UNIT-2

INTRODUCTION TO GIS

DEFINITION OF GIS

An organized collection of computer hardware, software, Geographical data and personnel designed to efficiently capture, store, update, manipulate, analyze & display all forms of Geographically referenced information is called GIS.

GIS provides the mechanisms for undertaking the manipulation and display of geographic knowledge

GIS definition

"… a special case of information system where the database consists of observations on spatially distributed features, activities or events, which are definable in space as **points, lines or area.**

A geographic information systems manipulates data about these points, lines and areas to retrieve data for adhoc queries and analyses"

Why Study GIS?

- 80% of **local government** activities estimated to be geographically based
  - plots zoning, public works (streets, water supply, sewers), garbage collection, land ownership and valuation, public safety (fire and police)
- a significant portion of **state government** has a geographical component
  - natural resource management
  - highways and transportation
- **businesses** use GIS for a very wide array of applications
  - retail site selection & customer analysis
  - logistics: vehicle tracking & routing
  - natural resource exploration (petroleum, etc.)
  - precision agriculture
  - civil engineering and construction
- **Military and defense**
  - Battlefield management
  - Satellite imagery interpretation
- **scientific research** employs GIS
  - geography, geology, botany
  - anthropology, sociology, economics, political science
  - Epidemiology, criminology

What GIS Applications Do:
manage, analyze, communicate

- make possible the **automation** of activities involving geographic data
  - map production
  - calculation of areas, distances, route lengths
  - measurement of slope, aspect, view shed
  - logistics: route planning, vehicle tracking, traffic management
- allow for the **integration** of data hitherto confined to independent domains (e.g property maps and air photos).
- by tieing data to maps, permits the succinct **communication of complex spatial patterns** (e.g. environmental sensitivity).
- provides answers to **spatial queries** (how many elderly in Richardson live further than 10 minutes at rush hour from ambulance service?)
- perform complex **spatial modelling** (*what if* scenarios for transportation planning, disaster planning, resource management, utility design)

HISTORY OF GIS

GIS has its roots in the stimulates provided by the development of Remote Sensing in the **late 1960s and early 1970s** as potentially cheap and effective source of earth observations.

The field of geographic information systems (GIS) started in the 1960s as computers and early concepts of quantitative and computational geography emerged. Early GIS work included important research by the academic community.

Many of the techniques for processing remote sensing data are highly specialized, more general GIS techniques become important in order to combine information derived from remote sensing with other collateral Information.

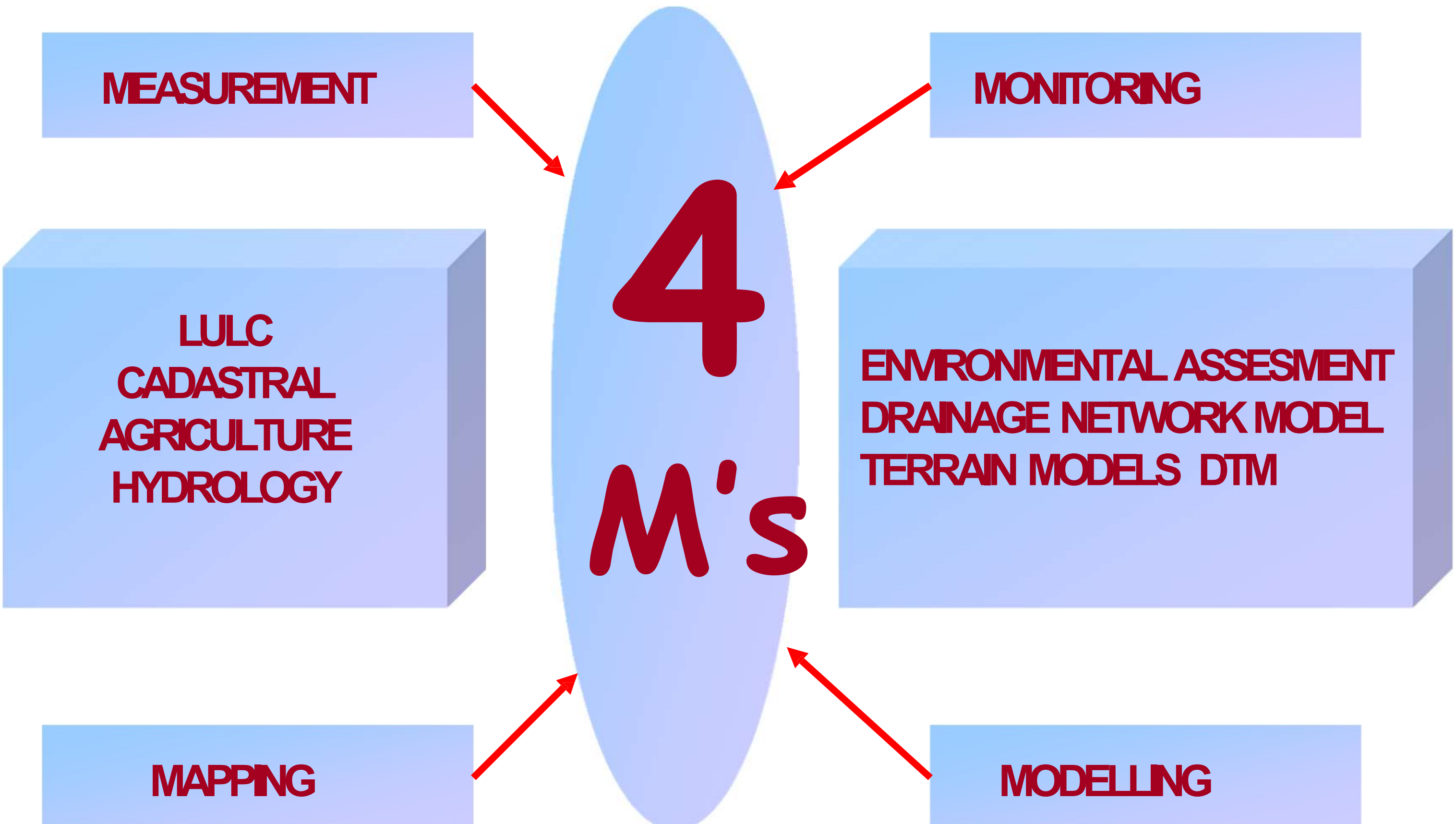
GIS has many roots of evolution like map production process, **one root lies in landscape, architecture and environmentally sensitive planning** another **root in urban and demographic data analysis.**

The roots of remote sensing merging with vector GIS, the root of larger scale data integration around a common data model.

GIS gives people the ability to create their own digital map layers to help solve real-world problems. GIS has also evolved into a means for data sharing and collaboration, inspiring a vision that is now rapidly becoming a **reality—a continuous, overlapping, and interoperable GIS database of the world, about virtually all subjects**. Today, hundreds of thousands of organizations are sharing their work and creating billions of maps every day to tell stories and reveal patterns, trends, and relationships about everything.

Today the term GIS tends to be applied whenever geographical information in digital form is manipulated, whatever be the purpose of that manipulation.

Thus using a computer to make a map is referred to as GIS.


