called the south latitude circle. Thus the latitude circles indicate a position on the globe to the north or south of the equator. Latitude circles have the following main characteristics:

(1) All latitude circles are formed parallel to each other and at the same distance.

(2) At all other places of the globe except the poles, the latitude circles cut the axes or posterior at right angles.

(3) Latitude circles are always in the form of exact east-west lines.

(4) The equator is a great circle and all the remaining latitudes are small circles.
(5) In kilometers of latitude circles, the actual length starts decreasing from the equator towards the poles.
(6) The 'latitudinal circles' of the spots are in the form of points.
(7) In addition to the poles, each point of the globe is situated on a rough latitude circle.
(8) The equator, which is a latitude circle, is situated at equal distance from both poles. The upper half of the globe between the equator and the North Pole is called the northern hemisphere and the other half of the globe located south of the equator is called the southern hemisphere.

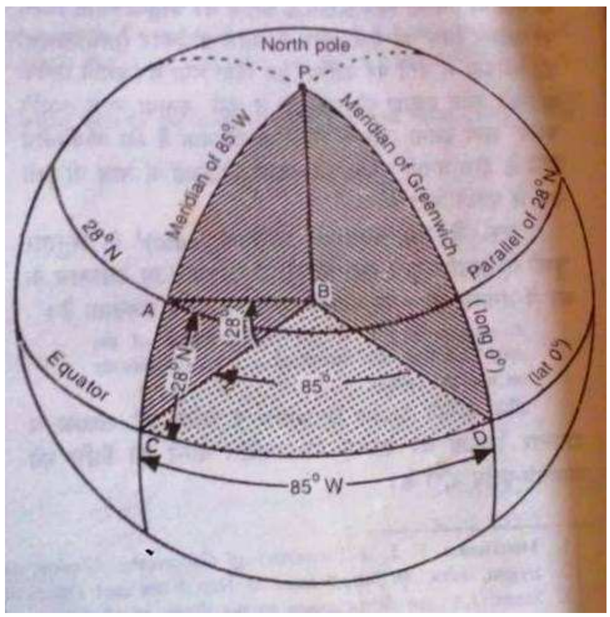

Fig. 2.2 (Source: Outlines of Practical Geography by J. P. Sharma)

2.3.3 Longitude :

The distance measured in degrees of a small arc of a latitude circle between the prime meridian and a given position on a longitude globe is called the longitude of that location. According to an international conference held in 1884, almost all the countries of the world have considered the post-matrimonial or poleward pass through the Greenwich Royal Observatory near London as the main post-meteorological. The other meridians are calculated towards the east and west, assuming the value of the meridian is 0 ° longitudinal. The values of longitudes are between 0 and 180 ° to the east or west of the main meridian (prenitch meridian). In Fig. 2.2, CD is a small arc on the latitude circle (equator) located between the PC meridian and the Minich meridian of A point whose distance from the major meridian is 85 ° west. Thus the longitude of point A is 85 ° west. Like the latitude, the longitude of a place is expressed in degrees, minutes and seconds like 30 ° 18 '15 "west longitude or 40 ° 25420' east longitude etc.

Actual distance of longitude on Earth

Latitude circle	Distance(km)	Latitude circle	Distance (km)
00	111.32	500	71.70
50	110.90	550	64.00
100	109.64	600	55.80
150	107.55	650	47.18
200	104.65	700	38.19
250	100.95	750	28.90
300	96.49	800	19.39
350	91.29	850	9.73
400	85.40	900	0.00
450	78.85		

Table -2.1

It is clear from Table 2.1 that the distance of 1 ° longitude is about 111.32 km at the equator, about half of it at 60 ° latitude circle and zero at the poles. From this fact we come to the conclusion that the distance in kilometers of 1 ° longitude depends on the value of which fraction is measured on the latitude circle. The distance of 1 ° longitude at the equator can be determined by dividing 360 by the circumference of the Earth,

That is,

Distance of 10 longitude at the equator.

$$= \frac{circumference\ of\ the\ earth}{360}$$

$$= \frac{40{,}075}{360} = 111.32$$

2.3.4 Meridians:

The hypothetical lines joining places with longitudinal points on the globe are called polar longitudinal lines or post- meteorological lines. There is a great circle after each meridian, half of which is called the eastern longitudinal line and the remaining half is called the western longitudinal line. The ends of these longitudinal lines meet at the northern and southern poles. In this way, any two longitudinal lines facing each other on the opposite side form a complete large circle. Since the circle has 360 °, 1. The total number of longitudinal lines at the interval of longitude is 360. Of these, 180 longitudinal lines are to the east of the main meridian and 180 longitudinal lines are to the west of the main meridian. The longitudinal lines located towards the east are called the longitudinal lines and the longitudinal lines towards the west. 180 ° East and 180 ° West have the same longitude. The middle hemisphere between the major meteorite and 180 ° E longitude is called the eastern hemisphere and the part between the major meteorological and 180 ° E longitude is called the western hemisphere (Figure 83B). As written above, any two mutually parallel long lines on the globe form a complete large circle which divides the globe into two equal parts. In this way, each perpendicular line is half of a large circle, that is, it is in the form of an arc of 180 ° of a large circle. Following are some other characteristics of longitudinal lines

(1) All the longitudinal lines are in the true north-south direction and their lengths are the same.

(2) The distance between two longitudinal lines at the equator is the highest which decreases to zero at the poles.

(3) Many longitudinal lines can be drawn on the globe, but for simplicity, draw longitudinal lines at the interval of a number (fraction) that divides 180 ° completely.

(4) By longitudinal line, there is a sense of the situation in the east or west of the main meridian of a place.

(5) Every point on the globe except the poles must have a long line.

2.3.5 The Earth grid:

The earth grid shows in fig 2.3, a network of latitude circles and meridians, in the geo-mid. With the help of this grid, the direction and location of a place on the ground is determined. For example, in the above diagram A point 45 ° North The latitude circle is located at 45 ° west longitude and hence its geometric location is 45 ° N Latitude and 45 ° W longitude. Similarly, the geometric location of B point is 30 ° D latitude and 30 ° east longitude. This geo-grid is created on a flat surface by different methods in map-interpolation. Remember, all the latitude circles of the geo-grid and post-meridians are in the form of imaginary lines on the ground.

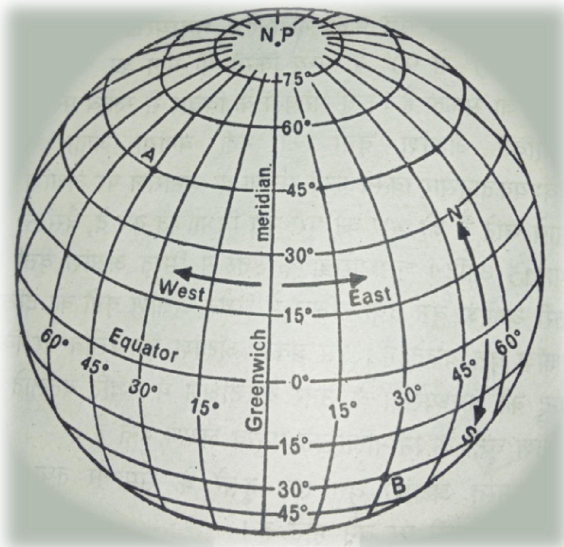

Fig. 2.3

2.3.6 Gore and zone:

The portion between two enclosed longitudinal lines on the globe is called gore, while the area between any two enclosed latitude circles is called a ligament. All the gore formed between successive longitudinal lines has equal areas on the globe. In contrast, the area on the globe of the ligament from the equator towards the poles decreases continuously.

2.3.7 Scale of Projection:

Scale and projections are two fundamental features of maps that usually do not get the attention they deserve. Scale refers to how map units relate to real-world units. Projections deal with the methods and challenges around turning a three-dimensional (and sort of lumpy) earth into a two-dimensional map. To make any map interpolation, we have to select the projections based on the geographical location of the area for which we draw a value. After this selection, a geographer uses the ruler to prepare a map of the terrain whose selection is dependent on the shape and texture of the area. For this, data is collected on the basis of a survey and considering the scale as the basis. An attempt is made to create the purest map of the region.

By basic concepts of the map, we mean those characteristics. Which always exist in all types of maps except for a few exceptions. From the definitions of the map given by various scholars, the five basic concepts of the map shed light on the basic concepts of the map (Fig. 2.4).

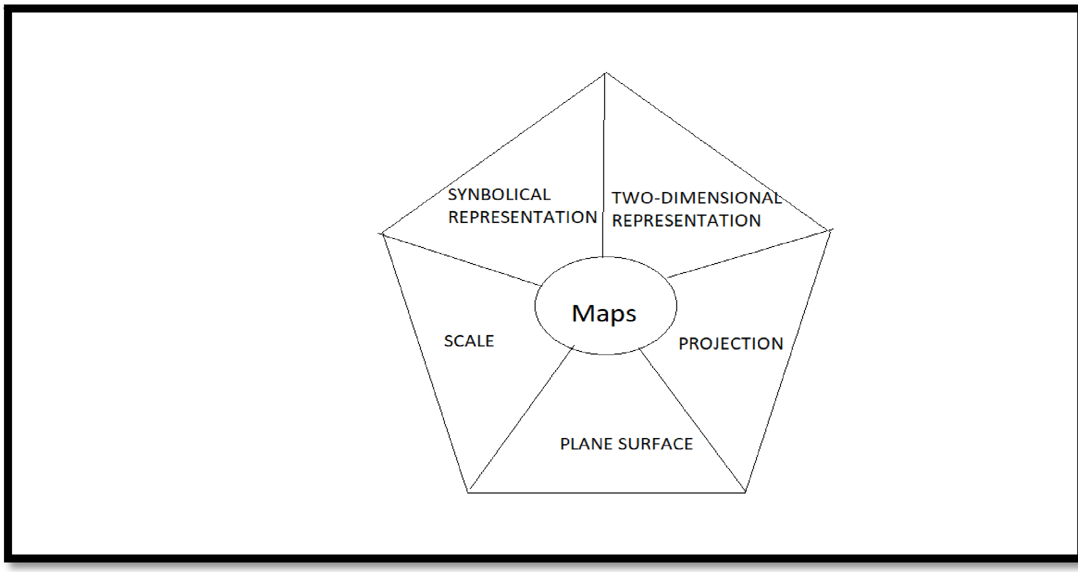

Fig. 2.4

MAP CONCEPTS

These concepts are as follows: The map shows the entire earth or any part of it in small size. So every map always made according to any predetermined measurements so that the ratio between distances measured on the ground and corresponding distances displayed on the map is always the same. In the absence of a scale, it is impossible to find the actual distance between any two points on the map. As a result of the use of a scale, the actual length, width and area of the regions displayed on the map can be calculated accurately which is not possible on line maps. Without remembering, a map made on the basis of only approximation without using a scale is called a line map. While choosing the scale, the size of paper etc. and (1) the quantity to be displayed in the map is taken into account. For simplicity, on each map, it is expressed in terms of the measurements in different fractions (e.g. 100.000) words (e.g. cm = 1 km) or graphical method. To express the scale only by the graphical method on the original copy of the map which is to be printed later by smaller or larger, the shape of our earth is spherical, which is displayed on the flat surface by the maps. Therefore, to make a map of the entire Earth or a large part of it, first of all, with the help of light or mathematical methods, the longitude-longitude network of the globe.

They are made on a flat surface and then carefully transfer the details of the globe in this grid. This mesh map of longitudinal lines formed on a flat surface is called interpolation. Maps of large tracts are always made according to a pre-fixed projection, but it is not considered necessary to make maps for small areas such as plan of houses or maps of settlements, etc., because the size of such areas is so small that in their maps, the effect of the spherical shape to the Earth remains negligible. There are many types of map interpolation. On some trajectories a map of the entire Earth can be drawn, while on some trajectories only one hemisphere or less can be shown; some projections are useful for Polar Regions or mid-latitudes and some projections are only suitable for equatorial regions. Similarly, some projections are orthomorphic, while some projections have the property of showing pure area or pure direction. But till date, no such projections have been made in which all the above qualities exist simultaneously. Therefore, while selecting the projection, it is absolutely necessary to keep in mind the purpose of making the map and the position on the globe of the area to be displayed in the map and the latitude-longitude expansion. The name of its projection should be written on each map so that a reader can understand the distortions of the existing shape, area or direction in the map.

2.4 SHAPE OF THE EARTH

Since the Earth is flattened at the poles and bulges at the Equator, geodesy represents the figure of the Earth as an oblate spheroid. The oblate spheroid, or oblate ellipsoid, is an ellipsoid of revolution obtained by rotating an ellipse about its shorter axis. It is the regular geometric shape that most nearly approximates the shape of the Earth. A spheroid describing the figure of the Earth or other celestial body is called a reference ellipsoid. The reference ellipsoid for Earth is called an Earth ellipsoid.

An ellipsoid of revolution is uniquely defined by two quantities. Several conventions for expressing the two quantities are used in geodesy, but they are all equivalent to and convertible with each other.

2.5 SIZE OF THE EARTH

Earth has a diameter of roughly 8,000 miles (13,000 kilometers) and is round because gravity pulls matter into a ball. But, it's not perfectly round. Earth is really an "oblate spheroid," because its spin causes it to be squashed at its poles and swollen at the equator.

2.6 AREAS AND GREAT CIRCLES-COORDINATE SYSTEM

A great circle, also known as an orthodrome, of a sphere is the intersection of the sphere and a plane that passes through the center point of the sphere. A great circle is the largest circle that can be drawn on any given sphere. Any diameter of any great circle coincides with a diameter of the sphere, and therefore all great circles have the same center and circumference as each other. This special case of a circle of a sphere is in opposition to a small circle, that is, the intersection of the sphere and a plane that does not pass through the center. Every circle in Euclidean 3-space is a great circle of exactly one sphere.

For most pairs of distinct points on the surface of a sphere, there is a unique great circle through the two points. The exception is a pair of antipodal points, for which there are infinitely many great circles. The minor arc of a great circle between two points is the shortest surface-path between them. In this sense, the minor arc is analogous to “straight lines” in Euclidean geometry. The length of the minor arc of a great circle is taken as the distance between two points on a surface of a sphere in Riemannian geometry where such great circles are called Riemannian circles. These great circles are the geodesics of the sphere.

2.7 CONCLUSION

Creating geo-maps by the Earth's shape, size, area and its other divisions, which determine the elements of the geo grid, latitude, longitude, equator, line and projection. It creates pure maps by which any map can be studied to the purest and it can prove useful in every department performing experimental works.

2.8 SUMMARY

All the tropics of latitude and longitude lines are helpful in some way or the other in making the globe map. They make a detailed determination of the real shape of the Earth and its areas. In every way, weather and time depend on the grid projected by our latitude and longitude lines. No city in a grid is ever the same in village weather and time, and the state of each grid accurately states all the above facts. The inclination of the earth from its end of 220 and a half to 240 on its axis, which is believed to be between 230 and a half 00. North and South are based on special orientations and this determines our entire universe, how the Earth changes itself in which tropics and which seasons and which types of regions. Under this latitude, longitude zone lines, grid, core, Mediterranean rakha, location of northern and southern axes, map created by scale which is rf With the help of which we have information on the purest shape and size of the Earth and its coordinate, so that we can know how the Earth works by coordinating with these characteristics and interconnecting the surface into a Provides durability.

Creating geo-maps by the Earth's shape-size area and its other divisions, which determine the elements of the geo grid, latitude, longitude, equator, line and projection. She creates pure maps by which any map can be studied to the purest and it can prove useful in every department performing experimental works.

2.9 GLOSSARY

- Elements = Element, Inwardness, quid, Essence
- Grid = a framework of spaced bars that are parallel to or cross each other; a grating. "the metal grids had been pulled across the foyer"
- Coordinate= bring the different elements of (a complex activity or organization) into a harmonious or efficient relationship.
- Scale= scale, ruler, gauge, dimension, volume, rule
- Sketch Map= a roughly drawn map that shows only basic details.
- Meridians= a circle of constant longitude passing through a given place on the earth's surface and the terrestrial poles.

"The European Broadcasting Area extends from the Atlantic to the meridian 40°E"

2.10 ANSWER TO CHECK YOUR PROGRESS

Q. What is the shape of earth?
Ans. Earth is an oblate spheroid. This means it is spherical in shape, but not perfectly round. It has a slightly greater radius at the Equator, the imaginary line running horizontally around the middle of the planet. In addition to bulging in the middle, Earth's poles are slightly flattened.

Q. What is gore and zone?
Ans. A gore is a sector of a curved surface or the curved surface that lies between two close lines of longitude on a globe and may be flattened to a plane surface with little distortion.

Q. What is the network of latitude and longitude lines called?
Ans. The latitude and longitude lines are called a grid.

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2.13 TERMINAL QUESTIONS

Q. Describe the latitude and longitude in the globe?

Ans. Latitude and Longitude lines are a grid map system too. But instead of being straight lines on a flat surface, Lat/Long lines encircle the Earth, either as horizontal circles or vertical half circles.

Latitude

Horizontal mapping lines on Earth are lines of latitude. They are known as "parallels" of latitude, because they run parallel to the equator. One simple way to visualize this might be to think about having imaginary horizontal "hula hoops" around the earth, with the biggest hoop around the equator, and then progressively smaller ones stacked above and below it to reach the North and South Poles

Longitude

Vertical mapping lines on Earth are lines of longitude, known as "meridians". One simple way to visualize this might be to think about having hula hoops cut in half, vertically positioned with one end at the North Pole and the other at the South Pole.

Q. Explain map projection in detail?

Ans. A map or geo-grid of latitudinal lines created by light or geometric methods to map a spherical earth or a large terrain of the earth on a flat surface is called map projection.

Map cartography is the method of transferring the latitude and longitude lines of the globe to the plane (paper) under cartography. The latitude and longitude lines drawn in this way are called "line traps". It is not possible to move the latitude and longitude lines of the globe purely on a plane, because the curve plane of the globe cannot be leveled without any inaccuracy.

UNIT 3: CLASSIFICATION OF MAP PROJECTIONS

3.1 OBJECTIVES

After reading this unit, you will be able to understand:

- Different types of Map Projections.
- Classification of Map Projections.

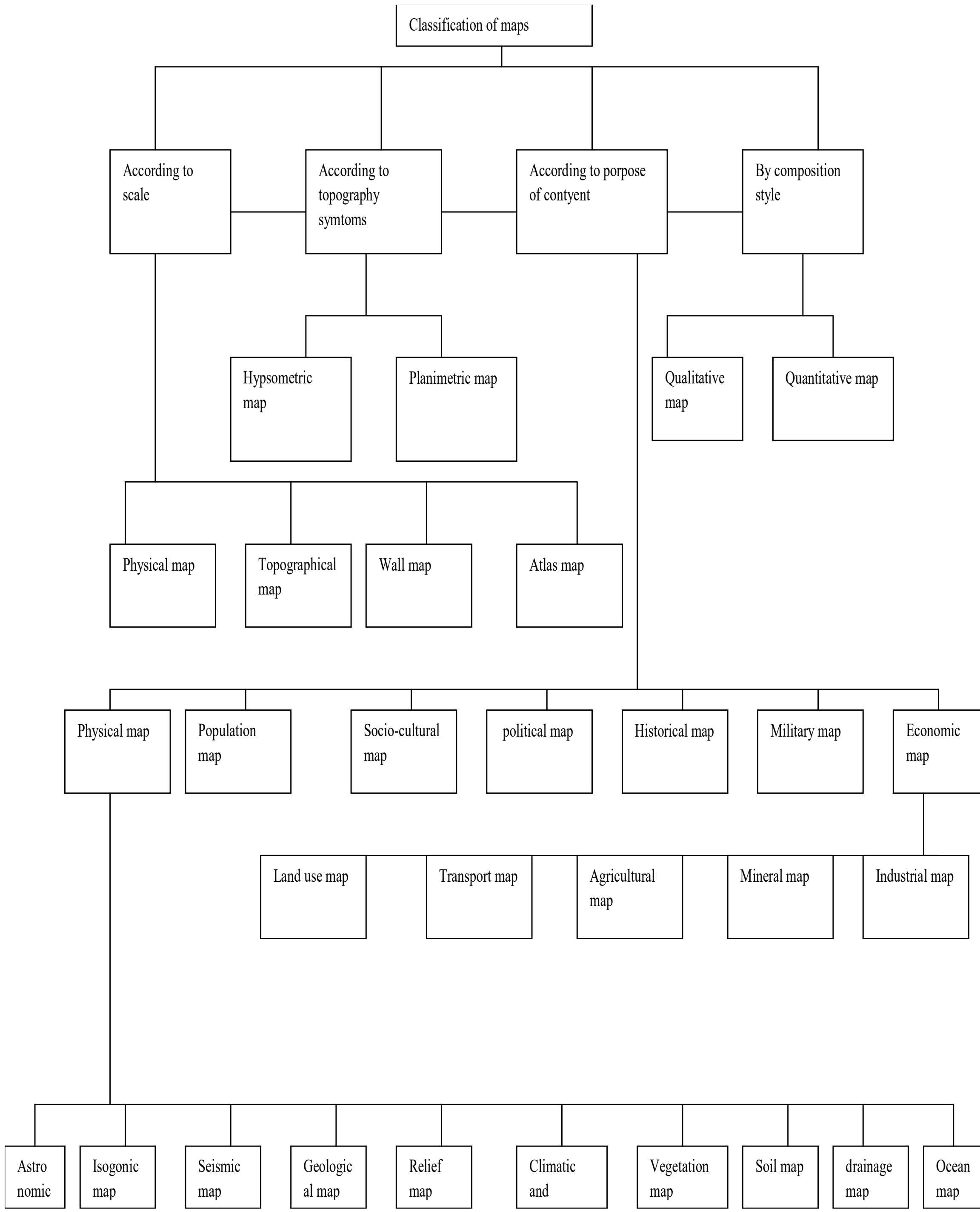
3.2 INTRODUCTION

There are two main purposes of making a map - First, the size of our Earth is so huge that it is impossible to see the whole part of it simultaneously by eye. The map makes the size and shape of the Earth understandable by reducing it according to the scale. The topographical features on the ground are in different types; Where are the rivers flowing in different areas; The rocks, vegetation, soils, mineral wealth and animals are like; How are the climate and weather conditions in a state; What are the distribution of population and patterns of settlements on earth; The purpose of the maps is to clarify the geographical facts and factors of the economic business there such as agriculture, factories, transport and trade etc. and how are the social, cultural and political systems. Second, different types of physical, economic, socio-cultural and political models exist simultaneously on the ground. Of these descriptions, maps are an important means of displaying only the truncated details as needed. Additionally, non-visible patterns on the ground can also be revealed by maps. Although diagrams, charts, frameworks and line maps are also made for this work, these methods are secondary and are not counted in the category of maps.

Since the First World War, the use of maps has increased in almost every country to describe plans for cultural development. Maps have a special place in military science. History is a witness to the fact that the more mistakes the soldiers of a country have made in reading maps, the more they have seen the face of defeat.

3.3 CLASSIFICATION OF MAP PROJECTION

Maps - There are four main grounds of classification (i) the amount of topographic features measured, (ii) the content or purpose of the map (iii) the style of the map, (iv) by composition style.



3.3.1 According to use of light:-

Maps based on light, projections are divided into the following two parts:

3.3.1.1Perspective map projections :

Maps made with the help of light - Projections are called perspective interpolation. In the composition of these projections, by casting a light from a fixed point on a network of latitudinal circles and meridians, it transfers its shadow to a flat surface. After this, a permanent picture of these shadows of latitude circles and meridians is obtained by pencil or photograph. Thus, in general colloquial language, the meaning of the word 'interpolation', perspective map - interpolation are the sign of the same meaning. These projections are also called geometrical projections.

3.3.1.2 Non-perspective map projections:

Perspective maps - Maps made by making necessary modifications by mathematical methods in interpolation are called non-random types. The composition of these projections depends on the method of modification and the purpose of creating the boundary map - projections. Since non-random maps - projections can be made to display as needed, natural, horizontal or pure direction, these projections are more important and useful than perspective maps.

3.3.2 According to the method of construction:

Composition - Classification of projections according to method (Classification of projections based on the method of construction) Creation - Map based on method - Projections can be divided into four classes - (i) Conical projections, (ii) cylindrical projections, (iii) zenithal projections, (iv) conventional projections. In these trajectories, the trajectory of the trajectory is formed by projecting a geo-grid on a flat surface, and the traps of cone and cylindrical trajectories are projected onto the paper cone and cylinder respectively. Paper cone and cylinder such

There are developable geometric forms that can be stretched as a flat surface cut perpendicular to the vertical direction after projection (fig 1). In this view, cylindrical and oblique trajectories are basically typical forms of cone interpolation., Suppose a paper cone, on whose outer surface the ground is projected, touches the globe at AB standard latitude (Figure parallel) (Fig. 3.1A). Clearly, the higher the standard latitude, the closer it is to the equator. The top of the cone will be located as far away from the pole. Now if the equator is the standard latitude, then the top of the cone placed on the globe will be located at an infinite distance from the smoke and in this case the cone will take the shape of a cylinder (Figure 3.1B). In contrast, as the distance of the standard latitude from the equator increases, the top of the cone will start approaching the pole. If the pole is chosen to be the standard latitude, then the distance between the pole and the top of the cone will be eliminated and the cone is fully spread in the tangent plane will not result, as in Kmdhy interpolation (Figure 3.1 C). It is clear from the above description that there is a definite relation between the cones, cylindrical and oblique projections, but for ease of study, it is useful to divide them into different classes.

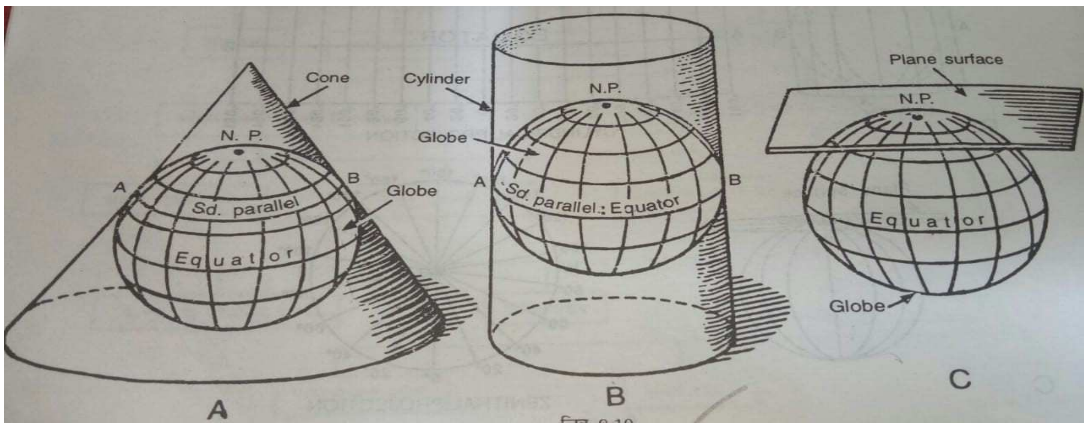


Fig. 3.1 (Source: Practical Geography by J.P. Sharma)

After projection a geo grid on the outer surface of a hollow cylinder of paper, the latitude and longitude line mesh obtained from spreading the paper flats is called

3.3.2.1 Conical projection:

The cone projections are based on the principle of transferring the geo-grid on the globe to the paper cone and spreading the cone paper flat after transfer. In the design of these projections, it is assumed that the paper cone touches the globe at selected latitude - circle (excluding the equator and pole) and that the top of the cone is just above the pole, the polar axis of the Earth extended. Is situated at some point of in other words, the center of the earth, the pole and the top of the cone are all in a straight line. The latitude on which the paper cone touches the globe is called standard parallel. The shape of this standard latitude in a cone-developed surface, i.e., map-interpolation, is similar to the arc of a circle and longitudinal lines are simple lines radiated from the pole at equal intervals, dividing the standard latitude into equal arcs. Other latitude circles are arcs of concentric circles. The scale is pure at standard latitude. The cone-projection is of two types - (i) simple conic projection, which has standard latitude and (ii) modified conic projection, in which the number of standard latitudes is more than one. And they are made of according to mathematical methods. Bonne's projection, polyconic projection, and international projection are examples of modified conjecture. No earth map on cone-interpolation can be made these trajectories are particularly useful for mapping temperate regions. 2. Cylindrical projections: After projecting a hollow grid of paper to the outer surface of the ground grid, the latitudinal longitudinal plane obtained from spreading the paper flat is called cylindrical interpolation (Figure 1B). In the normal position, this cylinder touches the globe at the equator and its axis is located on the polar axis of the Earth, but in the transverse position, the cylinder is connected to any great circle formed by two longitudinal lines can touch. Cylindrical projections of normal condition have the following characteristics. (1) All latitude circles are in the form of simple and parallel lines of equal length, so the scale is impure on all latitude circles except the equator. (2) All longitudinal lines are simple and parallel lines of equal length and the distance between them is same. (3) Each perpendicular line intersects the latitudinal circles at right angles resulting in a rectangular shape of cylindrical projection. (4) The distance between latitude circles is determined by mathematical methods according to the purpose of making the projection. In equidistant cylindrical interpolation, latitudinal circles are formed at equal distances apart, as in natural cylindrical interpolation (Mercator interpolation) the distance between latitudinal circles increases from equator to poles while in equilateral cylindrical interpolation this distance decreases towards the poles. Cylindrical trajectories are particularly useful for making maps of equatorial regions because the scale at the equator is pure. Apart from this, Mercator interpolation is very useful for making a pure-direction and pure-shape map of the world. TE 3. Zenithal projection - Latitude projected on a plane surface assumed to touch the globe at a point - longitudinal trajectory is called the mean projection (Figure 1C). The point of perfect projection where the projection plane touches the globe is called the center of projection and the point where the light is visualized is called the eye point or point of origin.

