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		b) Visual and Digital classification
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		b) Image restoration, mossaicing, sub-setting
		c) Image classification
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5	**Global Navigational Satellite Systems (T – 8, P – 14)**	**i) concepts of GNSS, Surveying, Mapping, Navigation, measurements, accuracy & errors**
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S. No	Topic	Sub Topic
7	**Other Applications (T – 7, P – 10)**	i) **Hands on with GoogleEarth/ Bhuvan etc**
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Chapter - I

Geodesy and Positioning, Maps and map reading

Definition: Geodesy is the science which deals with the methods of precise measurements of elements of the surface of the earth and their treatment for the determination of geographic positions on the surface of the earth. It also deals with the theory of size and shape of the earth. Geodesy may be broadly divided into two branches, namely,

1. Geometric Geodesy.
2. Physical Geodesy.

Geometric geodesy appears to be purely geometrical science as it deals with the geometry (shape and size) of the earth. Determination of geographical positions on the surface of earth can be made by observing celestial bodies, and thus comes under geodetic astronomy, but this can be included under geometric geodesy.

Physical geodesy is concerned with determining the Earth's gravity field, which is necessary for establishing heights. Earth gravity field is a physical entity and is involved in most of the geodetic measurements, even the purely geometric ones. The measurement of geodetic astronomy, triangulation and leveling, all make essential use of plumb line being the direction of gravity vector. Thus, astro-geodetic methods which use astro determination of latitude, longitude, and azimuth and geodetic operations e.g. triangulation, trilateration, base measurement etc., may be considered as belonging to **Physical geodesy** fully as much as the gravimetric methods.

Satellite Geodesy: Satellite geodesy comprises the observational and computational techniques which allow the solution of geodetic problems by the use of precise measurements to, from or between artificial, mostly near the earth satellites.

GEODESY AND POSITIONING - EARTH SHAPE MODELS

Flat earth models are still used for plane surveying, over distances short enough so that earth curvature is insignificant (less than 10 km).

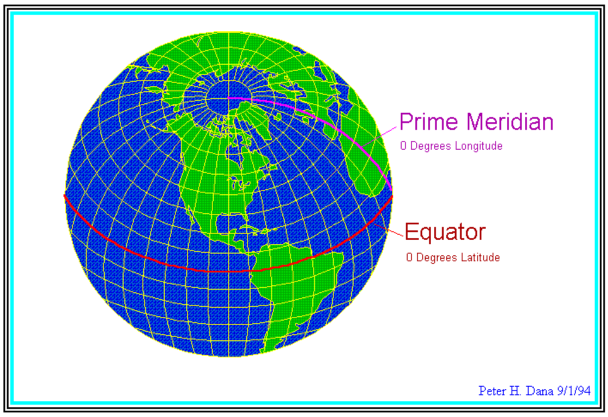
Spherical earth models ***(Earth centered model)*** represent the shape of the earth with a sphere of a specified radius. Spherical earth models are often used for short range navigation (VOR-DME) and for global distance approximations. Spherical models fail to model the actual shape of the earth. The world is approximately a sphere. The sphere is the shape that minimizes the potential energy of the gravitational attraction of all the little mass elements for each other. The direction of gravity is toward the center of the earth. It is the direction that a string takes when a weight is at one end - that is a plumb bob.

Ellipsoidal earth models are required for accurate range and bearing calculations over long distances. Ellipsoidal models define an ellipsoid with an equatorial radius and a polar radius. The best of these models can represent the shape of the earth over the smoothed, averaged sea-surface to within about one-hundred meters. The equatorial radius is longer than the polar axis by about 23 km. The direction of gravity does not point to the center of the earth.

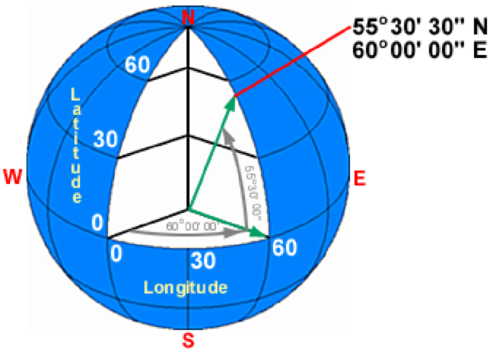
Although the earth is an ellipsoid, its major and minor axes do not vary greatly. In fact, its shape is so close to a sphere that it is often called a ***spheroid*** rather than an

ellipsoid. But sometimes, the spheroid confused people. SOI (Survey of India) often call ellipsoid.

- Spherical Earth's surface - radius 6371 km
- Meridians (lines of longitude) - passing through Greenwich, England as prime meridian or 0º longitude.
- Parallels (lines of latitude)
- using equator as 0º latitude.
- Degrees-minutes-seconds (DMS),
- Decimal degrees (DD)



- Degrees-Minutes-Seconds (DMS), GPS result: 34º04'04.27'' N, 106º54'20.87 " W
- Decimal Degrees (DD): 34.06785 N, 106.90580 W
- Parallels are parallel and spaced equally on meridians. Meridians and other arcs of great circles are straight lines (if looked at perpendicularly to the Earth's surface). Meridians converge toward the poles and diverge toward the Equator.



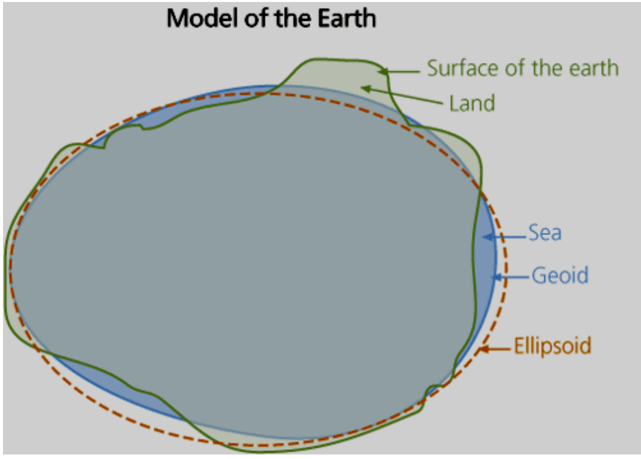
- Meridians are equally spaced on the parallels, but their distances apart decreases from the Equator to the poles. At the Equator, meridians are spaced the same as parallels. Meridians at 60° are half as far apart as parallels. Parallels and meridians cross at right angles. The area of the surface bounded by any two parallels and any two meridians (a given distance apart) is the same anywhere between the same two parallels.
- The scale factor at each point is the same in any direction.