MEASUREMENT
MONITORING
LULC
CADASTRAL
AGRICULTURE
HYDROLOGY
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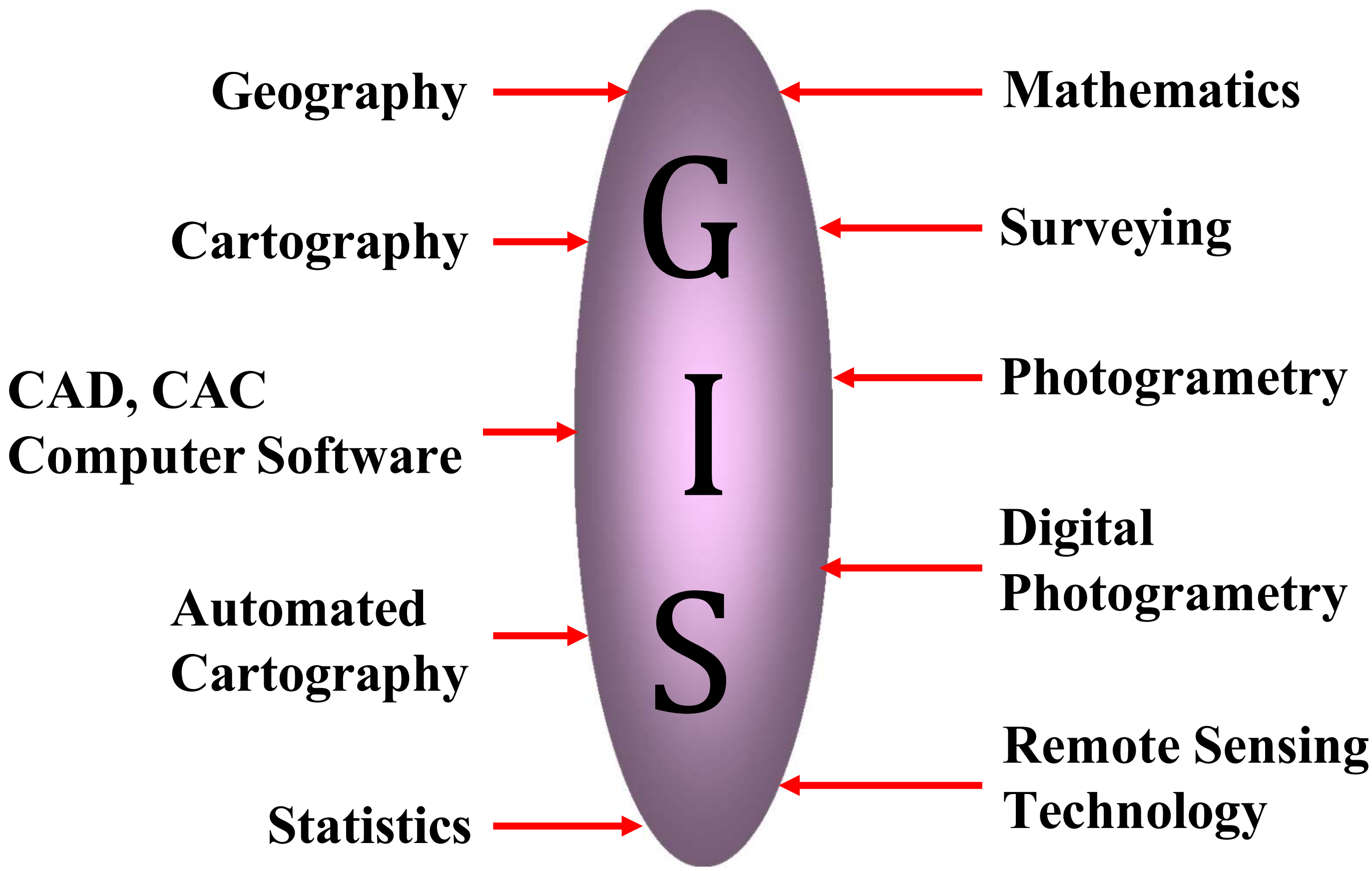
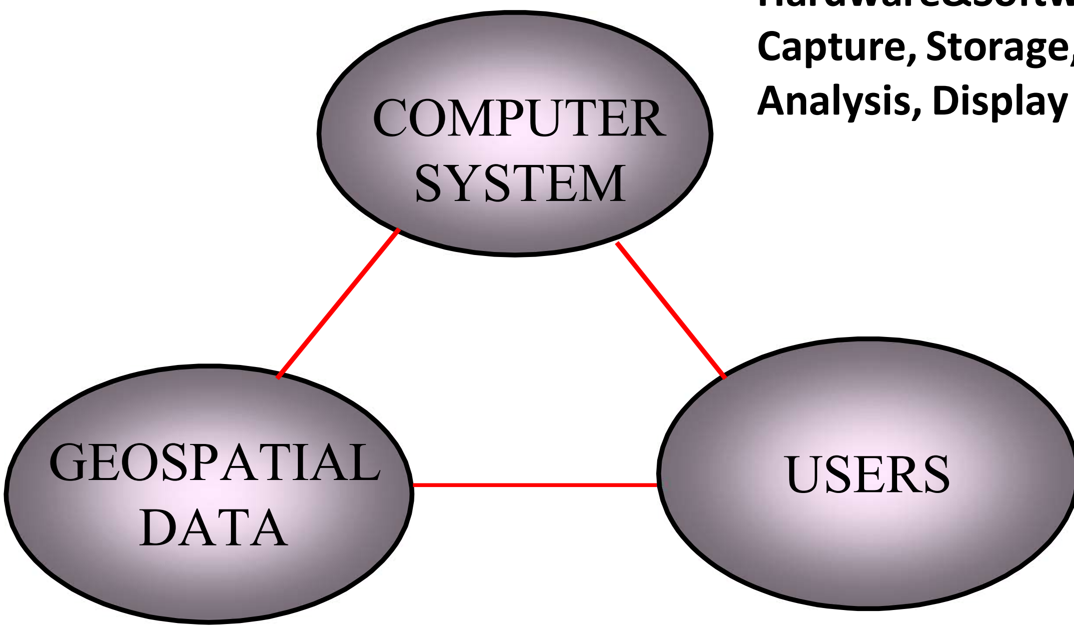
M's
ENVIRONMENTAL ASSESMENT
DRAINAGE NETWORK MODEL
TERRAIN MODELS DTM
MAPPING
MODELLING

Contribution Disciplines



KEY COMPONENTS OF GIS

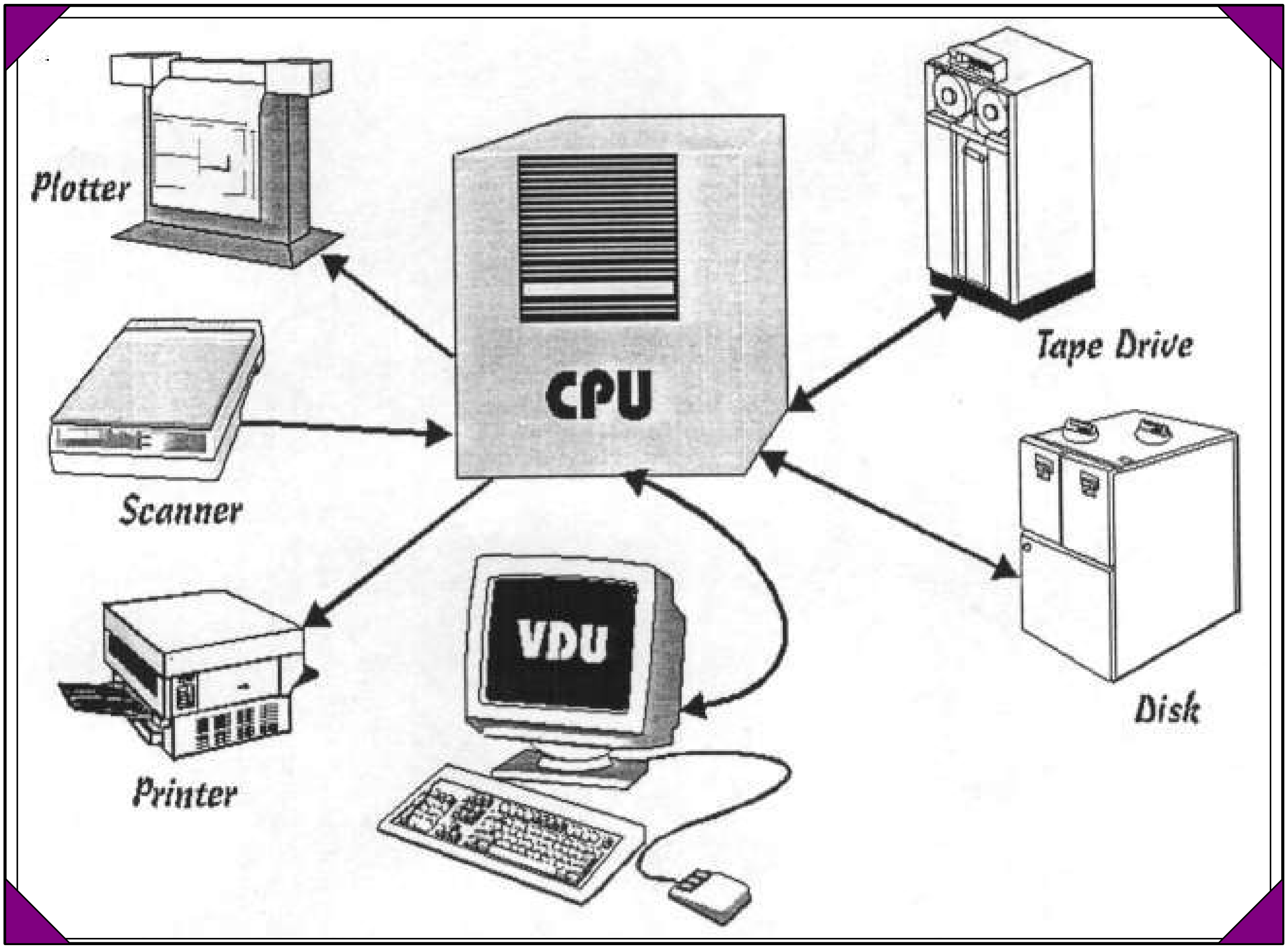
Hardware&Software
Capture, Storage, processing
Analysis, Display etc.,