3.3.2.2 Cylindrical projections:

After projection a geo grid on the outer surface of a hollow cylinder of paper, the latitude and longitude line mesh obtained from spreading the paper flats is called cylindrical interpolation. The area close to tangent point will be more accurate. The more distant it is from tangent points the more distortion will be shown. This type of projection is typically used to map the world in particular areas between 80 degrees north and 80 degrees south latitudes. The cylindrical projection is classified into three types:

3.3.2.3 Zenithal projection:

The Latitude projected on a plane surface assumed to touch the globe at a point longitudinal trajectory is called the mean projection (Figure 1C).
The point of perfect projection where the projection plane touches the Globe is called the center of projection and the point where the Light is visualized is called the eye point or point of origin.

The floor of the projection
One can touch the globe at any point between the equator, the pole or between them. Similarly, the eye space can be at the center of the globe or outside the globe. But in each case, the projection-center, center of the globe and eye-place are all in a simple line and the projection plane touches the globe forming a right angle with this simple line. According to the different positions of the eye-space and the projection-plane, the mean projections are divided into the following subclasses. There are three types: (i) Nuclear or Gnomonic projection - When creating these projections, the position of the eye space is assumed to be at the center of the globe (ii.) Stereographic projection In stereoscopic projections, the position of the eye at the diametrically opposite point of the center of the projection (i.e. the point at which the projection - the bottom touches the globe) is considered (ii.) Orthographic projection - In these projections, there is an eye-spot at an infinitely spaced point on the forward diameter, joining the center of the projection and the globe, resulting in light coming from the eye space. - Rays are considered as simple and parallel lines (a) Differential of Projection Changes according to Projection-Floor Position There are also three classes of Projection-

Projection as per Projection - Floor Position. (A) Polar-zenithal projection - In these projections, the projection - the floor touches the globe on the east. (ii.) Oblique zenithal projection - In these projections, projection at any point between the equator and the pole can touch the bottom globe (ii.) Equatorial zenithal projection) - At which point of the equator in these projections does the projection touch the bottom globe (Figure Equivalent potential projections are also called normal zenithal projection.

It is clear from the above description that the projection on the globe - according to the position of the plane, there can be three positions in each of the Nomonic, Stereoscopic and Perpendicular vertical projections - polar, oblique and equatorial or normal. All types of silent projections have the following characteristics: (1) All large circles that pass through the center of the silent projection are represented by simple lines in the map. In other words, each straight line drawn from the center of the projection in the map is a large circle and their bearing or azimuth is pure. These decimals can be measured by the central meridian in the projection. All points at equal distances are equidistant on the map. The circle joining these equidistant points is called horizon circle. The shape of all the horizon circles on the map (3) remains a circular circle at the same distance from the center of the map. The amount of change and distortion of shape are also same. (4) If one hemisphere is displayed on the mean projection, the outer edge of the map will be a large circle and all the points on it will be equally spaced from the center.

3.3.2.4. Conventional projections:

In order to fulfill a certain objective, interpolation built on the axiomically sorted principle is called a conventional projection. The meaning of the word 'interpolation' which is commonly applied does not appear from these projections. The shape of conventional projections is so modified and conservative that it cannot be included in any category written above projections. Some conventional interpolations, especially those projections on which the map of the entire world can be made, are very useful.

3.3.3 According to merit:

Interpolation is omnidirectional. Five attributes or attributes in an all-encompassing interpolation - (i) pure-figure display, (ii) pure-field display, (iii) pure-direction display, (iv) pure-scale display and (v) simplicity related to composition, are required. . The first three of these properties are very important. But the difficulty is that while making the natural projections, the area is not pure and the shape gets distorted in the field projections. Hence, on the basis of merit, there are three main classes of maps - projections, which are given below briefly.

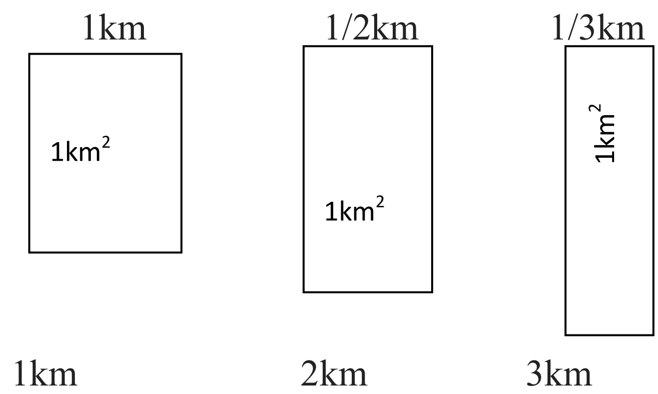
3.3.3.1 Orthomorphic Projections :

If any small part of the surface on the map has the same shape that is on the globe of the area, then the map's projection will be called orthomorphic conformal. There are two main characteristics of natural projections

The loss of area resulting from the transformation of the (1) latitude and longitudinal lines at each location in the maps on these trajectories of the other direction intersect each other at right angles like a globe. It is necessary to indicate here that all such projections in which the above symptoms are present are not natural. (2) It is not possible to display all the globes in a single map on any natural projection. In fact, the principles related to the composition of these projections are such that the need for infinite size paper to show the entire globe is felt which is not possible. Mercator and stereoscopic projections are good examples of natural projections. In order to display a pure shape and pure direction on the map, natural projections are required. For example, outline maps made on the natural trajectory are selected to show air direction, ocean currents and transport routes.

3.3.3.2. Homolographic projections:

In maps made on horizontal projections, the area is always pure. In these projections, the scale is increased in one direction and decreased in the other direction, due to which the area of a region in the map remains pure but its actual shape changes. In other words, the loss of area resulting from the change of scale in one direction causes loss of the other direction. The scale is completed by changes. Although the length - width (ie shape) of these geometric figures are different from each other, they have the same area. The Mallweed interpolation and the Sanson-flagged sinusoidal interpolation are examples of projections on which the maps are accurate in area. Political, statistical and Outline maps built on equilateral projections are used to create distribution maps. 3. Pure-direction projections.



3.3.3.3 Azimuthal projections:

Directions remain pure in maps made on Mercator projection and end projection. By pure direction, we mean that the straight line joining any two points on the map has the same direction as the large circle joining those points on the globe.

3.4 CONCLUSION

All projections are used in the map for line drawings to be drawn through a ruler. These measurements depend on the geographical location and size of the area. Different map scales are prepared by different parents at the same place by different parents. For the maps of the latitudes which have less latitudinal expansion, it is helpful to study the equatorial regions and the study of navigational and arctic regions for the study of astronomical maps or to study the whole earth and to make the distribution maps of the world. They are beneficial for study.

3.5 SUMMARY

Map projection: It is a method of moving a spherical surface to a flat surface. This is the systematic and systematic work of moving a network of spherical parallel and longitude meridional lines of a spherical earth or any part thereof at a convenient scale.

The construction of the purest shape maps for small and large terrains based on interpolation and the estimation and construction of projections for crops and industries.

There are two main purposes of making a map - First, the size of our Earth is so huge that it is impossible to see the whole part of it simultaneously by eye. The map makes the size and shape of the Earth understandable by reducing it according to the scale. The topographical features on the ground are in different types; Where are the rivers flowing in different areas; The rocks, vegetation, soils, mineral wealth and animals are like; How are the climate and weather conditions in a state; What are the distribution of population and patterns of settlements on earth; The purpose of the maps is to clarify the geographical facts and factors of the economic business there such as agriculture, factories, transport and trade etc. and how are the social, cultural and political systems. Second, different types of physical, economic, socio-cultural and political models exist simultaneously on the ground. Of these descriptions, maps are an important means of displaying only the truncated details as needed. Additionally, non-visible patterns on the ground can also be revealed by maps. Although diagrams, charts, frameworks and line maps are also made for this work, these methods are secondary and are not counted in the category of maps.

Since the First World War, the use of maps has increased in almost every country to describe plans for cultural development. Maps have a special place in military science. History is a witness to the fact that the more mistakes the soldiers of a country have made in reading maps, the more they have seen the face of defeat.

3.6 GLOSSARY

- Non-prospective = A technique of depicting volumes and spatial relationships on a flat surface.
- Perspective = A particular attitude towards or way of regarding something; a point of view.
- Stereographic = The stereographic projection is a particular mapping that projection a sphere onto a plane.
- Conventional projection = It is a pure mathematical constructions designed to map the entire sphere with minimal distortion.

3.7 ANSWER TO CHECK YOUR PROGRESS

Q. What is cylindrical interpolation?
Ans. The process of displaying a network of latitude and longitude lines on a globe through a cylindrical plane is called cylindrical interpolation.

Q. Describe the major types of conical side?
Ans. Conical projection is as follows.

- Simple Conical Projection with one standard Parallel.
- Simple Conical Projection with two standard Parallel.
- Bome projection.
- Polyconic projection.
- International projection.

Q. How is the length of the equator found?
Ans. Equator lines = $2\pi R$
Where $the\ value\ of\ \pi\ is\ \frac{22}{7}$ and R is the radius.

Q. Which projection is best for the projection of rubber in the world?
Ans. Cylindrical equal area projection is best for showing the production of rubber in the world.

Q. What are the different types of projection based on light?
Ans. There are two types of projection based on light.
1. Perspective 2. Non- perspective.

True and False:

1. When the conical of the Paper touches the globe on one of the latitude lines, it is called a standard normative latitude projection. True / False
2. The distance between the latitude lines decreases when the equator to the pole. True/ False
3. The pole is represented by a straight line. True/False
4. The latitude lines are parallel and equal to the equator. True/ False
5. Is there are 5 types of conical projections. True/ False

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3.10 TERMINAL QUESTIONS

Question. To construct a graticule on simple conic projection on 1.25,000,000 scale at the interval of 50 for an area stretching between 500N 700N and 50E-350E,

Ans. Let the standard parallel be 600N which will be the central parallel of the area and 200 E be the central meridian. The radius of the sphere on the given scale

$$= \frac{250,000,000}{25,000,000} = 10''$$

Graphical Construction

Draw a circle AEQ with 10” radius. From its centre O draw OA, making the $< EOA = 600$. From the point A, drawn AV as tangent to the circle at A to meet the polar diameter produced at V. Now VA is the projected radius of the 600north latitude line. Make the $< rOQ = 50$, the given interval between two parallels. Qr is the true distance between two parallels at 50 interval. With centre O and radius Qr describe a semi-circle which centre OA at the point a. from a draw ab parallel to EO, the line ab meeting OV at b. Thus AB is the longitudinal distance between two meridians at the interval of 50 along standard parallel (Fig 3).

Then draw VO in the centre of the paper. With centre V and radius VA draw the arc ACB. From C mark-off the points Y, Z, M, L along VO, making, CY, CM, YZ and ML equal to Qr. With centre V draw concentric arcs passing through L, M, Y, Z respectively. Similarly mark along ACB longitudinal points at distance equal to ab. Draw straight line from V passing through the points thus marked. In this way complete the graticule for the area.

Trignometrical Construction

The projection radius of the standard parallel

= R cot 600 = $10 \times 0.58 = 5.8"$

The length of the standard parallel

$= 2\pi r \cos 600$

$$\frac{2 \times 22 \times 10 \times 0.5}{7} = 31.4"$$

The distance between the two meridians along the standard parallel

$$\frac{31.4}{360} \times 5 = 0.44"$$

The true distance between the two parallels at 50 interval

$$= \frac{2\pi R}{360} \times 5 = \frac{55}{63} = 0.87".$$

The construction may now be completed as in the foregoin, to produce the require graticule (Fig 3.3A)

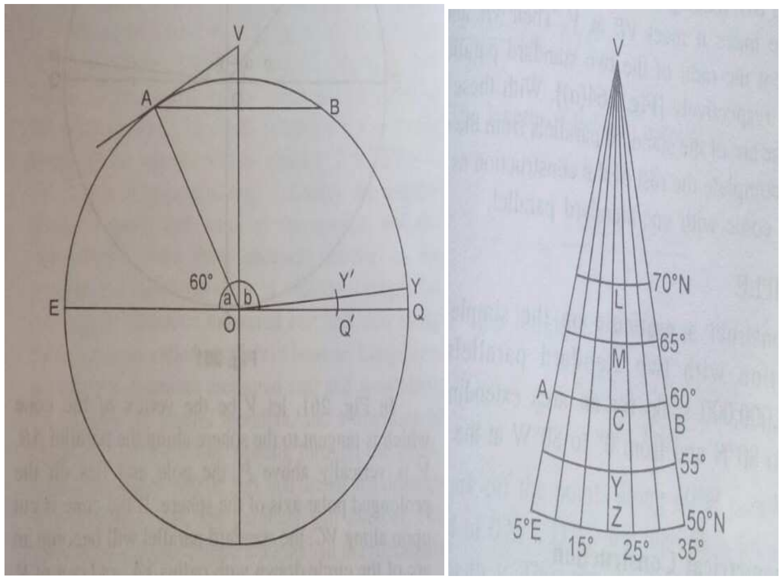

Fig. 3.3 (Source: Elements of Practical Geography)

UNIT 4: CONSTRUCTION MERITS OF MAP PROJECTION

4.1 OBJECTIVES

After reading this unit you will be able to :

- Understand the uses and limitations of different types of projections.
- Understand different types of interpolation.

4.2 INTRODUCTION

Many other ways have been described for characterizing distortion in projections.[Like Tissot's indicatrix, the Goldberg-Gott indicatrix is based on infinitesimals, and depicts flexion and skewness (bending and lopsidedness) distortions.Rather than the original (enlarged) infinitesimal circle as in Tissot's indicatrix, some visual methods project finite shapes that span a part of the map. For example, a small circle of fixed radius (e.g., 15-degrees angular radius). Sometimes spherical triangles are used.[citation needed] In the first half of the 20th century, projecting a human head onto different projections was common to show how distortion varies across one projection as compared to another. In dynamic media, shapes of familiar coastlines and boundaries can be dragged across an interactive map to show how the projection distorts sizes and shapes according to position on the map. Another way to visualize local distortion is through grayscale or color gradations whose shade represents the magnitude of the angular deformation or areal inflation. Sometimes both are shown simultaneously by blending two colors to create a bivariate map. The problem of characterizing distortion globally across areas instead of at just a single point is that it necessarily involves choosing priorities to reach a compromise. Some schemes use distance distortion as a proxy for the combination of angular deformation and areal inflation; such methods arbitrarily choose what paths to measure and how to weight them in order to yield a single result. Many have been described.

4.3 CONICAL PROJECTIONS WITH ONE AND TWO STANDARD AND BONE PROJECTION

Simple Conical Projection with one standard parallel:-

In this interpolation, the contraction of the globe touches the clock at one latitude. This interpolation can be composed by leaving the latitude standard to any latitude circle except the equator and pole. The composition of this interpolation is very simple as compared to other cone projections. This interpolation is used to make maps of small countries located in the middle latitudes. In addition, maps of such territories are also made on this earth. Those who have less latitudinal expansion.

Properties - A simple cone with a standard latitude - interpolation has the following properties - religions:

(1)The scale at the standard latitude is pure, but the scale at the remaining latitude circles is not pure.

(2) The scale is pure on all longitudinal lines. Therefore, this interpolation is also called equidistant cone interpolation.

(3) The farther away from the standard latitude a location in the map formed on this projection is, the more the scale of the latitude circle of that location will be impure. Thus, as the distance from the standard latitude increases, the distortion starts to increase in the shape and area of the regions.

(4) The shape and area at standard latitude is accurately demonstrated to a great extent.

(5) Only one hemisphere (northern or southern) map can be drawn on this projection.

(Identification) - A simple cone with standard latitude - interpolation can be identified based on its following characteristics:

(1) All latitudes are arcs of concentric circles with the center of the circle cone as the center and the distance between them is one. Is the same.

(2) All longitudinal lines are in the form of simple lines, which merge together at the top of the cone.

(3) The pole of the projection appears by an arc.

(4) Latitude circles and longitudinal lines intersect each other at right angles.

(5) The distance between longitudinal lines from pole to equator increases, but the distance between longitudinal lines on any one latitude circle is the same.

Simple Conical Projection with two Standard Parallel:-

This interpolation is a modified form of ordinary cone interpolation with standard latitude. The composition of this interpolation is based on the assumption that the paper cone enters the globe and cuts or touches the surface of the globe using two latitude circles, both of which are considered standard latitudes. The cone interpolation of two standard latitudes is sometimes called the boreal conic interpolation. But it is flawed to say so. Because the distance between the two standard latitudes in the same as the distance between them. While the arcular distance is used in cone interpolation of two standard latitudes.

In this map on the interpolation, as the distance from the standard latitudes increases, the shape of the regions and the deformation in the area begin to increase. In Europe and Australia, this projection has been used a lot to make maps of different countries or states.

Identification - Identify this interpolation on the basis of the following characteristics:

(1) All latitude circles would be arcs drawn at the same distance apart as concentric circles.

(2) All longitudinal lines are in the form of simple lines drawn from the top of the cone.

(3) In the projection the pole is manifested by an arc.

(4) Latitude circles and longitudinal lines cut each other at right angles.

(5) The distance between longitudinal lines on each latitude circle is the same.

(Properties) - Two standard latitude cones - interpolation has the following properties:

(1) The scale at both standard latitudes is pure, but the scale at other latitude circles is not pure.

(2) The scale is pure on all longitudinal lines.

(3) Since the scale is pure only at standard latitudes and longitudinal lines, this projection is neither economical nor equidistant.

(4) Since this interpolation has two standard latitudes, it is more pure than an ordinary cone-interpolation with the one standard latitude.

(5) A map of the entire world cannot be made on this projection.

(6) Since the pole appears from an arc in this interpolation, this interpolation is not suitable for mapping polar regions.

(Bonne's projection)

This is a modified conic projection, which was first created by Rigobert Bonne, because it is a plane-projection. The design of this interpolation is very similar to that of a normal cone-interpolation with standard latitude. The only difference is that to make longitudinal lines in the cone-interpolation of standard latitude, only the standard latitude is divided, whereas to make longitudinal lines in a bone interpolation it is necessary to divide all the latitude circles. The line of bone interpolation can be compared to the vertical projection of Sanson Flamsteed.

Identification - Bone interpolation can be identified by its following features:
(1) All latitudes are arcs of concentric circles with the apex of the circle cone as the center and the distance between them is the same.
(2) The central meridian is simple and8 the shape of all other longitudinal lines is curved.
(3) All latitude circles intersect the central meridian, but as the distance increases from the central meridian to the east or west side, the intersections of the latitudinal circles and longitudinal lines become more and more oblique.
(4) Since the length of all latitudinal circles in the Bone projection is pure, the pole is represented by a point in this projection as opposed to the cone projections of one standard latitude and two standard latitudes.
(5) The distance between longitudinal lines is the same on different latitudes.

Properties - This projection consists of the following properties - religions:
(1) The scale is pure on all latitude circles and the central meridian.
(2) As the distance from the central meridian increases, the scale of longitudinal lines also increases, due to which the shape of the areas near the edges becomes very distorted.
(3) Since the scale on the latitude circles is pure and each latitude circle is at a net distance from its adjacent latitude circles, the property of the plane is retained in this projection.
(4) At most one hemisphere is shown on this projection. can go .

Use - Bone interpolation is used extensively in maps to map Europe, Asia, North America, South America, Australia and other large areas. But this projection is particularly useful for displaying areas with less longitudinal expansion. For example, if the central meridian is chosen 70 ° west, an ideal map of Chile can be made on the Bonus projection. The reason for this is that along with the area near the central meridian in the bone projection, the shape is also pure to a large extent.

Despite increasing the distortion in the shape of the parts away from the central meridian, this projection is used extensively for the distribution and statistical maps of the middle latitudes. In addition, topographic maps are also made on this projection in countries such as France, Switzerland and Belgium.

4.4 CYLINDRICAL PROJECTION

After projection a geo grid on the outer surface of a hollow cylinder of paper, the latitude and longitude line mesh obtained from spreading the paper flats is called cylindrical interpolation. The area close to tangent point will be more accurate. The more distant it is from tangent points the more distortion will be shown. This type of projection is typically used to map the world in particular areas between 80 degrees north and 80 degrees south latitudes. The cylindrical projection is classified into three types:

True or perspective cylindrical projection

In this projection, the surface of the globe is transferred to the paper cylinder by assuming the position of light in the center of the globe. This cylinder of paper touches the globe along the equator. This projection is also called nomonic cylindrical cylindrical projection), assuming the position of the source of light in the center of the globe.

Identification –

(1)Each latitude circle is of equal length as the equator in the form of a simple and parallel line.

(2) Parallel lines are simple and parallel lines of mutually equal length.

(3) In interpolation, longitudinal circles intersect at right angles.

(4) The distance between latitudes increases from the equator towards the fog. (5) The longitudinal lines are drawn by dividing the equator into equal parts, so the distance between them remains constant.

Properties

(1)Due to the position of the light source at the center of the globe, the surface of the cylinder does not cast a shadow of the poles, hence the poles cannot be displayed in this projection.

(2)The interpolation is only measured at the equator. The amount of impurity in the scale starts to move from the equator to the poles.

Use - Use of this interpolation to make a map is very limited due to the shape, area and direction displayed in all other parts of the equator.

Simple or cylindrical equidistant projection

In this projection, latitudinal circles and longitudinal lines are drawn at equal distance of distance, hence it is called equidistant cylindrical or plate carree projection. The method of creation of this interpolation is very simple.

Identification - (1) Because of the latitude and longitudinal lines being the same distance, it is similar to the line formed by interpolation squares.

(2) The length of each latitude circle is equal to the equator. All latitude circles are like simple and parallel lines.

(3) The longitudinal lines are also simple and parallel and they cut the latitude circles at right angles.

(4) The length of each longitudinal line in the interpolation is half of the equator.

(Properties) - (1) In the interpolation, all the latitude circles are formed at the correct distance from the equator, so the scale is pure at each longitude.

(2) The scale is pure at the equator, where the paper cylinder touches the globe.

(3) All the latitude circles except the equator are larger than their actual length and hence the scale is impure on them. The impurity of the scale on the latitudes increases from the equator to the poles, that is, the measurement at higher latitudes is more impure than at the lower latitudes.

(4) In the projection, the poles are represented by long lines equal to the equator, so that the latitudes are on the circles.

The scale can be easily estimated as impure.

Use - This interpolation is neither natural nor has the property of an area. In the interpolation, the shape and area near the equator are displayed correctly. Therefore, this interpolation is of limited use to map equatorial regions. This projection is not useful for making maps of regions or worlds located in high latitudes.

Cylindrical equal area projection

The equal area map projection, also known as the equivalent map projection, aims to preserve the area relationships of all parts of the globe. You can easily identify most equal area map projections by noting that the meridians and parallels are not at right angles to each other. Additionally , distance distortion is often present on equal area map projection, and, shape is often skewed.

Even with the distortion of distance and shape. equal area map projection is useful for genera quantitative thematic maps when it is desirable to retain area properties. This is especially useful for choropleth maps, when the attribute is normalized by area. Holding areal properties. To be true , allows for an apple to apple comparison of density between different enumetation units, such as counties.

The cylindrical equal area map projection is an example of an equal area, or equivalent map projection, which aims to keep the areal relationships of all parts of the globe correct.

A second example of an equal area projection is the hammer aitoff map projection. Again, like the cylindrical equal area projection, this map projection aims to hold areas true. Also note, that on this map projection, the parallels and meridians do not intersect at 900 angles, which is a hint that lets us know that this may be an equal area projection.

Identification - (1) Latitude circles are simple and parallel lines and the length of each latitude circle is equal to the equator.

(2) The distance between the latitudes decreases from the equator to the poles. (3) The longitudinal lines are also simple and mutually parallel, but the distance between them is same.

(4) Latitude circles and longitudinal lines intersect each other at right angles.

(5) The pole, which is a point on the globe, is represented in the projection by a long straight line of equator.

Properties: (1) The equator is equal to its actual length. Therefore, the scale at the equator is pure.

(2) Other latitude circles are larger than their actual length. Therefore, the scale is not pure on them.

(3) Since the longitudinal lines in the interpolation are drawn equal to the polar diameter of the Earth's miniature sphere, they are smaller than their actual length. As a result, the scale on the longitudinal lines becomes impure.

(4) It is an equidistant projection, but the shape of the regions becomes very distorted when moving away from the equator.

Use - Although distribution maps of the world are sometimes drawn on this interpolation, this interpolation is particularly useful for distribution maps of areas near the equator.

Polar zenithal equidistance projection

This is a very simple projection, in which the plane of the projection is assumed to touch the pole. This projection consists of concentric circles drawn at the same distance apart, with the latitude circle being the center and longitudinal lines drawn at the same angle as the simple lines, but only one hemisphere (northern or southern) is displayed. Can. The mathematical method and graphical method of making this interpolation are the same.

Identification: - (1) Latitude circles are concentric circles drawn with the pole as the center. The distance between latitudes is the same.
(2) Longitudinal lines are simple lines radiated at the exact angular distance from the pole.
(3) Latitude circles and longitudinal lines intersect each other at right angles. (4) The pole appears from a point.

(Properties) - (1) The scale on each longitude is pure because the latitude circle is at a real distance
(2) The scale starts increasing on the latitude circles from the pole to the equator 1.2%, 60 ° at 75 ° latitude circle- The scale increases by 4.5% on the latitude circle and 11.0% on the 45 ° latitude circle.
(3) Although it is not a natural projection, the shape remains quite pure from a distance of 30 ° from the pole (ie 60 ° north to 90 ° north). From 60 °, the shape of the regions towards the equator starts elongated in the east-west direction.
(4) In this interpolation, the area is also not displayed pure, but the distance from the center of the places and directions on the map remains pure.
(5) At most half of the globe can be displayed on this projection.

Use - This interpolation is particularly useful for general purpose maps of Arctic regions. In addition, this projection is also used for maps related to polar exploration and polar navigation.

Equatorial zenithal equidistant projection

In this projection, the projection touches the plane globe at one point of the equator. Therefore, it is also called normal equidistant projection of normal or equatorial case. The graphical method and mathematical method of making this interpolation are similar.

Identification - (1) The equator is a straight line of pure length and all the other latitude circles are arcs of circles drawn from different centers and different radii. From the equator towards the poles, the lengths of the radius of latitude circles begin to decrease.
(2) The central meridian is a simple line of pure length and the rest of the perpendicular lines are arcs of circles drawn from different centers and different radii. The interpolation has bordering longitudinal lines in the form of semicircles.
(3) The equator cuts each longitudinal line and the central meridian intersects each latitude circle at right angles. As the distance between the poles and the central meridian increases, the angles formed by the intersection of the latitudinal circles and longitudinal lines begin to decrease, but they are never very oblique. (4) The distance between longitudinal lines on any one latitude circle or the distance between longitudinal circles at any one longitude is the same.