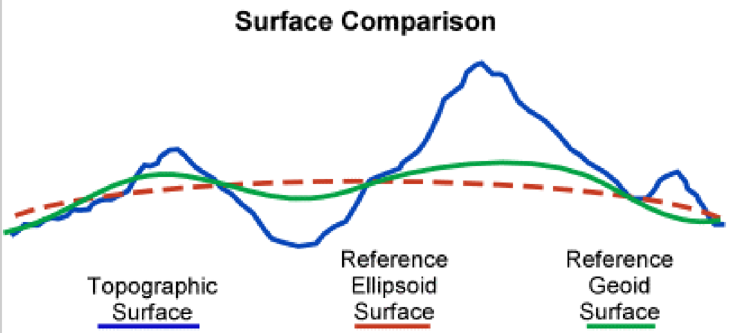
Earth Surface: Ellipsoid, Geoid, Topo

Surveyors cannot really find the ellipsoid. But they can find the sea surface. Surveying inland from the sea gives height with respect to sea level. In the process of these surveys the equipment is always set level - that is perpendicular to the local down. We will see that this causes the heights to be measured with respect to the **geoid**. There are three surfaces that are used in measuring heights. For maps we use the **geoid.** We commonly call this **mean sea level** heights. These are formally called **orthometric heights**. For satellite work, the ellipsoid is used. Heights measured from the ellipsoid are called **ellipsoidal heights**. For aircraft the height above the ground is sometimes used. The topography is the reference here.

- The ***reference ellipsoid*** surface (a map of average sea level).

- The ***reference geoid*** surface (a mean sea level surface).
- The **real surface** of the Earth (the ground) also called the topographic surface





Mean Sea Level is a surface of constant gravitational potential called **the Geoid.** Since the Geoid varies due to local anomalies, we must approximate it with a ellipsoid. The differences between ellipsoidal and orthometric (map) heights are much smaller. They vary over a range of -100 m to +100 m. The average over the world is zero. (This is one way to define the geoid.) The distance from the ellipsoid to the geoid is called the undulation of the vertical or just the undulation

2. Co-ordinate system, datum and map projection

2.1 Co-ordinate System:

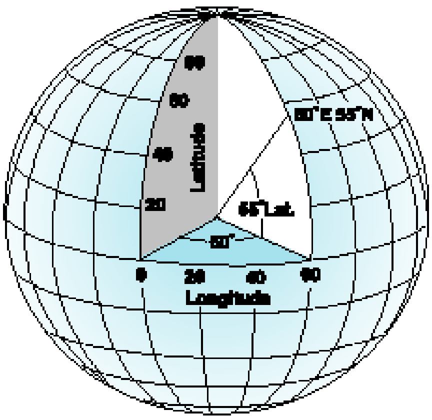
A *geographic coordinate system* (GCS) defines locations on the earth using a three-dimensional spherical surface. A GCS is often incorrectly called a datum, but a datum is only one part of a GCS. A GCS includes an angular unit of measure, a prime meridian, and a datum (based on a spheroid).

A feature is referenced by its *longitude* and *latitude* values. Longitude and latitude are angles measured from the earth's center to a point on the earth's surface. The angles are measured in degrees (or in grads).

In the spherical system, 'horizontal' or east–west lines are lines of equal latitude or *parallel*s. 'Vertical' or north–south lines are lines of equal longitude or *meridian*s. These lines encompass the globe and form a girded network called a *graticul*e.

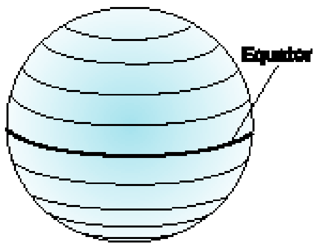
The world as a globe showing the longitude and latitude values

The line of latitude midway between the poles, the horizontal axis, is called the equator and defines the line of zero latitude. The vertical axis, which defines the line of zero longitude, is called the prime meridian. For most geographic coordinate systems, the prime meridian is the longitude that passes through Greenwich, England. Other countries use as prime meridians longitude lines that pass through Bern, Bogota, and Paris. Where the equator and prime meridian intersect defines

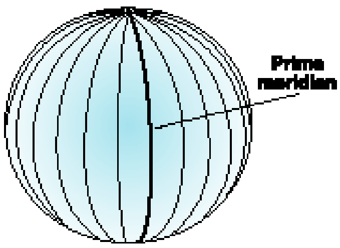


the origin (0,0). The globe is then divided into four geographical quadrants based on compass bearings from the origin. Above and below the equator are north and south, and to the left and right of the prime meridian are west and east.

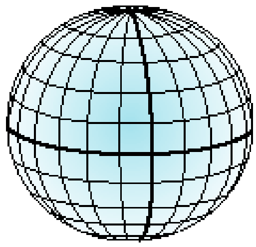
Latitude and longitude values are traditionally measured in decimal degrees or in degrees, minutes, and seconds (DMS). Latitudes are measured relative to the equator and range from -90° at the South Pole to +90° at the North Pole. Longitude is measured relative to the prime meridian positively, up to 180°, when traveling east and measured negatively up to -180°, when traveling west. If the prime meridian is at Greenwich, then Australia, which is south of the equator and east of Greenwich, has positive longitude values and negative latitude values. Although longitude and latitude can locate exact positions on the surface of the globe, they are not uniform units of measure. Only along the equator does the distance represented by one degree of longitude approximate the distance represented by one degree of latitude. This is because the equator is the only parallel as large as a meridian. (Circles with the same radius as the spherical earth are called *great circle*s. All meridians and the equator are *great circle*s.)



Parallels
(Lines of Latitude)



Meridians
(Lines of longitude)

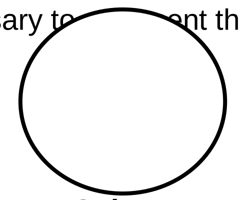


Graticular
Network

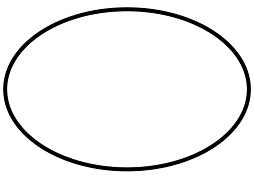
Above and below the equator, the circles defining the parallels of latitude get gradually smaller until they become a single point at the North and South Poles where the meridians converge. As the meridians converge toward the poles, the distance represented by one degree of longitude decreases to zero. On the Clarke 1866 spheroid, one degree of longitude at the equator equals 111.321 km, while at 60° latitude it is only 55.802 km. Since degrees of latitude and longitude don’t have a standard length, you can’t measure distances or areas accurately or display the data easily on a flat map or computer screen.

2.2 Spheroid and Sphere:

The shape and size of a geographic coordinate system’s surface is defined by a sphere or spheroid. Although the earth is best represented by a spheroid, the earth is sometimes treated as a sphere to make mathematical calculations easier. The assumption that the earth is a sphere is possible for small-scale maps, those smaller than 1:5,000,000. At this scale, the difference between a sphere and a spheroid is not detectable on a map. However, to maintain accuracy for larger-scale maps (scales of 1:1,000,000 or larger), a spheroid is necessary to represent the shape of the earth.



Sphere



Spheroid (Ellipsoid)

A sphere is based on a circle, while a spheroid (or ellipsoid) is based on an ellipse. The shape of an ellipse is defined by two radii. The longer radius is called the semi major axis, and the shorter radius is called the semi minor axis. Rotating the ellipse around the semi minor axis creates a spheroid. A spheroid is defined by the semi major axis ‘a’ and the semi minor axis ‘b’ or by ‘*a’* and the *flattenin*g. The flattening is the difference in length between the two axes expressed as a fraction or a decimal.