Maps, Aerial photographs, Satellite Images, Statistic Tables etc,

Design of Standards, Updating, Analysis and Implementations

HARDWARE COMPONENTS



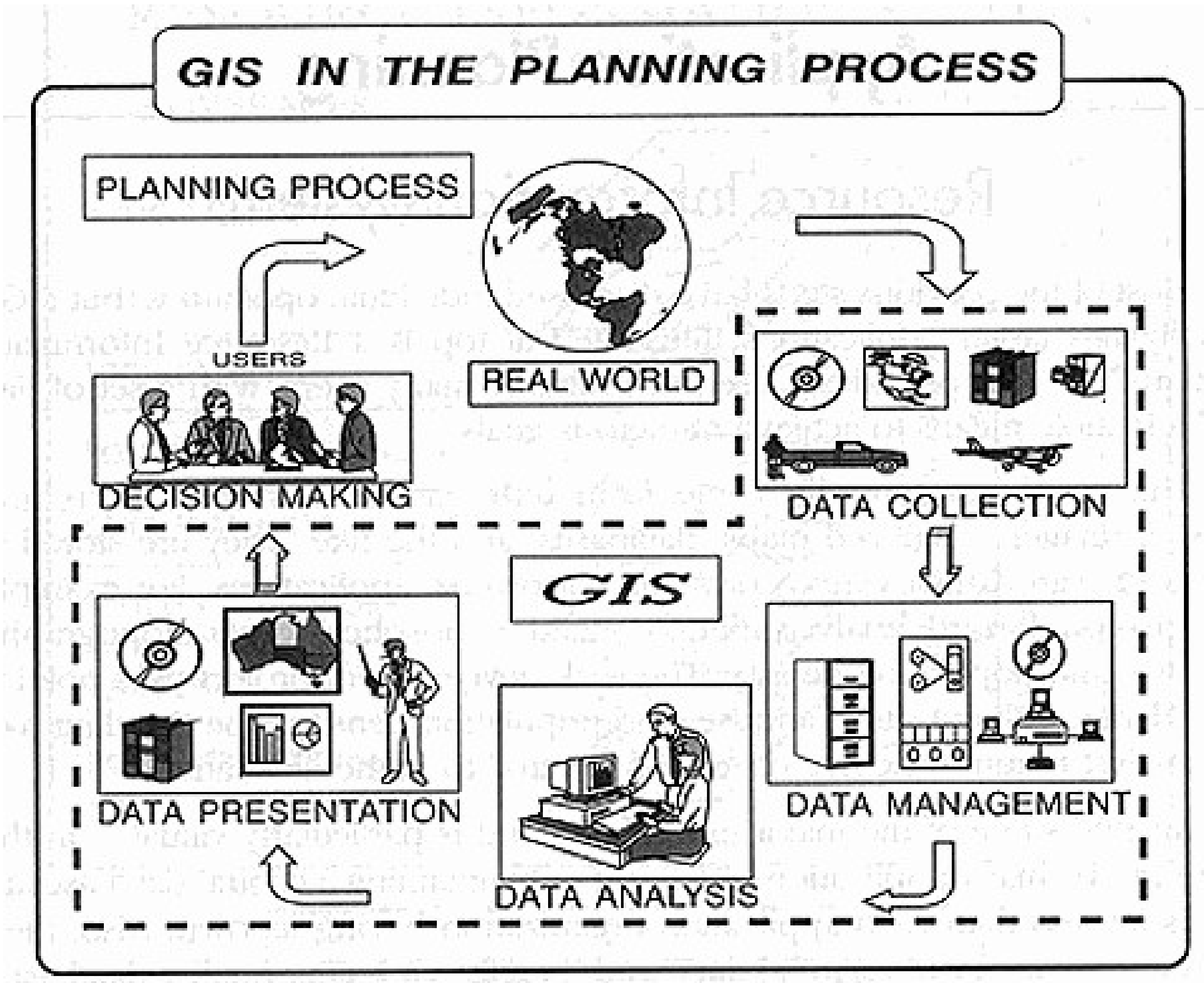
Geographic Information systems have three components, namely computer hardware, sets of application software modules, and proper Organizational setup.

GIS run on the whole spectrum of computer system ranges from portable personal computers To multi-user supercomputers, and are programmed in a wide variety of software packages.

In all the cases, there are a number of elements that are essential for effective GIS operations. These includes

a) The presence of a processor with sufficient power to run the software.
b) Sufficient memory for the storage of large volumes of data
c) A good quality, high resolution color graphics screen.
d) Data input and output devices, like digitizers, scanners, keyboards, printers and plotters.

General hardware components of a GIS include control processing unit which is linked to mass Storage units, such as hard disk drivers and tape drivers


GIS IN THE PLANNING PROCESS
PLANNING PROCESS
REAL WORLD
USERS
DECISION MAKING
DATA COLLECTION
GIS
DATA MANAGEMENT
DATA PRESENTATION
DATA ANALYSIS

GIS APPLICATIONS IN REAL LIFE

- Agricultural applications
- Forestry applications
- Rangeland applications
- Water resources applications
- Urban and regional planning applications
- Wetland mapping
- Land use/ Land cover mapping
- Geologic and soil mapping
- Wildlife ecology applications
- Archaeological applications
- Environmental assessment, monitoring and management

1. Agricultural Applications:

Technological innovations and geospatial technology help in **creating a dynamic and competitive agriculture** which is protective of the environment and capable of providing excellent nutrition to the people**. While natural inputs in farming cannot be controlled, they can be better understood and managed with GIS applications**. GIS can substantially help in effective crop yield estimates, soil amendment analyses and erosion identification and remediation. More accurate and reliable crop estimates help reduce uncertainty.

2. Forestry Applications:

Geographical Information System (GIS) is an amazing technology that is used to create **public policies related to forests and environmental planning. This technology has been responsible for the decision making processes for a couple of** years now. GIS together with other foresting technologies have helped foresters and environmentalists to keep clear records regarding forests and make decisions based on the data obtained. With the rapid advancement of technology, GIS is becoming popular every passing day due to its immense benefits on the environment.

3. Rangeland Applications:

GIS (Geographic Information Systems) and GPS (Global Positioning Systems) technologies have become important tools for assessing and updating the environmental status of rangeland allotments National Forest. **The GIS maps derived with these data layers help identify areas of overlapping use, assist in establishing key monitoring sites and prescribe recommendations on acceptable livestock management practices.**

4. Water Resource Applications:

GIS is, however used in various activities involving water management. Water management using GIS is beneficial for monitoring water resources.

Uses of GIS in water resources:

Storage and management of geospatial data:
Hydrologic management:
Modeling of groundwater: Groundwater
Quality analysis of water:
Water supply management:
Sewer system management:
Storm water control and Floods disaster management

5. Urban and Regional planning Applications

GIS in urban planning enables **spatial analysis and modeling**, which can contribute to a variety of important urban planning tasks. These tasks include site selection, land suitability analysis, land use and transport modeling, the identification of planning action areas, and impact assessments.

6. Wetland Mapping:

Wetlands are recognized as one of the world's most valuable natural resources. With the increasing world population, human demands on wetland resources for agricultural expansion and urban development continue to increase. **Geographic Information System (GIS) and remote sensing technologies have proven to be useful for mapping and monitoring wetland resources.** Recent advances in geospatial technologies have greatly increased the availability of remotely sensed imagery with better and finer spatial, temporal, and spectral resolution.