Properties: (1) The scale is pure on the central meridian. As the distance from this line increases, the scale increases along the longitudinal lines. The scale increase on the border longitudinal lines is about 57%.
(2) The scale at the equator is pure, but at other latitude circles, the scale is slightly increased or slightly decreased.
(3) The shape of the areas towards the border parts of the map gets very distorted, but the shape near the center remains quite pure.
(4) The area gets enlarged as the plots are extended in the north-south direction in the border parts.
(5) Both the direction and distance from the center of interpolation remain pure.
(6) Only one hemisphere can be displayed on this projection.

Use - Maps that draw airways of equatorial regions are often drawn on this trajectory. In addition, this projection is also used for navigational maps of these areas.

Polar zenithal equal - area projection

This is a random projection which was credited with the creation of the first. H. Is given to a cartographer named Lambert (J. H. Lambert). Therefore, it is also called Lambert's polar mean plane projection. The composition of this interpolation is very simple.

Identification - (1) In a projection, the latitude circle is the concentric circle drawn with the pole as the center.
(2) Perpendicular lines are lines radiated at the difference of true angular distance from the pole.
(3) Latitude circles and longitudinal lines intersect each other at right angles.
(4) The distance between the latitude circles from the pole (center of interpolation) towards the equator begins to decrease.

Properties: (1) The scale of the longitudinal lines from the pole towards the equator starts decreasing, but there is a slight decrease in the distance from the pole to 30 ° (ie, between 60 ° to 90 ° latitude).
(2) The scale of the longitudinal circle is increased as much as the length of the perpendicular line is decreased at a point in the interpolation. In this way, the area is pure in the projection due to the mutual balance between the scales of latitude circles and longitudinal lines.
(3) Only one hemisphere map can be made on this interpolation.
(4) Like other silent projections, in this projection the direction from the pole to each side is pure.
(5) The shape of the proximal parts of the pole is quite pure, but the shape of the regions towards the equator, away from the pole, increases the amount of distortion.
Use – This projection is particularly useful for distribution maps of Arctic regions. In addition, this projection is also used for maps related to polar exploration and polar navigation.

4.5 CONCLUSION

When we select map projections according to properties, the map depends on the properties of the terrain such as the net shape through the created projections, the appropriate direction display, the exact shape, the net area net scale display, net direction display and When all these facts work together, a suitable and pure map interpolation is created. A map constructed in this way assesses and evaluates each part of that terrain. Easily done by the method of mathematic and geographical, and the shape created in this way is pure and appropriate, which in today's time, every department that works through the survey has to work through such projections. It is easy, whether it is road related work or building related work, the work done without projections can be faulty and flawed, so we must always work by means of the shapes made by projections, different Types of interpolation variations are saved and can also be easily created for each terrain. Is demanded.

Many other ways have been described for characterizing distortion in projections.[Like Tissot's indicatrix, the Goldberg-Gott indicatrix is based on infinitesimals, and depicts flexion and skewness (bending and lopsidedness) distortions.Rather than the original (enlarged) infinitesimal circle as in Tissot's indicatrix, some visual methods project finite shapes that span a part of the map. For example, a small circle of fixed radius (e.g., 15-degrees angular radius). Sometimes spherical triangles are used.[citation needed] In the first half of the 20th century, projecting a human head onto different projections was common to show how distortion varies across one projection as compared to another. In dynamic media, shapes of familiar coastlines and boundaries can be dragged across an interactive map to show how the projection distorts sizes and shapes according to position on the map. Another way to visualize local distortion is through grayscale or color gradations whose shade represents the magnitude of the angular deformation or areal inflation. Sometimes both are shown simultaneously by blending two colors to create a bivariate map. The problem of characterizing distortion globally across areas instead of at just a single point is that it necessarily involves choosing priorities to reach a compromise. Some schemes use distance distortion as a proxy for the combination of angular deformation and areal inflation; such methods arbitrarily choose what paths to measure and how to weight them in order to yield a single result. Many have been described.

4.6 SUMMARY

A map projection is used to portray all or part of the round Earth on a flat surface. This cannot be done without some distortion. Every projection has its own set of advantages and disadvantages. There is no "best" projection. The mapmaker must select the one best suited to the needs, reducing distortion of the most important features. Mapmakers and mathematicians have devised almost limitless ways to project the image of the globe onto paper. Scientists at the U. S. Geological Survey have designed projections for their specific needs—such as the Space Oblique Mercator, which allows mapping from satellites with little or no distortion. This document gives the key properties, characteristics, and preferred uses of many historically important projections and of those frequently used by mapmakers today.

4.7 GLOSSARY

- Equidistant = at equal distances."the line joins together all points which are equidistant from the two axes"
- Assumed = suppose to be the case, without proof."topics which assume detailed knowledge of local events"
- Zenithal = the point in the sky or celestial sphere directly above an observer.
- Properties = a thing or things belonging to someone; possessions collectively.

4.8 ANSWER TO CHECK YOUR PROGRESS

Q. Which map is very useful for navigation purpose? Discuss the limitations and uses of this projection.

Answer: Mercator projection is very useful for navigational purpose. Limits of Mercator interpolation (i) The scale of the scale increases sharply at higher latitudes with the help of post-meteorological and latitudes. As a result, the size of the countries closest to the pole exceeds their actual size. For example, the size of Greenland is comparable to that of the United States, while it is 1 / 10th of the size of the United States. (ii) Poles cannot be displayed in this projection. Is, because 90 ° latitude parallel and all the lines are infinite. Use of Mercator interpolation (i)

It is very useful for world map. And it is used in making atlas maps. (ii) It is very useful for navigation on sea and air routes. (iii) It is suitable for showing on the map the runoff patterns, ocean currents, temperature, winds and their directions, distribution of rainfall throughout the world, etc.

Q. What are the main features of cone interpolation with standard latitude and explain its limitations.
Answer- The main properties of cone interpolation with standard latitude are (i) arcs of parallel circles of all latitudes and the distance between them is equal. (ii) All posterior lines are straight, which join at the poles. The posterior parallelogram cuts the right angle. (iii) The scale of all post-mortem is correct, that is, all the distances on the meridian are correct. (iv) The arc of a circle represents the pole. (v) The scale is pure at standard parallel, but distorted away from it. (vi) One moving near post-poles. They come close to each other. (vii) This projection is neither equidistant nor economical. Limitations (i) It is not suitable for the world map, because the hemisphere in which the standard latitude circle is chosen. In the opposite hemisphere there is extreme deformity. (ii) It is also not suitable for the hemisphere in which it is made, because it is also inappropriate for displaying large area due to its distortion on the pole and near the equator.

Q. What is cylindrical Projection?
Ans. The process of displaying a network of latitude and longitude lines on a globe through a cylindrical plane is called cylindrical interpolation.

Q. Describe the major types of conical side?
Ans. Conical projection is as follows.

- Simple Conical Projection with one standard Parallel.
- Simple Conical Projection with two Standard Parallel.
- Bome projection.
- Polyconic Projection.
- International projection.

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4.10 SUGGESTED READINGS

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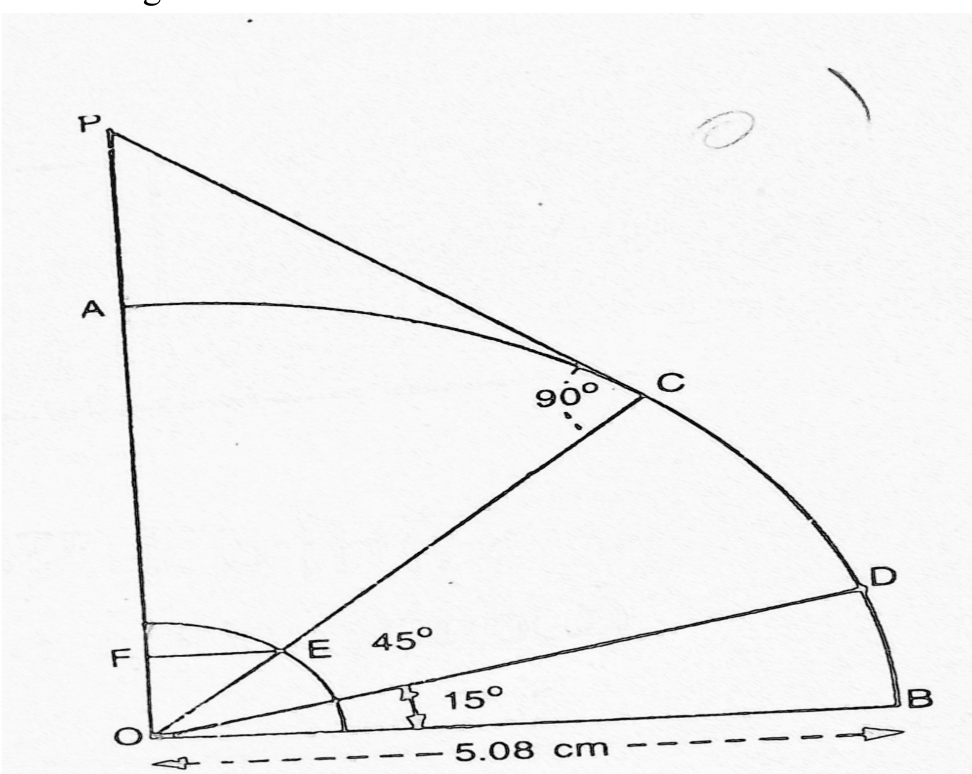
4.11 TERMINAL QUESTIONS

Example (1) Draw a simple cone with a standard latitude based on the following description: Scale, 1: 125,000,000; Standard latitude, 45 ° north; Area expansion, 0 ° to 75 ° northern latitude and 60 ° F to 60 ° eastern longitude; Interval 15 °.

Graphical method – According to the scale, the radius of the spherical earth sphere that is

$$R = 635{,}000{,}000/125{,}000{,}000 = 5.08\text{cm}$$

Draw 5.04 cm radius ABO quadrant ABO as per Figure 9A. Draw an angle DOB equal to 15 ° at the 0 point of the OB line and an angle COB equal to the standard latitude. Ctend perpendicular to the point which
The extended OA cuts the line at the P point. Now, taking 0 as the center, draw a circle from BD radius, which is the OC lineCuts at 5 points. From the E point, draw the EF perpendicular to the OA line. To make the projection of PC, draw a vertical straight line PG, which will be the central meridian in this projection and its value will be 0 ° longitude according to the question (Figure 2B). Now take an equal distance and draw a circle from the point P 'which will reveal the standard latitude line of 45 ° north in the projection. To make another latitude circle, put two signs towards P 'and three towards G from the standard latitude line at the distance of BD distance on the central meridian. Taking the P 'point as the center, draw the arcs of the circles through these signs and write the values in degrees of latitude lines on these arcs according to the picture. Now put four signs on either side of the central meridian in standard latitude at the difference of EF distance. Draw simple lines matching these signs with the P 'point. These simple lines will reveal longitudinal lines in interpolation. Complete the interpolation by writing their values on longitudinal lines.



Draw 450 and 600 northern standard latitudes from PD 'radii respectively. Find the intermediate point of both the standard halves on the central midline. The distance of this point from any standard latitude will be equal to EB and the arc of the concentric circle passing through it will reveal a 50 N. latitude circle. To create another latitude circle, as in Example 1, place the required number of signs on the central meridian at the difference of EB distance and consider P as the center and draw the arcs of circles through these signs. At the standard latitude of 600, place six signs on either side of the central meridian at a distance of GH perpendicular distance and draw simple lines matching these signs with P 'which will reveal longitudinal lines in the interpolation. Remember, if you have to cover 40 ° standard latitude to make longitudinal lines, then F1 distance will be taken in place of GH. Complete the projection by writing their values on the latitude circles and longitudinal lines.

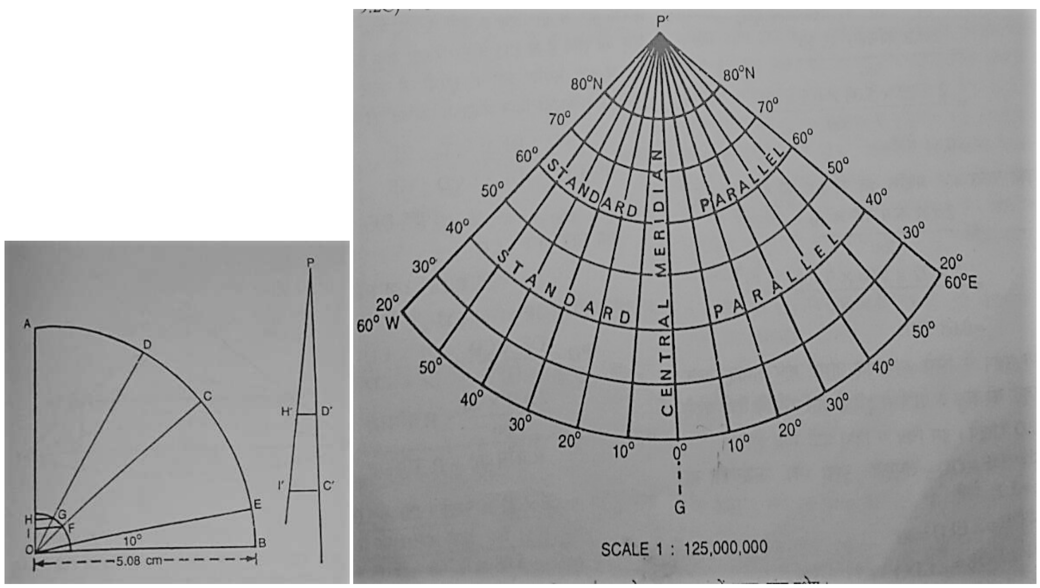


Fig (1A, 1B, 1C)

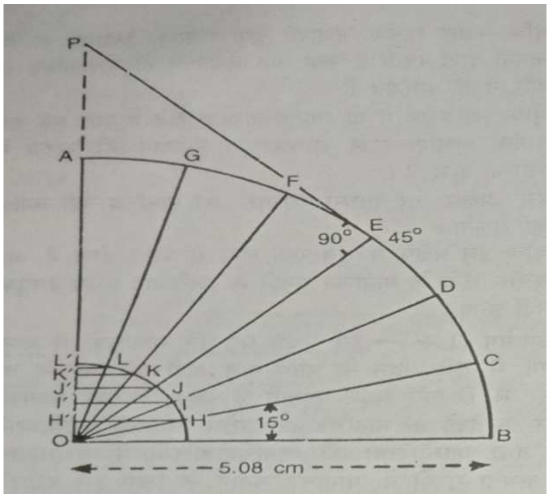
Example (3) Draw a line of bone interpolation with the following details: Scale, 1: 125,000,000; Longitudinal, 15 °; Standard latitude, area expansion, 15 ° N to 75 ° northern latitude and EW 165 ° East Longitude

Graphical method – According to the scale, the radius of the spherical earth sphere that is

$$R = 635{,}000{,}000/125{,}000{,}000 = 5.08cm$$

According to Figure 11A, draw a quadrant ABO of the circle with radius 5.08 cm. At point 0 of the OB line Fifteen - Draw the lines OC, OD, OE, OF and OG making angles at the difference of fifteen degrees. Draw a tangent line at E point which cuts the extended OA line at P point. Now rotate the arc by assuming CB to be the point 0 from the radius which cuts the OC, OD, OE, OF and OG lines at the points H, I, J, K and L respectively. From these intersection points, drop the HH ', II', JJ ', KK' and LL 'lengths respectively on the OA line. Now draw a perpendicular straight line PM as per Figure 11B, which will be the central meridian in the projection. Assuming P 'as the center, draw an arc from the PE radius which cuts the central meridian at the N point. This arc will reveal a standard latitude of 45 ° north. Fill in the BC distance circle and mark the two signs on the central meridian from the N point towards the pole and the two signs from the N point towards the equator. Draw the arcs of concentric circles from P 'center through these signs and write 15 °, 30 °, 450, 60 ° and 75 ° answers on them. Remember, P 'point will not be a pole. In fact, if we mark another sign on the central meridian at a distance equal to BC beyond the 75 ° north latitude circle, this sign will reveal the North Pole.

To create longitudinal lines at a difference of HH 'on a latitude circle of 15 °, II' on a latitude circle of 30 °; JJ 'at a standard latitude of 45 °; Put a mark on the latitude circle KK 'at 60 ° and LL' at a latitude circle of 75 °. Five symbols will be placed on each latitude circle on either side of the central meridian. Complete the longitudinal lines, adding the same number of signs as the latitude circles and write its values in degrees on each longitudinal line.



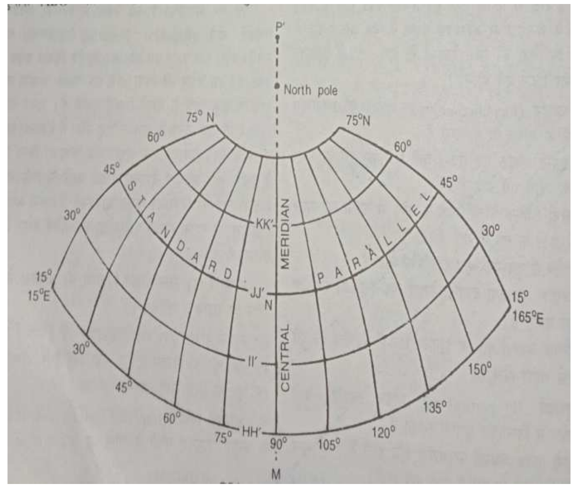


Fig. 2A Fig. 2 B

Example (4) Construct a perspective cylindrical interpolation to map the world at a scale of 1: 350,000,000. Keep the interval 15 ° in the interpolation.

Graphical method - to create cylindrical projections as stated above Firstly with the help of formulas, the radius (R) of the elliptical sphere of the earth, the length of the equator and the length of the equator between two enclosed longitudinal lines at the given interval are determined. In this example

Example (4) Construct a perspective cylindrical interpolation to map the world at a scale of 1: 350,000,000. Keep the interval 15 ° in the interpolation.

Graphical method - to create cylindrical projections as stated above Firstly with the help of formulas, the radius (R) of the elliptical sphere of the earth, the length of the equator and the length of the equator between two enclosed longitudinal lines at the given interval are determined. In this example

$$R = 635{,}000{,}000/350{,}000{,}000 = 1.8cm$$

$$Length\ of\ Equator = 2\pi R$$

$$= (2 \times 22 \times 1.8)/7 = 11.3cm$$

□□□□□□□□□ □□□□□□□□ □□□ □□□□□□□□□ □□□□□□□□□□ □□□□□□ =

$$= \frac{2\square\square \times \square\square\square\square\square\square\square\square\square\ (\square\square\square\square\square\square\square\square\square)}{\square\square\square\square h'\square\square\square\square\square\square\square\square\square\square\square\square\square\square\square\square(\square\square\square\square\square\square\square\square\square)}$$

$$= \frac{11.3 \times 15}{360} = 0.47$$

To make the projection, assuming 0 as the center, draw ABC at half of the circle from the radius 1.8 cm (ie R) (Fig. 12). Proceed to join the points 1 0 and B, and in this enlarged straight line 11.3 cm (ie equator). Cut the BD distance equal. Draw vertical lines EF at point B and GH at point D. Draw the lines at the 0 point of the OB line upwards and downwards making angles of 150, 30 °, 45 ° and 60 °, which, when extended, bend the BE perpendicular to the points I, J, K and E and OB respectively. The BF perpendicular line down the line is L, M, N and F respectively Bites on points. Draw parallel lines BD (ie equator) from the points E, K, J, I, L, M, N and F. These parallel lines will be the latitude circles of the respective degrees in the projection. To draw longitudinal lines, draw perpendicular lines dividing the BD equator into 24 equal parts at a distance of 0.47 cm (ie 15 ° intervals). According to Figure 11 write their values on latitude circles and longitudinal lines.

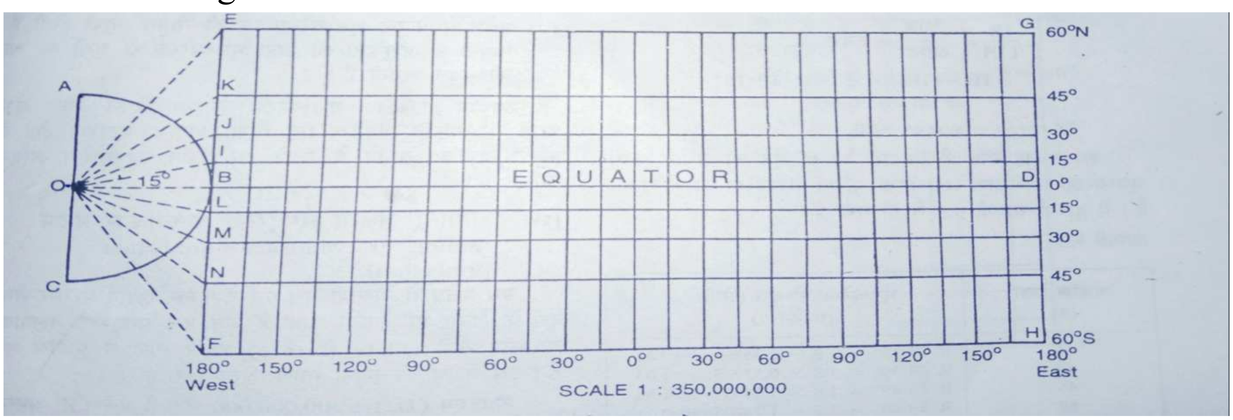


Fig. 3

Example . Make a equidistant cylindrical projection to scale 300,000,000 and map the world at 15 intervals.

Composition - According to the question,

(1) The radius of the Earth's miniature sphere, That is

$$R = 635,000,000 / 300,000,000 = 2.1 \text{ cm.}$$

$$\text{Of equator. Length} = 2\pi R$$

$$= 2 \times 22 \text{ x } 2/1 .7 = 13.2 \text{ cm}$$

(3) Distance between two longitudinal lines $= 2\pi R \times \frac{\text{intervals (degrees)}}{360}$

$$= \frac{13.2 \times 15}{360} = 0.55$$

above calculation work. After that draw a straight line AB of 13.2 cm long (Fig. 13). It will be the equator in the interpolation. Raise CD at the A point of this line and EF perpendicular to point B. Now by geometric method or filling distance of 0.55 cm in type AB line. Divide it into 24 equal parts and draw perpendicular points on both sides of the equator like CD. These perpendicular lines will reveal the longitudes in the interpolation. The CD line on either side of the A point is six at a difference of 0.55 cm. Put signs and complete the latitudinal circle by drawing lines parallel to the equator from these pictures.

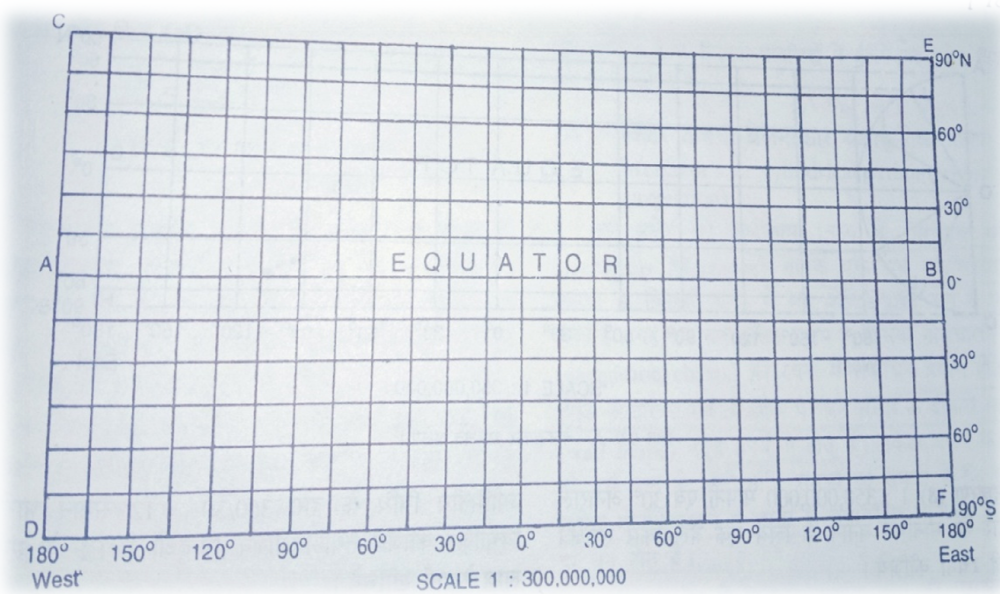


Fig. 4

Example: Construct a cylindrical horizontal projection to map the world at a scale of 350,000,000 and at 30 ° intervals.

Graphical method - According to the question,

R = 635,000,000/350,000,000 =1.8 cm

Length of equator = 2πR

$$= \frac{2 \times 22 \times 1.8}{7} = 11.3\ cm$$

Distance between two enclosed longitude lines $= 11.3 \times \frac{30}{360} = 0.94\ cm$

To make a projection of make ABC as half of the circle with a radius 1.8 cm, assuming a point 0 as the center, in which the AC line is the polar diameter of the circle (Fig. 14) with 10 and B joining the points. Go ahead and cut the BD line equal to 11.3 cm (i.e., equator) in the extended line. Draw EF at point B and GH at point D. These perpendicular lines will reveal longitudinal lines of 180 ° west and 180 ° east respectively in interpolation. Now draw the lines O and OJ upwards at an angle of 30 ° at the 0 point of the OB line. Similarly, draw OK and OL lines at the bottom. Complete the latitudinal circles of 90 ° N, 60 ° 30,30 ° 30, 30 ° 60, 60 ° D and 90 ° D by drawing lines parallel to BD from points A, J, I, K, L and C. To make the remaining longitudinal lines, the BD line should be spaced at 0.94 cm

BLOCK 2 : TECHNOLOGY AND ITS APPLICATION IN GEOGRAPHY

UNIT 5 : AERIAL PHOTOGRAPHY

5.1 OBJECTIVES

The objective of this chapter is to understand the technology of an aerial photography in the field of remote sensing and their use in mapping and updating the maps. Students have to understand how to plan for aerial photography. They can also understand the types of an aerial photograph and their use. The students has to understand about the photo-interpretation and photogrammetry.

5.2 INTRODUCTION

The term an 'Aerial photography' means a process of taking photographs from an airborne platform, in general, photography from the air by the mean of an aircraft. It gives a *bird's eye view* of the earth surface because photo has been taken from a certain height.Basically, the term 'photography' derived from a Greek word *photos* means *light* and *graphy* means *writing w*hich means, '*Drawing with Light'*. Photograph is a picture which is formed by the action of light on a base material coated with an emulsion which is sensitive to light. The base material may be a plastic or a paper. It may be positive or negative image recorded, permanently on a sensitised material through the action of light by the camera. The electro-magnetic spectrum, ranges between 0.3µm and 1.2µm wavelength is used for photography is also known as photographic region.The importance of an aerial photography increased in the inaccessible areas where the ground survey is very difficult such as high mountain ranges, forest area, big water bodies, desert area. The traditional field survey on the ground is very tedious and time consuming but in an aerial photography it can be happened within few hours. It also provide base for mapping and updating the large area especially urban environment because it provide detail pictorial view about an area photographed.

There is also some limitation in an aerial photography due to bad weather condition when the flight cannot be taken place to perform an aerial photography. Another issue is to identify the feature on an aerial photo. There is no symbology available on the photograph as well as it provides the top view of the earth features, so the interpreter must have the knowledge of the elements by which they can identify the features on the photograph. On the map, the scale is uniform throughout the map but in the photograph it is not uniform because of the central projection system so photogrammetric knowledge is must before making the quantitative analysis of an aerial photograph. But, the conjunction with field work, existing topographic map and an aerial photography technology are complementary to each other for understanding the changing nature of our earth features.

Purpose of photograph:

There are two basic purposes of photograph; one is photogrammetry and another is photo-interpretation. Photogrammetry is a science of obtaining reliable measurements by means of photograph in order to primarily determine geometric characteristic such as position, size, and form of the object in photograph. The term photogrammetry is derived from Greek words photos (light), Gramma (written), and Metron (measure), means measuring from a photograph. The photogrammetry is a technique of taking quantitative measurements by using an aerial photographs. When the photograph is used in such a way to get descriptive information about the photographed object such as built-up area, agricultural area, forest etc., then the photo-interpretation term is used in different disciplines such as geography, geology, forestry, urban planning etc. An act of examining an aerial photographs for the purpose of identifying objects and judging their significance is process of photo-interpretation.