The flattening, f, is $f = (a - b) / a$

The flattening is a small value, so usually the quantity *1/f* is used instead. Sample values are a = 6378137.0 meters 1/f = 298.257223563

The flattening ranges between zero and one. A flattening value of zero means the two axes are equal, resulting in a sphere. The flattening of the earth is approximately 0.003353. Another quantity is the square of the eccentricity, e, that, like the flattening, describes the shape of a spheroid.

$$e^2 = \frac{a^2 - b^2}{a^2}$$

2.3 Defining Spheroid for Accurate Mapping:

The earth has been surveyed many times to better understand its surface features and their peculiar irregularities. The surveys have resulted in many spheroids that represent the earth. Generally, a spheroid is chosen to fit one country or a particular area. A spheroid that best fits one region is not necessarily the same one that fits another region. Until recently, North American data used a spheroid determined by Clarke in 1866. The semi major axis of the Clarke 1866 spheroid is 6,378,206.4 meters, and the semi minor axis is 6,356,583.8 meters. Because of gravitational and surface feature variations, the earth is neither a perfect sphere nor a perfect spheroid. Satellite technology has revealed several elliptical deviations; for example, the South Pole is closer to the equator than the North Pole. Satellite determined spheroids are replacing the older ground-measured spheroids. For example, the new standard spheroid for North America is GRS 1980, whose radii are 6,378,137.0 and 6,356,752.31414 meters. Because changing a coordinate system’s spheroid changes all previously measured values, many organizations don’t switch to newer (and more accurate) spheroids.

2.4 Datum:

While a spheroid approximates the shape of the earth, a datum defines the position of the spheroid relative to the center of the earth. A datum provides a frame of reference for measuring locations on the surface of the earth. It defines the origin and orientation of latitude and longitude lines. Whenever you change the datum, or more correctly, the geographic coordinate system, the coordinate values of your data will change. Here’s the coordinates in DMS of a control point in Redlands on NAD 1983.

-117 12 57.75961 34 01 43.77884

Here’s the same point on NAD 1927.

-117 12 54.61539 34 01 43.72995

The longitude value differs by about a second while the latitude value is around 500th of a second. In the last 15 years, satellite data has provided geodesists with new measurements to define the best earth-fitting spheroid, which relates coordinates to the earth's center of mass. An earth-centered, or geocentric, datum uses the earth's center of mass as the origin. The most recently developed and widely used datum is the World Geodetic System of 1984 (WGS84). It serves as the framework for location measurement worldwide. A local datum aligns its spheroid to closely fit the earth's surface in a particular area. A point on the surface of the spheroid is matched to a particular position on the surface of the earth. This point is known as the 'origin point' of the datum. The coordinates of the origin point are fixed, and all other points are calculated from it. The coordinate system origin of a local datum is not at the center of the earth. The center of the spheroid of a local datum is offset from the earth's center. The North American Datum of 1927 (NAD27) and the European Datum of 1950 are local datum's. NAD27 is designed to fit North America reasonably well, while ED50 was created for use in Europe. A local datum is not suited for use outside the area for which it was designed.

2.5 Map Projection:

The mathematical transformation of three-dimensional surface in to a two dimensional surface is commonly referred as a *map projecti*on. One easy way to understand how map projections alter spatial properties is to visualize shining a light through the earth onto a surface, called the projection surface. A spheroid can't be flattened to a plane any easier than flattening a piece of orange peel—it will rip.

Representing the earth's surface in two dimensions causes distortion in the shape, area, distance, or direction of the data. A map projection uses mathematical formulas to relate spherical coordinates on the globe to flat, planar coordinates.

Different projections cause different types of distortions. Some projections are designed to minimize the distortion of one or two of the data's characteristics. A projection could maintain the area of a feature but alter its shape. In the above graphic, data near the poles is stretched. The diagram on the next page shows how three-dimensional features are compressed to fit onto a flat surface.

Map projections are designed for specific purposes. A map projection might be used for large-scale data in a limited area, while another is used for a small-scale map of the world. Map projections designed for small-scale data are usually based on spherical rather than spheroid geographic coordinate systems.

2.5.1 Conformal projection

Conformal projections preserve local shape. Graticule lines on the globe are perpendicular. To preserve individual angles describing the spatial relationships, a conformal projection must show graticule lines intersecting at 90-degree angles on the map. This is accomplished by maintaining all angles. The drawback is that the area enclosed by a series of arcs may be greatly distorted in the process. No map projection can preserve shapes of larger regions.

2.5.2 Equal area projections

Equal area projections preserve the area of displayed features. To do this, the other properties of shape, angle, and scale are distorted. In equal area projections, the meridians and parallels may not intersect at right angles. In some instances, especially maps of smaller regions, shapes are not obviously distorted, and distinguishing an equal area projection from a conformal projection may prove difficult unless documented or measured.

2.5.3 Equidistant projections:

Equidistant maps preserve the distances between certain points. Scale is not maintained correctly by any projection throughout an entire map; however, there are, in most cases, one or more lines on a map along which scale are maintained correctly. Most projections have one or more lines for which the length of the line on a map is the same length (at map scale) as the same line on the globe, regardless of whether it is a great or small circle or straight or curved. Such distances are said to be *tru*e. For example, in the Sinusoidal projection, the equator and all parallels are their true lengths. In other equidistant projections, the equator and all meridians are true. Still others (e.g., Two-Point Equidistant) show true scale between one or two points and every other point on the map. Keep in mind that no projection is equidistant to and from all points on a map.

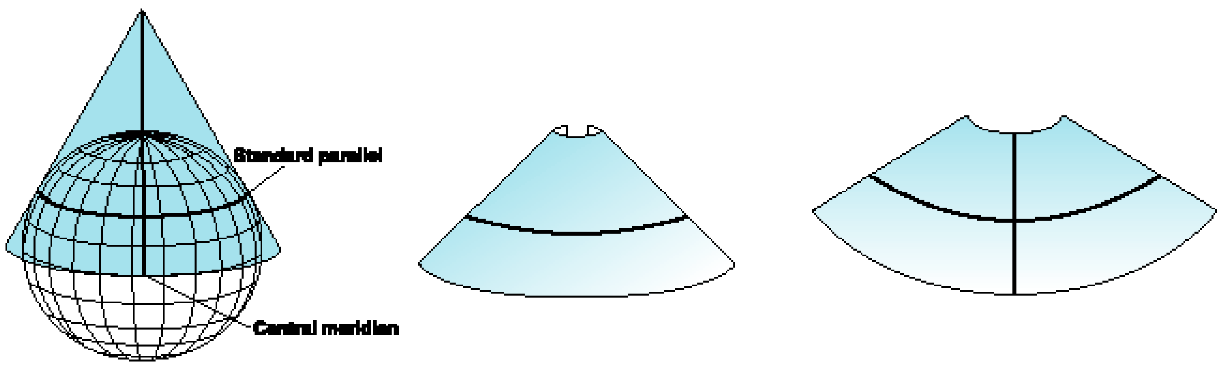
2.5.4 True-direction projections:

The shortest route between two points on a curved surface such as the earth is along the spherical equivalent of a straight line on a flat surface. That is the great circle on which the two points lie. True-direction or *azimuthal* projections maintain some of the great circle arcs, giving the directions or azimuths of all points on the map correctly with respect to the center. Some true-direction projections are also conformal, equal area, or equidistant.