7. Land use / Landover Applications:

Mapping of LULC and change detection using remote sensing and GIS techniques is a cost effective method of obtaining a clear understanding of the land cover alteration processes due to land use change and their consequences.

8. Geologic and Soil mapping

The application of remote sensing in geology means scientists can use electromagnetic radiation to collect detailed information from all over the world.

THE NATURE OF GEOGRAPHIC DATA

1. **SPATIAL DATA-** **Generally Speaking, spatial data Represents the location size and shape of an object on planet Earth, such as a building, lake, mountain or township.**

2. **ATTRIBUTE DATA-** **Attribute data is the data Give information about the spatial data.**

DATA

1. **SPATIAL DATA**

2. **ATTRIBUTE DATA**

GIS Data and Structures

- SPATIAL DATA
  - RASTER DATA
  - VECTOR DATA
- NONSPATIAL DATA / ATTRIBUTE DATA
- THE RELATIONSHIP BETWEEN SPATIAL DATA AND NON-SPATIAL DATA IS TOPOLOGY

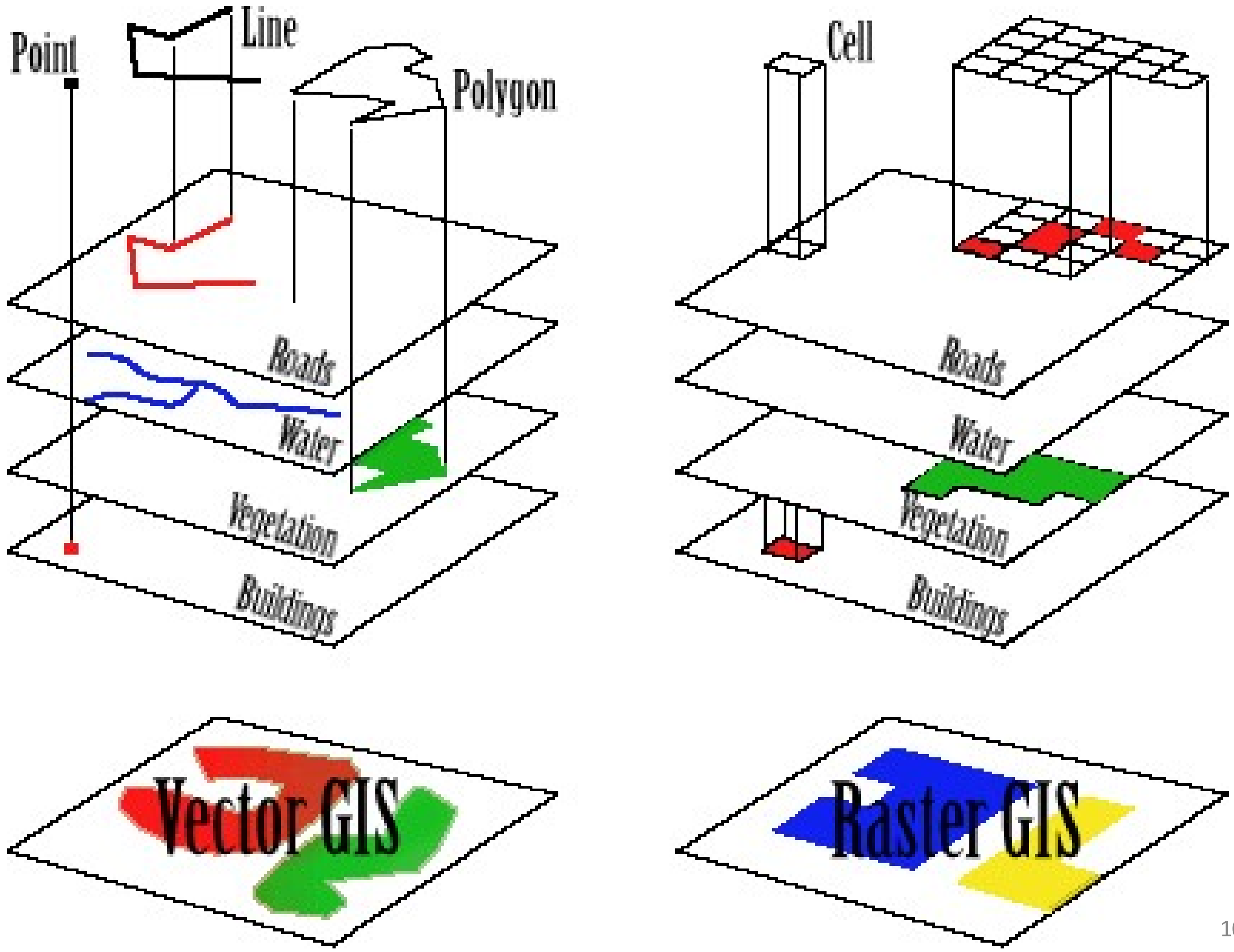
Examples of Spatial Data

- Spatial data is a road map that contains two dimensional points, lines and polygons to represent cities, roads and state boundaries.

- The location of cities, roads, and political boundaries are projected onto a two dimensional display or piece of paper, preserving the relative positions and relative distances of the rendered objects.

- **GIS applications store, retrieve and render earth-relative spatial data in terms of longitude and latitude.**

Vector and Raster

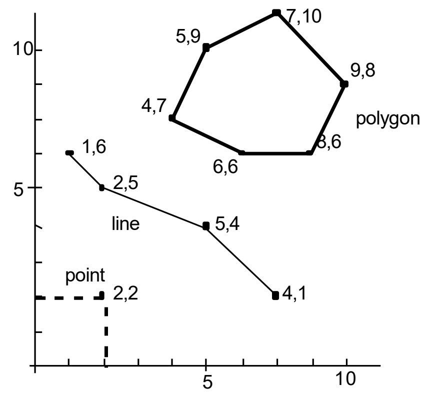



Software
Hardware
GIS
Data
People
Methods

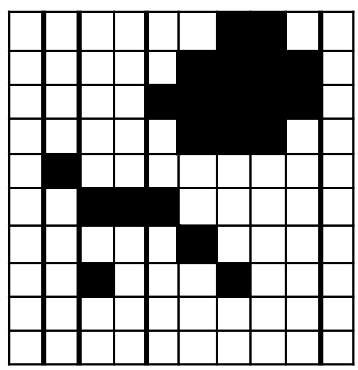

Land Use
Streets
Districts
Parcels
Parks
River
Discharge Point
Sand and Gravel
Sandstone Aquifer
Water Table
Shale

Spatial data storage

- Vector model



as geometric objects:
points, lines, polygons



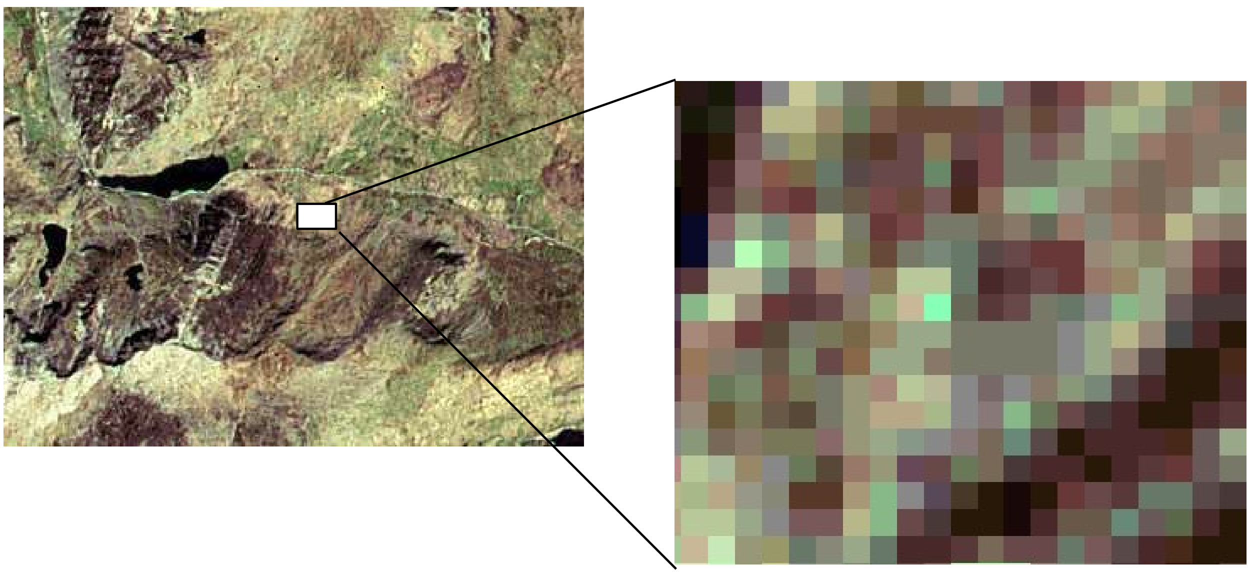
as image files
composed of grid-cells
(pixels)