5.3 METHODS & TYPES OF AERIAL PHOTOGRAPHY

Flight planning for vertical aerial photograph:

The planning of flight is depends on the objective of the study. There are various important issues should be checked as follows:

Study area delineation*:* This is the most important to delineate the study area accurately in terms of size and shape before flying the aircraft.

Flight lines*:* It should be parallel, oriented in the correct direction. For the maximum efficiency of the aircraft, the flight line should be parallel along the axis of the study area.

Film*:* The camera film is determined by the use of the photograph. It can be panchromatic, natural colour and infrared.

Overlap and side lap *:* For the stereo-pair, overlap should be 60 per cent along the flight line and 20 per cent should be side lap between adjacent flight line. At the beginning and end of the each flight line at least two photographs should be added as a margin for assurance of total coverage.

Scale of photography*:* The scale of the photograph that determine the height of the flight. It is the ratio between focal length and flying height.

Required time and season*:* Depends on the user need, the season and time is decided. The acceptable cloud cover also should be specified by the user.

Type of an aerial photograph:

There are different criteria to classify an aerial photographs, depending upon the following:

1. On the basis of *frame,*an aerial photograph can be single or multi-frame. The single frame photograph is a common type of photograph when single camera lens is used for photography such as vertical and oblique photography. The multi-frame photograph is a composite type of photographs taken with two cameras with single lens or one camera having two or more lenses. The photographs are combinations of two or four, eight obliques around a vertical. The obliques are rectified to permit assembly as verticals on a common plane. This type of photograph can be used to make 3-D models for emergency work. Trimetrogon and convergent type of photography

produce multi-frame photographs. The trimetrogon type of photography is an assemblage of three photographs taken at the same time, out of three one vertical view and two high oblique camera in a direction of the flight line at right angle are used for photography as shown in figure 5.1. The combination these three camera produce horizon to horizon composite photograph with two side obliques and one vertical.

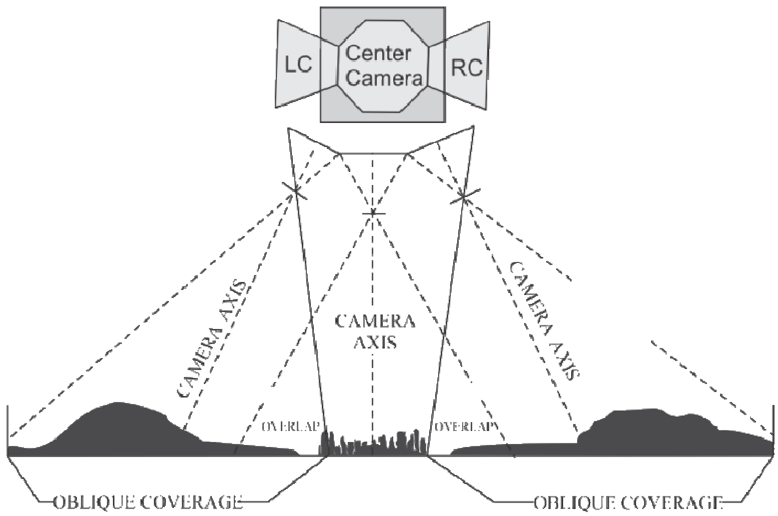


Figure 5.1: Trimetrogon photography

Another, multi-frame type photography is convergent photography. This is combination of a single twin-lens wide-angle camera, or two single-lens, wide-angle cameras which are parallel to the flight line as shown in figure 5.2. Both camera are intentionally tilted around 15^0 to 20^0 from vertical and exposed at the same time. This is used for reconnaissance survey.

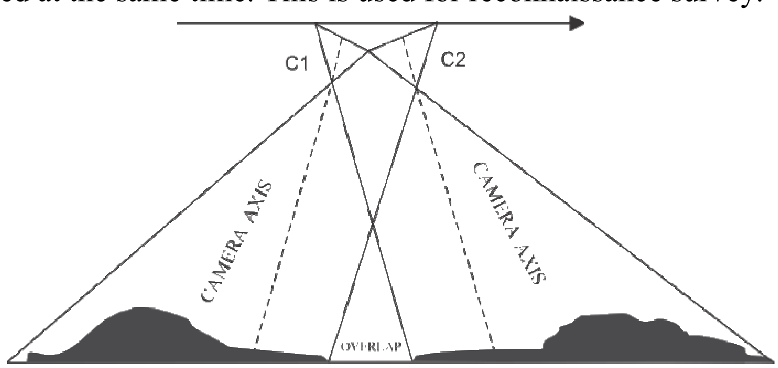
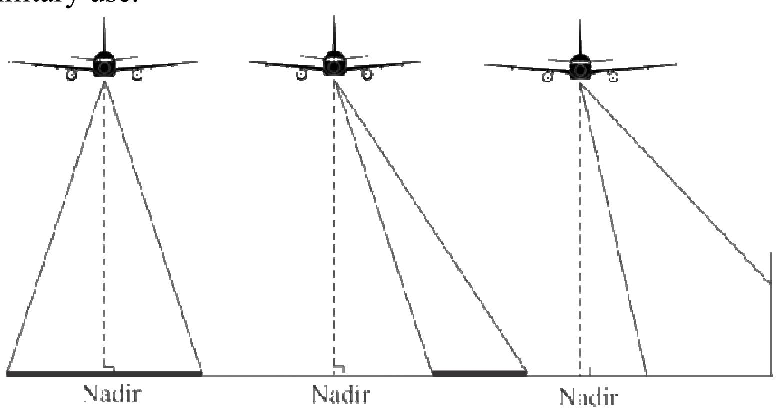


Figure 5.2: Convergent photography

2. On the basis of *scale,*an aerial photograph can be small, medium and large scale. In the small scale of an aerial photograph, the RF are larger than 1: 50,000; medium scale the RF are in between 1:20,000; and 1:50,000; in large scale the RF between 1: 20,000 or less. The scale factor is basically a relative concept, for example 1:100,000 are small scale and 1:50,000 is large scale.
3. On the basis of *tilt,*an aerial photograph can be divided into two part i.e. vertical aerial photograph and oblique aerial photograph (Figure 5.3). Tilt is an intentionally inclination of the camera axis. The angle subtended at the perspective centre between the optical axis of the

camera and the vertical. The direction of tilt is represented by swing. Vertical air photograph are taken with the axis of an aerial camera vertical or near vertical which is less than 3 degree. The vertical photographs are taken directly above the object or phenomena and closely resemble a map. It is normally used for cartographic use and photo-interpretation. The shape of the vertical aerial photograph is almost square and it covers smaller area than oblique photograph. The camera lens axis is directly perpendicular to the earth surface so the relief is not visible. On the uniform surface, direction and distance is more precisely measure (Table 5.1).

When the photograph is taken the side of an aircraft with the optical axis of an aerial camera intentionally tilted from the vertical are known as oblique photographs. These photographs cover large areas of ground but clarity of detail diminishes towards the far end of the photograph. Oblique aerial photograph is basically two type one is low oblique and another is high oblique. In the low oblique photograph taken with the camera which is inclined about 30° from the vertical axis. The shape of the ground coverage is trapezoid, although in the vertical aerial photographs it is square or rectangular. It seems the top view of a high rise building or the hill top. The scale of the entire low oblique is not uniform so measurement is not correct. In this low oblique photograph the horizon is not visible due to low inclination, it shows only ground at far. The basic application of low oblique is for reconnaissance survey for damage assessment due to natural calamities such as flood, drought, and defense use as well as it is used as map substitute. The high oblique is a photograph taken with the camera inclined about 60° from the vertical axis and horizon is always visible. The relief feature of earth is visible due to high inclination of camera axis. The major application of this type of photograph is for making the aeronautical charts and some military use.



(a) (b) (c)

Figure 5.3: (a) Vertical, (b) low oblique and (c) high oblique photography

Table 5.1: *Characteristics of vertical, low oblique and high oblique photography*

Sl. No.	Type of photograph	Vertical	Low oblique	High oblique
1.	Characteristics	Tilt smaller than 3°	No horizon	horizon
2.	Coverage	Least	Less	Greater
3.	Area	Rectangular	Trapezoidal	Trapezoidal
4.	Scale	Uniform, if flat	Decreases from foreground to background	Decrease from foreground to background
5.	Difference in comparison with map	Least	Less	Greater
6.	Advantage	Easiest to map	Economical and illustrative	Economical and illustrative

4. On the basis of *Angular coverage* of the camera lens, an aerial photograph can be narrow, normal, wide and super wide angle. In the narrow angle photography the focal length of the camera is more than 60 mm and coverage angle is less than 50 degree. The normal angle coverage is 60 to 75 degree where the focal length is around 30-35 mm. In the wide angle the coverage is 75 to 100 degree and focal length is less than 15 mm. In the super wide angle the coverage is more than 100 degree and the focal length is 8.5 mm. There is an inverse relationship between the focal length and coverage angle (Figure 5.4).

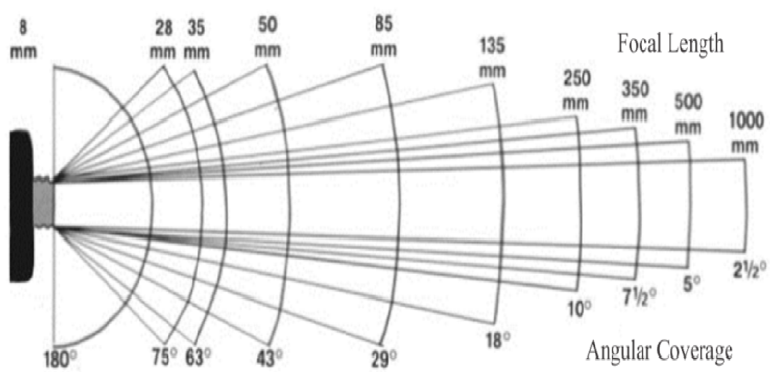
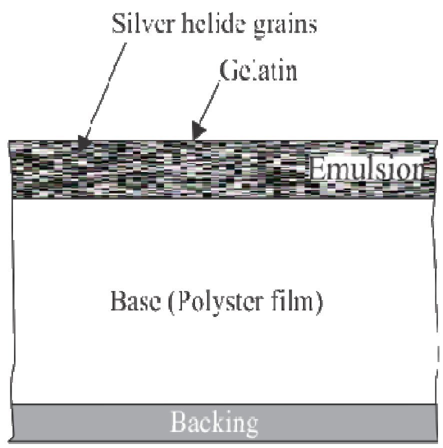


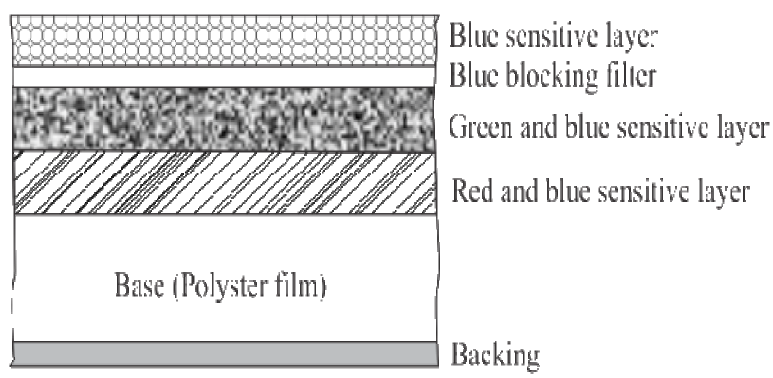
Figure 5.4: Focal length and angular coverage of camera lens

5. On the basis of *camera film,*an aerial photograph can be categories into four i.e. panchromatic black and white, infrared black and white, aero-colour (true colour) and acro-crome infrared (false colour). The light sensitive emulsion of silver halide crystals on a base of paper, plastic film or glass, which is exposed in a camera to form images (Figure 5.5). The black and white

panchromatic records the amount of light reflected from objects in tones of gray running from white to black and most of an aerial photography is taken with panchromatic film. Infrared black and white film is sensitive to infrared waves. It can be used to detect artificial camouflage materials and to take photographs at night if there is a source of infrared radiation. This is very much use in military purpose. The true colour ofan aerial photography is limited in its use because of the time required to process it and its need for clear, sunny weather for photography. The acro-crome or false colour is a special type of film that records natural vegetation in a reddish color. When artificial camouflage materials are photographed, they appear bluish or purplish colour. This film is also known as camouflage detection film.



Black & White



Colour

Figure 5.5. Film Structure

Panoramic photography: This is a scanning type of camera that sweeps the area of interest from side to side in the direction of flight line as shown in figure 5.6. The coverage of the panoramic photograph is very wide used for reconnaissance survey. It is different from the frame camera which is exposed in such a way that gives sufficient overlap between successive frames.

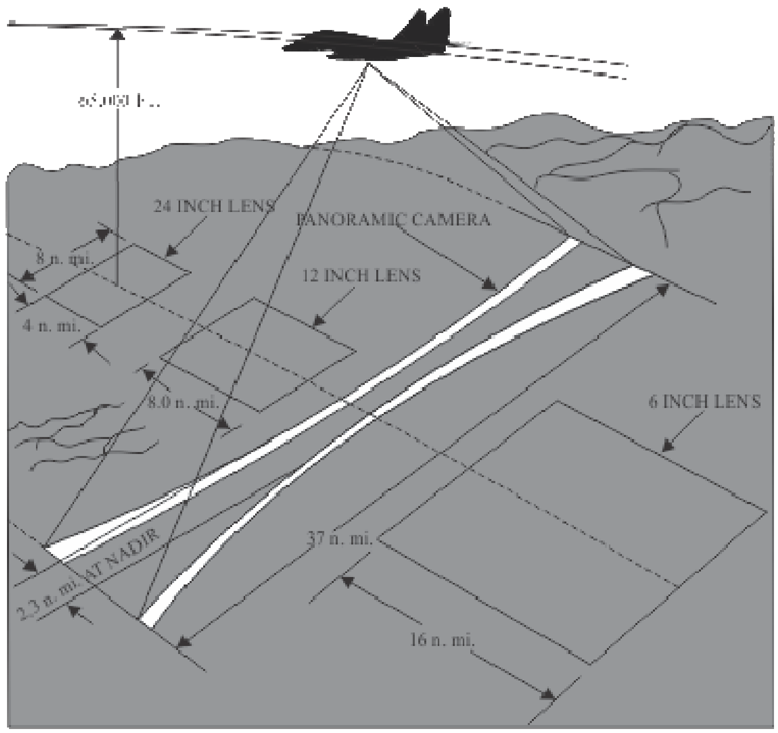


Figure 5.6: Panoramic photography

Elements of An aerial Photo/Image Interpretation:

Tone: It refers to the relative brightness or tonal variation on a photographic film and photograph represents the radiance value received by the sensor from the object of the earth's surface. Some objects appear darker and crispier than others. Light tones represent areas with a high radiance and dark tones represent areas with low radiance. The nature of the materials on the earth's surface affects the amount of light reflected. The terms light, medium and dark are used to describe the tonal variation. For example, the area of laterite soil is dark grey in tone and the areas of salt affected soil are light grey in tone; dry soil has light tone and wet soil has dark tone in photograph.

Colour: The objects are easily identify in first instant by the colour. In the multispectral imagery, colour is most important element to discriminate two features which cannot be easily identified by tonal variation in panchromatic imagery. For example, in the true colour image healthy vegetation represented by green colour but I panchromatic, it is represented in grey colour, even in standard false colour composite, it will represent red in colour. The tone and colour is the basic and primary elements of the interpretation(Figure 5.7).

Size: Some features are easily identified by the size of the objects. It is with reference to the length, width, perimeter and area in the context of the scale of the photograph. The size is a relative term which may be small, medium and big, varying according to the scale of the photograph/imagery. The size of the water body will help to determine a small pond or a big lake. National highways can be easily distinguished from smaller roads. Long rivers can be distinguished from smaller tributaries. Residential area is easily distinguished from industrial area in urban environment.

Shape: Shape refers to the geometric shapes such as linear, curvilinear, circular, elliptical, radial, square, rectangular, triangular, hexagonal, star, elongated, etc. Consolidated agricultural areas tend to have geometric shapes like rectangles and squares. Streams are linear (line) features that can have many bends and curves. Canals, roads, railway line frequently have fewer curves than streams. Stadium may be circular or elliptical shape. Some objects can be identified almost solely on the basis of their shapes such as Pyramid in Egypt, Pentagon building in USA.

Texture: This is the roughness and smoothness of the features in an aerial photograph/imagery. It is the arrangement of tonal variation or repetitions of tone and colour in an aerial photograph/imagery. The textural classes may be smooth (uniform, homogeneous), intermediate, and rough (coarse, heterogeneous) represent relatively. The grass appears smoother than the forest. Paddy field appears smoother than sugarcane field. The water in the lake and cemented area appears smoother than ploughed agricultural land. The size, shape and texture are the secondary element for interpretation.

Pattern: The feature of the earth surface produces regular, linear, systematic, irregular or randomly spatial arrangement. It may be natural or the man-made features. The difference between planned (systematic) and unplanned (random) cities. Chandigarh city has checkerboard pattern while Connaught Place in New Delhi is radial pattern. The pattern of the drainage such as radial, trellis, dendritic, etc.The difference between forest, forest plantation and orchards. The pattern formed by the feature in the photograph/imagery can be used to identify the objects.

Shadow: The shadow is a clue to identify an object which is cast by the object on the vertical aerial photograph. These shadows provide more information than the object themselves in the photograph particularly height determination. For example the shadows cast by hill or mountain to identify physiographic information, QutubMinar, Eiffel tower, bridge or sign board are often more informative. It also helps to determine the height of the features such as high rise building in an aerial photograph. The pattern and shadow are the tertiary element of interpretation.

Site or Location: It is refers to geographical location. This characteristic of photograph/imagery is more important in identifying the feature located in particular area or region such as various vegetation types and landforms. For example, some tree species are found more commonly in one geographic location than in others such as evergreen forest, mangrove, etc; some landforms are found in particular location such as sand dunes, alluvial fans, river delta, large circular depressions in the ground are identified as sinkholes in central Florida; some cultural features such as brick-klins, thermal power plant, nuclear power plant.

Association: Some objects on the earth surface are always found in association with other objects. These associated features provide clue to identify the object such as sugar mill associated with surrounded by sugarcane agriculture field, molasses tank, storage godown, etc. A vegetated area within an urban setting may be a park. Commercial centers will likely be located next to major roads, rail, or waterways. Industrial areas are associated with several clustered. Some structures may also help us determine the precise nature of enterprises such as combination of one or two tall chimneys, a large central building, along water way, cooling towers and solid fuel piles point to correct identification of a thermal power station.

Resolution: Resolution of a sensor system may be defines as its capability to discriminate two closely spaced objects from each other. It may be high, medium and low resolution, relatively.

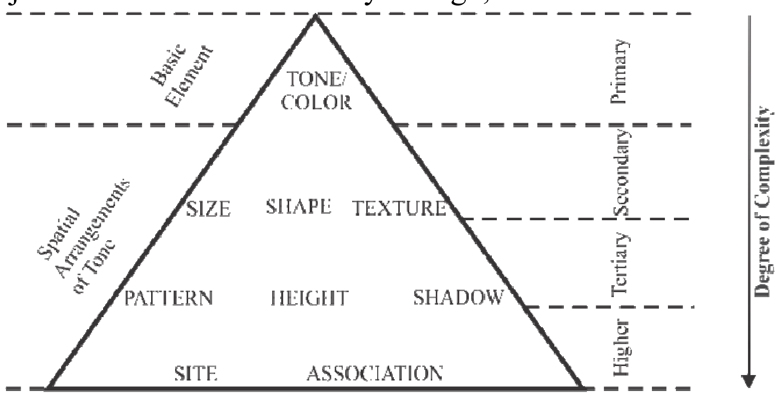
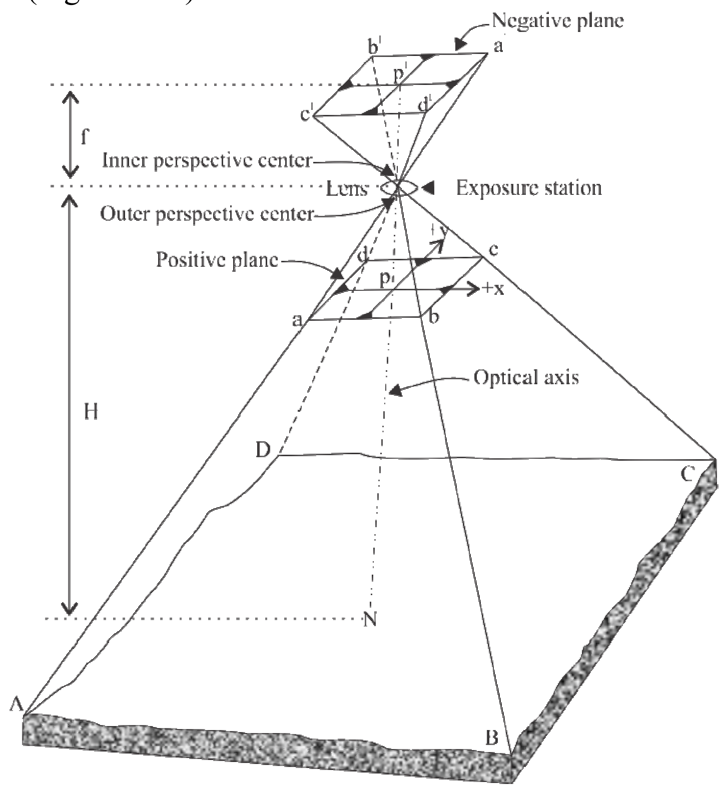


Figure 5.7: Elements order for feature identification

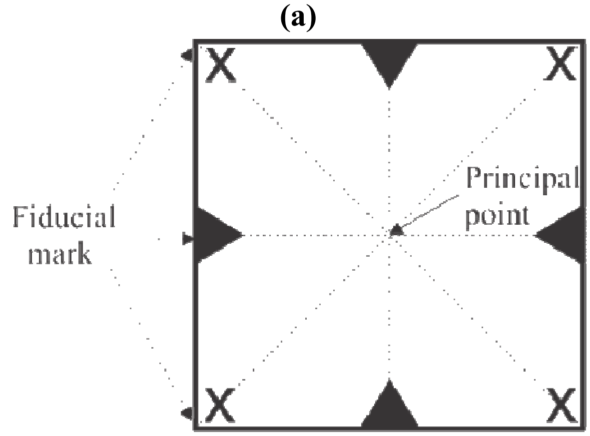
The small features can be identified from the high resolution imagery. For example cadastral level or infrastructure mapping needs the high resolution imagery where individual plots or houses can be drawn. The regional level mapping requires comparatively low resolution imagery.

Geometry of an aerial photograph

The vertical aerial photographs taken from an exposure station of an aircraft with the axis of an aerial camera is true vertical (without any tilt) or near vertical where unintentional tilt is less than 3 degree. The extent of an area A, B, C, D (Figure 5.8a) is photographed from exposer station and impression is made on negative plane a’, b’, c’ and d’. The exposure station is basically the centre of the camera lens, where all light from the ground are converge and diverge to the negative plane of the camera known as perspective centre. It is the point of origin (inner perspective centre) or termination (outer perspective centre) of perspective rays. In a distortion free lens camera system, perspective rays from the interior perspective centre to the photographic images form the same angles, as do the corresponding rays from the exterior perspective centre to the objects photographed. The distance between the camera lens and ground (datum), usually mean sea level is known as *flying height* (H), and the distance between camera lens to negative plane is called *focal length* (f). It is the perpendicular distance from the interior perspective centre to the plane of the photograph. The negative plane has a reversal of tone and geometry of the feature on ground and the positive (tone and geometry are similar as ground feature) can be obtained by the contact printing (a, b, c and d) (same focal length) of the negative photo. The point on the ground surface vertically below the camera centre at the time of exposure is known as *nadir point* (N) and the same location on photograph is known as *principal point* (p' on negative plane and p on positive plane). It is the foot of the perpendicular from the interior perspective centre to the plane of the photograph. On photograph corner or side, there are four to eight crosses or arrow marks known as *fiducial marks*and by intersecting these fiducial marks to get the principal point (Figure 5.8b).



(a)



(b)

Figure 5.8 (a), (b): Geometry of vertical aerial photograph.

The stereo-pairs photographs are taken continuously and maintaining overlaps (60 per cent) between consecutive aerial photographs. This pair of photograph known as a stereo-pair can be used for flight line determination and three-dimension visualization with the help of stereoscope (Figure 5.9 a, b).

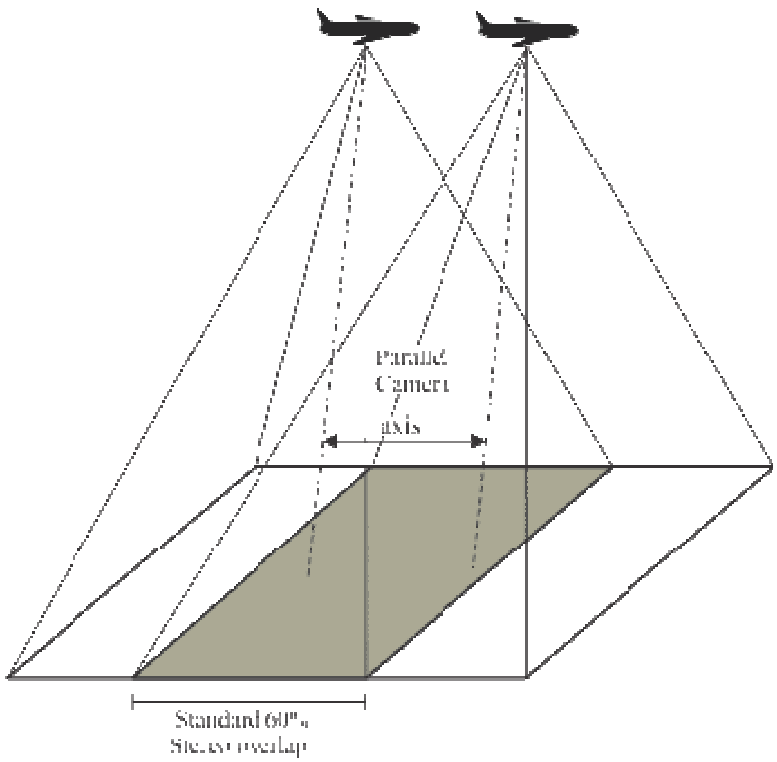


Figure 5.9 (a): Stereo-Photography

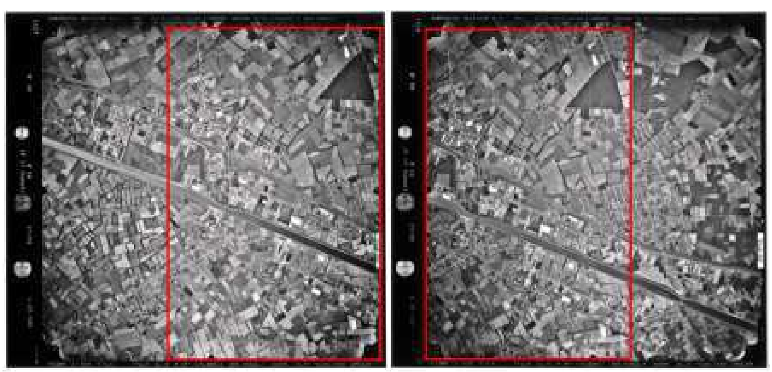


Figure 5.9(b): Stereo-pair (source: ims.seos-project.eu)

Stereoscope is a device by which stereo-pair are viewed to depth perception or three-dimensional (3D) views. It can be pocket or mirror stereoscope. The pocket stereoscope, sometimes known as a lens stereoscope, consists of two magnifying lenses mounted in a metal frame as shown in figure 5.10a. Because of its simplicity and ease of carrying, it is the type used most frequently by military personnel. The mirror stereoscope is larger, heavier, and more subject to damage than the pocket stereoscope. It consists of four mirrors mounted in a metal frame as shown in figure 5.10b.

