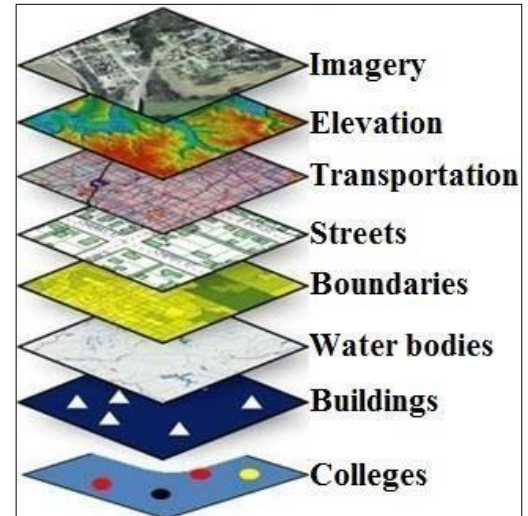


MODULE 3: GEOGRAPHIC INFORMATION SYSTEM (GIS)

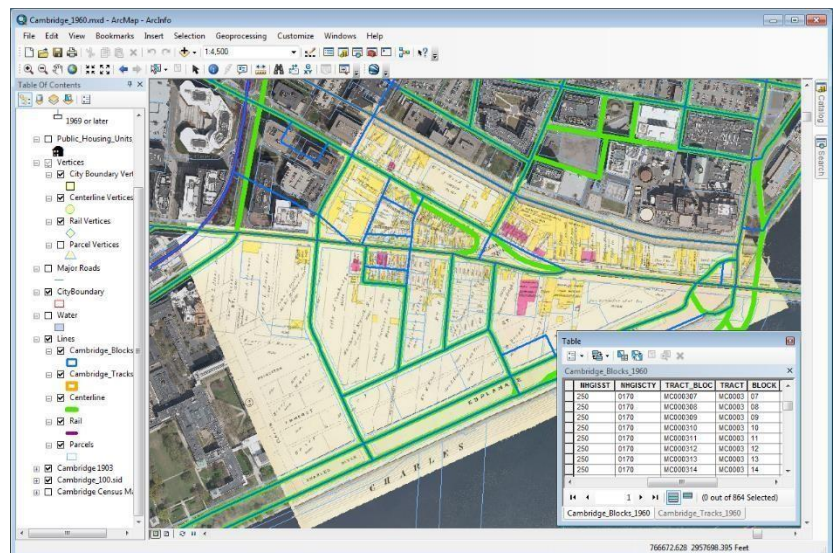
INTRODUCTION: Geographic Information System consists of two distinct disciplines, namely GEOGRAPHY and INFORMATION SYSTEM. Here the word “Geographic” deals with spatial objects or features which can be referred or related to specific locations on the earth surface which may be natural or man-made features. Likewise the word “Information” deals with the large volume of data about particular object on the earth surface. The data includes a set of qualitative and quantitative aspects with the real world objects. The term “System” is used to represent systems approach where the complex environment is broken down into their component parts for easy understanding and handling, but is considered to form an integrated whole for managing and decision making.



Geographic information systems have emerged in the last decade as an essential tool for urban and resource planning and management. Their capacity to store, retrieve, analyze, model and map large areas with huge volumes of spatial data has led to an extraordinary proliferation of applications. Geographic information systems are now used for land use planning, utilities management, ecosystems modelling, landscape assessment & planning, transportation & infrastructure planning, market analysis, visual impact analysis, facilities management, tax assessment, real estate analysis and many other applications.

GIS: It is computer based software used for mapping, analyzing, displaying, storing, and managing the geographical data. This provides solutions to real world problems and help in planning for the future. GIS extract useful information from digital maps, aerial photographs, satellite images and Global Positioning System (GPS) data along with tabular database information.

Geographic (exact location on land and water) information can be associated with a place name, a street address,



township, a zip code, or coordinates of latitude and longitude. All government bodies require geographic information; at least 70% of all information used by local governments is geographically referenced.

Some of the major objectives of GIS are to

- Maximizing the efficiency of planning and decision making.
- Integrating information from multiple sources.
- Facilitating complex querying and analysis.
- Eliminating redundant data and minimizing duplication.
- Capacity to integrate information from many source.

Some of the terms used in GIS are briefly explained below:

1. **Data planes:** These are discrete sets of data such as an imagery, a thematic map, a topographic sheet, a page of field survey data each constitutes a data plane.
2. **Themes:** These are the maps containing different types of information like a toposheet contains contour, roads, railway tracks, forest boundaries etc.
3. **Registration:** It means to associate a digital image file with locations in physical space using the points of interest such as roads, places, bridges, or buildings. Scales may different images may vary along with traditional and rotational errors. This process of correction and development of an invariant spatial relationship between different data planes is called as registration.
4. **Database:** This is the spatially registered set of data constitutes a spatial database. In addition, each spatial object has an associated attribute. This could be a name, a number, a range of values etc.
E.g., A contour has a number, a road has a name, and such attributes also form a part of the database.
5. **Spatial objects:** All spatial objects can be represented by points, lines and polygons. A city is a point, a road is a line and a forest area is a polygon. The manner in which these fundamental units are represented are defined by the spatial data model.
Ex., K.R circle is a point object; DD Urs road is a line object and Kukkarahalli lake is a polygon object.
6. **Scale:** Relationship between distances on an image with that of distances on real ground surface.
7. **Resolution:** This is the smallest element which can be distinguished in a data set. In case of imagery, this usually is the pixel size or a multiple to the pixel size. This may be taken to mean the smallest mappable feature.