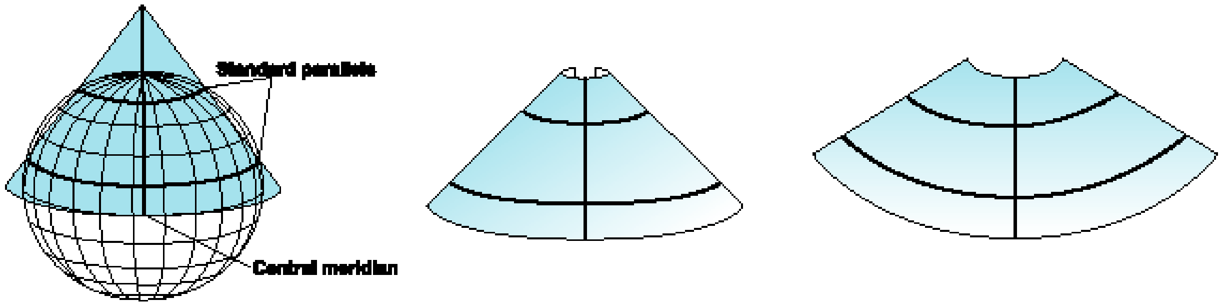
The first step in projecting from one surface to another is to create one or more points of contact. Each contact is called a *point* (or *lin*e) *of tangenc*y. Planar projection is tangential to the globe at one point. Tangential cones and cylinders touch the globe along a line. If the projection surface intersects the globe instead of merely touching its surface, the resulting projection is a secant rather than a tangent case. Whether the contact is tangent or secant, the contact point or lines are significant because they define locations of zero distortion. Lines of true scale are often referred to as *standard line*s. In general, distortion increases with the distance from the point of contact.

2.5.5 Conic projections:

The simplest conic projection is tangent to the globe along a line of latitude. This line is called the *standard paralle*l. The meridians are projected onto the conical surface, meeting at the apex, or point, of the cone. Parallel lines of latitude are projected onto the cone as rings. The cone is then ‘cut’ along any meridian to produce the final conic projection, which has straight converging lines for meridians and concentric circular arcs for parallels. The meridian opposite the cut line becomes the *central meridia*n.



In general, distortion increases away from the standard parallel. Thus, cutting off the top of the cone produces a more accurate projection. This is accomplished by not using the polar region of the projected data. Conic projections are used for mid-latitude zones that have an east-to-west orientation. Somewhat more complex conic projections contact the global surface at two locations. These projections are called *secant* conic projections and are defined by two standard parallels. It is also possible to define a secant projection by one standard parallel and a scale factor.

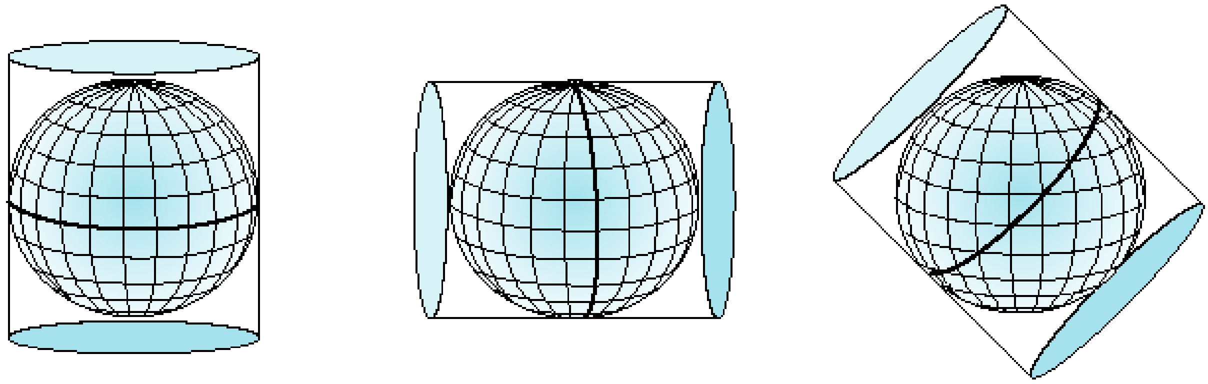


The distortion pattern for secant projections is different between the standard parallels than beyond them. Generally, a secant projection has less overall distortion than a tangent case. On still more complex conic projections, the axis of the cone does not line up with the polar axis of the globe. These are called *oblique*. The representation of geographic features depends on the spacing of the parallels. When equally spaced, the projection is equidistant in the north– south direction but neither conformal nor equal area such as the Equidistant Conic projection. For small areas, the overall distortion is minimal. On the Lambert Conic Conformal projection, the central parallels are spaced more closely than the parallels near the border, and small geographic shapes are maintained for both small-scale and large-scale maps. Finally, on the Albers Equal Area Conic

2.5.6 Cylindrical projections:

Cylindrical projections can also have tangent or secant cases. The Mercator projection is one of the most common cylindrical projections, and the equator is usually its line of tangency. Meridians are geometrically projected onto the cylindrical surface, and parallels are mathematically projected, producing graticule angles of 90 degrees. The cylinder is 'cut' along any meridian to produce the final cylindrical projection. The meridians are equally spaced, while the spacing between parallel lines of latitude increases toward the poles. This projection is conformal and displays true direction along straight lines. *Rhumb lines,* lines of constant bearing, but not most great circles, are straight lines on a Mercator projection.

For more complex cylindrical projections the cylinder is rotated, thus changing the tangent or secant lines. Transverse cylindrical projections such as the Transverse Mercator use a meridian as the tangential contact or lines parallel to meridians as lines of secancy. The standard lines then run north and south, along which the scale is true. Oblique cylinders are rotated around a great circle line located anywhere between the equator and the meridians. In these more complex projections, most meridians and lines of latitude are no longer straight. In all cylindrical projections, the line of tangency or lines of secancy have no distortion and thus are lines of equidistance. Other geographical properties vary according to the specific projection.