- Raster model

Vector data

Land use parcels

Raster data



TYPES OF SCALES

The four commonly referred levels of measurement are,

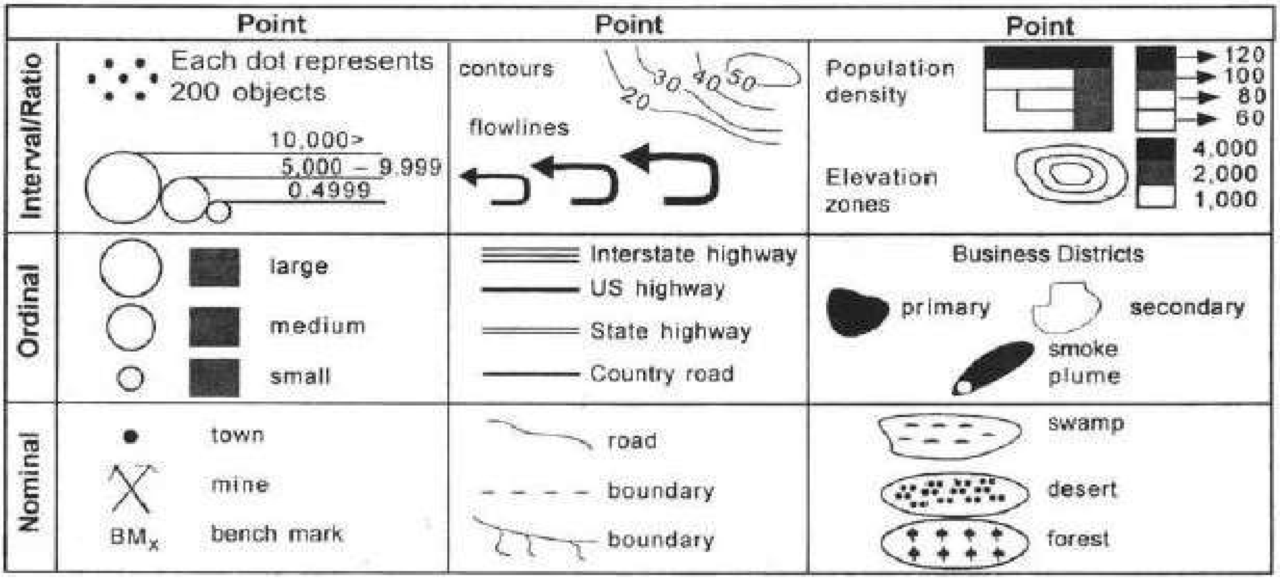
Nominal Scale, Ordinal scale, Interval Scale, Ratio Scale

(i) Nominal scale: are those variables which are described by **name, with no specific order. for example,** Land use, parks, residential areas and so on. **These are 'named' data**. The system allow us to make statements about what to call the object, but it does not allow direct comparisons between one named object and another

(ii) Ordinal scale: Ordinal variables are those variables which are lists in discrete classes but with an inherent order, for example, **classes of streams, like I order and II order.**

(iii) Interval scale: In the interval scale of measurement, the numbers are assigned to the items measured

(iv) Ratio scale: **The ratio variables have the same characteristic as interval variables, but they have natural zero or a starting point.** Rainfall per month is an example of ratio variable



Data	Unit of measurement	Scale/level
Hotel name	Text	nominal
Status of Hotel	Three Star	ordinal
Average Tariff	in Rupees	Interval
Size of the Hotel	m^2	Ratio

MAP SCALE

INTRODUCTION: The **process of representing geographic features on a sheet of paper involves The reduction of these features**. The ratio between the reduced depiction on the map and the geographical features in the real world is known as the map scale, that is the ratio of the **Distance between two points on the map and the corresponding distance on the ground.**

The scale may be represented in three ways

1) Fractional scale
2) Graphic Scale
3) Verbal Scale

4) Fractional Scale: If two points are **1 km apart in the field**, they may be represented on the Map, say 1 cm as separated by some fraction of that distance. In this instance, the scale is 1 cm to a kilometer. **There are 1: 100,000 cm in 1 km. So this scale can be expressed as the fraction or ration of 1: 100,000**

5) Graphic scale: This scale is a line printed on the map and divided into units that are equivalent to some distance **such as 1km or 1mile**. The measured ground distance appears directly on the Map in graphical representation.

6) Verbal Scale: This is an expression in common speech such as " **four centimeters to the kilometer" , "an inch to a mile"**

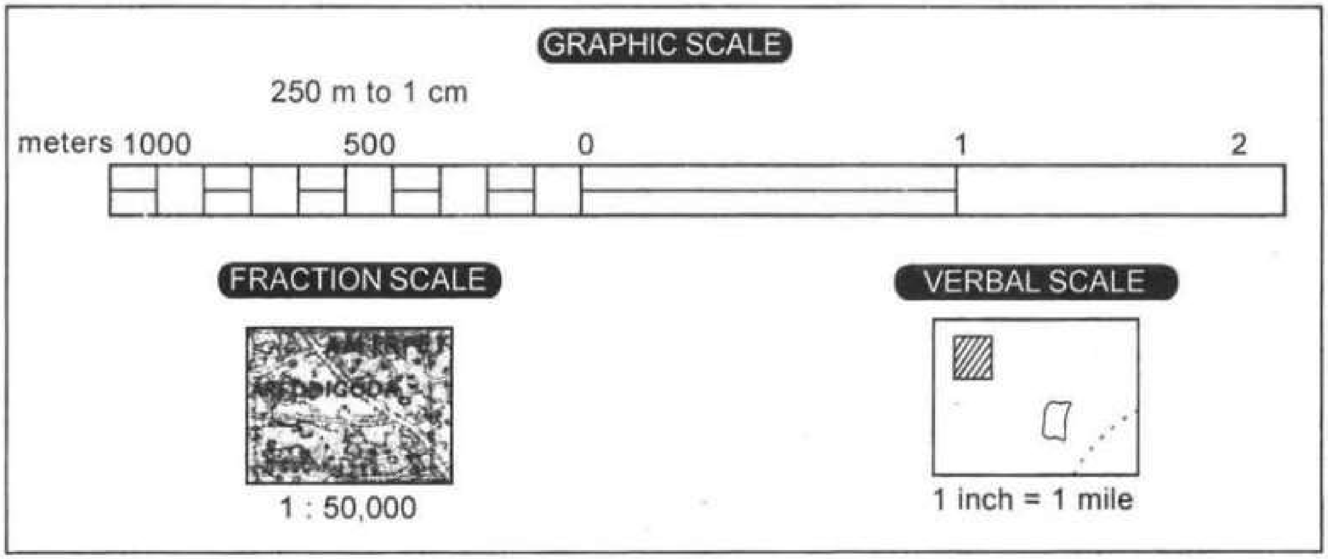


Fig. 1.4 Three different types of scale representation.

MAP AND GLOBE

What is a Map?

A map is a representation or a drawing of the earth's surface, or a part of it, on a flat surface, according to a scale. **It could be hand drawn or printed**. It helps us identify the places and locations within an area helping us to navigate from one place to another.

Types of Maps

Maps are of several types. They are mainly classified into:

Physical or Relief Maps: These show natural features of the earth.
Political Maps: These maps show the cities, town and villages, countries and states of the world with their boundaries.
Thematic Maps: These maps focus on specific information like the map of a rainfall, roads, tourist places.