COMPONENTS OF GIS

A GIS is divided into three components to create successful output of useful images. They are:

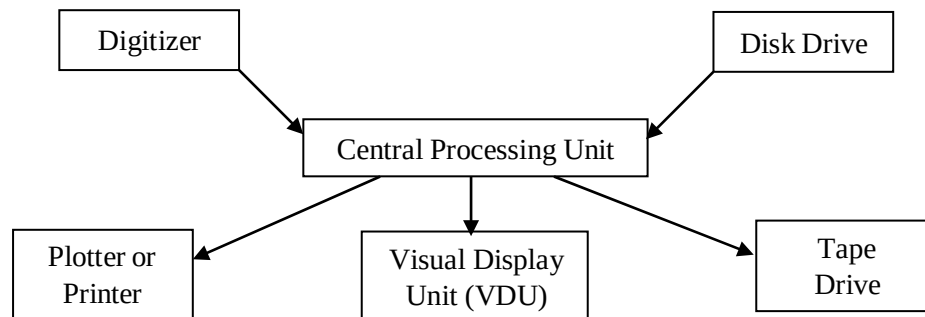
1. Hardware

2. Software

3. Organizational Setup

GIS can function properly if these three components are maintained in balance.

1. Hardware components of GIS



- i. **CPU:** Central Processing Unit is linked to disk drive, which provide space for storing data & programs.
- ii. **Digitizer:** It is a device used to convert data from analog to digital form and stores into a computer.
- iii. **Printer or Plotter:** Plotter is a hardware device in which we provides the data to a plotter, then it processed and present results on a paper.
- iv. **Tape Drive:** It is used to store data or programs on magnetic tape for communicating with other systems.
- v. **VDU (Visual Display Unit):** It is used to control the computer and other peripherals. It is otherwise known as terminal or workstation.

2. Software component consists of five basic modules as follows:

- i. Data Input and Verification System:** This is also called as data capture subsystem. It deals with getting inputs given by the use or input from Global Positioning System (GPS) or from scanning photographs from Remote Sensing or processing digital data received from satellites. The data is stored in computer in the digital form.
- ii. Data Base Management:** This deals with the efficient storage.
- iii. Data Output & Presentation:** This deals with retrieval and manipulation of data.
- iv. Data Transformation:** It deals with the transformation of data from one form to another which mainly works on TWO operations such as maintenance data and its utilization.
- v. User Interpretation:** GIS system should be proceed with eco-friendly language that the user can understand easily and it can proceed with command where it is used.

3. Organizational Context: It is nothing but the way the information flows go the way in which the analysis is done. The organizational context involves three sub components such as

- i. Data:** It is the information being used for the analysis.
- ii. People:** The people involved in the analysis and the creation of information system.
- iii. Methods:** the step procedures which are used for the analysis and in the making of the information system.

APPLICATION AREAS OF GIS

To understand the advantages and importance of GIS in a better way, it is very important to know the applications and uses of GIS. A GIS enables us to better understand and evaluate our data by creating graphic displays using information stored in our database. Major areas of GIS applications are:

- 1. Electric/gas utilities:** The GIS is used on a daily basis by the cities and utilities to help them in mapping, in inventory systems, track maintenance, monitor regulatory compliance, or model distribution analysis, transformer analysis and load analysis.
- 2. Environment:** The GIS is used every day to help protect the environment. An environmental professional uses GIS to produce maps, inventory species, and measure environmental impact or trace pollutants. The environmental applications for GIS are almost endless.
- 3. Forestry:** Nowadays, managing forests is becoming a more complex and demanding challenge. With GIS, foresters can easily see the forest as an ecosystem and manage it efficiently.
- 4. Geology:** Geology use GIS every day in a wide variety of applications. The GIS can also be used to study geologic features, analyses soils and strata, assess seismic information, or create 3D displays of geographic features.
- 5. Hydrology:** The GIS can also be used to study drainage systems assess groundwater, and visualize watersheds and in many other hydrologic applications.
- 6. Mapping:** It is an essential function of a GIS. People in a variety of professions use GIS to help others a skilled cartographer to made maps with a GIS.
- 7. Military:** Military analysts and cartographers use GIS in a variety of applications such as creating base-maps, assessing terrain and aiding tactical decisions.
- 8. Risk management:** A GIS can help with risk management and analysis by showing us which areas are likely to be prone to natural or manmade disasters. When such forthcoming disasters are identified, preventive measures can be developed that deal with different scenarios.

9. **Site planning:** People around the world use GIS to help them locate sites for new facilities or locate alternative sites for existing facilities.
10. **Transportation:** A GIS can be used to in managing transportation infrastructure or in managing logistical problems. They can help in monitoring rail systems and road conditions or finding the best way (route) to deliver our goods or services.
11. **Water/Waste water industry:** People in the water/waste water industry use with the planning, engineering, operations, maintenance, finance and administration functions of their water/waste water networks.
12. **Web mapping:** Google Maps and Bing Maps are the specific websites give the public access to huge amounts of geographic data.

LIMITATIONS OF GIS

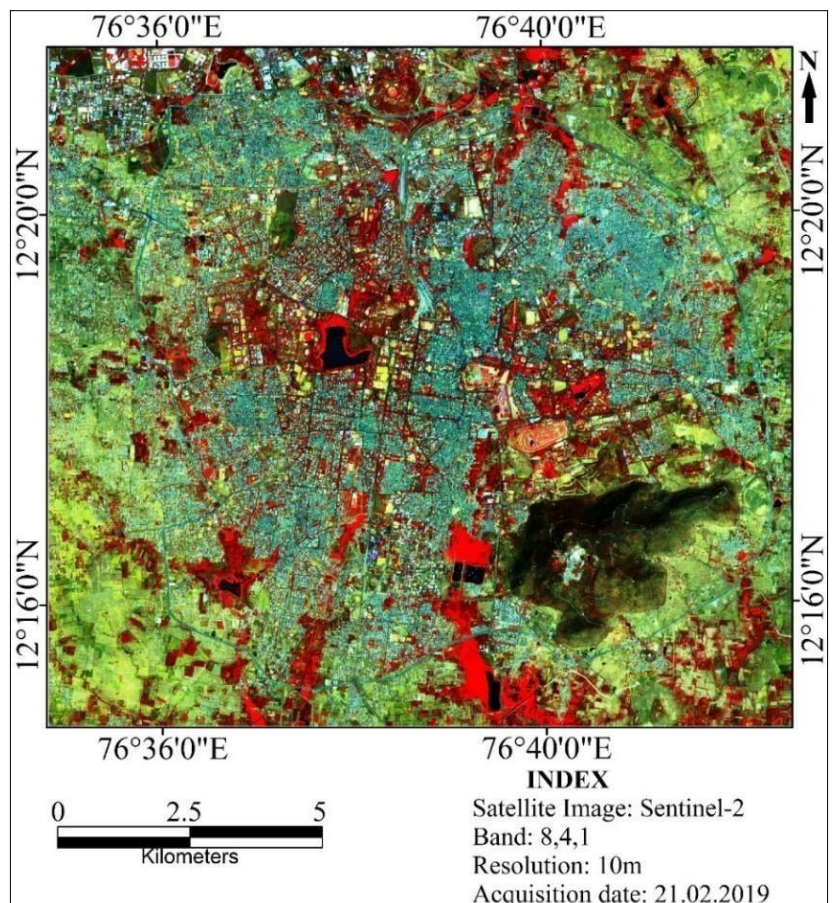
A GIS has many beneficial applications, however, like other technological systems, there are also some limitations to its use. The following are some examples:

- i. Data for a specific area may lack spatial or temporal continuity.
- ii. GIS data are relatively expensive than traditional data.
- iii. Collection of data can be very time consuming.
- iv. GIS often relies on the quality of available data which may introduce serious errors.
- v. GIS data may also be subject to misuse or misinterpretation.
- vi. Learning time on GIS software and systems can be long, because it easily becomes the objectives of the study rather than just a tool.

GEOGRAPHICALLY REFERENCED DATA

Geographically referenced data or georeferencing means that the internal co-ordinate system of a map can be related to real ground features of geographical co-ordinates. Geodata represents real world features of both locations & characteristics of spatial features of buildings, roads, land parcels and water bodies. These georeferenced data typically stored as GeoPDF/ GeoTIFF within the image file. In general, geo-referencing means digital image information associated with locations in physical space and its area measurement. Geo-referencing may be applied to any kind of object or structure that can be related to a geographical location, such as points of interest, roads, places, bridges, or buildings.

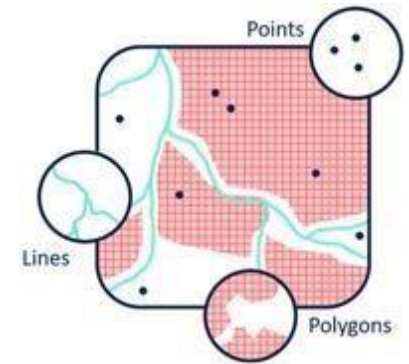
Geographic locations are most commonly represented using a coordinate reference system, which in turn can be



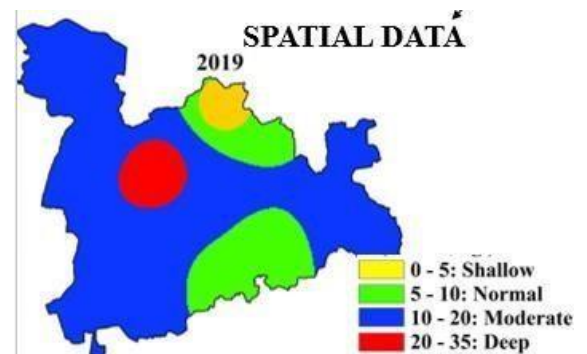
related to a geodetic reference system such as WGS-84. To define an objects position on the earth a spatial reference known as georeferenced is used. In the case of a direct spatial reference the information about the location is defined by two or three dimensional co-ordinate in the co-ordinate reference system. The commonly used reference system at the zones like Tropic of Cancer & Tropic of Capricorn is WGS-84. In case of indirect spatial reference system closer to everyday human experience are used as georeferenced locations of real world objects such as administrative areas, coastal address, coastal posts & place name.

GIS SOFTWARE USES TWO BASIC TYPES OF DATA

1. SPATIAL DATA: It represents the exact location of specific features on the earth's surface. Spatial data can be obtained from satellite images or scanned maps and similar resources. Essentially, any format of a geographical image with location or co-ordinate points can be used as spatial data. Spatial data contain the coordinates and identifying information for various map features. Three types of features can be represented on the Map View:



- a. **Points:** Point data is most commonly used to represent discrete data. These have zero dimensions, therefore you can measure neither length nor area with this dataset. E.g., K.R. Circle.
- b. **Polylines:** Line data is used to represent linear features with only one dimension used to measure length. Line features have a starting and ending point. Length of Cauvery River, road, powerline, telephone lines are the best examples.
- c. **Polygons:** Polygons are used to represent areas such as the boundary of a Mysuru city, perimeter of Kukkarahalli lake, or Bandipur forest boundary. These are 2D information which can be used to measure the area and perimeter of a geographic feature.



Each provides information connected to geographical locations using X-Y coordinate systems. Furthermore, image data consists of a matrix of cells or pixels arranged into rows and columns. Each cell contains a value representing information. Spatial data is any type of data that directly or indirectly references a specific geographical area or location called as geospatial data or geographic information. Spatial data of geo reference data is commonly characterized by the presence of two fundamental components,

1. The physical dimension or class i.e height of the forest canopy, demographic class, rock types, vegetation type, details of a city etc.
2. The spatial location of the phenomena i.e., specified with reference to common coordinate system.

Spatial databases provide a strong foundation for accessing, storing, and managing your spatial data empire. A database is a collection of related information that permits the entry, storage, input, output, and organization of data. A Database Management System (DBMS) serves as an interface between users and their databases. A spatial database includes location, geometry as points, lines and polygons. GIS combines spatial data from many sources with many different people. Databases connect users to the GIS database.

For example, a city might have the wastewater division, land records, transportation, and fire departments connected and using datasets from common spatial databases.