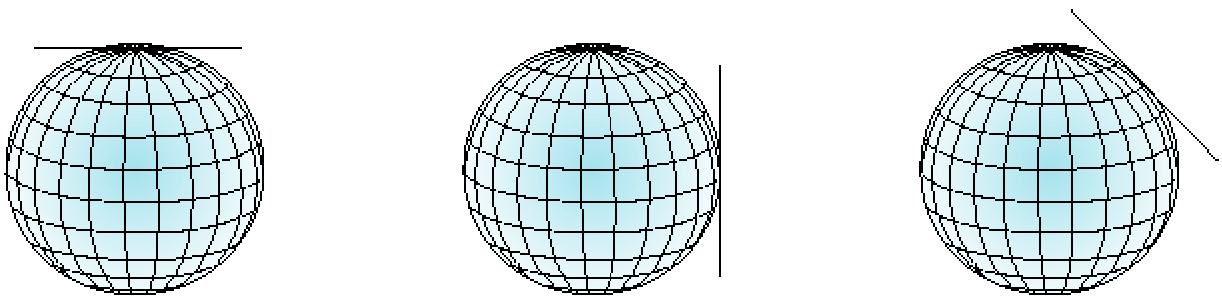


Normal Transverse Oblique

2.5.7 Planar projections:

Planar projections project map data onto a flat surface touching the globe. A planar projection is also known as an azimuthal projection or a zenithal projection. This type of projection is usually tangent to the globe at one point but may be secant. The point of contact may be the North Pole, the South Pole, a point on the equator, or any point in between. This point specifies the *aspect* and is the focus of the projection. The focus is identified by a central longitude and central latitude. Possible aspects are *polar, equatorial,* and *obliqu*e. Polar aspects are the simplest form. Parallels of latitude are concentric circles centered on the pole, and meridians are straight lines that intersect at the pole with their true angles of orientation. In other aspects, planar projections will have graticular angles of 90 degrees at the focus. Directions from the focus are accurate.

Great circles passing through the focus are represented by straight lines; thus the shortest distance from the center to any other point on the map is a straight line. Patterns of area and shape distortion are circular about the focus. For this reason, azimuthal projections accommodate circular regions better than rectangular regions. Planar projections are used most often to map Polar Regions, Projections. Perspective points may be the center of the earth, a surface point directly opposite from the focus, or a point external to the globe, as if seen from a satellite or another planet.



Polar **Equatorial** **Oblique**

2.5.8 Polyconic Projection:

As its name implies, the Polyconic projection is derived from the elements of a multiplicity of cones tangent to the earth at each parallel. A central meridian is chosen, upon which the parallels are truly spaced. Each parallel is the arc of a circle which is developed on its own tangents cone. The apexes of the cones lie on the extension of the central meridian. The arcs of the parallels are not concentric since they are described by radii while decrease, as the cotangents of the latitudes. The arcs of the developed parallels are subdivided true to scale, and the meridians are drawn through the corresponding subdivisions, consequently the scale of the straight line central meridian is correct, as is the scale of the parallels. All lines of the graticule except the central meridian and equator are curves and the meridian and parallels intersect at oblique angles except at the central meridian. The other meridians are concave towards the central meridian.

Although neither conformal nor equal area, the Polyconic projection is an excellent compromise of desirable properties over a limited area. It has been widely used for topographic mapping.

Maps an Map Reading

"MAP is graphical depiction of information on certain environment on a media like Paper, Cloth, Wall which can be used for visualization and understanding of such information by using Colors, Patterns and Symbols."

"A map is a symbolic representation of selected characteristics of a place, usually drawn on a flat surface." Maps present information about the world in a simple, visual way. They teach about the world by showing sizes and shapes of countries, locations of features, and distances between places. Maps can show distributions of things over the Earth, such as settlement patterns. They can show exact locations of houses and streets in a city neighborhood.

Mapmakers, called cartographers, create maps for many different purposes. Vacationers use road maps to plot routes for their trips. Meteorologists—scientists who study the weather—use weather maps to prepare forecasts. City planners decide where to put hospitals and parks with the help of maps that show land features and how the land is currently being used.

Some common features of maps include scale, symbols, and grids.

Scale

"Scale refers to the relationship or ratio between a distance on a map and the distance on the earth it represents. Maps should display accurate distances and locations, and should be in a convenient and usable size."

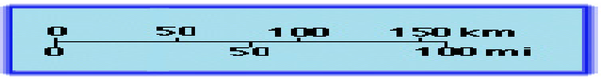
A map's scale indicates the relationship between the distances on the map and the actual distances on Earth. This relationship can be expressed by a graphic scale, a verbal scale, or a representative fraction. The most common type of graphic scale looks like a ruler. Also called **a bar scale,** it is simply a horizontal line marked off in miles, kilometers, or some other unit of measuring distance. The **verbal scale** is a sentence that relates distance on the map to distance on Earth. For example, a verbal scale might say, "One centimeter represents one kilometer" or One inch represents eight miles."

The **representative fraction** does not have specific units. It is shown as a fraction or ratio—for example, 1/1,000,000 or 1:1,000,000. This means that any given unit of measure on the map is equal to one million of that unit on Earth. So, 1 centimeter on the map represents 1,000,000 centimeters on Earth, or 10 kilometers. One inch on the map represents 1,000,000 inches on Earth, or a little less than 16 miles.

$$R.F = \frac{Distance\ \ between\ two\ points\ on\ the\ map}{Distance\ \ between\ the\ same\ two\ points\ on\ the\ ground}$$

Map scales can be expressed as

- **representative fraction or ration**: **1:100,000 or 1/100,000**

- **graphical scale**: 

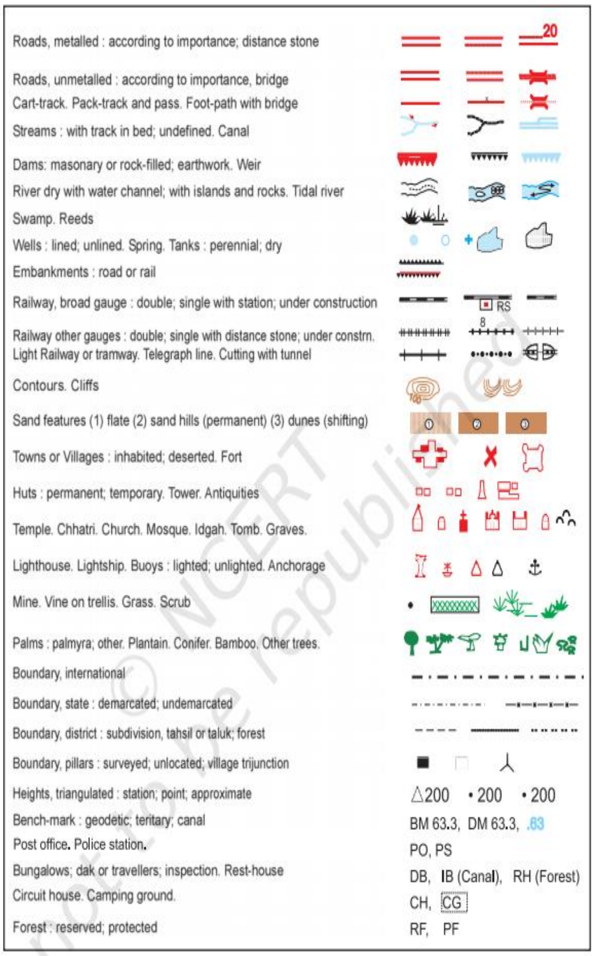
- **verbal-style scale**: **1 inch in map equal to 2000 feet on the ground or**

1 inch = 2000 feet

The size of the area covered helps determine the scale of a map. A map that shows an area in great detail, such as a street map of a neighborhood, is called a **large-scale map** because objects on the map are relatively large. A map of a larger area, such as a continent or the world, is called **a small-scale map** because objects on the map are relatively-small.