Components of Maps

Maps have three components: **distance, direction, and symbol**. We measure distance in terms of scale. A scale is a ratio between the actual distance on the ground and the distance shown on the map. To measure large areas like continents or countries on a paper, we use a small scale map. To show a small area like your village to town on a paper, we use a large scale map. Directions are cardinal points like North, South, East and West. And symbols are certain letters, shades, colours, pictures and lines, which give us information about a limited place. Various other things like sketches and plans are used to draw an area of a large scale.

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Globe Versus A Map

A globe differs from a map in many aspects. Let us look at some key points of difference between a globe and a map**. A compilation of many maps is called an atlas.**

A globe is a three-dimensional sphere while a map is two-dimensional.

The globe represents the whole earth, whereas a map may represent the whole earth or just a part of it.

A globe can be used to get a broad-level picture of the world while maps provide more specific information about different places.

A globe, being spherical in shape, spins around an axis. However, maps, are a representation on a piece of paper, does not spin.

Globes are made of hard materials and cannot be folded making them difficult to be carried around. However, you can easily fold and carry maps all along with you.

You can use a map for navigating from one place to another. However, globes don't provide enough specific details to help you in navigation.

COORDINATE SYSTEM

A map is a record of the locations of selected real world features in a given geographic Space defined using the mathematical concept of coordinates.

A **coordinate is one of a set of numerical values that fixes the location** of a point in a space of a given dimension.

A map is two dimensional space, in which the location of a point is fixed by a set of two Numerical values (x,y)

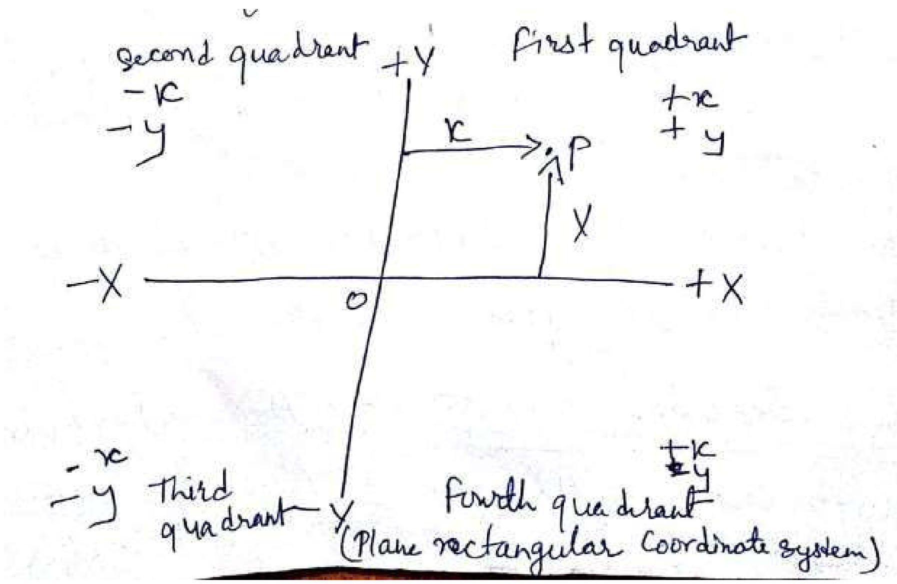
A digital elevation model (DEM) is a three dimensional space, in which the location of a point is fixed by a set of three numerical values(x,y,z)

Three basic types of coordinates are used for fixing the locations of geospatial data on maps and in GIS data bases.

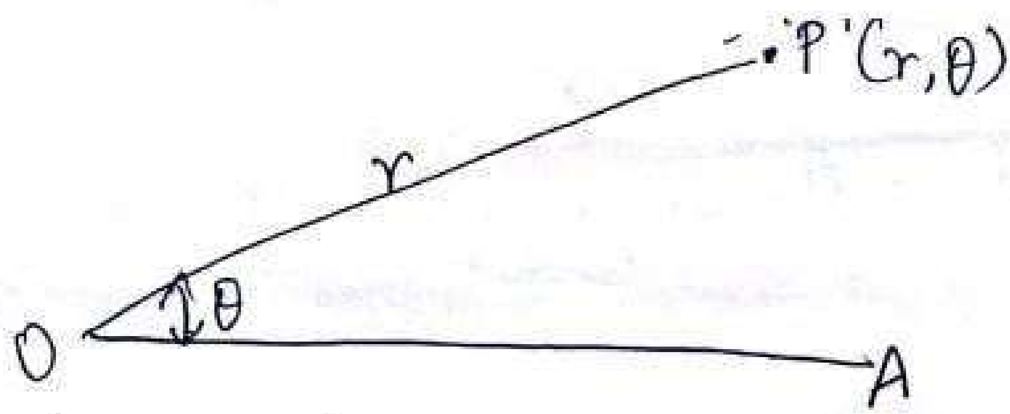
1) **Plane Rectangular coordinates**
2) **Plane polar coordinates**
3) **Geographic coordinates**

Plane Rectangular coordinates: **A rectangular coordinate system for fixing the locations of Real world feature in a two dimensional space**. In this particular coordinate system two **Straight lines intersecting one another at right angles are used to define the geographic Space.** These two lines are called the **axis of coordinate system**, and they define the Directions of the two families of lines.

The point of intersection of the two lines is called the origin of the rectangular coordinate System. The horizontal axis OX is called the X axis while the vertical OY is called the Y axis .



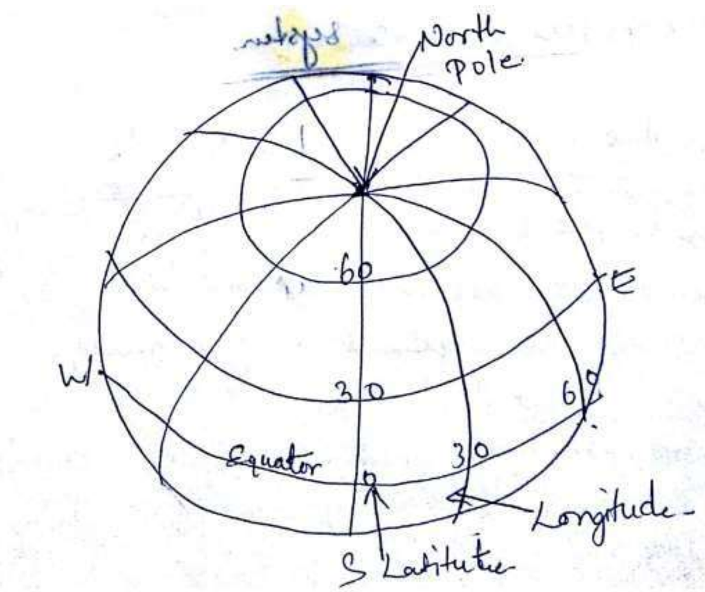
Plane Polar Coordinate System: The polar coordinates system is a **two dimensional Coordinates systems** in which each point on a plane is determined by a distance from reference point and an angle from the reference directions.



plane polar coordinate system

Geographic Coordinate System of Earth

In order to **fix locations on Earth's surface, spherical coordinate reference system known as the geographic coordinate system** has been developed the takes into Account its shape. This coordinate system make use of a **network of latititute and Longitudes to uniquely identify points on Earth surface.**



In this coordinate system, **the two reference points on Earth are North and south Geographic poles as defined by the two points on the surface of earth intersected by its axis of rotation.** Halfway between the two poles as defined by the two points on the surface of the earth intersected by its axis of rotation.

MAP PROJECTIONS

The term map projection can be thought of literally as a projection. **For ex: If we switch On a light bulb placed inside a translucent globe the images on the surface of the globe Will be projected outward.**

When a **projected image hit a wall we have map projection**. Map projection is not done using analog method. Instead **cartographers use mathematical Formula to create projections.** Therefore **map projections can be defined simply as the mathematical transformations of locations in three dimensional space of earth's surface**

Onto two dimensional space of map sheet.

BASIC CONCEPTS AND PROPERTIES OF MAP PROJECTIONS

If we squash an orange on a flat surface , the skin of the orange will split and spread out in all the directions, and the original properties of the orange such as its shape will change. A Similar change

properties will occur when we try to project features on Earth's surface on to a piece of paper.