2. ATTRIBUTE DATA: The second type of data used in a GIS is attribute data. Attribute tables are similar to spreadsheets. Attribute data is the detailed table data used in combination with spatial data to obtain the meaningful information of a map. These data are descriptions or measurements of geographic features in a map. This represents its characters such as number of people, status of employment and labeling of locations that can be linked to the spatial data. Every feature has characteristics that we can describe as a building has a built year, number of floors and its type (Residential, educational or commercial). Attributes are the facts we know, but the built year is not visible. An attribute table represents both Rows and Columns which displays the type of building, its built year and number of floors in it. In a GIS, clicking on the row will highlight the corresponding feature on the map.

ATTRIBUTE DATA

SI	Stations	Latitude	Longitude	2019
1.	Bhogadi	12.305	76.5964	26.50
2.	Devalapura	12.2246	76.7002	8.96
3.	Elwala	12.3437	79.5834	10.31
4.	Jayapura	12.2044	76.5538	19.91
5.	Kadakola	12.1933	76.6653	6.24
6.	Keelanapura	12.253	76.8186	12.04
7.	Siddalingapu			2.52

Some popular sources of attribute data are from town planning and management departments, policing and fire departments, environmental groups and online media. For instance, the spatial data might represent a water distribution pipe network and contain information for each pipe when it was installed, last inspected, pipe material (i.e., cast iron, PVC, etc.), pressure rating, roughness coefficient, and so forth. These can be numeric and or character data such as timber type, timber volume, road size, well depth etc. Attribute data are descriptions, measurements, and/or classifications of geographic features in a map. Attribute data can be classified into 4 levels of measurement such as

- a. **Nominal:** The nominal level is the lowest level of measurement for distinguishing features quantitatively using type or class (e.g. tree species).
- b. **Ordinal:** Ordinal data are ranked into hierarchies but does not show any magnitude of difference (e.g. city hierarchy).
- c. **Interval:** The interval measurement indicates the distance between the ranks of measured elements, but a starting point is arbitrarily assigned (e.g. Celsius Temperature).
- d. **Ratio:** Ratio measurements, the highest level of measurements, includes an absolute starting point.

Types of Attribute data: Defined by data types allowed in GIS package

- i. Character string
- ii. Integers
- iii. Real numbers
- iv. Date
- v. Time interval

JOINING/ LINKING SPATIAL DATA AND ATTRIBUTE DATA: A spatial join joins the attributes of two layers based on the location of the features in the layers. Like joining two tables by matching attribute values in a field, a spatial join appends the attributes of one layer to another. You can then use the additional information to query your data in new ways. While you can also select features in one layer based on their

location relative to another layer, a spatial join provides a more permanent association between the two layers because it creates a new layer containing both sets of attributes.

1. The geo-relational data model store spatial data and attribute data in separate files.
2. Each map feature has unique label ID.
3. Linked by feature ID, the two sets of data files can be queried, analyzed and displayed.
4. Attribute data are stored in a table caused feature attribute table.
5. A row is called as record; while a column is called as field.
6. Most GIS projects have many attributes.
7. To store all attributes in a single table is not efficient both time & computer space and difficult to use & update.
8. A Database Management System (DBMS) provides tools for data input, search, retrieval, manipulation and output to manage, integrate and share the database.
9. Most GIS package include DBMS:
 - i. Infor for ArcInfo
 - ii. MS Access for IDRISI, Arcview & ArcGIS

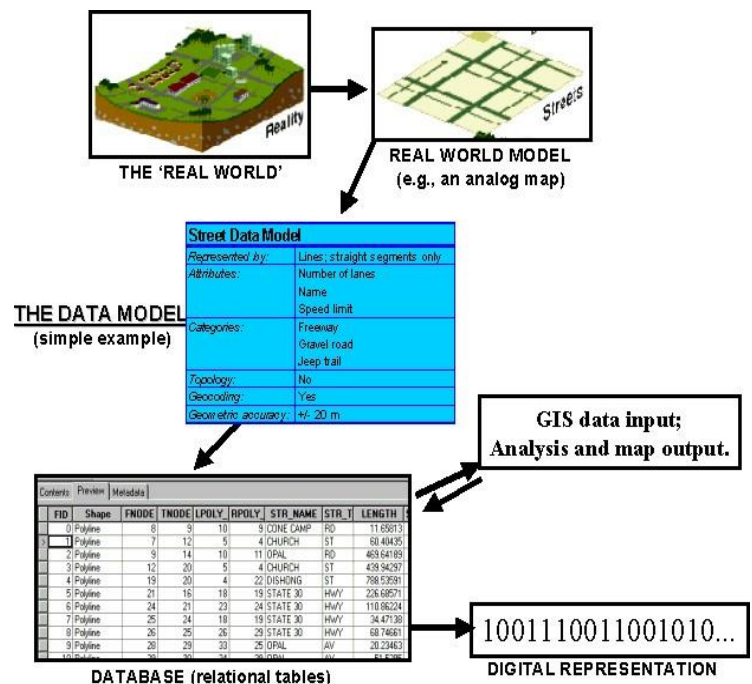
Overlay: Overlay is several information of one area placing one above the other based on the coordinate system. The overlay function creates composite maps by combining diverse data sets. The overlay function can perform simple operations such as laying a road map over a map of local wetlands, or more sophisticated operations such as multiplying and adding map attributes of different value to determine averages and co-occurrences.

Raster and vector models differ significantly in the way overlay operations are implemented. Overlay operations are usually performed more efficiently in raster-based systems. In many GISs a hybrid approach is used that takes advantage of the capabilities of both data models. A vector-based system may implement some functions in the raster domain by performing a vector-to-raster conversion on the input data, doing the processing as a raster operation, and converting the raster result back to a vector file.