Large scale map	**Small scale map**
Area covered is small	Area covered is large
Details are more, objects are seen as large	Less details, objects are seen as small

Today, maps are often computerized. Many computerized maps allow the viewer to zoom in and out, changing the scale of the map. A person may begin by looking at the map of an entire city that only shows major roads and then zoom in so that every street in a neighborhood is visible.



Symbology

Contour Map

Topographic maps show the shape of Earth's surface by using contour lines, the lines on the map that join points of equal elevation. They are among the most well-known symbols on modern maps as they are self-explanatory and accurately represent their phenomena. They make it possible to depict height, depth, and even slope. Contour lines will be closer together or spaced apart to show the steepness of the area. If the line is spaced closer together, it means that there is a steeper slope. If they are farther apart, the area has a low slope.

Apart from showing just contour lines, topographic maps also use a lot of map symbols to represent its features. Features are represented by using point, line, and area symbols. Individual features, such as houses, are shown as point symbols like a small dot or square. However, a cluster of houses or neighborhood can be shown as a shaded area or polygon. Areas of importance or landmarks may receive special symbols that represent what they are. For instance, a church may be symbolized as a picture of a little church or cross or the town hall may have a special color or symbol.

Topo tip: ***Conventional signs and symbols***

• Use contour lines to determine elevations of mountains and flat areas. The closer together the lines are, the steeper the slope.

• Contour elevation numbers indicate the direction of elevation by always reading (pointing) uphill.

Type of Maps

a. Cadastral: These maps register the ownership of land property. They are prepared by government to realize tax and revenue. A village map is an example of cadastral map which is drawn on a scale of 16 inches to the mile or 32 inches to the mile.

b. Topographical: Topographical maps are prepared on fairly large scale and are based on precise survey. They don't reveal land parcels but show topographic forms such as relief, drainage, forest, village, towns etc. The scale of these maps varied conventionally from 1/4 inch to the mile to one inch to the mile. The topographical maps of different countries have varying scales.

- Topographical survey map of British Ordnance Survey are one inch maps.
- The scale of European toposheets varies from 1:25000 to 1:100000.
- USA toposheets are drawn on the scale 1:62500 and 1:125000.
- The international map which is a uniform map of the world is produced on the scale of 1:1000000.

c. Chorographical/Atlas: Drawn on a very small scale, atlas maps give a generalized view of physical, climatic and economic conditions of different regions of the world. The scale of atlas map is generally greater than 1:1000, 000.

On the basis of **Purpose** or the content, the maps can be classified as follows:

a. Natural Maps: These maps represent natural features and the processes associated with them. Given below is the list of some such maps:
Astronomical map : It refers to the cartographic representation of the heavenly bodies such as galaxies, stars, planets, moon etc.
Geological map *:* A map that represents the distribution of different type of rocks and surficial deposits on the Earth.
Relief map : A map that depicts the terrain and indicates the bulges and the depressions present on the surface.
Climate map : A climate map is a depiction of prevailing weather patterns in a given area. These maps can show daily weather conditions, average monthly or seasonal weather conditions of an area.
Vegetation map : It shows the natural flora of an area.
Soil map : A soil map describes the soil cover present in an area.

b.Cultural Maps

These maps tell about the cultural patterns designed over the surface of the earth. They describe the activities of man and related processes. Given below is the list of such maps:

Political map: A map that shows the boundaries of states, boundaries between different political units of the world or of a particular country which mark the areas of respective political jurisdiction

Military map: A military map contains information about routes, points, security and battle plans.

Historical map: A map having historical events symbolized on it.

Social map: A map giving information about the tribes, languages and religions of an area.

Land-utilization map: A map describing the land and the ongoing activities on it.

Communication map: A map showing means of communication such as railways, road, airways etc.

Population map: A map showing distribution of human beings over an area.

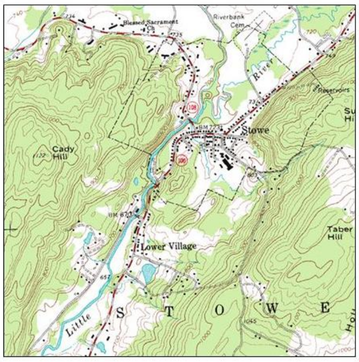
Shape and color of topographic symbols

Many of the symbol features on maps of the earth will be shown by straight, curved, dashed, or solid lines. They may also be colored to represent different classes of information. The typical color standard for topographic maps depicts contours in brown, bodies of water in blue, boundaries in black, and grids and roads in red. Topographic maps may use different colors to represent area features. Most topographic maps will use green for vegetation or national parks and wildlife management areas. They will also use blue for rivers, lakes, or other bodies of water. Red may also be used to represent areas of significant importance.

Without symbols, maps would not be possible. Both shapes and colors can be used for symbols on maps. Colors may cover larger areas of a map, such as green representing forested land and blue representing waterways. To ensure that a person can correctly read a map, a map legend is a key to all the symbols used on a map. It is like a dictionary so you can understand the meaning of what the map represents. It typically includes a sample of each symbol (point, line, or area), and a short description of what the symbol means.

- Detailed maps showing the elevations of hills and valleys of an area.
- Use lines, symbols, and colors to represent changes in elevation and features on Earth's surface.

Topography = shape



Representative symbols should be vertically displayed and the symbols should be horizontally centered. The symbols should be vertically centered with the definitions. The definitions are supposed to be horizontally centered to the left.

Representing spatial phenomena

Symbols are used to represent geographic phenomena. Most phenomena can be represented by using point, line, or area symbols. It is necessary to consider the spatial arrangement of the phenomena to determine what kind of symbolization it will require. Discrete phenomena occur at isolated points, whereas continuous phenomena occur everywhere. There are basically five types of spatial dimensions that are used to classify phenomena for map symbolization. Point phenomena are assumed to have **no spatial extent and are said to be zero-dimensional**. These use point symbols on a map to indicate their location. An example of these would be trees in a park. Linear phenomena are **one-dimensional and have a length**. This would include any line feature on a map like roads. Areal phenomena are **2-D that has both a length and a width**. The best example of this would be a lake or other body of water. When volume comes into consideration, it is broken down into two types, 2 ½ dimensions and 3-D. A good example of 2 ½ D would be the elevation of a place above sea level, while 3-D being any three-dimensional objects.

UNITS OF MEASURE

- **British System: INCHES, FEET AND MILES**
- **Metric System: CMS, METERS AND KILOMETERS**
- **Real world Coordinate System: DEGREES MINUTES AND SECONDS**
- **GRIDS**
- **SCALE BARS**

Map Accuracy

Map accuracy should be determined by the intended use of the map. Historically, map accuracy determined the scale at which the map would be drawn. Until recently it has been customary to specify the scale of aerial photography for digital orthophotos, planimetric features, and topographic features, and then apply the National Map Accuracy Standard or other similar standard to determine the accuracy of the map. Recent trends, however, are to treat accuracy as a property of the map to be reported, rather than a specification for producing the map.