Figure 5.10(a): Pocket stereoscope

Figure 5.10(b): Mirror stereoscope

Orientation of Stereo Model:

The stereo-pair can use for the orientation of stereo model under stereoscope by preparing the instrument base line about of 50 cm length as shown in figure 5.11. Mark a point C about 15 cm from A and draw a perpendicular line of 25 cm. Put the mirror stereoscope in such a way that the left eye looks straight on point C, then mark the point D on base line by fusing the both point (C,D). In this way the instrument base is prepared. The next step is to find the principal point (P1 and P2) on both stereo-pair by intersecting the fiducial mark on it and transfer the principal point of first photograph to second photograph and mark TP1 and similarly, transfer the principal point of second photograph to first photograph and mark TP2 with the help of mirror stereoscope. Fix the first photograph in such a way that the principal point coincide over C at flight line. The successive photograph is fixed at point D in such a way that the TP1 coincide over the D point. In this way the principal point and conjugate principal point (TP1 and TP2) are in straight line that shows the flight direction and stereo-pair is ready for the stereoscopic view with the help of mirror stereoscope.

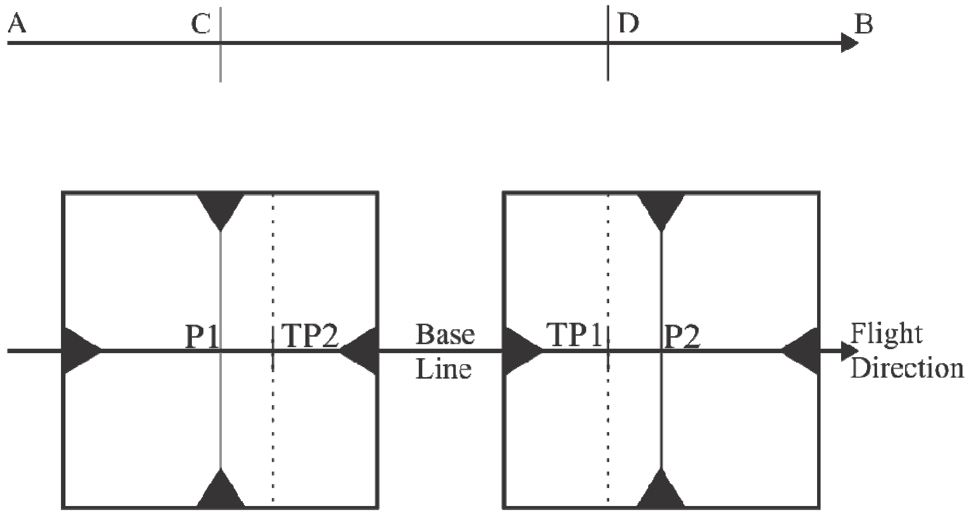


Figure 5.11: Orientation of Stereo-pair for Stereoscopic View

Scale of an aerial Photograph

Scale is the ratio of the distance measure on a map to the corresponding ground distance. The scale of an aerial photograph, hence, show relationship between the distance on the photograph and the corresponding ground distance. Conventional methods of expressing scale include the use of fraction and also the statement in different units. The scale of an aerial photograph is determined by a number of ways. In order of decreasing accuracy there are three major methods to establish relation to ground, map and focal length.

1. Establishing the relation of an aerial photograph to ground: If the corresponding distances of an aerial photograph and ground are known, the photo-scale can be determined by using the formula

$$SP = \frac{DP}{DG}$$

Example 1: If the distance between two points on an aerial photograph is 2cm and corresponding distance on ground is 200 mtrs. Find the scale of an aerial photograph.

Solution: DP (Distance on photograph) = 2 cm

DG (Distance on ground) = 200mtrs.

$$Scale\ of\ the\ aerial\ photograph\ = \frac{DP}{DG} = \frac{2\ cm}{200\ metre}$$

$$= \frac{1\ cm}{100\ metre} = \frac{1\ cm}{10{,}000\ cm}$$

The scale of an aerial photograph is 1:10,000

Establishing the relation of an aerial photograph to map scale: the scale of an aerial photograph can be determined if a reliable map of the area is available. The photo-scale can be determined by using the formula

$$SP = \frac{DP}{DM} \times MAP\ SCALE$$

Example 2: If the distance between two points on an aerial photograph is 10centimetre and corresponding distance on map is 5centimetre. calculate the scale of an aerial photograph when the scale of the map is 1:50000

Solution: DP (Distance on photograph) = 10 centimetre

DM (Distance on map) = 5 cm

Map Scale 1 : 50000

$$Scale\ of\ the\ aerial\ photograph = \frac{10cm}{5cm} \times \frac{1cm}{50{,}000cm}$$

$$= \frac{10cm}{2{,}50{,}000cm} = \frac{1cm}{25{,}000cm}$$

The scale of an aerial photograph is 1:25,000

Establishing the relation between focal length of the camera and flying height. There are three equations to calculate the scale of an aerial photograph at different terrain condition.

In the vertical aerial photograph of the uniform terrain at mean sea level then the scale of an aerial photograph is the ratio between focal length and flying height.

$$SP = \frac{f}{H}$$

Example 3: If the focal length of the camera lens is 15cm and the flying height of the aircraft is 5000 metre as shown in figure 5.12, then calculate the scale of an aerial photograph.

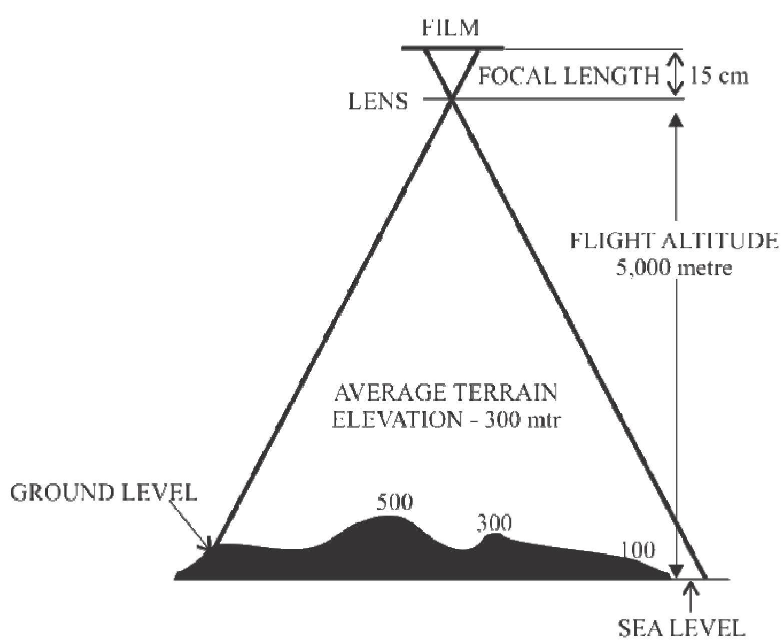


Figure: 5.12: Geometry of an aerial photograph

Solution: Focal length (f) = 15cm

Flying height (H) = 5000 metre

$$Scale\ of\ the\ aerial\ photograph = \frac{15\ cm}{5{,}000\ mtrs.} = \frac{15\ cm}{5{,}00{,}000\ cm} = \frac{1\ cm}{33333.33\ cm}$$

The scale of an aerial photograph is 1:33,333.33 (Approx.). However, if the ground terrain is a table-land or ground above sea level, then the scale of an aerial photograph is determined by using formula:

$$SP = \frac{f}{H - h}$$

Example 4: If the focal length of the camera lens is 15cm and the flying height of the aircraft is 5000 metre, then calculate the scale of an aerial photograph when terrain height is 500 metre above mean sea level (msl).

Solution: Focal length (f) = 15cm

Flying height (H) = 5000 metre

Terrain height (h) = 500 metre

$$Scale\ of\ the\ aerial\ photograph = \frac{15\ cm}{5{,}000\ metre - 500\ metre}$$

$$= \frac{15\ cm}{4{,}500\ metre}$$

$$= \frac{15\ cm}{4{,}50{,}000\ cm} = \frac{1\ cm}{30{,}000\ cm}$$

The scale of an aerial photograph is 1:30,000 (Approx.).

If the ground terrain is not uniform, then the scale of an aerial photograph is determined by using formula:

$$SP = \frac{f}{H - h(avg)}$$

Example 5: If the focal length of the camera lens is 15cm and the flying height of the aircraft is 5000 metre, then calculate the scale of an aerial photograph when terrain height is 100, 300 and 500 metre above mean sea level (msl).

Solution: Focal length (f) = 15cm

Flying height (H) = 5000 metre

Terrain height (h) = 100, 300 and 500 metre

$$h\ average\ (avg.) = \frac{100 + 300 + 500\ metre}{3} = \frac{900}{3}$$

$$= 300\ metre$$

$Scale\ of\ the\ aerial\ photograph$

$$= \frac{15\ cm}{5{,}000\ metre - 300\ metre}$$

$$= \frac{15\ cm}{4{,}700\ metre}$$

$$= \frac{15\ cm}{4{,}70{,}000\ cm} = \frac{1\ cm}{31{,}333.33\ cm}$$

The scale of an aerial photograph is 1:31,333.33 (Approx.).

Mosaic:
Mosaic is an assemblage of two or more overlapping photographs by cutting, matching and pasting to form a continuous photography over a large area. The process of mosaic is known as mosaicking. In the large scale mapping, the study area is not cover in a single photograph, so there is a need to mosaic the continuous overlap photograph to make single map for updation or preparing new map. There are three types of mosaic on the basis of compilation method, controlled mosaic, semi-controlled and uncontrolled mosaic. The controlled mosaic is the assemblage of scaled and rectified photograph to fulfill certain map accuracy specifications. They are the good map substitutes for calculating distance and area of a feature. The semi-controlled mosaic is an assemblage of without rectified photograph or utilizing ground control points to fulfill some rough specifications of accuracy of the map. Uncontrolled mosaic is an assemblage of without any ground control point photograph. The photographs are oriented in position by matching corresponding features on adjacent photographs. There is an advantage of mosaic by substituting maps which may be not available or out of date. In mosaic, the details of surface features are not lost as compare to the map where few details are available. The mosaic presents a large area for study in a composite form for the planning purpose.

5.4 CONCLUSION

The aerial photography is an art of taking photograph from camera with several heights by using aerial platform in good weather condition. It is one of the tools to get the spatial database of our earth surface in few days of planning. Basically, the image is form on a emulsion coated paper or film which is sensitive to light, so photograph is a writing of light. An aerial photography has five criteria for their classification such as frame, scale, tilt, angle and colour. The different type of an aerial photography can use for different purposes. The main use of aerial photograph is photo-interpretation and photogrammetry. In photo-interpretation, we are identifying the features on the photograph and judging their significance for their existence on a single or stereo-pairs and photogrammetry solve the geometry of an aerial photograph by calculation such as scale, distance, etc. The consecutive photograph can be cut and paste to make a large map by the process of mosaic. The aerial photography conjunction with fieldwork and existing map can be complementary to each other for understanding he changing nature of our earth features.

5.5 SUMMARY

Basically, an aerial photography is an act of taking photograph from an airborne platform by the means of usuallyan aircraft. It provides a photograph of large surface area in a single frame. Photograph is a picture which is formed by an action of light on a base material coated with chemical, known as an emulsion that is very much sensitive to light. An aerial photography has a remarkable importance when area is inaccessible for ground survey such as flooded area assessment and it can be planned and implement in few days, as compare to satellite launching.

Due to the low height of the aircraft it provides a detailed picture of the ground surface which is very much useful in large area planning,especially an urban planning. The bad weather condition is an enemy of an aerial photography because a flight cannot be takeoff in a bad condition.

An aerial photograph can be classified by different criteria; one is on the basis of a frame,it can single-frame photographand multi-frame photograph; on the basis of scale, it can be large-scale, medium-scale and small-scale; on the basis of tilt of camera axis, it can be vertical photograph and oblique photograph; on the basis of angular coverage of the camera lens, it can be very narrow-angle, narrow-angle, wide-angle and super-wide-angle; on the basis of camera film, it can be panchromatic black and white photograph, infrared black and white photograph, true colour photograph and false colour photograph. The act of taking an aerial photograph by different criteria is also known as that kind of photography for example, colour photography can produce colour photograph and oblique photograph is produced by oblique photography.

However, an aerial photograph can be utilized for two purposes one is photo-interpretation and another is photogrammetry. The photo-interpretation is an act of identifying and judging their significance of the features in an aerial photograph. The photo-interpretation of an aerial photograph can be done on single or stereo-pair photograph. The cutting and pasting of stereo-pair can make a mosaic for large area mapping. The photo-interpretation can be done by using the photo elements such as tone, colour, size, shape, texture, pattern, shadow, location, association and resolution.

Initially, photogrammetry of an aerial photograph can be understood by the geometry of vertical aerial photograph. There are various methods of calculating scale from aerial photograph by establishing the relation between photograph and ground; photograph and map; focal length of camera lens and flying height of an aircraft. Before going for aerial photography, the perfect planning is required according the objective of the flight. The few issues must be checked such as delineation of the study area, number of flight lines, type of films, percentage of overlaps, scale, time, season, etc. The aerial photography conjunction with fieldwork and existing map can be complementary to each other for understanding he changing nature of our earth features.

5.6 GLOSSARY

- Aerial photograph : A picture formed by the action of light on a emulsion coated material such as film or paper which is sensitive to light.
- Aerial photography : An act of taking photograph from airborne platform.
- Convergent photography : The combination of two single-lens camera which is parallel to the flight line.
- Fiducial mark : The 4 or 8 marks on sides or corner of an aerial photograph, which is used to get the principal point by intersection these marks diagonally.
- Flight line : The uniform flying height of an aircraft where aerial camera exposes successively.

- Flying height : The height between the mean sea level and camera lens which is mounted of an aircraft.
- Focal length : The distance between camera lens and photo plane
- Forward overlap : The overlap of photograph in the successive direction on flight line.
- Nadir point : The point on the ground surface vertically below the camera centre at the time of exposure is known as *nadir point*
- Oblique aerial photograph : The photograph is taken from an aircraft with the optical axis of an aerial camera intentionally tilted from the vertical are known as oblique photographs.
- Perspective centre : The centre of the camera lens, where all lights from the ground are converge and diverge to the negative plane of the camera isknown as perspective centre.
- Photogrammetry : It is a science of measurement from an aerial photograph.
- Photographic Camera film : It is strip of transparent plastic coated with emulsion on one side of film that is sensitive to light.
- Photographic Emulsion : It is a light sensitive silver halide and gelatin coated on the film or paper to record light.
- Photographic region : The electro-magnetic spectrum, ranges between 0.3μm and 1.2μm wavelength is used for photography is also known as photographic region.
- Photo-interpretation : It is an act of identifying objects and judging their significance in the aerial photograph
- Principal point : The center of an aerial photograph which is marked by intersecting fiducial marks.
- Reconnaissance survey : It is an examination of study area in general by the means of road or aircraft.
- Sidelap : The overlap between the photograph of two adjacent flight line.
- Stereo-pair : It is a pair of aerial photograph of same area taken from two different positions for stereoscopic view.
- Stereoscope : It is an instrument to view stereo-pair to depth perception or three-dimensional view (3D view).
- Tilt : Tilt is an intentionally inclination of the camera axis.
- Trimetrogon photography : The combination 3 camera, assemble in a way that one camera looks true vertical and two camera looks high oblique to take photograph at the same time.
- Vertical aerial photograph : When the photograph is taken with the axis of an aerial camera vertical or near vertical where tilt is less than 3 degree.

5.7 ANSWER TO CHECK YOUR PROGRESS

Q1. Define stereoscope.

Q2. Define mosaic.

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5.10 TERMINAL QUESTIONS

Q1. What do you understand by aerial photography? Define types of an aerial photograph.

Q2. Discuss in detail an elements of image interpretation.

Q3. Write a short note on panoramic photography?

UNIT 6 : REMOTE SENSING

6.1 OBJECTIVES

The main objective of this chapter is to understand and develop a skill among the students to learn the concept of remote sensing to create near real time database for mapping.

6.2 INTRODUCTION

The term 'remote sensing' simply means 'sensing remotely'. The term 'remote' means distance, it could be one metre to thousands metre or more. Another term 'sensing' means acquiring knowledge. So remote sensing means acquiring knowledge from a distance. The literal meaning of remote sensing is not only the sensing but it includes the complete processes in which the data about the earth surface is recorded through electromagnetic energy, processing in the laboratory to make data usable for different application and analysis of rectified data in multidisciplinary approach.

Colwell (1966) define the term 'remote sensing' in its broadest sense merely means 'reconnaissance at a distance'. He also defined (1983) 'The measurement acquisition of information of some property of an object or phenomenon, by a recorded device that is not in physical or intimate contact with the object or phenomenon under study'. Further, he defined (1997) 'The art, science, and technology of obtaining reliable information about physical objects and the environment through the process of recording, measuring, and interpreting imagery and digital representations of energy patterns derived from non-contact sensor systems'.

Fussell (1986) defines 'Remote sensing is the acquiring of data about an object without touching it'.

According to *Robert A. Schowengerdt (1997)*'Remote sensing is the measurement of object properties on the earth's surface using data acquired by sensors on board aircraft and satellite'.

According to *Thomas M. Lillesand and Ralph W. Kiefer (2000)* 'Remote sensing is the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation'.

According to *James B. Campbell (2003)*, 'Remote Sensing is the practice of deriving information about the earth's land and water surfaces using images acquired from an overhead perspective, using electromagnetic radiation in one or more regions of the electromagnetic spectrum, reflected or emitted from the earth's surface'.

According to *John. R. Jensen (2007)*, 'Remote sensing is the process of collecting data about objects or landscape feature without coming into direct physical contact with them'.

Remote sensing is a multidisciplinary activity which deals with the inventory, monitoring and assessment of natural resources through the analysis of data obtained by observations from a remote platform. So remote sensing can be defined as an art, science and technique of collecting real information, without being physical contact with an object or phenomena through the sensor or camera from the various platforms over the wide range of electromagnetic energy by the means of tripod, aircraft or spacecraft or satellite for multidisciplinary activity.

Platforms and sensors

In remote sensing, platforms may be moving or static place where sensor can mount to collect the images or photo. In general, platform is a mean of holding the sensor aloft. It is a stage to mount the camera or sensor to acquire the information about the target under investigation. The moving platforms such as balloon, kite, pigeon, aircraft and spacecraft/satellites. The static platforms are high rise building, tripods, etc., used for collecting ground information (ground truth) or laboratory simulation or experimental purposes. On the basis of altitude above the earth surface, platform may be classified as, groundborne, airborne and spaceborne.

Type of platforms:

Groundborne : As the term imitate that, the sensor is positioned near to the ground by the means of tripod, building top, hand held or moving vehicle is a groundborne platform, to collect the information is known as groundborne remote sensing. The ground based remote sensing system for earth resources studies are mainly used for collecting the ground truth or field work or for laboratory simulation studies before sensor mounting on the airborne or spaceborne platform. It may be static or moving. E.g. camera or radiometer mounted to a pole or tripod or moving vehicle to assess the reflectance behavior of an object or phenomenon or a specific crop during day or season.

Airborne : when camera or sensor are mounted on an aircraft to collect the information about the earth is known as airbourne remote sensing. Earlier pigeon, balloons or kites was used for airborne remote sensing. This platform providesdifferent altitude (platform) and convenient to acquire the data in terms of time and requirements. Airborne observations are possible from 100 metres to35-30 km height above ground. The speed of the aircraft can vary between 140 – 600 km/hrs. In India the task of aerial photography is carried out by three agencies: Indian Air Force, Air Survey Co. (Pvt.) Ltd., Dum Dum, Kolkata and National Remote Sensing Centre (NRSC), Hyderabad.

Spaceborne : when the sensor is mounted on the satellite and placing with the help of satellite launching vehicle in the circular space orbit in spaceborne platform. The spaceborne platform provide the high speed of the satellite, large field of view and more spatial coverage due to continuous observations of the earth surface. This platform is not affected by the earth's atmosphere as in found in airborne platform. Depending upon the altitude, there are two types of orbit i.e. polar orbit and geostationary orbit, are used to place the satellites, depending on the objectives of the mission. The polar orbiting satellite moving north-south direction and cover the whole earth, placed at the height of around 700 km. Polar orbit satellites is also known as sun-synchronous satellite because it is synchronised with the local sun-time at same latitude or it passes over all the places on earth having the same latitude at the same local sun-time. For example, if satellite passes at 10.30 am on equator, then every local time satellite passes on equator at 10.30 am at different longitude. All the remote sensing resource satellite is the polar orbit. This orbit covers whole globe periodically and gives repetitive coverage. For example, Landsat, SPOT, IRS.

***Geostationary orbit* : As** name suggests, it is stationary with respect to earth. The geostationary satellite also has a motion from west to east direction and the speed of satellite is synchronised with the speed of the earth. The coverage of the satellite is near hemispheric i.e. 70^0 north to 70^0 south and it can view only one-third of the earth over the same area day and night. The view the whole earth requires at least three geostationary satellites. The geostationary orbits are also concentric but it has zero inclination, placed at height of 36000 km. The main use of this orbit is in the field of telecommunication and meteorology. E.g. GOES, METEOSAT, INSAT and GSAT series or telecommunication relay satellites.

Sensor:

The It measures reflected, scattered or emitted electromagnetic energy from the area of interest. Our eyes are also act as a sensor to see the object or phenomena but it has some limitations. The photographic camera, as we commonly use, is also a type of sensor that provide the photographs in digital as well as analog.

Type of sensor - Depending upon the *source of light*, sensor can be passive or active.

Passive sensor: If the sensor receiving the external source of energy, generally by the sun (reflected energy) as well as from the earth surface (emitted energy) emission, is a *passive sensor*. These sensors don't have their own source of energy and used in the day time by solar energy and at the night-time uses the emitted energy from earth i.e. thermal energy sensed by the thermal sensors.

Active sensor: If the sensor using their own source of energy then it is known as ***active sensor***. Flash gun with camera is act as active sensor by providing light to the target and reflected energy us received by the sensor. For example, RADAR (RAdio Detection And Ranging).

Depending upon the *sensor system,* sensor may be imaging and Non-imaging sensor system.

Non-imaging sensor: This includes sounders and altimeters for measuring of high accuracy locations; and topographic profiles, spectrometer and spectro-radiometer for measurement of high spectral resolution along-track lines or swath; and radiometers, scatterometers and polarimeters for high accuracy intensity measurements and polarisation changes measurements along-track line or wide swath.

Imaging sensor system: The sensor that provides image, are two types, one is framing system and another is scanning system. The photo of an area taken by the camera, frame by frame is known as framing system. It can be stored in photo sensitive film or digital media. This includes images from photographic film cameras, digital camera and Return Beam

Sensor's Resolution:

Resolution means resolving power. It is measure of the ability of an optical system or sensor to distinguish between signals that are spatially near or spectrally similar. Ability to separate closely spaced objects on an image or photograph. Resolution is defined as the ability of the sensor to render the information at the smallest discretely separable quantity in terms of*Distance (Spatial resolution), Wavelength band (Spectral resolution), Radiation quantity (Radiometric resolution) and Time (Temporal resolution).*

Spatial resolution: It is sensor capability to sense the ground segmentat any instant. It is also called ground resolution element (GRE). It can be defined as the Instantaneous Field of View (IFOV) which can be defined as the field of a scanner with the scan motion stopped. If one pixel is a ground cell sample of 5.8 by 5.8 metre then no objects smaller than 5.8 metre can be distinguished from their background. This does not mean that the object cannot be detected. Examples are IRS-1A / 1B, LISS-I sensor has 72.5 metre, LISS-II sensor has 36.25 metre, IRS-1C/1D, LISS-III sensor has 23.5 metre, IRS-P6 (Resourcesat) LISS-IV sensor has 5.8 metre spatial resolution.

Spectral resolution : The specific wavelength intervals in the electro-magnetic spectrum that a sensor can record. Spectral resolution of a remote sensing instrument (sensor) is determined by the bandwidths of the Electro-magnetic radiation of the channels used. High spectral resolution, thus is achieved by narrow bandwidths collectively, are likely to provide a more accurate spectral signature for discrete objects than broad bandwidth. Examples are IRS-1A/1B, LISS-I and II has 4 bands, LANDSAT 1-2 has 3 bands, TM has 7 bands,SPOT 3-4 multispectral has 5 bands, IRS-P6 (Resourcesat) PAN has 1 band.

Radiometric resolution: The number of digital levels (colour) used to express the data collected by the sensor. Number of discrete levels into which a signal strength may be divided or quantisation. In general, the greater the number of levels the greater the detail in information. For example 6 bit data has 64 levels (0 – 63), 7 bit data has 128 levels (0–127), 8 bit has 256 levels (0 – 255), 9 bit data has 512 levels (0 – 511) and so on.

Temporal resolution: It is a revisit period of the satellite over the same area or time between successive image acquisitions over same area. Temporal resolution is also called the repeativity of the satellite in the case of satellites. For example, IRS-1A/1B, 1C/1DLISS-I and II has 22 days, LISS-III has 24 days, PAN has 5 days; LANDSAT MSS has 18 days, TM has 16 days; SPOT has 5/26 days.

6.3 PRINCIPLES OF REMOTE SENSING

The remote sensing is totally dependingupon electromagnetic energy, refers to all energy that moves with the speed of light in a harmonic wave pattern and broadly, includes lights, heat and radio waves. It is propagating through the space in a sine wave with constant speed which has two fields, one is electrical and another is magnetic, called electro-magnetic energy (figure 6.1).

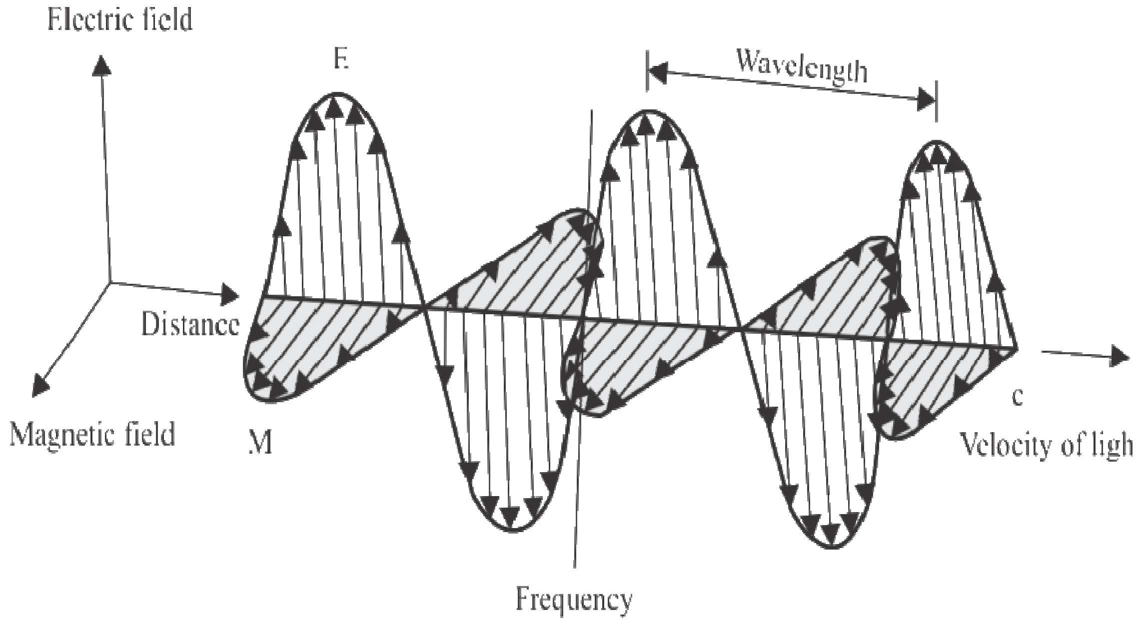

Figure 6.1: Electromagnetic energy

There are three measurements used to describe electromagnetic wave such as wavelength, frequency and velocity. The wavelength is distance between successive wave crests or troughs and it is denoted by *lamda* (λ), measured in metre (m), nanometer (nm or 10^{-9} m) and micrometer (μm or 10^{-6} m). The frequency (υ) is the number of cycles of a wave passing through a fixed point. It is measured in hertz (Hz), corresponding to one cycle per second. The speed or velocity (c) of the electromagnetic energy is equal to the speed of light i.e. 3×10^{8} metre/second (3,00,000 km/second or 186000 miles/second). There is a relationship between the wavelength, frequency and energy in the electromagnetic energy radiation (Figure 6.2). Shorter the wavelength, high the frequency and energy. Conversely, longer the wavelength, low frequency and energy. There is inverse relationship between wavelength and frequency. For example, gamma rays ($< 10^{-9}$ m) has more energy, high frequency and short wavelength whereas, radio waves (>1m) has less energy, low frequency and long wavelength. In remote sensing, it is very difficult to detect the long wavelength than short wavelength.