GIS OPERATIONS

A GIS consists of database coupled with a graphics output. There are three major types of operations in GIS are as follows:

1. SPATIAL DATA INPUT: A satellite image is simply a raster dataset with file coordinates (rows/columns) that need to be converted to map coordinates. Likewise, aerial photography, recent satellite images commonly used in GIS operations and sometimes comes as already georeferenced data. Spatial data representing geographic features (points, lines and areas) and attribute data (descriptive information). Data input should be done with utmost care, as the results of analyses heavily depend on the quality of the input data. Data input is the procedure of encoding data into a computer-readable form and writing the data to the



GIS data base. There are two types of data to be entered in a GIS - spatial (geographic location of features) and non-spatial (descriptive or numeric information about features).

There are three types of data entry:

- i. **Manual (via typing on keyboard or importing text files):** Manual data entry can bring into GIS either collected or measured data. These data exist as simple text files or binary files. Text files should have at least two columns with X and Y coordinates. These columns allow georeferencing of the file i.e. association of it with specific geographic coordinate system. Binary files are usually a product of the software package associated with measuring device (for example files from Global Positioning System data collection). They also have X and Y data, associated with description of the collected features, but in encoded format that could be read by special software. Digitizing is a process of entering digital codes of analyzed data into computer.
- ii. **Digitizing:** Digitizing can be manual (using digitizing tablet) or automatic (using scanner). The difference between two methods is that digitizing tablet allows to do georeferencing during the digitizing process, while scanning require georeferencing later, after digital file (usually TIFF, GIF or JPEG image) has been created. Another difference between methods is speed and accuracy of the data processing. Apparent slowness of the work on digitizing tablet compensates often for the amount of editing after scanning process. At the same time good scanning allows automatic layer separation (for example, separation of red-colored roads from brown-colored contour lines), while digitizing of the map on a tablet requires manual creation of separate themes. In this case the condition of the original hardcopy is very important. Since human operator can use more cognitive tools and knowledge than the software support for scanning device, digitizer can handle better the hardcopy in a poor condition. Special kind of scanned data is remote sensing image, taken either by satellite camera, digital camera or video camera.
- iii. **Scanning:** Analysis and modeling in a GIS requires input of relevant data. Any textural or tabular data can be referenced to a geographic feature, e.g, a point, line or area can be input into a GIS. Attribute data is usually input by manual keying or via DBMS software. ASCII format is the default standard for the transfer and conversion of attribute information. Data input is the operation of encoding both types of data into the GIS database formats such as manual digitizing, automatic scanning, entry of coordinates using coordinate geometry and the conversion of existing digital data. The creation of a clean digital database is the most important and time consuming task upon which the usefulness of the GIS depends. The process of creating the GIS data from the analog data or paper format is called digitization. Digitization process involves registering of raster image using few GCP or known coordinates. This process is widely known as rubber sheeting or georeferencing. Polygon, lines and points are created by digitizing raster image.

Attribute Data Management System (ADMS): open-database-connectivity to manage attribute data in order that the data in ADMS can be shared, be conversed and be communicated with other data in other databases. ArcInfo, as a representative of many commercial GIS softwares, employed relational database to manage attribute data, while graphic data is managed like management of common files. Feature identifier (ID) is presented for connecting attribute data and graphic data.

- i. **Attribute data input and management** Attribute data should be stored in the form of table. The ADMS is able to accept, process and sort various types of data automatically as well as guarantee data security always.

- ii. Attribute data query: The ADMS should provide multiple query schemes in order that users can fast query things that they require in various practices.
- iii. Attribute data dynamic updating: The ADMS should be designed to support different types of attribute data updating, such as, editing, erasing, deleting, adding, and so on so that the data is current, accurate and reliable.
- iv. Statistics and analysis: The ADMS should have the functions of statistical analysis and development prediction to various attribute data.
- v. Data (base) operating: The ADMS should be simple to learn, convenient to operate because the users vary from beginner to sophisticated operators.
- vi. User interface: Friendly user interface, such as menu bar, pull-down menu, diagonal box, pop-up menu, toolbar, and so on.

CO-ORDINATE SYSTEM

A GIS is to be created from available maps of different thematic layers (soils, land use, temperature, etc). The maps are in two-dimensions whereas the earth's surface is a 3-dimensional ellipsoid. Every map has a projection and scale.

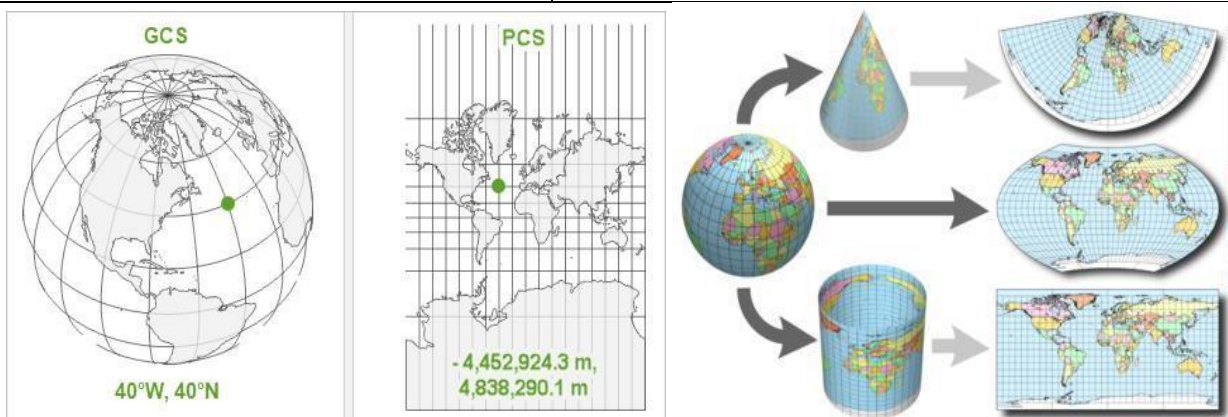
To understand how maps are created by projecting the 3-d earth's surface into a 2-d plane of an analogue map, we need to understand the georeferencing concepts. Georeferencing involves 2 stages: specifying the 3-dimensional coordinate system that is used for locating points on the earth's surface that is, the Geographic Coordinate System (GCS) and the Projected Coordinate System that is used for projecting into two dimensions for creating analogue maps.