Positional accuracy can be illustrated as Relative Accuracy and Absolute Accuracy. Positional Relative Accuracy as the measure of how objects are positioned relative to each other. It is always illustrated as (+ or -) meter or feet or inch. For example: the distance measurement between two electric poles on the ground and the distance measurement between two poles on the map must be within certain relative accuracy (+ or -) meter or feet or inch. Positional Absolute Accuracy as the indicator or measure of how a spatial objects is accurately positioned on the map with respect to its true position on the ground, within an absolute reference frame.

Horizontal accuracy: “For maps on publication scales larger than 1:25,000, not more than 10 percent of the points tested shall be in error by more than 1/30 inch, measured on the publication scale; for maps on publication scales of 1:20,000 or smaller, 1/50 inch.”

Vertical accuracy: as applied to contour maps on all publication scales, shall be such that “not more than 10 percent of the elevations tested shall be in error more than one-half the contour interval." In checking elevations taken from the map, the apparent vertical error may be decreased by assuming a horizontal displacement within the permissible horizontal error for a map of that scale.

The accuracy of any map may be tested by comparing the positions of points whose locations or elevations are shown upon it with corresponding positions as determined by surveys of a higher accuracy.

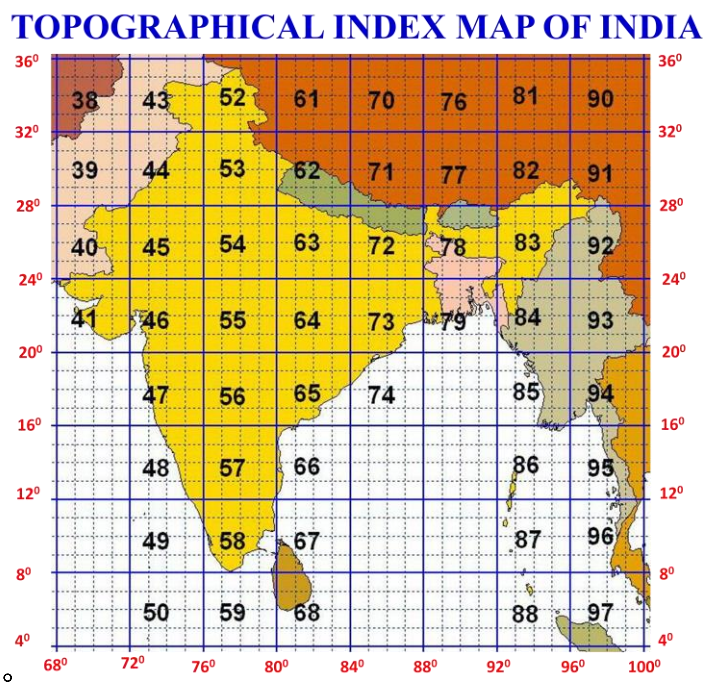
When a published map is a considerable enlargement of a map drawing (manuscript)

Map scale	***accuracy, or resolution (corresponding to 0.5 mm map distance)***
1:1,250	***0.625 m***
1:2,500	***1.25 m***
1:5,000	***2.5 m***
1:10,000	***5 m***
1:24,000	***12 m***
1:50,000	***25 m***
1:100,000	***50 m***
1:250,000	***125 m***
1:1,000,000	***500 m***
1:10,000,000	***5 km***

or of a published map, that fact shall be stated in the legend. For example, "This map is an enlargement of a 1:20,000-scale map drawing," or "This map is an enlargement of a 1:24,000 scale published map."

A useful rule of thumb for features on paper maps

Toposheet Indexing

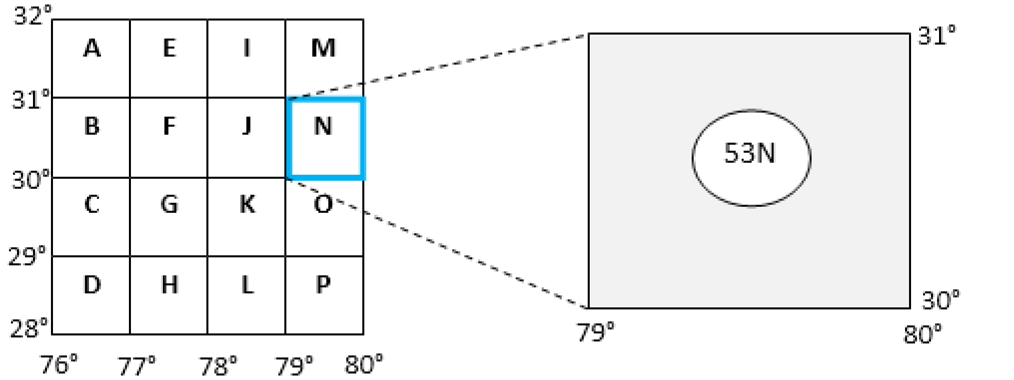


Survey of India produces the topographic maps of India. These maps are produced at different scales. In order to identify a map of a particular area, a numbering system has been adopted by the Survey of India.

For the purpose of an international series (within 4° N to 40° N Latitude and 44° E to 124° E Longitude) at the scale of 1: 1,000,000 is considered as a base map. This map is divided into sections of 4° latitude × 4° longitude and designated from 1 to 136 consisting of the segments that cover only land area.

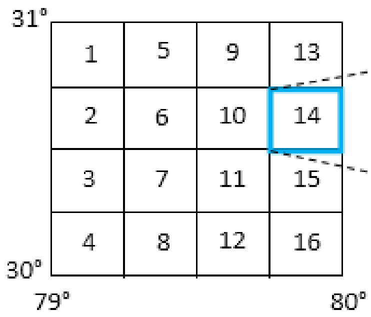
Each section is further divided into 16 sections (4 rows and 4 columns) each of 1° latitude × 1°

longitude. The sections start from Northwest direction, run column wise and end in Southeast direction.

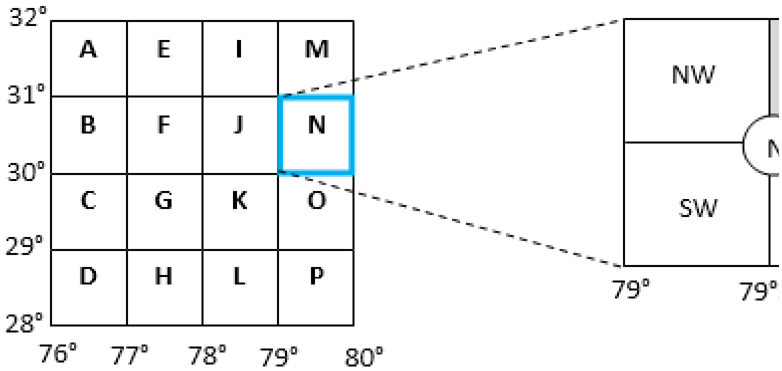


A sheet of 4° × 4° (scale: 1: 1,000,000)

A sheet of 1° × 1° (scale: 1: 250, 000)



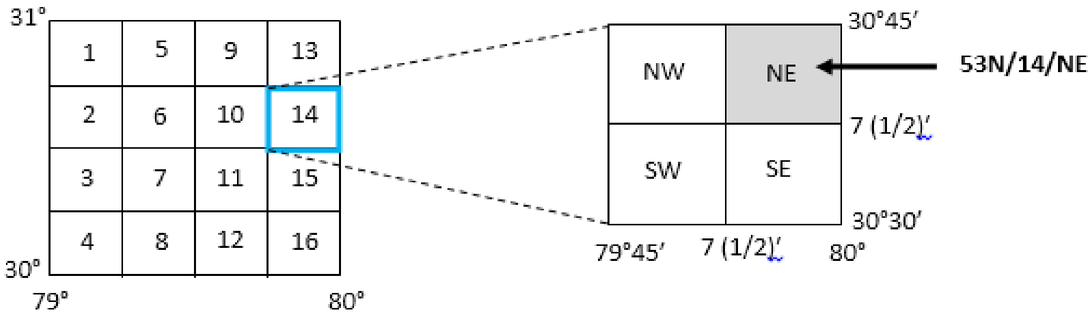
The 1°×1° sheets are further subdivided into four parts, each of 30′ latitude × 30′ longitude. These are identified by the cardinal directions NE, NW, SE and SW.