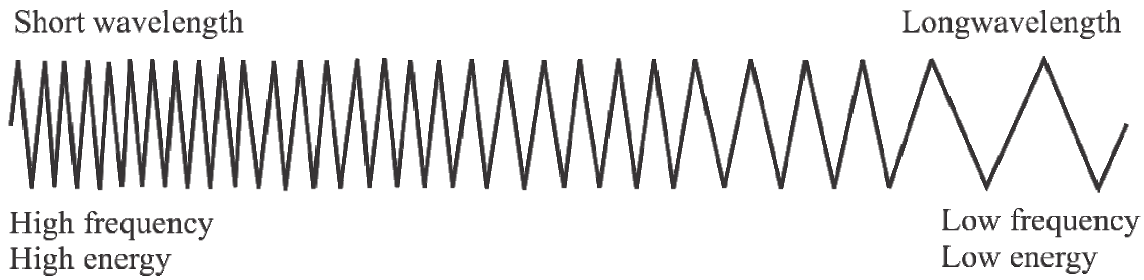

Figure 6.2: Relation between wavelength, frequency and energy

Electromagnetic Spectrum:

Theelectromagnetic energy is categories on the scale of wavelength is called the Electromagnetic spectrum (Figure 6.3). It is extending from the gamma rays (smallest wavelength) to radio waves (largest wavelength). It is categories into various spectral regions also known as spectral bands. The electromagnetic spectrum is divided into two parts, one is optical region and another is microwave region. Optical region of the electromagnetic spectrum refers to that part of the spectrum in which optical laws can be applied. These relate to phenomena, such as reflectance and refraction that can be used to focus the radiation. The optical ranges from X-rays (.02 µm) through the visible part of the electromagnetic to far infrared (1000 µm) region. The microwave region is extending from 1mm to 1 metre.

Gamma rays (shorter than 0.03 nm) and X-rays (0.03 nm to 0.3 µm): This region have been used to an even lesser extent because of atmospheric opacity. Their use has been limited to low-flying aircraft platforms or to the study of planetary surfaces with no atmosphere (e.g., the Moon). This spectral region is used mainly to sense the presence of radioactive materials.

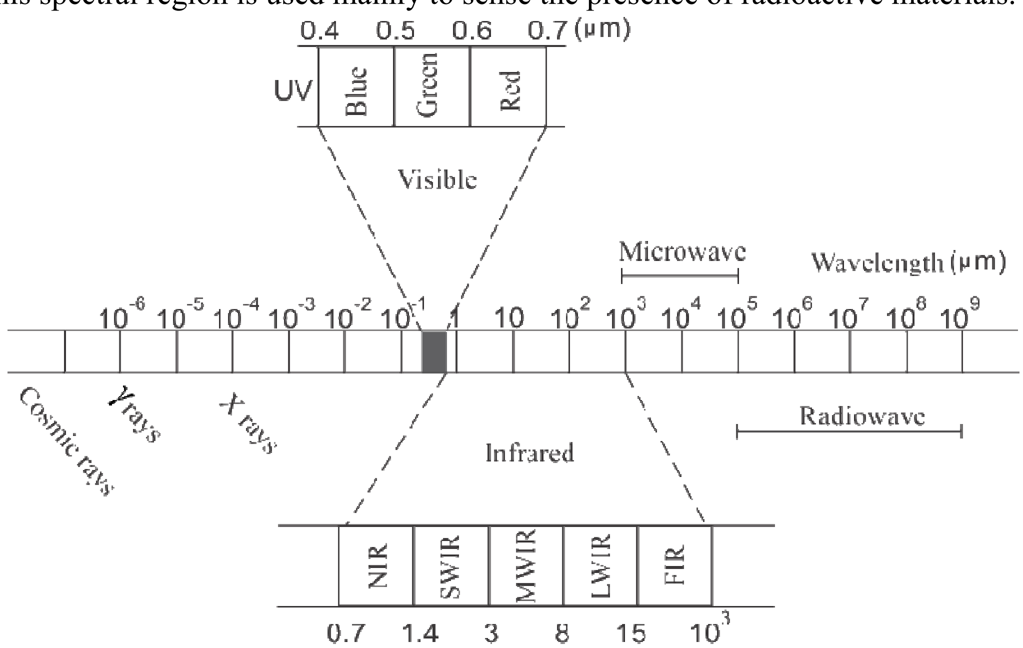

Figure 6.3: Electromagnetic spectrum

The ultraviolet region (0.3 µm to 0.4 µm): Ultraviolet sensors have been used mainly to study planetary atmospheres or to study surfaces with no atmospheres because of the opacity of gases at these short wavelengths. An ultraviolet spectrometer was flown on the voyager spacecraft to determine the composition and structure of the upper atmosphere of Jupiter, Saturn and Uranus.

The visible region (0.4**µm** – 0.7**µm**): This region plays an important role in remote sensing because it has maximum illumination by sun and widely available sensor to detect this energy. This is also known as 'light'. It occupies a relatively small portion in the electromagnetic spectrum but it only region that is associated with the concept of colour, i.e. blue, green and red which are known as primary colours.

Infrared region (0.4µm - 10^3µm): This region is sub-divided into sub-regions called reflected infrared, thermal infrared and far infrared. The reflected infrared divided into near infrared (NIR), wavelength is 0.7 µm to 1.4 µm and Short Wave Infrared (SWIR), wavelength is 1.4 µm to 3.0 µm. The thermal infrared also categories into Mid Wave Infrared (MWIR), wavelength is 3.0 µm to 8.0 µm and Long Wave Infrared (LWIR), wavelength is 8.0 µm to 15.0 µm. the far infrared sub-region wavelength is 15.0 µm to 1000 µm or 1mm.

The microwave region (1mm – 1metre): It covers the neighboring region, down to a wavelength of 1 mm (300 GHz frequency). In this region, most of the interactions are governed by molecular rotation, particularly at the shorter wavelengths. This region is mostly used by microwave sensors such as radiometers and radar systems.

The radio wave region (more than 10 cm): It covers the region of wavelengths longer than 10 cm (frequency less than 3 GHz). This region is used by active radio sensors such as imaging radars, altimeters, and sounders, and, to a lesser extent, passive radiometers.

Interaction of electromagnetic radiation with atmosphere:

The atmosphere is never completely transparent to electromagnetic radiation. However, at some wavelengths it has good transparency or absorbing characteristics. The atmospheric constituents restrict the interactions of the direct solar radiation and reflected radiation with the target called atmospheric effects. The atmosphere is interacting with electromagnetic radiation by Atmospheric refraction, scattering, absorption and reflection.

Refraction : It means the bending of light when it passes from one medium to another. Refraction occurs because the different density of atmospheric layers in which electromagnetic radiation passes through it. The amount of refraction is depending on the distance between source and target as well as density of the air. The locational error is occurring in the image due to refraction.

Scattering : The multiple reflections of electromagnetic energy by particles and surfaces is known as scattering. It is an 'unpredictable' reflections. (i*n reflection the direction of reflection is predictable).* Thereare three types of scattering occurs in the atmosphere such as rayleigh, mie and non-selective, depending on the size of the scatterers (atmospheric constituents) in relation to the wavelength of radiation being scattered.

- **(a) Rayleigh scattering**: When radiation interacts with atmospheric constituents such as molecules and other tiny particles that are much smaller in diameter than the wavelength of the interacting radiation, causing the sky to appear blue, otherwise black. It also causes the sky to appear orange to red at sunrise and sunset because the sun rays travel through a longer atmospheric path length than during noon. It effects on imagery to become hazy and reduce the crispness or contrast of the image.
- **(b) Mie scattering**: when particle size is equal to the wavelength such as water vapor and fine dust particles in the atmosphere, fulfill this condition for Mie scattering. It also effects the visibility in the imagery by heavy atmospheric haze
- **(c) Non-selective**: When particles size is larger than wavelength such as water droplets, fine dust particles and cloud with diameters ranging from 5 – 100 μm, that scatters allwavelengths of visible and near to mid infrared region.The fog and cloud appear whitish because the mixture of all the visible light, produces the white light.

Atmospheric absorption: The atmosphere is not open for all electromagnetic radiations to reach the earth's surface, some are absorbed by the constituents such as various gas molecules available in the atmosphere. The most efficient absorbers of solar radiation in this regard are water (H_2O), carbon dioxide (CO_2), ozone (O_3), oxygen (O_2) and nitrous oxide (CO_2). The cumulative effect of the absorption by the various constituents cause the atmosphere to close down completely in certain regions of the spectrum called atmospheric absorption band. There is no energy is available to be sensed by sensor. The absorption and scattering act to reduce the amount of radiation received by satellite and the combined effect of these two is called attenuation, the energy loss caused by the atmosphere.

Interaction of Electromagnetic Radiation with Earth Surface's Feature:
When electromagnetic energy is incident on any given earth surface feature, three fundamental energy interactions with them i.e. reflected, absorbed and transmitted (Figure 6.4).There is a close relationship between these three energy interactions as

$E_I (l) = E_R (l) + E_A (l) + E_T (l)$

$E_R (l) = E_I (l) – [E_A (l) + E_T (l)]$

Where

E_I = Incident Energy

E_R = Reflected Energy

E_A = Absorbed Energy

E_T = Transmitted Energy

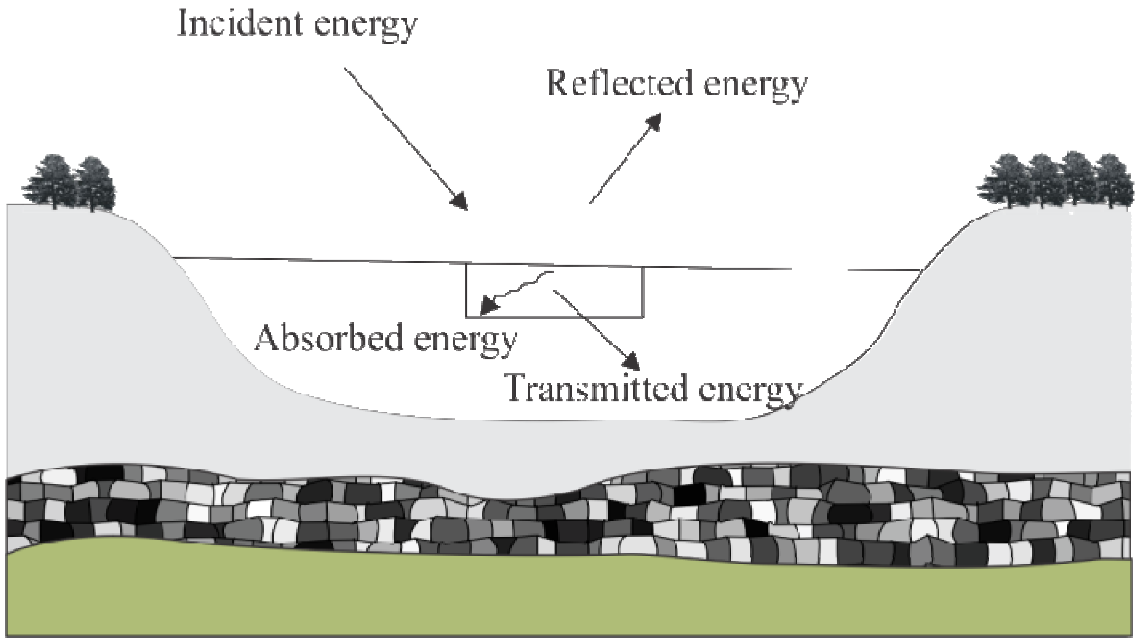

Figure 6.4: Interaction of Electromagnetic Radiation with Earth Surface's Feature

The proportions of energy reflected, absorbed and transmitted from earth features is depend upon the material type, condition and wavelength. These differences permit us to distinguish different features on an image. Thus, two features may be indistinguishable in one spectral range and easily distinguishable in another wavelength band. Many remote sensing systems operate in the wavelength regions in which reflected energy predominates, so the reflectance properties of earth features are most important to identify features in image (Table 6.1).

Table 6.1: *Atmospheric windows for remote sensing.*

	Spectral Regions	Spectral Bands
1.	VIS (Visible)	0.4–0.70 µm
2.	NIR (Near Infrared)	0.7–1.10 µm
3.	SWIR (Short wave Infrared)	1.1–1.35 µm 1.1–1.80 µm 2.0–2.50 µm
4.	MWIR (Mid wave Infrared)	3.0–5.00 µm 4.5–5.00 µm
5.	TIR (Thermal Infrared)	8.0–9.50 µm 10.0–14.0 µm
6.	Microwave	0.1–100 µm

Reflectance: It is a ratio of the reflected light spectrum to the incident light spectrum. The process by which a beam of particles or a wave in collision with an opaque surface may be deviated or reversed in direction. Reflectance may be s*pecular* or *diffuse*. Specular reflectors are flat surfaces that apparently mirror like reflections, where the angle of reflection is equals to the angle of incidence such as calm water or very smooth surface. The diffuse or Lambertian reflectors are rough surfaces that reflect uniformly in all directions (Figure 6.5). Most of the earth surfaces are neither perfectly specular nor diffuse reflectors. So their characteristics are in between the two extremes which is very much useful in remote sensing.

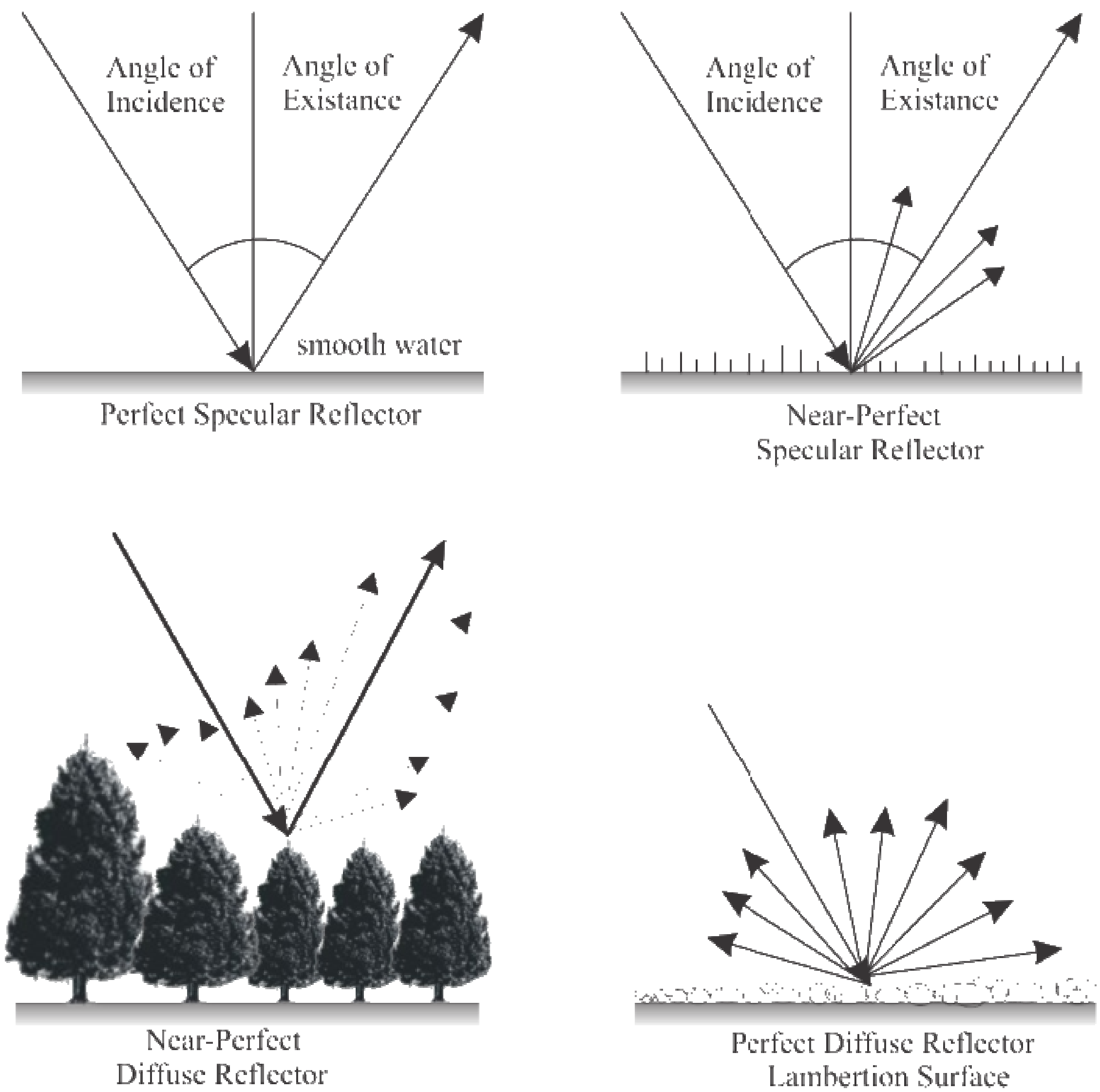

Figure 6.5: Reflectance behavior of specularand defuse energy

When the wavelength of incident energy is much smaller than the surface particle size that make up a surface, the reflection from the surface will diffuse. For example, in relatively long wavelength radio range, a sandy beach can appear smooth texture to incident energy, whereas, in the visible portion of the spectrum, it appears rough texture. In remote sensing,diffuse reflectance from the surface is most important because it contains spectral information or the 'colour' of the reflecting surface, whereas, specular reflection do not contain any colour, it appears bright or dark in the imagery.

The reflectance characteristics of earth surface features may be quantified by measuring the portion of incident energy that is reflected. This is measured as a function of wavelength called spectral reflectance. A graph of the spectral reflectance of an object as a function of wavelength is termed as a spectral reflectance curve (Figure 6.6).

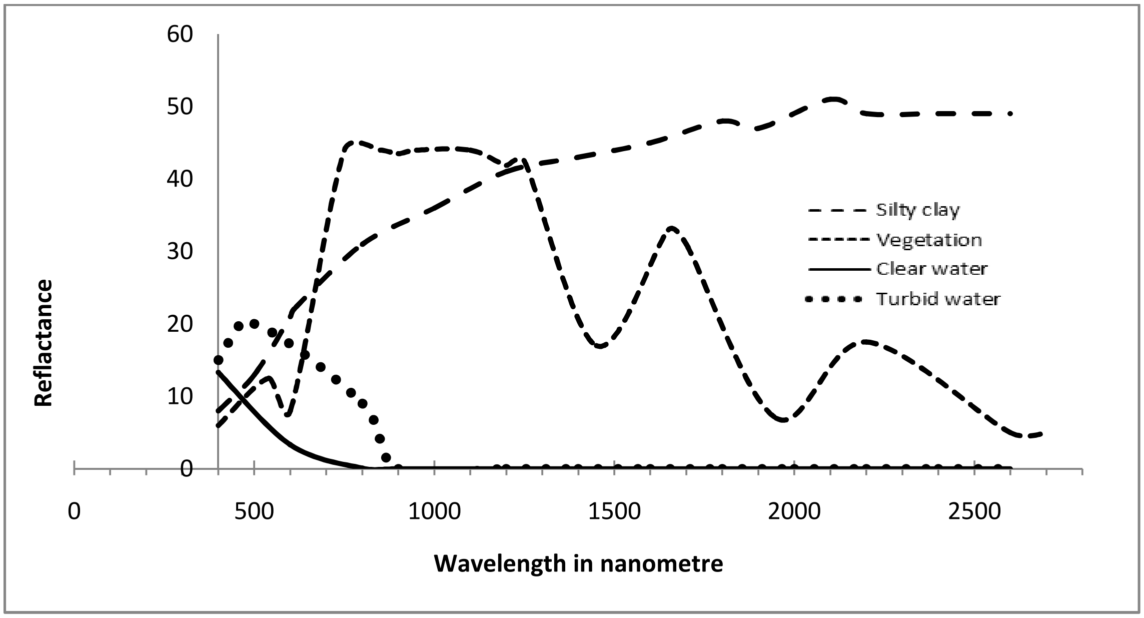

Figure 6.6: Spectral reflectance curve

Interaction of Electromagnetic radiation with soil : The various characteristic of the soil such as soil moisture, texture, surface roughness, minerals and organic matter,interact differently with the electromagnetic energy. Coarse texture of sandy soils are usually well drained, resulting low moisture content and relatively high reflectance of electromagnetic energy. Poorly drained fine-textured soil will generally have lower reflectance of electromegnetic energy. The absence of water in the soil will show the reverse tendency, coarse-textured soils will appear darker in the imagery than fine-textured soils. Surface roughness and organic matter like iron oxide in the soil decreasesoil reflectance.

Interaction of Electromagnetic radiation with vegetation : The vegetation is mostly consisting of leaf, contains pigment, chlorophyll, structure and moisture. Our eyes perceive healthy vegetation as green in color because of the very high absorption of blue and red energy by plant leaves and the very high reflection of green energy. The blue and red bands are the chlorophyll absorption region. The stress on plant decrease chlorophyll production, resulting less chlorophyll absorption in blue and red bands. The structure of the leaf is highly variable between different plant species such as banyan leaf, mango leaf, banana leaf, etc., near-infrared region can be useful to discriminate tree species, even if thy look same in visible region. There is a water absorption at 1.4, 1.9 and 2.7 µm is referred as water absorption bands and 1.6 and 2.2 µm wavelength has peak reflectance between absorption bands, used to identify the moisture condition.

Interaction of Electromagnetic radiation with water: As you know stagnent water surface is act as specular reflection. But the suspended material in the water and the bottom of the shallow water body interact differently with the electromagnetic energy. Clear deep water is act as a blackbody for the near infrared and beyond energy, that is absorbed by the water. The suspended material of water increases the reflectance of the energy. The chlorophyll concentration in the water tend to decrease reflectance in blue region and increase reflectance in green region, used to monitor the concentration of algae through remote sensing data. The snow has very high reflectance in visible region, but it drops in near-infrared region. The mid-infrared (SWIR) region is used to identify snow and cloud due to low reflectance by snow and comparatively high reflectance from cloud.

Atmospheric Window

The atmosphere interacts differently with the wide range of electromagnetic energy and selectively transmits energy of certain wavelengths of energy. These wavelengths offer maximum transmission and minimal attenuation through a particular medium with the use of a specific sensor.The spectral bands for which the atmosphere is relatively transparent are known as atmospheric windows. In another word, a portions or wavelength intervals of the spectrum that transmit radiant energy effectively are called atmospheric windows. These windows play important role in remote sensing of the earth resources from satellite platforms.

6.4 ELEMENTS OF REMOTE SENSING

In the remote sensing process, various mechanism/activities are involved while supplying the final data to the user community. The mechanism/activities are as follows (Figure 6.7).

(a) **Source of energy:** There are two natural sources of energy i.e. sun and earth. The sun is major source of energy in the form of electromagnetic energy that illuminate the object. The other sources energy is flash gun, radar, geo-thermal energy etc. which is interacting with an object.

(b) **Interaction of electromagnetic radiation with an atmosphere:** The electromagnetic energy travels through the different thickness of the atmospheric layer to reach the target. It travels twice a time in the atmosphere when it reaches to the sensor.

(c) **Interaction of electromagnetic radiation with an earth surface:** The energy is interacting with earth surface features such as land, water and vegetation. Depending upon the properties of the various features on earth, the electromagnetic energy interacted differently.

(d) Electromagnetic energy received by the sensor: After interacting the energy with an object on the earth surface, is reflected back to atmosphere. That reflected energy is acquired by the sensor. The amount of energy received by the sensor is depends on the object behavior and the atmospheric condition.

(e) Transmission to the ground station: The electromagnetic energy, received by the sensor is converted into signals and transmitted to ground receiving station located at various part of the world. In India, Hyderabad and many more cities has a facilities to receiving these signals.

(f) Rectification of data: These received signals are converted into the picture elements and make image data. These image data, in raw form supplied by the sensor, is not useful to the common user community. These data are rectified according to the need of the user requirement.

(g) Supply to the user: The rectified image data called imagery is supplied to the user for their requirement in the form of digital or analog. These data are finally digitally or visually analyses and drawing the conclusion that can be applied to the various fields or application.

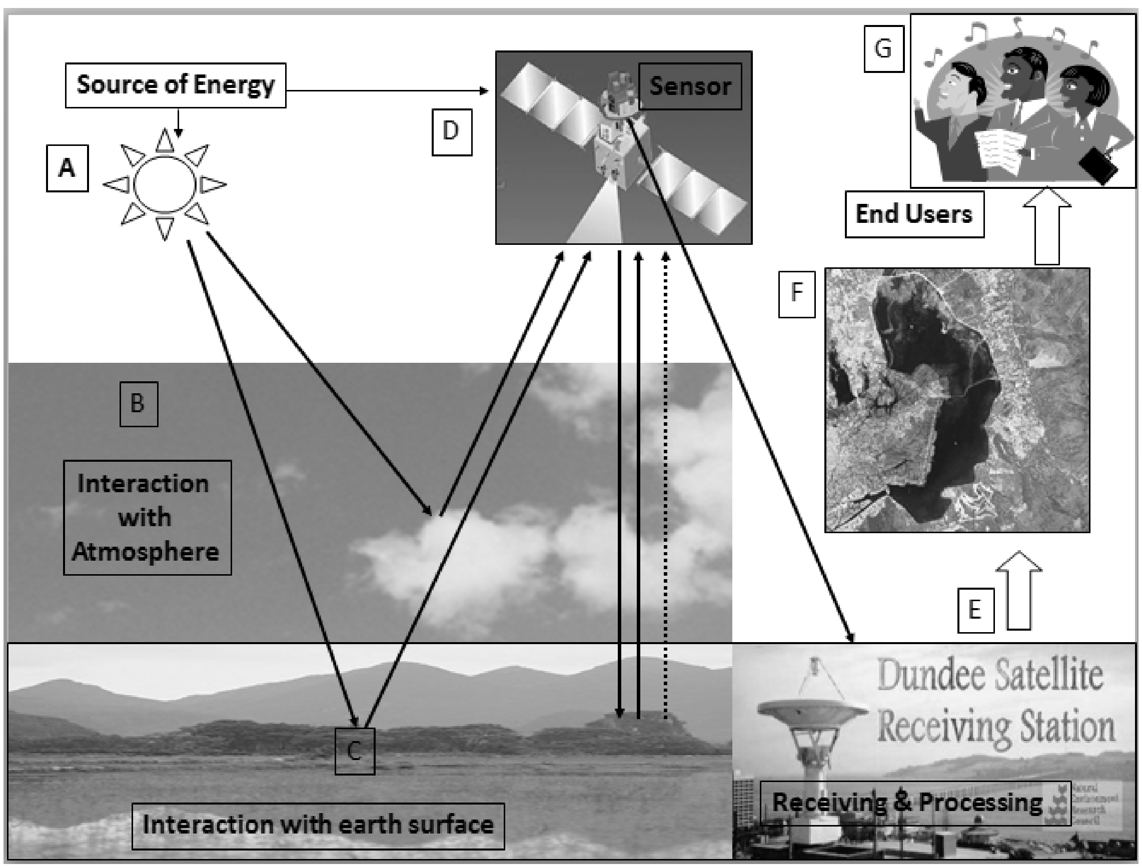

Figure 6.7: Stages of remote sensing

DIGITAL IMAGE PROCESSING:

The satellite image in the form of raw image which is not useful to the user community, requires a significant amount of processing. So, digital image processing in general involves the use of computers for manipulating digital image in order to improve their quality and/or modify their appearance (Wolf and Dewitt, 2000). It is a task of processing and analysing the digital image using some image processing algorithm to perform an interpretation according to certain conditions defined by the operator.Digital image is a two-dimensional rectangular array of cell or picture element known as pixel (Figure 6.8). Each pixel has numerical value, represents the energy reflected or emitted from the earth's surface which is measured by the sensor, known as digital numbers (DNs) or pixel value or grey level. The range of the DNs is varying according to the radiometric characteristics of the sensor, for example in 8-bit quantification data has a range of 0 to 255 = 256 grey levels, where 0 represent *black* and 255 represent *white* colour in the image.The coordinates of the digital image are represented by row and column number and it is calculated from upper left corner to upper right corner represent column and upper left corner to lower left corner represent row. Depending upon on the sensor characteristics, digital image can be single band or multi-band. The coordinates of all the bands are common and overlay as layer stack.The single band image is display by grey level of black to white. The colour images are composition of the three-band can display in real colour or the false colour composite (FCC).The standard false colour composite which is generally used for image processing is infrared band to red channel, red band to green channel and green band to blue channel. The combination of false colour composite is depends on the application by the user.The main processes are preprocessing, enhancement and image classification. Before understanding the process, we much understand about the digital image.