Co-ordinate systems are ways of splitting of the world in order to transform units related to points on the map. Different co-ordinate systems have different methods of splitting up of the earth. A co-ordinate system enables every location on the earth to be specified by a set of co-ordinates known locations on a grid. There are two major co-ordinate systems:

1. Geographic Coordinate System

2. Projected Coordinate System

It's shaped like a globe-spherical.	A projected coordinate system (PCS) is flat.
A (GCS) is a reference framework that defines the locations of features on a model of the earth.	It contains a GCS, but it converts that GCS into a flat surface, using math (the projection algorithm) and other parameters.
Its units are angular and usually degrees.	Its units are linear, most commonly in meters.
A GCS is necessary for data to know where exactly on earth's surface it is located.	A PCS is necessary to draw the data on a flat map.



Geographic Coordinate System (GCS): The traditional way of representing locations on the surface of the earth is in the 3-dimensional coordinate system is by its latitude and longitude. Note that the distance between two points on the 3-d earth's surface varies with latitude. The 3-d system therefore does not provide a consistent measure of distances and areas at all latitudes.

The true surface of the Earth is not the smooth ellipsoid but is quite uneven and rugged. The GCS which is the surface used for specifying the latitude and longitude of a point on the earth's surface is also an approximation and a 3-d model of the earth. Several standard models of the ellipsoid are available to define the GCS (WGS 84, Everest ellipsoid) etc. The different models vary in their critical parameters (semi major or equatorial axis and semi minor or polar axis of the ellipsoid and the point of origin). The ellipsoid model that is used to calculate latitude and longitude is called the datum. Changing the datum, therefore, changes the values of the latitude and longitude.

Specifying the Geographic Coordinate System therefore requires specifying the Datum. The datum is a fixed 3-d ellipsoid that is approximately the size and shape of the surface of the earth, based on which the geographic coordinates (latitude and longitude) of a point on the Earth's surface are calculated. In fact describing a place by its lat/long is not complete without specifying its datum. In India the Everest Ellipsoid is used as the Datum for the Survey of India maps.

The ideal solution would be a spheroidal model of the Earth that has both the correct equatorial and polar radii, and is centered at the actual center of the Earth. One would then have a spheroid, that when used as a datum, would accurately map the entire Earth. All lat/longs on all maps would agree. That spheroid, derived from satellite measurements of the Earth, is GRS80, and the WGS84. datum matches this spheroid. The most common system is geographic co-ordinate system which uses measures of latitudes & longitudes to determine your location. Lines of latitudes run North & South parallel to the equator with positive numbers representing Northern hemisphere & negative numbers representing Southern hemisphere. The equator represents 0° and as overall 181 lines of latitudes. Line of longitudes runs East and West parallel to the prime meridian with positive numbers representing Eastern hemisphere and negative numbers representing western hemispheres.

The prime meridian represents 0° proceeded by 360 lines which are called as great circles along with the equator. The units for GCS systems is represented in degree's, minutes & seconds. To identify exact locations on the surface of the Earth, a geographic coordinate system is used. Normally, an x and y-axis are used in mathematical systems, but in geography, the axes are referred to as lines of latitude (horizontal lines that run east-west) and longitude (vertical lines that run north-south). Each axis represents the angle at which that line is oriented with respect to the center of the Earth, and so the units are measured in degrees (°).

A geographic coordinate system is a reference system for identifying locations on the curved surface of the earth. Locations on the earth's surface are measured in angular units from the center of the earth relative to two planes: the plane defined by the equator and the plane defined by the prime meridian (which crosses Greenwich England). A location is therefore defined by two values: a latitudinal value and a longitudinal value. Examples of latitudinal lines are shown on the left and examples of longitudinal lines are shown on the right. The 0° degree reference lines for each are shown in red (equator for latitudinal measurements and prime meridian for longitudinal measurements).

A latitude measures the angle from the equatorial plane to the location on the earth's surface. A longitude measures the angle between the prime meridian plane and the north-south plane that intersects the location of interest. For example Colby College is located at around 45.56° North and 69.66° West. In a GIS system, the North-South and East-West directions are encoded as signs. North and East are assigned a positive (+) sign and South and West are assigned a negative (-) sign. Colby College's location is therefore encoded as +45.56° and -69.66°.

Building the Geographic Coordinate System

A Geographic Coordinate System (GCS) is defined by the ellipsoid model and by the way this ellipsoid is aligned with the geoid (defining the datum). It is important to know which GCS is associated with a GIS file or a map document reference system. This is particularly true when the overlapping layers are tied to different datums (and therefore GCS'). This is because a location on the earth's surface can take on different coordinate values. For example, a location recorded in an NAD 1927 GCS having a coordinate pair of 44.56698° north and 69.65939° west will register a coordinate value of 44.56704° north and 69.65888° west in a NAD83 GCS and a coordinate value of 44.37465° north and -69.65888° west in a sphere based WGS84 GCS. If the coordinate systems for these point coordinate values were not properly defined, then they could be misplaced on a map. This is analogous to recording temperature using different units of measure (degrees Celsius, Fahrenheit and Kelvin)—each unit of measure will produce a different numeric value.



Map of the Colby flagpole in two different geographic coordinate systems (*GCS NAD 1983* on the left and *GCS NAD 1927* on the right). Note the offset in the 44.5639° line of latitude relative to the flagpole. Also note the 0.0005° longitudinal offset between both reference systems.

PROJECTED COORDINATE SYSTEMS: The development of GIS starts with an available map on paper (an analogue map). This map therefore represents a projection of a 3-d GCS in 2-dimensional form. Projection is a mathematical transformation used to project the real 3-dimensional spherical surface of the earth in 2-dimensions on a plane sheet of paper. The projection causes distortions in one or more spatial properties (area, shape, distance, or direction). There are many methods of map projections, since there are an infinite number of ways to project the 3-dimensional earth's surface on to a 2-dimensional planar surface. The 3-d to 2-d projections can be done to a plane or to the surface of a cone or cylinder leading to azimuthal, conic or cylindrical projections respectively with many variations.