Some of the properties of the spherical earth will be lost and as a result, the areas and **Shape of the features as they appear on the paper will be changed, and distances and Directions between individual features can no longer be maintained after the Projection.**

Therefore , whole idea of map projection is about preserving the properties of real-world Features when they are depicted on map .

These properties include the following:

1) Area 2) Shape 3) Distance and Direction

1) Area : A map projection may be designed to be of equal area, so that any area measured on earth. Such a map projection is called equal- area or equivalent projection. The equal area Property can be fulfilled by distorting the shape of the garaticule(A graticule a network of Line representing meridians and parallels, on which a map or plan can be represented.)

This properties show s the sizes of real world features to be visually compared on the same area basis.

Shape: **A map projection can maintain the correct shape of the spatial features on maps.** This Property is accomplished by making the scale along the meridian and the parallel the same in both directions.

Distance: **Preservation of the distance can be achieved only by selecting certain lines along the scale remains true.** The line of the true scale include the central meridians of the cylindrical classes of projections as well as the standard parallels of the conic class of projections. Distance preserving map projections are called equidistant.

Direction: If direction measurement made on the map are the same as those made on the ground, the projection is called true direction map projection

CLASSIFICATION OF MAP PROJECTIONS

Map projections according to the type of developable surface onto
Which the network of meridians and parallels is projected. A developable surface is surface that can be laid out flat without distortion.

There are three types of developable surface

1) Cylindrical
2) Conical
3) Planner

1) **Cylindrical Projection**: A cylinder is assumed to circumscribe a transparent globe

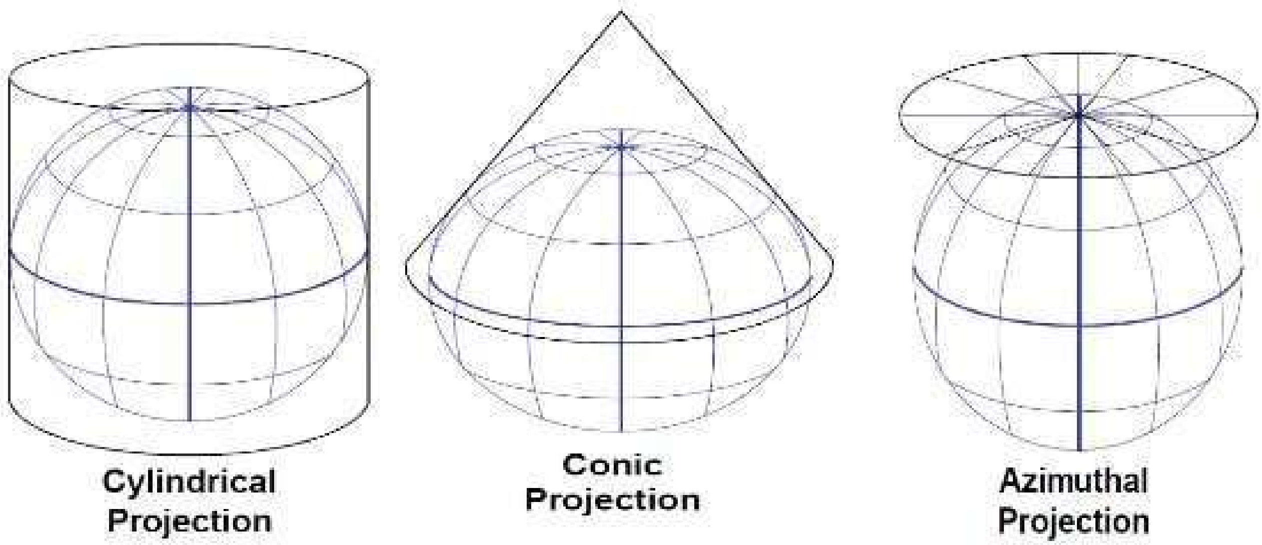
So that the cylinder touches the equator throughout its circumference. Assume that a

Light bulb is at the centre of the globe so that the graticule of the globe is projected

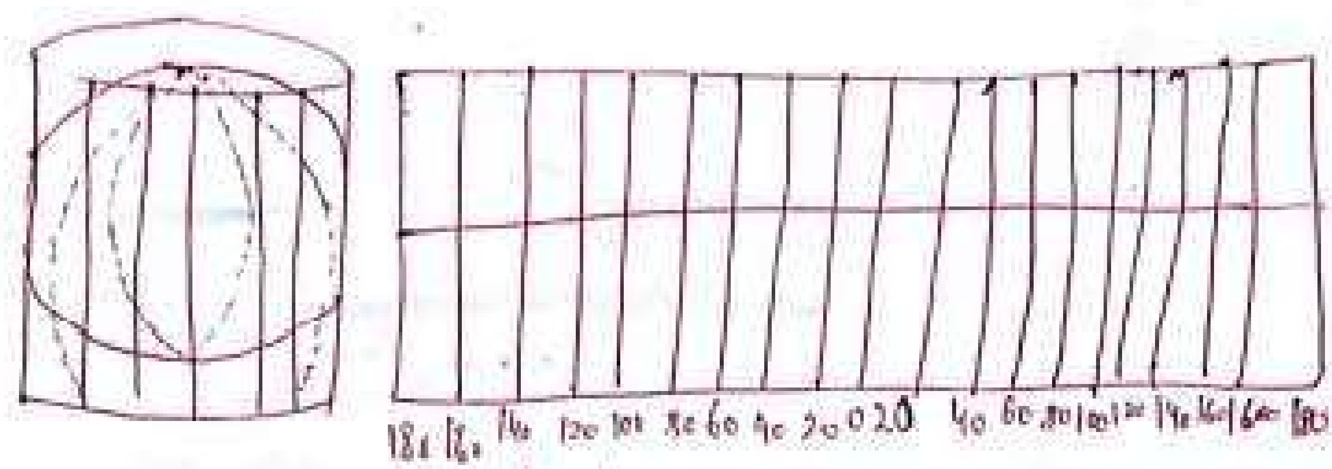
On to the cylinder

Three main types of map projection are:

1. Cylindrical projection
2. Conic projection
3. Azimuthal or planar projection



By cutting open the cylinder along a meridian and unfolding it. A rectangular cylindrical projection is obtained. The meridians are vertical and parallel straight line, intersecting the equator at right angles **and dividing it into 360 equal parts**. The parallel will be horizontal straight lines at some selected distance from the equator and from each other.