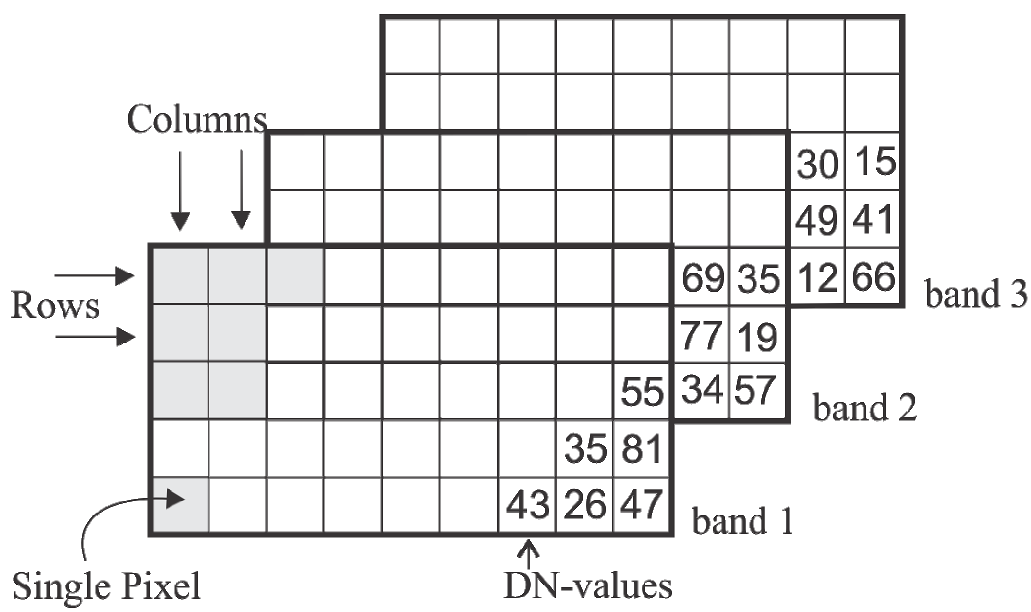

Figure 6.8: Structure of Image

Pre-processing:

It is a process of image rectification and restoration to correct the distorted or image to create a more faithful representation of the original image. Typically, geometric correction, radiometric correction and noise correction is applied.Geometric correction means the repositioning of the pixels from their original locations in the data array into a specified reference grid or providing geographical coordinates to the image by using the various projection parameters. The radiometric correction means alter the pixel value. In the raw image there are various problems in the visibility in the imagery due to different noise and line dropout where information is missing, which can be rectified by various algorithms.

Image Enhancement:

Image enhancement involves techniques for increasing the visual distinctions between features in a scene. It can be divided into two parts, one operate on individual pixels and enhance the individual value of pixel without reference to their spatial context, also known as radiometric enhancement e.g. contrast enhancement, histogram equalization; and another, use of spatial information deals with the average value of neighboring pixels known as spatial enhancement. e.g. spatial filtering. Contrast enhancement is a conversion of original digital range into full range of display. It is only intended to improve the visual quality of a displayed image because of low visibility in the raw image. Spatial filtering changes the image data according to the pixel values in its neighborhood. Spatial averaging is one of the spatial filtering, which is used to reduce noise or speckle in the data. spatial filtering is a means of improving image by suppressing (low pass filtering) or enhancing (high pass filtering) certain spatial frequencies, directions and textures.Low pass filter: Low pass filter would pass low frequencies and block high frequencies. It preserves the local mean (the sum of their weight is one) and smooth in the output layer resulting the blurring effect in the output image.High pass filter: The high pass filter remove the local mean (the sum of their weight is zero) and produce an output which is measure of the deviation of the input signal from the local mean (figure 6.9).

Image = low pass + high pass

Low pass = image – high pass

High pass = image – low pass

0	0	0
0	0	0
0	0	0

Original image

1	1	1
1	1	1
1	1	1

Low pass filter

-1	-1	-1
-1	+9	-1
-1	-1	-1

High pass filter

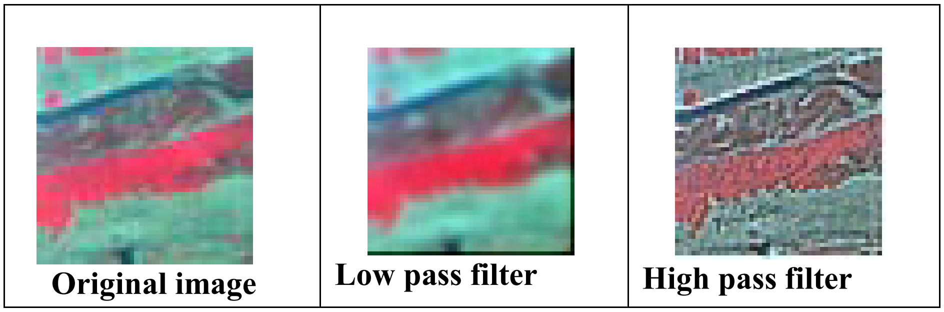

Figure 6.9: Low and high pass filtering

IMAGE CLASSIFICATION:

The rectified image can be used for extracting the information by two methods, one is visual image interpretation by taking the hardcopy printout of the rectified image and another is digital image classification. Image classification is process of generating thematic map by categorisation of the similar pixels. The level of classes is depending on the resolution of the sensor by which the image has been taken. There are various classification systems with different level are available as given by Anderson (Table 6.2). It is generally accepted that the Anderson level I categories can be reliable mapped using Landsat MSS imagery, and level II categories with TM and SPOT multispectral imagery (Lillesand and Kiefer, 1987). Level III and further requires SPOT, IRS LISS IV or higher resolution imagery for classification.

Table 6.2:*Land use and land cover classification system for use with remote sensor data (Anderson at al., 1976)*

Level I	Level II
1 Urban or Built-up Land	11 Residential 12 Commercial and Services 13 Industrial 14 Transportation, Communications, and Utilities 15 Industrial and Commercial Complexes 16 Mixed Urban or Built-up Land 17 Other Urban or Built-up Land
2 Agricultural Land	21 Cropland and Pasture 22 Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas 23 Confined Feeding Operations 24 Other Agricultural Land
3 Rangeland	31 Herbaceous Rangeland 32 Shrub and Brush Rangeland 33 Mixed Rangeland

4 Forest Land	41 Deciduous Forest Land 42 Evergreen Forest Land 43 Mixed Forest Land
5 Water	51 Streams and Canals 52 Lakes 53 Reservoirs 54 Bays and Estuaries
6 Wetland	61 Forested Wetland 62 Non-forested Wetland
7 Barren Land	71 Dry Salt Flats. 72 Beaches 73 Sandy Areas other than Beaches 74 Bare Exposed Rock 75 Strip Mines Quarries, and Gravel Pits 76 Transitional Areas 77 Mixed Barren Land
8 Tundra	81 Shrub and Brush Tundra 82 Herbaceous Tundra 83 Bare Ground Tundra 84 Wet Tundra 85 Mixed Tundra
9 Perennial Snow or Ice	91 Perennial Snowfields 92 Glaciers

Visual Image Interpretation:

It is defined as an act of examining image to identify the object or phenomenon and judging their significance by interpreter. It is an interpreter ability to extract the information visually with the help of various characteristics present in the image known as elements of image interpretation such as colour, tone, texture, pattern, site, shadow, etc. With the help of this element or a set of elements, interpreter prepares the interpretation key, a reference material which provides the logical rules to identify the feature or objects on the image such as forest, waterbodies, settlement, agriculture, etc. The visual interpretation has certain disadvantage i.e. it requires intensive labour work for delineation and evaluation of each and every theme. Our eyes cannot discriminate certain feature due to poor tonal characteristics of some feature, resulting entire spectral characteristic cannot be utilised by the interpreter. It is also difficult to incorporate into the GIS environment for further analysis in compare to digital classification.

Digital Image Classification:

There are basically, two methods for digital image classification, one is supervised and another is unsupervised, but hybrid classification is done by combination of both methods. The ultimate aim of the digital image classification is to increase the accuracy of the classified image.

Supervised classification: This method is performed when the interpreter has a priori knowledge about an image area. There are few steps, should be follow while applying supervised classification method like selection of training samples, evaluation of selected samples, appropriate classification algorithms. The training samples are sets of pixels selected to represent the individual land use/cover class (feature class). The samples must be the pure and representative of the particular class.The accuracy classification of an image is totally depending on the training samples, needs to evaluate and to estimate the expected error in the classification for various feature combination as well as band combination.

Unsupervised classification: Unlike supervised classification, unsupervised classification does not use the training sample to classify the image. An algorithm determines the internal structure of the data not the training sample. The classification of classes is based on clusters or natural grouping of data value known as spectral classes. These classes or cluster are initially unidentified, needs to be identify with the help of knowledge of the interpreter.

Hybrid: The main objective of the image classification is to produce the accurate thematic map from the image. In this regards, sometime supervised and unsupervised classification technique individually, do not produce the desire level of accuracy. For example, in supervised classification, user may not able to delineate the particular signature or in results, the class signature is not statistically separable in feature space. In the case of unsupervised classification, this algorithm only considers the internal structure of the data and sometime produces insignificant classes to the user. The combined approach can eliminate both classification drawbacks and produce satisfactory results. In this approach, initially unsupervised classification is applied with approximately 5 to 10 times more desired clustering. Then these clusters must be evaluated by various field data, resulting some cluster may be combine or sub-divide. Finally, the evaluated classes can be utilising for the supervised classification.

Accuracy Assessment

Once the image is classified, there is a need to assess the accuracy of the classification that can represent the true information about an area. It is not possible to check each pixel of an image to verify. The sampling method is one of the best methods to collect the samples in the classified image for accuracy assessment. These collected samples can be verified with the field work or other ancillary data known as reference data. The overall verification of the sample data is known as ground truthing. It is an acquisition of knowledge about the study area by various sources may be primary or secondary like, field work, analysis of previous image or photograph, personal experiences, etc. Ground truth data are considered to be the most accurate data available about the area of study. They should be collected at the same time as the remotely sensed data, so that correspond as much as possible.

6.5 CONCLUSION

Remote sensing is an art science and technology of collection information without being physical contact with an object or phenomena. It an unbiased tool to collect the information for the mapping the earth features. It is a multi-disciplinary activity which is utilized by many people such as geographer, geologist, agriculturist, planner, etc.

6.6 SUMMARY

The term ‘remote sensing’ simply means ‘sensing remotely’. The term ‘remote’ means distance, it could be one metre to thousands metre or more. Another term ‘sensing’ means acquiring knowledge. So remote sensing means acquiring knowledge from a distance. So remote sensing can be defined as an art, science and technique of collecting real information, without being physical contact with an object or phenomena through the sensor or camera from the various platforms over the wide range of electromagnetic energy by the means of tripod, aircraft or spacecraft or satellite for multidisciplinary activity.

In remote sensing, platforms may be moving or static place where sensor can mount to collect the images or photo. It is a stage to mount the camera or sensor to acquire the information about the target under investigation. On the basis of altitude above the earth surface, platform may be classified as, groundborne, airborne and spaceborne. Groundborne platform is used for field verification and laboratory simulation. By the mean of aircraft airborne platform is used but it has effected by the local weather condition. The spaceborne platform is not affected by the earth’s atmosphere as in found in airborne platform. Depending upon the altitude, there are two types of orbit i.e. polar orbit and geostationary orbit, are used to place the satellites, depending on the objectives of the mission. The polar orbiting satellite moving north-south direction and cover the whole earth, placed at the height of around 700 km. Polar orbit satellites is also known as sun-synchronous satellite because it is synchronised with the local sun-time at same latitude or it passes over all the places on earth having the same latitude at the same local sun-time. The geostationary satellite also has a motion from west to east direction and the speed of satellite is synchronised with the speed of the earth, placed at height of 36000 km.

Sensor measures reflected, scattered or emitted electromagnetic energy from the area of interest which is mounted on platforms. There are basically two type of sensor on the basis of source of light, one is passive sensor and another is active sensor. Depending upon the *sensor system,* sensor may be imaging and Non-imaging sensor system. The major characterstics of sensor is their resolution. So sensor resolution is measure of the ability of an optical system or sensor to distinguish between signals that are spatially near or spectrally similar. Ability to separate closely spaced objects on an image or photograph. Resolution is defined as the ability of the sensor to render the information at the smallest discretely separable quantity in terms of *Distance (Spatial resolution), Wavelength band (Spectral resolution), Radiation quantity (Radiometric resolution) and Time (Temporal resolution).*

Basically, remote sensing is totally depending upon electromagnetic energy, refers to all energy that moves with the speed of light in a harmonic wave pattern and broadly, includes lights, heat and radio waves. It is propagating through the space in a sine wave with constant speed which has two fields, one is electrical and another is magnetic, called electro-magnetic energy.

There are three measurements used to describe electromagnetic wave such as wavelength, frequency and velocity. There is a relationship between the wavelength, frequency and energy in the electromagnetic energy radiation. Shorter the wavelength, high the frequency and energy. Conversely, longer the wavelength, low frequency and energy. There is inverse relationship between wavelength and frequency. In remote sensing, it is very difficult to detect the long wavelength than short wavelength. The electromagnetic energy is categories on the scale of wavelength is called the Electromagnetic spectrum. It is extending from the gamma rays (smallest wavelength) to radio waves (largest wavelength). It is categories into various spectral regions also known as spectral bands. The electromagnetic spectrum is divided into two parts, one is optical region and another is microwave region. Optical region of the electromagnetic spectrum refers to that part of the spectrum in which optical laws can be applied. These relate to phenomena, such as reflectance and refraction that can be used to focus the radiation. The optical ranges from X-rays (.02 μm) through the visible part of the electromagnetic to far infrared (1000 μm) region. The microwave region is extending from 1mm to 1 metre.

The atmosphere is never completely transparent to electromagnetic radiation. However, at some wavelengths it has good transparency, known as atmospheric windows; and some wavelength has absorbing characteristics. The atmosphere is interacting with electromagnetic radiation by Atmospheric refraction, scattering, absorption and reflection. When electromagnetic energy is incident on any given earth surface feature, three fundamental energy interactions with them i.e. reflected, absorbed and transmitted, depend upon the material type, condition and wavelength. These differences permit us to distinguish different features on an image. Thus, two features may be indistinguishable in one spectral range and easily distinguishable in another wavelength band.

The reflectance characteristics of earth surface features may be quantified by measuring the portion of incident energy that is reflected. This is measured as a function of wavelength called spectral reflectance. A graph of the spectral reflectance of an object as a function of wavelength is termed as a spectral reflectance curve.

There are various characteristic of the soil such as soil moisture, texture, surface roughness, minerals and organic matter, interact differently with the electromagnetic energy. The vegetation is mostly consisting of leaf, contains pigment, chlorophyll, structure and moisture. Our eyes perceive healthy vegetation as green in color because of the very high absorption of blue and red energy by plant leaves and the very high reflection of green energy. The blue and red bands are the chlorophyll absorption region. Clear deep water is act as a blackbody for the near infrared and beyond energy, that is absorbed by the water. The suspended material of water increases the reflectance of the energy. The chlorophyll concentration in the water tend to decrease reflectance in blue region and increase reflectance in green region, used to monitor the concentration of algae through remote sensing data.

In the remote sensing process, various mechanism/activities are involved while supplying the final data to the user community. The mechanism/activities such as Source of energy, Interaction of electromagnetic radiation with an atmosphere, Interaction of electromagnetic radiation with an earth surface, Electromagnetic energy received by the sensor, Transmission to the ground station, Rectification of data and Supply to the user community.

The satellite image in the form of raw image which is not useful to the user community, requires a significant amount of processing. So, digital image processing in general involves the use of computers for manipulating digital image in order to improve their quality and/or modify their appearance. The main processes are preprocessing, enhancement and image classification. Once the image is classified, there is a need to assess the accuracy of the classification that can represent the true information about an area.

6.7 GLOSSARY

- Active sensor: If sensor is using own source of energy such as camera flash or RADAR to illuminate the earth feature is known as active sensor.
- Airborne platform: when camera or sensor are mounted on an aircraft to collect the information about the earth is known as airbourne remote sensing.
- Atmospheric absorption band: the atmosphere to close down completely in certain regions of the spectrum called atmospheric absorption band.
- Atmospheric window: A portions or wavelength intervals of the spectrum that transmit radiant energy are called atmospheric windows.
- Digital image processing: It is a task of processing and analysing the digital image using some image processing algorithm to extract information.
- Digital image: Digital image is a two-dimensional rectangular array of cell or pixel that represents the energy reflected or emitted from the earth's surface which is measured by the sensor,
- Electro-magnetic energy: The energy moves with the speed of light in a harmonic wave pattern and broadly, includes lights, heat and radio waves, that is propagating through the space in a sine wave with constant speed,

which has two fields, one is electrical and another is magnetic, called electro-magnetic energy.

- Electro-magnetic spectrum: The electromagnetic energy is categories on the scale of wavelength is called the Electromagnetic spectrum. It is extending from the gamma rays (smallest wavelength) to radio waves (largest wavelength).
- Geometric correction: The repositioning of the pixels from their original locations in the data array into a specified geographical coordinates to the image.
- Groundborne platform: when the camera or sensor mounted on tripod, building top or moving vehicle to collect the ground information, is known as groundborne platform.
- Image classification: It is a process of generating thematic map by categorizing similar pixel.
- Image enhancement: it is a technique for increasing the visual interpretability between feature in an image by contrast-brightness increase.
- Passive sensor: If sensor is using natural source of energy such as solar energy or geo-thermal energy to illuminate the earth feature is known as passive sensor.
- Radiometric correction: when the altering the pixel value of the image is known as radiometric correction.
- Radiometric resolution: this the sensor capability to quantify the signal strength into grey levels. It is measured in bit. In general, greater the grey-level more detail information.
- Reflectance: It is a ratio of the reflected light spectrum to the incident light spectrum.
- Refraction: The bending of light when it passes from one medium to another.
- Remote sensing platform: Remote sensing platform is a place where camera or sensor are mount.
- Remote sensing: the art, science and technique of collecting information without being physical contact with the object or phenomena.

- Scattering: The multiple reflections of electromagnetic energy by particles and surfaces is known as scattering which is an 'unpredictable' reflections.
- Sensor resolution: It is an ability of the sensor to distinguish different feature in terms of distance, wavelength, radiation quantity and time.
- Sensor: sensor is a device, that measures and records electro-magnetic energy by converting it into a signal and presents it in a form of either digital or an image about the target under investigation.
- Spaceborne platform: when the sensor is mounted on the satellite that is placing with the help of satellite launching vehicle in the circular space orbit is known as spaceborne platform.
- Spatial resolution: it is a sensor capability to distinguish two feature spatially.
- spectral reflectance curve: A graph of the spectral reflectance of an object as a function of wavelength is termed as a spectral reflectance curve.
- Spectral resolution: This is a sensor capability to sense number of wavelength bands.
- Temporal resolution: The revisit period of the satellite over the same area.

6.8 ANSWER TO CHECK YOUR PROGRESS

1. Define remote sensing.
2. What are the components of remote sensing?
3. What are the types of resolution?
4. What is electromagnetic spectrum?
5. What is the wavelength of Near IR?

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6.11 TERMINAL QUESTIONS

1. Describe the electromagnetic spectrum with neat sketch for remote sensing data.
2. Explain the atmospheric interaction with electromagnetic radiation.
3. Explain the spectral reflectance characteristics for soils, water & vegetation.
4. What are types of scattering signature? Explain.
5. Write short note on spectral signature concepts

UNIT 7 : GIS: PRINCIPLES AND APPLICATION

7.1 OBJECTIVES

After reading this unit you will be able to know :

- GIS objectives, Concept and Definition.
- GIS Need, Scope and Importance.
- GIS History.
- Components of GIS and GIS types.

7.2 INTRODUCTION

In the previous units you have studied about the basics of remote sensing, electromagnetic radiation, platforms, sensors, resolution types, remote sensing data interpretation and analysis. Remote sensing techniques provide you very quick, timely and reliable information about the land surface features based on your requirement and objectives. Those information facilitate various kinds of planning, management and developmental activities for socio-economic development and prudent/judicious use of natural/cultural resources. The temporal remote sensing data highlights the changes and dynamism of earth surface cover types and land uses which is utmost essential for future planning and taking precautionary measures about the danger/alarming/crucial situations if those are showing negative trends but if positive the planning will be followed accordingly. But in most of the cases, the collection or obtaining information/data itself does not prove the complete solution until and unless we integrate, analyse it and make modeling for the required purposes. For example you have the information about the availability of land or kind of resources but you do not know about their suitability or fitness for a particular kind of use or management and planning towards their development. Therefore the GIS (Geographical Information System), which is the most powerful computerised tool for collection, storage, analysis, manipulation, modeling and retrieval of information, is equally essential like remote sensing, for successful planning, management and optimization of land uses/resource utilisation. In fact remote sensing based data/information and its analysis and modeling through GIS tools and techniques are complementary to each other for all kinds of developmental planning.

GIS is a multi-disciplinary subject that includes a variety of technologies and concepts. In order to understand the capabilities of GIS, it is important to learn cartography, mapping, spatial and statistical analysis, different types of database, database management, and programming. All of them will be discussed in the next units except GIS objectives, concept, definitions, need, scope, importance, history, components of GIS and GIS types which are being described/explained in this unit.

7.3 PRINCIPALS OF GIS

GIS Objectives:

i) To improve the efficiency of decision making processes and planning.
ii) Provide efficient means for data distribution and handling.
iii) Eradication of the duplicated data,
iv) Integration of information from many sources.
v) Analysis of queries involving geographical reference data for generation of new information, update data quickly and at the minimum cost.

Concepts and Definition:

People around the world may like to know the geographic, social, economic, political, and environmental information in digital form for their practical knowledge, academics, services, responsibilities etc. To explore geo-referenced digital information, electronic tools designed for acquiring, presenting, and interacting with information that links location with measured values are needed. One such tool is called a geographic information system, better known as GIS.. GIS technology powers solutions for telecommunications, utilities, agriculture, defense, oil, health care, transportation, mining, environmental management, petroleum, water/wastewater, and many other industries as well as local, state, and federal government agencies. The following points highlight the concepts and definitions of GIS:

- A geographic information system (GIS), also known as a geospatial information system, is a system for capturing, storing, analyzing and managing data and associated attributes which are spatially referenced to the Earth.
- GIS provides Geographic/geospatial information about the places on earth`s surface, knowledge about "what, where, when, how, how far etc within the spatial domain and the Geographic/ geospatial synonym.
- It is an Information System capable of integrating, storing, editing, analyzing, sharing, and displaying Geographically Referenced information.
- Generally, GIS is a tool that allows users to create interactive queries, data editing, analyse the spatial information, creation of maps, and presentation of results.
- GIS and its location based intelligence applications becomes the base for many of the other location-enabled services that rely on analysis and visualization.
- GIS makes relationships with unrelated information by using location as the key index variable.
- All Earth-based spatial–temporal location and extent references should be relatable to one another and ultimately to a "real" physical location or extent.

Generally, GIS is based on an integrating technology consisting of:

- Remote Sensing
- Cartography and Mapping

- GPS
- Computers
- RDMS
- Information Technology
- Communication technology
- Survey and field data collection

GIS is a type of software which consists of a computer system that allows us to handle information about the location of features or phenomena on the Earth's surface. It has all the functionality of a conventional DBMS plus much of the functionality of a computer mapping system. GIS as a DBMS that allows us to explicitly handle the spatial data. Common examples are QGIS, ArcGIS and MapInfo.

NEED, SCOPE AND IMPORTANCE OF GIS:

Geographic information systems are among the most exciting and powerful geomatics decision-making tools in the world. A GIS uses computer technology to integrate, manipulate and display a wide range of information to create a picture of an area's geography, environment and socio-economic characteristics. Beginning with a computerised topographic map as its base, a GIS *overlays and integrates* graphic and textual information from separate databases. The end result is a customised and reliable tool that can support decision making and problem solving and provide almost instantaneous answers to complex questions (Geomatics Canada Web Site, 2000). The following lines highlight this sub-title:

- Geographic information system technology can be used for scientific investigations, resource management, asset management, Environmental Impact Assessment, Urban planning, etc. For example, GIS might allow emergency planners to easily calculate emergency response times in the event of a natural disaster.
- GIS is used to find wetlands that need protection from pollution, or GIS can be used by a company to site a new business to take advantage of a previously underserved market.
- In the modern concept of Information technology, GIS is termed as Geo-Information technology. The technology is involved with the integration of Surveying and Mapping techniques, Remote sensing and Satellite Imagery, Photogrammetry, Geography, Geology, Geomorphology, Cartography and Global Positioning Systems (GPS).
- The scope of using GIS techniques is a well known aspect in the sectors of forestry and forest management, land suitability classification, agricultural and horticultural land optimisation, irrigation, rural development, industrial land uses and industries, minerals, energy, transport, communications, Science, Technology and Environment. GIS can be used for scientific investigations, resource management, and development planning.
- GIS used in Computer Science, Civil Engineering, Mathematics, Statistics and Operations Research. With GIS, we can create new approaches that help us understand the relationship

between man and the environment. This calls for more integrated tools that build a holistic and comprehensive approach to resolving planning problems.

- GIS includes the merging of cartographical data, statistical analysis, and database technology. As GIS can be thought of as a system, it digitally creates and "manipulates" spatial areas that may be jurisdictional, purpose or application oriented for which a specific GIS is developed. Hence, a GIS developed for an application, jurisdiction, enterprise, or purpose may not be necessarily interoperable or compatible with a GIS that has been developed for some other application, jurisdiction, enterprise, or purpose.
- Any organization, government private is in some way or another strongly linked to the geography in which it operates. A GIS that has been designed in a proper manner has the capability of providing quick and easy access to large volumes of data of these Geographical features.

GIS has a great role in the organizational benefits and in almost every industry. There is a growing interest and awareness of the economic and strategic value of GIS because of more standards-based technology demonstrated by its users. The number of GIS enterprise solutions and it strategies that include gis are growing rapidly. The importance of GIS generally fall into the following five basic categories:

i) Efficiency based cost saving

This is associated with automating or improving a workflow and improvements in the mission itself. GIS functions as a repository of information associated with fixed assets. Municipal GIS captures information about the city's assets – typically land use information (such as parcel number, parcel owner, permits and zoning) and physical items (such as street lights, traffic signals, utility meters, water pipes, sewer infrastructure, street trees, pavement, curbs and sidewalks). What makes GIS different from traditional databases is that it associates geographic placement, in latitude and longitude, with each asset. Consequently it's possible to make decisions based not only on a type of asset but also on the asset's location.

According to a study carried out in California, by using GIS to automate the notification process, the city reduced by 90 percent the amount of staff time needed to do the job. Here the GIS-based process had been simple and concerned to the following points:

a) Identify the parcel containing the planned development;
b) Instruct the GIS system to identify all parcels whose boundaries cross or are inside a specific radius; and
c) Generate mailing labels to the parcel owners.

The cost and time savings associated with even this simple GIS operation paid for the system deployment.

ii) **Prompt and the Best Decision Making**

This typically has to do with making better decisions about location. Common examples include real estate site selection, route/corridor selection, zoning, planning, conservation, natural resource extraction, etc. People are beginning to realize that making the correct decision about a location is strategic to the success of an organization.

iii) **Improved communication**

GIS-based maps and visualizations greatly assist in understanding situations and storytelling. They are a new language that improves communication between different teams, departments, disciplines, professional fields, organizations, and the public.

iv) Better geographic information recordkeeping

Many organizations have a primary responsibility of maintaining authoritative records about the status and change of geography (geographic accounting). Cultural geography examples are zoning, population census, land ownership, and administrative boundaries. Physical geography examples include forest inventories, biological inventories, environmental measurements, water flows. GIS provides a strong framework for managing these types of systems with full transaction support and reporting tools. These systems are conceptually similar to other information systems in that they deal with data management and transactions, as well as standardized reporting (e.g., maps) of changing information. However, they are fundamentally different because of the unique data models and hundreds of specialized tools used in supporting GIS applications and workflows.

v) Managing geographically

In government and many large corporations, GIS is becoming essential to understand what is going on. Senior administrators and executives at the highest levels of government use GIS information products to communicate. These products provide a visual framework for conceptualizing, understanding, and prescribing action. Examples include briefings about various geographic patterns and relationships including land use, crime, the environment, and defence/security situations.