It is defined on the flat dimensional system unlike the GCS, a PCS has constant length, angles & areas across 2D. A PCS is always based on geographical co-ordinate system i.e., on spheroid or sphere. In addition to the GCS, the PCS includes a map projection a set of projection parameter that customize the map projection for a particular location & unit for measurement. In PCS locations are identified by X & Y axis on grid with the original center of grid each portion has values that reference it to central location, one specifies its horizontal & the other position is vertical on a gridded network of equally spaced horizontal line represents X-axis & vertical Y-axis.

Datum: The geographic shapes of the earth is called as datum of the earth which can apply to maps so co-ordinate system can still work properly. Datum is classified into 2 types:

- i. **Global referencing datum (Standard referencing datum):** The global referencing datum best approximates the size & shape of the earth as a whole on international level.
- ii. **Local referencing datum:** A local referencing datum is a datum that has been developed for a set of local area often on a national level.

CONCEPT OF MAP

Map: The traditional method of presenting geographical information in two dimensions is in the form of maps. Maps are graphic representations of the earth's surface on a plane paper. They shape the way we visualize, assess and analyze spatial information. A map consists of points, lines and area elements that are positioned with reference to a common coordinate system (usually latitude and longitude).. They are drawn to specified *scales* and *projection*. Map scales can vary and depend on the purpose for which the maps are created. Projection is a mathematical transformation used to represent the real 3-dimensional spherical surface of the earth in 2-dimensions on a plane sheet of paper. The map legend links the non-spatial attributes (name, symbols, colours, thematic data) to the spatial data. The map itself serves to store and present data to the user. Such, analogue maps (on paper) are cumbersome to produce and use, particularly when there are a large number of them to be used for analysis. Computer based GIS facilitates both creation of maps and using them for various complex analyses. It allows working with geographic data in a digital format to aid decision making in resources management. Depending on the scale and the agreeable tradeoffs with respect to distortions, a specific projection form is chosen. Different countries have adopted different standard projections at different map scales. In India, the polyconic projection is commonly used by Survey of India (SOI). All SoI topo sheets are in the polyconic projection.

A map is the representation of the earth's surface/ pattern as a whole or a part of it on the plane surface, with the conventional signs, drawn to a scale and projection so that each and every point on it correspond to the actual position of the earth. Maps are abstract representation of the physical features of a portion of the earth's surface, graphically displayed on a planar surface. A map portrays (describe) three kinds of information about geographic features:

- a. Location and extent of the feature.
- b. Attributes (characteristics) of the feature.
- c. Relationship of the feature to other features.

Map Scale: Map Scale is the ratio of distances on map to distances to on the surface of the earth. It is specified in verbal, numeric or graphical form on all standard maps. A graphical scale should be present on all maps that are used in GIS as it ensures that any changes in scale in photocopying, etc. are accounted for.

The Standard map scales are as follows	
1:12,50,000	Country level map (India)
1:10,00,000	State level map (Karnataka)
1: 250, 000	District level map (Mysuru district)
1: 50,000	Taluk level map (Mysuru taluk)
1: 12,500	City level map (Mysuru city)
Survey of India maps are available at all the above levels except the micro-level.	

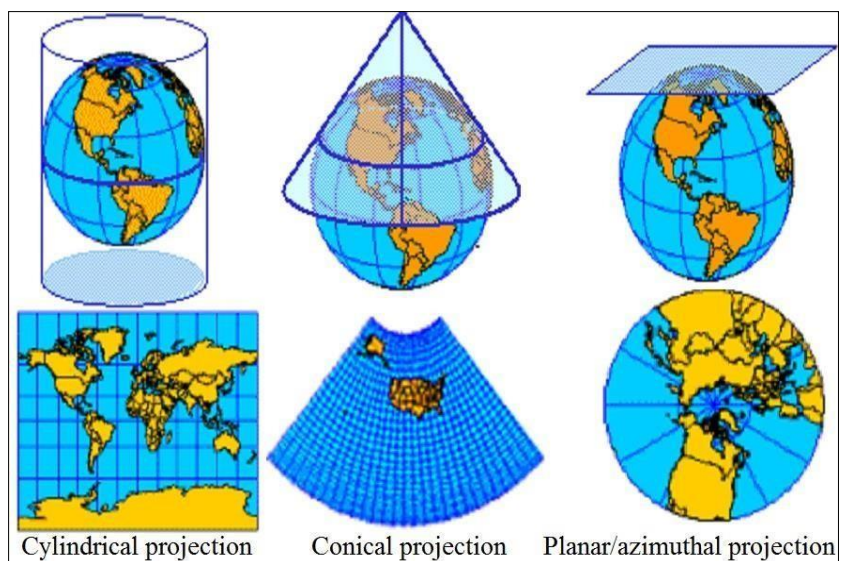
CLASSIFICATION OF MAPS: According to purpose, maps may be classified as follows:

1. **Cadastral maps:** It is a map showing boundaries and ownership of lands. Some cadastral maps show ownership of landed property by demarcating boundaries, as well as boundaries and ownership details, such as survey district names, block numbers, adjoining and adjacent street names etc.
2. **Topographical maps:** These are also called as contour maps, topomaps or toposheets. This map represents the topography or land contours by means of contour lines. These maps usually show not only the contours, but also any significant streams or other bodies of water, forest cover, built-up areas, roads, and other features and points of interest. These are multipurpose maps, and represents both physical and cultural details of an area.
3. **Thematic maps:** It displays the spatial pattern of a theme or series of attributes. In contrast to general reference maps that show many geographic features, thematic maps emphasize spatial variation of one or a small number of geographic distributions. General reference maps show where something is in space, thematic maps tell a story about that place. These maps are prepared to serve some special purpose with reference to a specific theme or attribute.
 - e.g., i. Relief maps- shows elevation differences of the surface.
 - ii. Geological maps- shows rock features, earth crust etc.
 - iii. Weather maps- shows weather condition.
 - iv. Vegetation maps- greenery of trees, herbs, shrubs, plants.
 - v. Political map- shows boundaries between different states.