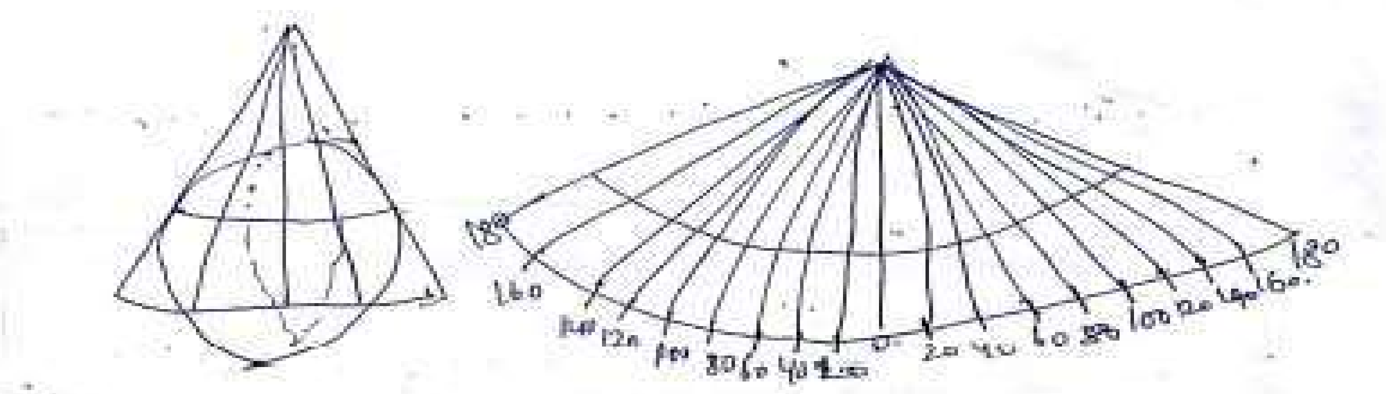


a Cylindrical

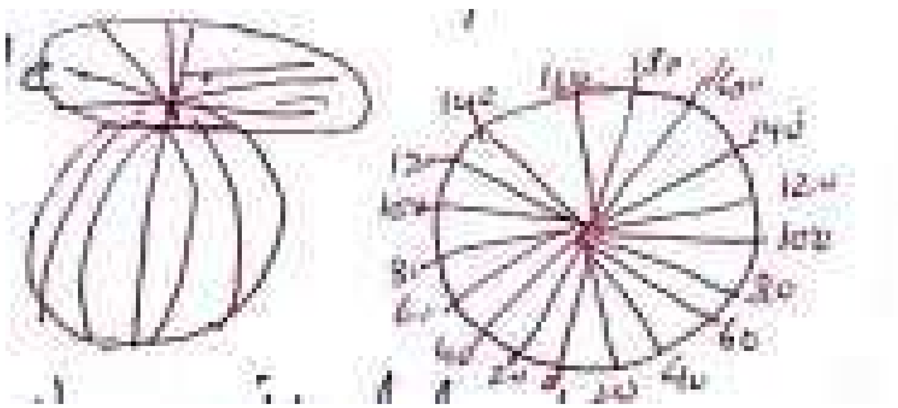
Conical Projection: A cone is placed over the globe in such a way that the apex of the Cone exactly over the polar axis. A cone must touch the globe along a parallel o latitude, kwon as standard Parallel, which can be selected by the cartographer.

Along a parallel of latitude, Known as the standard parallel, which can be selected By the cartographer. Along this standard parallel, the scale is correct and distortion is the least.

When the cone is cut open along the meridian and laid flat, a fan shaped map is produced with meridians as straight lines radiating from the vertex at equal angles.



Planner or azimuthal Projection: **a plan is placed so that it touches the globe at north or south pole. This can be conceived when the cone becoming increasingly flattened until its vertex reaches the limit of 180^{0}.** The projection resulting is better known as the polar azimuthal Projection. As straight lines radiating from center at the circle which is the pole. These meridians projected as straight lines radiating from center of the circle which is the pole. These meridians are spaced at their true angles. The parallels are complete circle centered at the pole.



MAP TRANSFORMATIONS

Geometric transformation is the process of using a set of control points and transformation equations to register a digitized map, satellite image or an aerial photograph onto a projected coordinate system.

In GIS geometric transformation includes **map to map transformation and image To image transformations.**

Control Points

Gcps are defined as points on the surface of the earth of known location used to georefernce. A ground control point (GCP) is a feature that you can clearly identify in the raw image for which you have kwon ground coordinates.

Control points for an image to map transformation, also called ground control points, **are Points where both image coordinates and real world coordinates can be identified**. GCPs are selected directly from a satellite image; the selection is not as straightforward as selecting four tics for a digitized map.

Geometric transformation is the process of using a set of control points and transformation equations to register a digitised map, satellite image, or an air photo to a projected coordination system.

GEOREFRENCING

Georeferencing : Georeferencing is the **process of assigning real world coordinates to each pixel of the raster.** Many times these **coordinates are obtained by doing field surveys collecting coordinates with a GPS device for few easily identified features in the image or map.**

The relevant coordinate transforms are typically stored within the image file though there are many possible mechanisms for implementing georeferencing. The most visible effect of **georeferencing is that display software can show ground coordinates** (**such as latitude/longitude or UTM coordinates) and also measure ground distances and areas.**

Geographic locations are most commonly represented using a **coordinate reference system**, which in turn can be related to a geodetic reference system such as **WGS-84**.

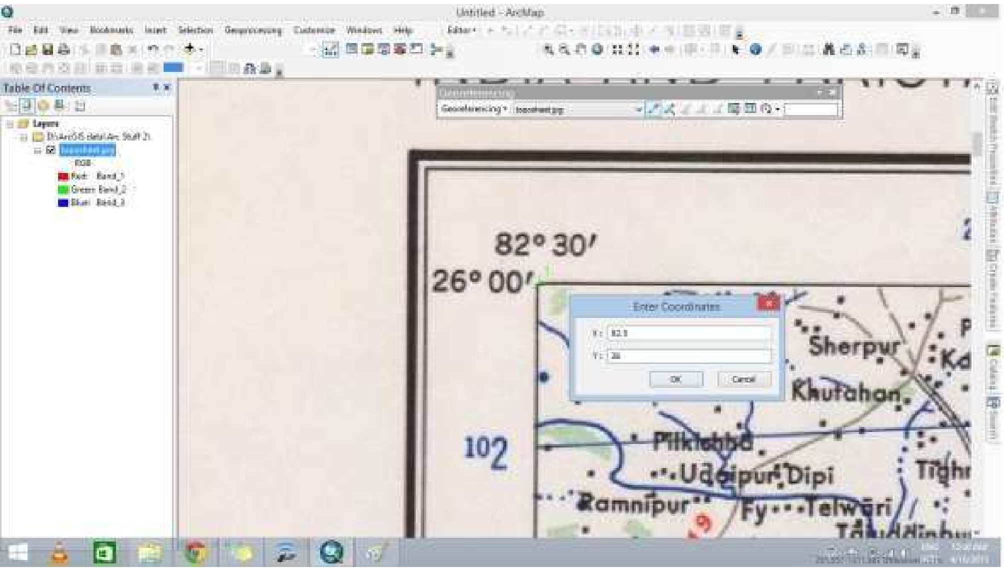
Latitude: Latitude is angular distance measured north and south of the equator.
The equator is 0 degrees, As you go north of the equator the latitude increases all the way up to 90 degrees at the south pole.

Longitude : X-axis it is the angular distance measured east and west of prime meridian. The prime meridian is 0 degrees longitude. As you go east from prime meridian the longitude Increases to 180 degrees. As you go to west from prime meridian the longitude increases to 180 degrees.

GCPs - Ground Control points- GCPs are defined as points on the surface of the earth of kwon location used to geo-reference

A ground control point(GCP) is a feature that you can clearly identify in the raw image for which you have known ground coordinate.

Ground coordinates can come from a variety of sources such as the global positioning System GPS , ground surveys, geocoded images, topographic maps.


Untitled - ArcMap
Table Of Contents
Georeferencing
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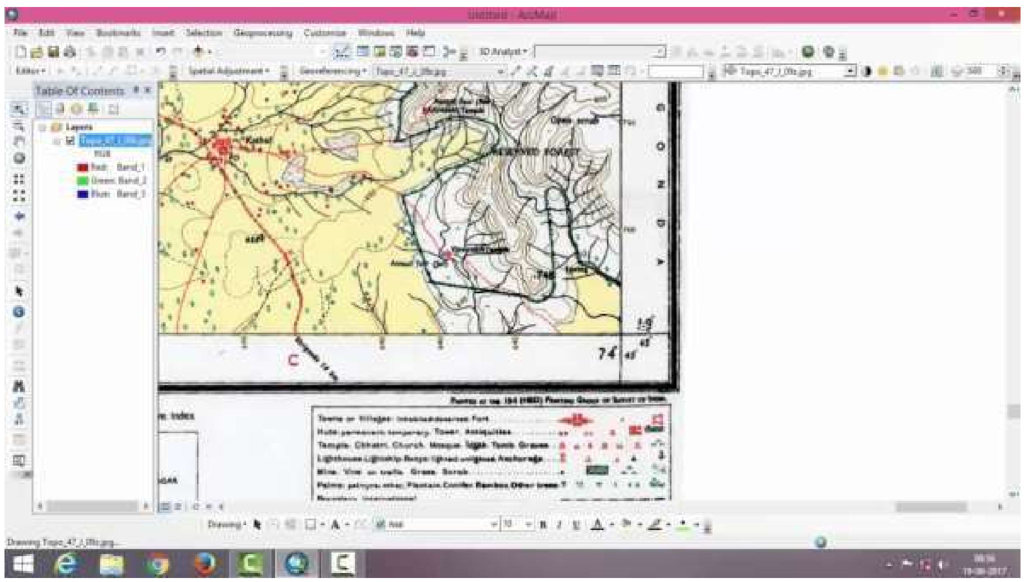
26° 00′
Enter Coordinates
OK
Cancel
Sherpur
Khutahan
102
Udaipur Dipi
Ramnipur
Telwari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