GIS is increasingly being implemented as enterprise information systems. This goes far beyond simply spatially enabling business tables in a DBMS. Geography is emerging as a new way to organize and manage organizations. Just like enterprise-wide financial systems transformed the way organizations were managed in the ‗60s, ‗70s, and ‗80s, GIS is transforming the way that organizations manage their assets, serve their customers/citizens.

Any organization, government private is in some way or another strongly linked to the geography in which it operates. A GIS that has been designed in a proper manner has the capability of providing quick and easy access to large volumes of data of these geographical features. The user can access & select information by area or by theme to merge one data set with another, to analyze spatial characteristics of data, to search for particular features, to update quickly and cheaply and asses alternatives.

In simpler terms, GIS allows the user to understand geographic information in an easy manner without having to go through large volumes of confusing data that is in tabular form. Visualizing the geography of a particular location is no doubt easier that trying to analyze raw data. The use of modern GIS offers many advantages over paper maps. The important characteristics of GIS is having its tool-kit which highlights the following important functional characteristics:

- Use either SI or CGS as primary units. (SI units

- **Manipulate spatially:**
  - ☐ Calculate distances and adjacencies
  - ☐ Change projections and scales
  - ☐ Integrate disparate sources

- **Analyse spatially:**
  - ☐ Quantitative analysis
  - ☐ Exploratory spatial data analysis
  - ☐ Qualitative analysis

- **Visualise data:**
  - ☐ Maps!
  - ☐ Tables, graphs, etc.
  - ☐ Animations
  - ☐ Virtual landscapes

- More robust and resistant to damage
- Faster and more efficient
- Requires less person time and money

The importance of GIS is also based on the facts that this system collects and stores information about the world as a collection of thematic layers that can be linked together by geography. This simple but extremely powerful and versatile concept has proven invaluable for solving many real-world problems from tracking delivery vehicles, to recording details of planning applications, to modeling global atmospheric circulation.

7.4 ELEMENTS OF GIS

COMPONENTS OF GIS

A GIS system in working order integrates the following five key components:

- Data
- Hardware
- Software
- Users/People
- Methods

Data:

Data is a set of values of subjects with respect to qualitative or quantitative variables. Data and information or knowledge are often used interchangeably. You may also define data as a collection of facts, such as numbers, words, measurements, observations or even just descriptions of things.

Data may be classified as i) qualitative and ii) quantitative. Qualitative data is descriptive information whereas Quantitative data is numerical information. For example slope of the hill is very steep is a qualitative information whereas slope of the hill is in between the slope range of 30 - 40% is quantitative information.

Geographic data refers to information about the earth's surface and the objects found on it. This information comes in three basic forms: spatial data, tabular data, and image data. Spatial data contains the locations and shapes of map features. Tabular data is collected and compiled for specific areas and is the descriptive data that GIS links to map features. Image data includes such diverse elements as satellite images, aerial photographs, and scanned data--data that's been converted from printed to digital format. Data can be created or bought.For example, a GPS receiver can be used to identify sites in an agricultural field where weed data is collected.A table can be created in the GIS showing location as well as species and number of weeds present in the measured area. Alternatively, data can be purchased. In most cases, images are bought from satellite or aircraft companies that used cameras to collect images of the Earth’s surface.

a. Map Data

Map is an essential tool for execution of various kinds of activities. Maps or GPS based ground coordinates act as input coordinate system in GIS spatial data domain. Geo-referenced remote sensing data is also equally helpful in creating spatial information. It becomes more realistic approach if you take the help of all three data types to prepare the spatial database. Map data provides information about location (Figure 1). Figure 1 represent the latitude and longitude points (graticules) on the polygon graphics formed by digitizing the feature from map.

b. Attribute Data

It provides you the information about what can be found at a particular location. The attributes of a river, for example, might include its name, length, average depth, rate of flow, water quality, how many dams are on it, and how many bridges cross it. Figure 2 represent both map and attribute data.

c. Hardware

Hardware is a Computer on which GIS software runs. There are a different range of computers like Desktop or server based. ArcGIS, ArcInfo and Arcview GIS softwre servers are server based computers where GIS software runs on network computer. The good computer hardware components must have high capacity. Examples of hardware components are: server, digitizer, PC, Printer, plotter, Hard driver, processor, graphics card, etc. These all component function together to run a GIS software smoothly. A mini hardware system of GIS is shown in figure 3

d. Software

Software is a GIS component, a technology for storing and analyzing location and attribute data. GIS Software) is designed to store, retrieve, manage, display, and analyze all types of geographic and spatial data. Figure 4 represent the spatial and attribute data within the computer software. Examples of GIS software are ArcGIS and ArcView for desktop, Web GIS, ArcInfo as server GIS etc.

e. GIS User/People/Personnel

GIS technology may have many limitations without the involvement of people who manage the system and develop plans for applying it to real world problems. GIS users range from technical specialists who design and maintain the system to those who use it to help them perform their everyday work. GIS user/people/personnel's specifically include the following categories of working environment:

- Project coordinators
- Data analysts
- Programmers
- Data and knowledge managers
- Librarians Types of GIS

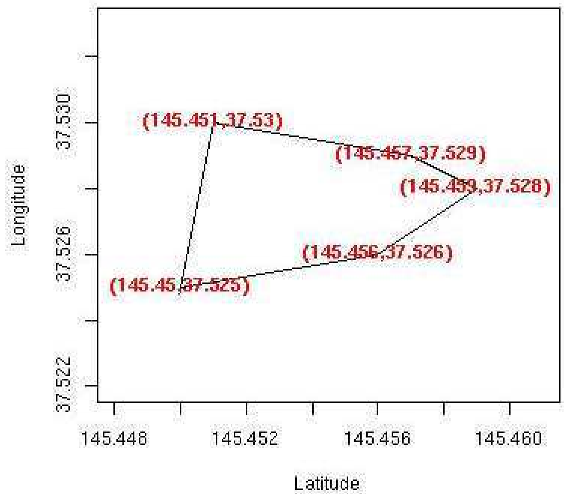

Figure 7. 1: Map data of GIS showing the Graticules after digitization of a particular feature from hard copy of a map.

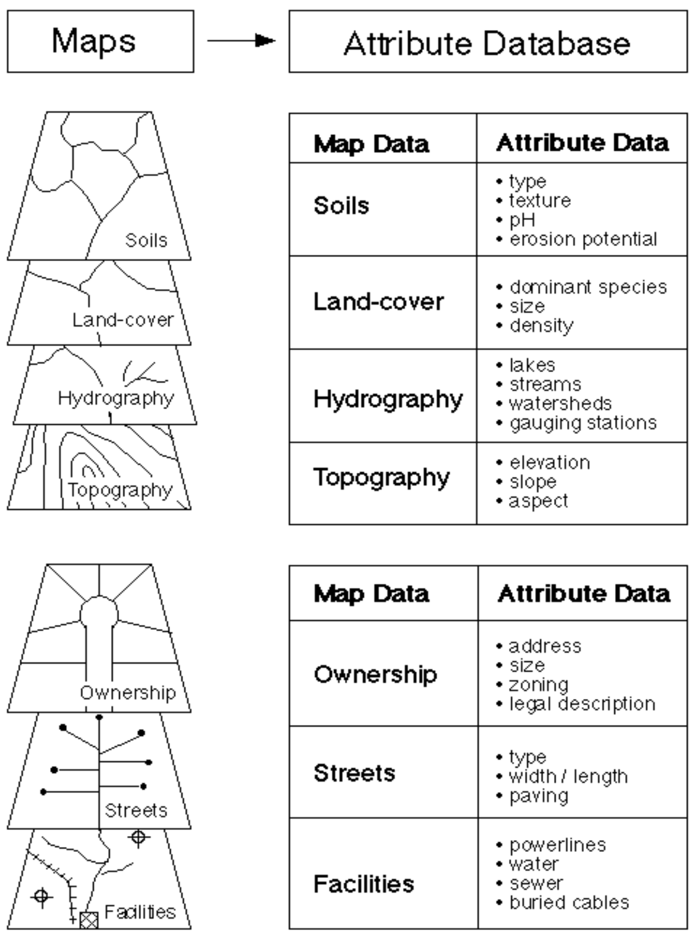

Figure 7.2 GIS Map showing Map and Attribute Data

Figure 7.3: GIS Hardware consists of CPU, Monitor, Plotter, and Printer

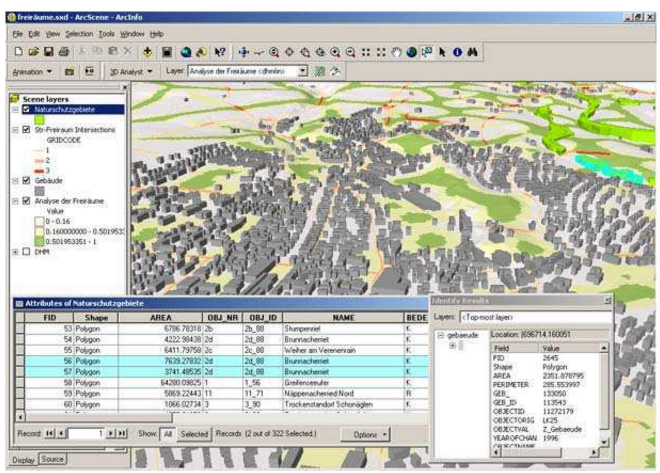

Figure 7. 4: GIS Software on the computer monitor

d. Methods

A successful GIS operates according to a well-designed plan and business rules, which are the models and operating practices unique to each organization.

Types of GIS

In recent time, there are nine types of GIS in practice. Thise are categorised as below:

- Desktop GIS
- Professional GIS
- Enterprise GIS

- Web GIS
- Internet GIS
- Mobile GIS
- Distributed GIS
- 4 D GIS
- Cloud GIS

Desktop GIS:

Desktop GIS is an immensely powerful computer mapping system. It is a tool for managing information of any kind according to where it is located. For example, businesses can track customer locations, optimize delivery routes, or decide where to site future businesses using GIS; scientists use GIS to manage sensitive wildlife habitats or track animal movements in an ecosystem; and health care specialists track the spread of infectious disease with GIS

Desktop GIS represents the real geographical features on a computer similar to the way maps represent the same on paper. Both GIS and paper maps convey information about places. However, desktop GIS has power and flexibility to change, if any, that paper maps lack. The scale of the map influences the size of what appears on it. With GIS, however, you can store and link huge amounts of information about the objects represented on maps. These objects are called features. Each map feature has a location, a representative shape, and a symbol that represents one or more of its characteristics. Because features on maps are organized according to relative location or position, maps are good for showing the relationships among feature locations. These relationships, called spatial relationships, are important because understanding them helps us solve problems.

While preparing the maps we use three basic shapes-- points, lines and areas to represent real-world objects location on the basis of geographical coordinates. Points represent objects that have discrete locations and are too small to be depicted as areas. Lines represent objects that have length but are too narrow to be depicted as areas. Areas represent objects too large to be depicted as points or lines. Shapes alone do not give you enough information, so maps use graphic symbols to help identify features and provide information about them.

Most features can be represented as more than one shape. The scale of a map tells how the size of the map features compares with the size of the geographic objects they represent. Map scales vary from small-scale to large-scale. For example, on a small-scale map a city may be represented as a point . That same city would be represented as an area on a large-scale map.

With desktop GIS, you are not limited to the amount of information you can get about what you see on the map. Desktop GIS stores all the information about map features in a GIS database and links the features on the map to the information about them. This means that you can access all the information about a feature by simply clicking on it.

The information that a desktop GIS stores about map features is referred to as attribute information, or attributes. Desktop GIS formats attributes in rows and columns, and stores them as tables. Each column stores a different attribute and each row relates to a single feature. The link between map features and their attributes is the basic principle behind how a desktop GIS works, and is the source of its power. Once the map features and attributes are linked, you can access the attributes for any map feature or locate any feature from its attributes in a table. GIS can also display features based on any attribute in the table. Because the link between features and attributes is a two-way relationship, changing an attribute in the table automatically results in a change on a map. Desktop GIS links sets of features and their attributes and manages them together in units called themes. A theme contains a set of related features, such as roads, streams, parcels, or wildlife habitat areas, along with the attributes for those features.

All the themes for a geographic area taken together make up a GIS database. The design of a GIS database is strong because it's flexible. You can add new themes to a GIS database or delete old ones; you can separate themes to create more themes, or combine themes if they have common characteristics. What you want to do with a GIS database, and what information you need, will determine the best design for you.

The GIS database can be 'queried' .This means a user can ask questions and get answers about the database. For example, in Figure 5, the user queries the database about location of the residential area in and around Brookings, SD. The results of the query are highlighted in yellow in both the table and the map.

Information can be presented as maps, charts, and tables, along with graphics you import from other programs or even graphics you draw yourself. The presentations you create can be output to a printer to produce hard copy, or displayed on your computer's screen. You decide what information to present and how much--how much detail, which colors and symbols, and how the final pieces will be arranged. And if you audience or your objective should change, it's easy to make your presentation reflect those changes, without having to start over.

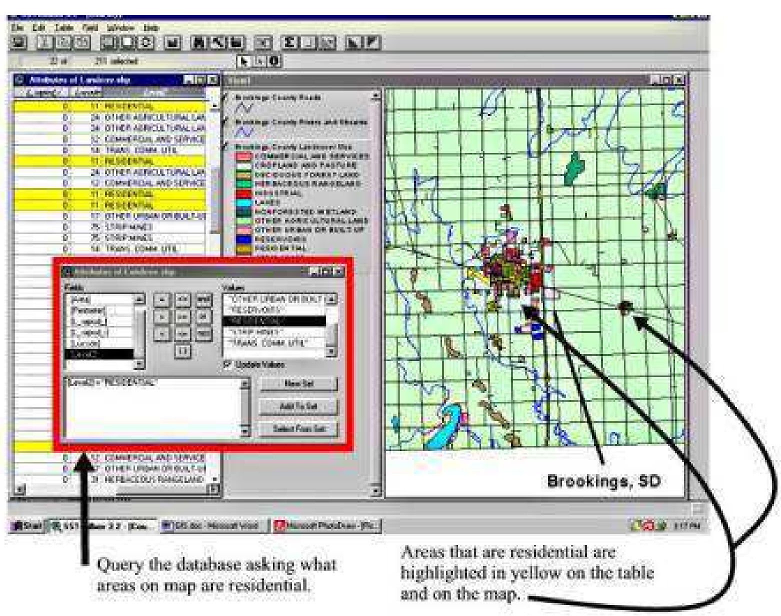

Figure 7.5 GIS Database Query

Professional GIS:

Professional GIS is important in the field of GIS as it helps to establish GIS as a true profession, ensures those who produce geographic information have competency in a core set of knowledge and skills, encourages long-term professional development, and promotes ethical behavior by members of the profession. For individuals, successful certification may improve advancement opportunities; result in higher compensation and greater career mobility, and greater recognition from employers and colleagues.

Enterprise GIS:

Enterprise GIS is a geographic information system that is integrated through an entire organization so that a large number of users can manage, share, and use spatial data and related information to address a variety of needs, including data creation, modification, visualization, analysis, and dissemination.

Web GIS:

Web GIS is a GIS system that uses web technologies. It often uses web technologies to communicate among different components of the system. Web GIS originates from a combination of web technology and the Geographical Information System, which is a recognized technology that is mainly composed of data handling tools for storage, recovery, management and analysis of spatial data. Web GIS is a kind of distributed information system. The simplest architecture of a Web GIS must have at least one client and one server that client is a desktop application or web browser application that allows users to communicate with server, and the server is a web server application.

Internet GIS:

Web GIS is a close term to Internet GIS. These two words are always used as synonymous with each other. There is a slight difference between these two words. The Internet supports many services with the Web being one of these services. So we can call a system as Internet GIS if it uses many of services of Internet not only Web service and if it uses only Web we should name

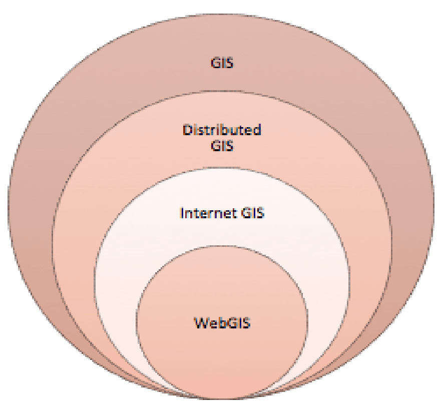

Figure 7.6: Internet GIS and web GIS Comparison

it Web GIS. This definition makes Internet GIS boarder than Web GIS. In real world Web is the most attractive service of Internet and it is why Web GIS is more common than Internet GIS.
The geospatial Web, or GeoWeb, is another term that uses to refer Web GIS , However the definition of Web GIS is not identical to Web GIS . GeoWeb can be defined by merging geospatial information with none geospatial information such as news, photos, stories and so on.

Mobile GIS:
Geographic Information Systems (GIS) being used out of the office and into the field is called Mobile GIS. A mobile GIS is used in the field to capture, store, update, manipulate, analyze, and display geospatial data and information. Mobile GIS integrates one or more of the following technologies:

- Mobile devices (such as a PDA, tablet, or laptop computer, and in some countries mobile phones)
- Geographic Information System (GIS) software.
- The Global Positioning System (GPS).
- Wireless communications for Internet-based GIS access.

For most applications, it is an extension of desktop GIS, although increasingly users are taking mobile GIS data and uploading it directly to powerful visualization tools online such as Google Earth. Mobile GIS can allow for edits and changes to be made in the field, increasing accuracy and saving time. Many mobile GIS systems are relatively inexpensive.

Distributed GIS:
It refers to GI Systems that do not have all of the system components in the same physical location. This could be the processing, the database, the rendering or the user interface. Examples of distributed systems are web-based GIS and Mobile GIS.

4D GIS:
4D GIS has developed into an essential component of GIS applications, incorporating 2D and 3D data with time. 4D GIS integrates, manages, and analyzes spatial and nonspatial information, providing quality visualization, simulation, and communication. While also facilitating better decision making by providing a geographic representation of the full scope of a project.
Cloud GIS:
This refers to hosted services on the internet meant for users of GIS technology or members of public who want to access maps. Services include map service, data storage and access, powerful analysis with applications, to manage assets and information.

GIS Data Types:
There are two types of data stored for each item in the database.
i)Attribute data:
Attribute data says ***what*** a feature is, eg. statistics, text, images, sound, etc.

ii) Spatial data:

Spatial data reflects where the features are existing, eg. all features, objects and related phenomenon. It has the following characteristics:

a. It is co-ordinate based

b. It may be a **Vector** data showing the following discrete features:

i. Points

ii) Lines

iii) Polygons (zones or areas)

c. It may be a **Raster** data which represent a continuous surface.

Details of raster and vector data will be discussed in the next unit.

HISTORY OF GIS:

While considering about the history of GIS, we must think over the conventional methods of map preparation as map is always at the heart of GIS. Mapping has revolutionized how we think about location. Maps are important decision-making tools. They help us get to places. And they are becoming more immersed in our everyday lives.

Conventional methods of map preparation dates back 1854. With the passage of time, there had been the tremendous changes in the field of cartography and mapping. In fact GIS has no meaning and no importance if we do not consider its strong powerful computerized tool and the varieties of software. GIS was developed by Geographers just because to overcome the conventional method of map making and the integration of different GIS layers, its analysis and modeling. The development of GIS has saved money, man power and the time. But the important point is saving paper containing map which we were bound to torn after a frequent stipulated time when the environment and surface features were changing and the maps had no meaning /no importance.

Advancements in GIS was the result of several technologies. Databases, computer mapping, remote sensing, programming, geography, mathematics, computer aided design, and computer science all played a key role in the development of GIS.

Today, we'll uncover some of the key moments in the history of GIS that has shaped it what it has become today:

Paper Mapping Analysis with Cholera Clusters:

The history of GIS all started in 1854 when British physician John Snow began mapping outbreak locations, roads, property boundaries and water lines of Cholera hit city of London. When he added these features to a map, something interesting happened: He saw that Cholera cases were commonly found along the water line.

John Snow's Cholera map was a major event connecting geography and public health safety. Not only was this the beginning of spatial analysis, it also marked the start of a whole field of study: Epidemiology – the study of the spread of disease. To this date, John Snow is known as the father of epidemiology. The work of John Snow demonstrated that GIS is a problem-solving tool. He put geographic layers on a paper map and made a life-saving discovery.

During 20th century, the concepts of printing different theme maps and to separate layers from a map were developed. But this concept did not represent a full GIS as there was no option to analyse mapped data. With the passage of time, many other concepts were developed but that did not full fill the whole concept of GIS. The actual concept of GIS was first introduced in the early 1960s, by Dr. Roger Tomlinson and it was subsequently researched and developed as a new discipline. The GIS history views Roger Tomlinson as a pioneer of the concept, where the first iteration was designed to store, collate, and analyze data about land usage in Canada. Thus Dr. Roger Tomlinson is generally recognized as the "father of GIS.” He is the visionary geographer who conceived and developed the first GIS for use by the Canada Land Inventory in the early 1960s.

During 1970s, the second phase of development in GIS history was continued and by the 1980s the concept progressed in a big way and likely to be adopted by different agencies. By the late 1980s, there was a focus on improving the usability of technology and making facilitates more user-specific.

Throughout the 1990s, software company Esri released ArcView, a desktop solution for mapping systems. The influx of the Internet saw widespread adoption of GIS heading into the millennium, and the technology reached governmental authorities. Many companies adopted the technology to provide services to cities, municipalities and private organizations to manage assets in the field, gather business intelligence, and easily send data to the company headquarters to analyze.

In recent past, the focus of GIS shifted to sharing data across multiple platforms, and if its history is anything to go by, the industry will continue to debate how to resolve problems arising from data ownership.

4D mapping is a logical step for GIS, and this will help specifically for urban planning. GIS is not only essential for developing an urban area, but it is also necessary for today’s fast-moving, technological landscape.

7.5 CONCLUSION

GIS is the most powerful computerized tool for collection, storage, analysis, manipulation, modeling and retrieval of information. GIS is equally important like remote sensing for successful planning, management and optimization of land uses/resource utilization. In fact remote sensing based data/information and its analysis and modeling through GIS tools and techniques are complementary to each other for all kinds of developmental planning.

7.6 SUMMARY

GIS is the most powerful computerised tool for collection, storage, analysis, manipulation, modeling and retrieval of information. GIS is equally important like remote sensing for successful planning, management and optimization of land uses/resource utilisation. In fact remote sensing based data/information and its analysis and modeling through GIS tools and techniques are complementary to each other for all kinds of developmental planning.

In this unit, the basics of GIS includes GIS objectives, concept, definition need, scope, importance, history, components of GIS and GIS types. Generally, GIS is based on an integrating technology consisting of remote Sensing, cartography and mapping, GPS, Computers, RDMS, information technology, communication technology, survey and field data collection.

Geographic information systems are among the most exciting and powerful geomatics decision-making tools in the world. A GIS uses computer technology to integrate, manipulate and display a wide range of information to create a picture of an area's geography, environment and socio-economic characteristics. Beginning with a computerised topographic map as its base, a GIS *overlays and integrates* graphic and textual information from separate databases. The end result is a customised and reliable tool that can support decision making and problem solving and provide almost instantaneous answers to complex questions. The important characteristics of GIS is having its tool-kit which highlights to manipulate and analyse the data spatially and visualise it in the form of maps, tables, graphs, animations and virtual landscapes.

Geographic data refers to information about the earth's surface and the objects found on it. This information comes in three basic forms: spatial data, tabular data, and image data. Spatial data contains the locations and shapes of map features. Tabular data is collected and compiled for specific areas and is the descriptive data that GIS links to map features. Image data includes such diverse elements as satellite images, aerial photographs, and scanned data--data that's been converted from printed to digital format. In addition to data GIS components include hardware, software, users and methods.

GIS types are categorised as desktop GIS, professional GIS, enterprise GIS, web GIS, internet GIS, mobile GIS, distributed GIS, 4 d GIS and cloud GIS. GIS data types consists of attribute data and spatial data. Examples of attribute data are statistics, text, images and sound of a feature. Similarly spatial data indicate the existance of feature, objects and related phenomenon. The nature of spatial data is either vector or raster.

Historically, the concept of GIS started a long back during 1854 when British physician John Snow began mapping of the probable sites for Cholera outbreak disease locations and found the real locations along the water lines of London city. During the period of 1854 -1960, there were some concepts developed related to this subject but none of them had been satisfactory.

The actual concept of GIS was first introduced in the early 1960s, by Dr. Roger Tomlinson, Geographer who is generally recognized as the "father of GIS." Since that time, there had been a tremendous developments in this field. Today the focus of GIS shifted to sharing data across multiple platforms, multiple numbers of Government and private organizations and even the critical problems are being solved through GIS and GIS software's like ArcView, *ERDAS Imagine etc.*

7.7 GLOSSARY

- **Altitude :** Altitude is specified relative to either mean sea level (MSL) or an ellipsoid. In simplest term altitude is the vertical distance from mean sea level.
- **Analysis :** Analysis is the process of identifying a question or issue to be addressed, modeling the issue, investigating model results, interpreting the results, and possibly making a recommendation.
- **ArcGIS :** A comprehensive desktop GIS software package developed by ESRI.
- **ArcMap :** Editing and map making module of ArcGIS.
- **ARC/INFO :** Private domain complete GIS software package from ESRI, Inc. that has very powerful modeling, analysis and output capabilities.
- **ArcView :** Private domain GIS software from ESRI, Inc. that allows users to organize, maintain, visualize, and disseminate maps and spatial information. This GIS software does not have the analysis and modeling capabilities like ARC/lNFO.
- **Attribute :** i) A characteristic of a feature in a Geographic Information System (GIS). Each identifiable feature has attributes. One common attribute of all geographic features is its position. other attributes depend on the type of feature. Example: a road may have a name or designation number, pavement type, width, number of lanes, etc. Each attribute has a range of possible values called its domain.

ii) Attribute is also called a column in a database table.

- **Attribute table:** A tabular file containing rows and columns. In a GIS, attribute tables are associated with a class of geographic features, such as wells or roads. Each row represents a geographic feature. Each column represents one attribute of a feature, with the same column representing the same attribute in each row.
- **Data type:** The characteristic of columns and variables that defines what types of data values they can store. Examples include character, floating point and integer.
- **DBMS:** Database management system. It is a set of computer programs for organizing the information in database. A DBMS supports the structuring of the database in a standard format and provides tools for data input, verification, storage, retrieval, query, and manipulation.
- **Geographic data:** The locations and descriptions of geographic features. The composite of spatial data and descriptive data.
- **Geographic database:** A collection of spatial data and related descriptive data organized for efficient storage and retrieval by many users.
- **Geographic feature:** A user-defined geographic phenomenon that can be modeled or represented using geographic data sets in a GIS. Examples of geographic features include streets, sewer lines, manhole covers, accidents, lot lines, and parcels.

7.8 ANSWER TO CHECK YOUR PROGRESS

- Describe GIS objectives, Concept and Definition.
- Explain Need, Scope and Importance of GIS.
- Discuss the History of GIS.
- Write about the Components of GIS and GIS types.

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7.10 SUGGESTED READINGS

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7.11 TERMINAL QUESTIONS

i) What is GIS and what does it do?
ii) How does Desktop GIS work?
iii) What do you need to know about the data?
iv) Explain the importance of GIS in the field of Efficiency based cost saving, Prompt and the best decision making and improved communication.
v) List the GIS types and differentiate between mobile and Internet GIS .
vi) What are the different GIS components? Explain GIS software
vii) Write the historical overview of GIS.
viii) Both remote sensing and GIS are complementary to each other for efficient planning and decision making processes. Elaborate this statement in context with the role of information technology.