Map projection: It is a mathematical expression using which the 3D surface of the earth is represented in a 2D plane. The process of projection results in distortion of one or more map properties such as shape, size, area or direction. A single projection system can never account for the correct representation of all map properties for all the regions of the world. Therefore hundreds of projected systems have been defined for accurate representation of a particular map element for a particular region of the world.

Classification/ Types of Map projections:-

Map projections are classified based on the development surface used projection properties position of light source method of construction. Whether you treat the earth a geoid or a spheroid, you must transfer its three dimensional surface to create a flat map sheet. This mathematical transformation is commonly referred as map projection. The world projection means to transfer a figure or picture from a transparent paper or a film to a wall or sheet. At present there are more than 250 projections in use however, a map can preserve only one or two characters of shape, area, distance & the direction:



The three basic projections are based on the types of developable surface and are introduced below:

- i. **Cylindrical projection:** In this time, it is assumed that a cone touches along a parallel of latitudes and apex (sharp edge above the polar region) lies vertically above the pole. The parallel along which the cone touches the globe is standard parallel. The meridians along which the cone holes from base to apex to the center meridian. Topographic map made by Survey of India uses conical projection. It is assumed that hollow cylinder touches the globe along equator & surrounds it. The parallels & meridians are transformed from globe to inner surface of the cylinder by various methods. A cylinder is then cut vertically and unrolled into a flat rectangular surface. This projection is best suited for tropical zones between 30°N & 30°S. It can be visualized as a cylinder wrapped around the globe. Once the graticule is projected into the cylinder. The cylinder is opened to get a grid like pattern of latitude and longitude. The longitude (meridians) and latitudes (parallel) appear as straight lines. The length of the equator on the cylinder is equal to the length of the equator, therefore is suitable for showing equatorial regions.
- ii. **Conic projection:** It can be visualized as a cone placed on the globe, tangent to it at same parallel. After projecting the graticule on to the cone, the cone is cut along one of the meridians and unfolded parallels appear as area with a pole and meridians as straight lines that converge to the same point. It can represent only on hemisphere, at a time, northern or southern. It is suitable for representing middle altitudes.
- iii. **Azimuthal/ Zenithal/ Planar projection:** It can be visualized as a flat sheet of paper tangent to any point on the globe. The sheet will have the tangent point as the centre of the circular map, where meridians passing through the centre are a straight line and the parallels are seen as a concentric circle. This is suitable for showing polar areas. It is a type of projection in which a part of the earth's surface is projected on a plane. It is assumed that a flat sheet of paper touches is called center of projection. The network of parallels & meridians are transferred into the paper either geometrically or by source of light. This type of zenithal projection is mainly used the polar views.

Universal Transverse Mercator (UTM): This is the proof for particular case Mercator projection. This is a worldwide plane co-ordinate system brought by the military during World War-II. This was adopted by the US army in 1947 for designating rectangular co-ordinates on a large scale military maps of the entire world. Its specifications are as follows:

- i. Transverse Mercator in zone 60 wide.
- ii. Reference ellipsoid clark 1866 North America which each other ellipsoid used elsewhere.
- iii. Longitudinal origin is the central meridian.
- iv. Latitudinal origin is the equator unit is in terms 'm' (meter).
- v. Assuming Northing as '0' meters for Northern hemisphere & 10^7 m in Southern hemispheres.
- vi. Assuming Easting 500000 as a reference line.
- vii. The latitudinal limits are 80°N & 80°S.

The surface of the earth is curved but maps are flat. A projected coordinate system (PCS) is a reference system for identifying locations and measuring features on a flat (map) surface. It consists of lines that intersect at right angles, forming a grid. Projected coordinate systems (which are based on Cartesian coordinates) have an origin, an x axis, a y axis, and a linear unit of measure. Going from a GCS to a PCS requires mathematical transformations. The myriad of projection types can be aggregated into three groups: **planar**, **cylindrical** and **conical**.

UTM zones used in GIS

UTM is the acronym for Universal Transverse Mercator, a plane coordinate grid system named for the map projection on which it is based (Transverse Mercator). The UTM system consists of 60 zones, each 6-degrees of longitude in width. The zones are numbered 1-60, beginning at 180-degrees longitude and increasing to the east. The military uses their own implementation of the UTM system, called the Military Grid Reference System (MGRS).

- One system is no more or less accurate than the other. They are just two different ways of positioning a point. Many experienced users prefer UTM over latitude/longitude when using 7.5' topographic quadrangle maps. Ocean-going sailors and other marine users almost always use latitude/longitude because navigation charts are optimized for this method. The UTM coordinate system is commonly used in GIS for larger scale areas within a certain UTM zone. The UTM projection is formed by using a transverse cylindrical projection, i.e., the standard line runs along a meridian of longitude. The effect is to minimize distortion in a narrow strip running pole to pole.
- UTM divides the earth into pole-to-pole zones 6 degrees of longitude wide. The first zone starts at the International Date Line (180 degrees east) and the last zone, 60, starts at 174 degrees east. Northings are determined separately for the areas north and south of the equator. Because distortion becomes extreme at northern latitudes, UTM is not normally used above 80 degrees North or South.
- **Universal Transverse Mercator (UTM) coordinate system** is a standard set of map projections with a central meridian for each six-degree wide UTM zone. Even though Google maps used the Mercator projection because it preserves shape decently, and north is always up.
- But Mercator map projections are really bad at preserving area. For most of us, the projection is common enough that it looks fine for us. In reality, Africa is huge on the globe. But Greenland appears to be as large as Africa, even though in reality it is only 1/14th the size. The Mercator puzzle game illustrates this point.