A sheet of 4° × 4° (scale: 1: 1,000,000)

A sheet of 30′ ›

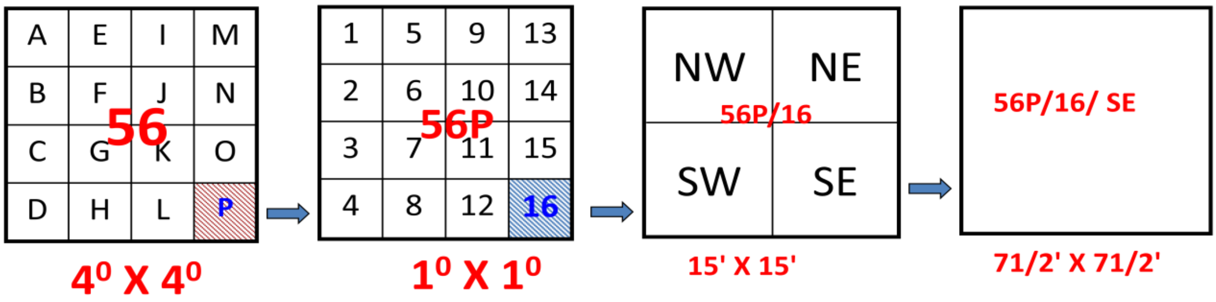
A 15′×15′ sheet can be divided into 4 sheets, each of 7(1/2)′ and are numbered as NW, NE, SW and SE



A sheet of 1° × 1° (scale: 1: 250, 000)

A sheet of 7(1/2)′ × 7(1/2)′ (Scale: 1: 25,000)

TOPOGRAPHICAL INDEX OF SURVEY OF INDIA MAPS



Interval	Index	Scale
4^0 X 4^0	56	1:M
1^0 X 1^0	56K	1:250,000
15' X 15'	56K/16	1:50,000
7 1/2' X 7 1/2'	56K/16/SW	1:25,000

OPEN SERIES MAPS

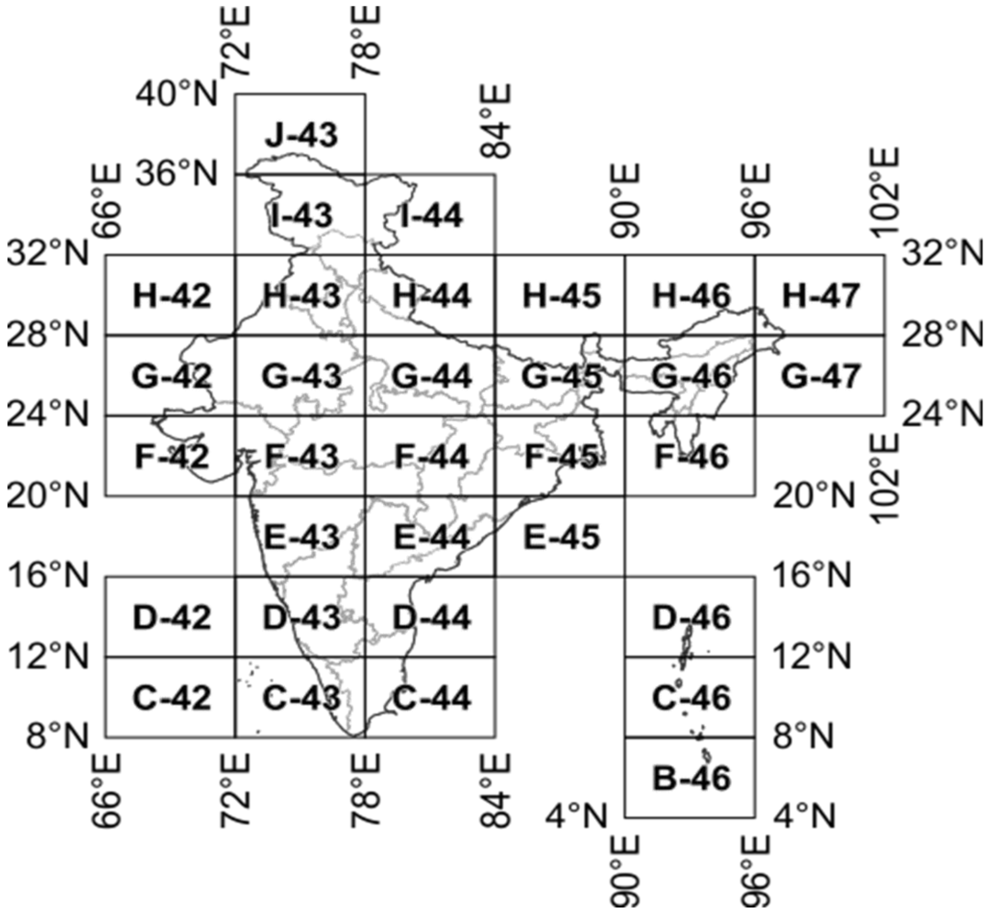
'Open Series Maps' have been introduced as per the National Map Policy of 2005 by Survey of India. For the same **a new map numbering system** has been adopted instead of the previous India and Adjacent Countries (IAC).

The map series is based on **Transverse Mercator projection on WGS-1984 datum**. A numbering system based on International Map of the World (IMW) is used.

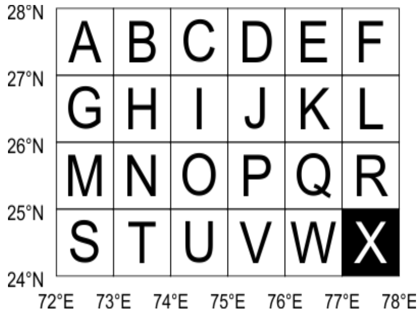
The **IMW numbering system** with minor modification is used up to 1°×1°/1:250,000 scale.

a. Since the IMW map number for India will always start with 'N' (India being in the northern hemisphere), the first letter is omitted.
b. The next alphabet and number of the IMW map number denotes the 6°×4° region of the IMW series. So sheet with Kalyanpur (77.65489°E 24.11981°N) would be in 'G-43' (from ~~N~~G-43):

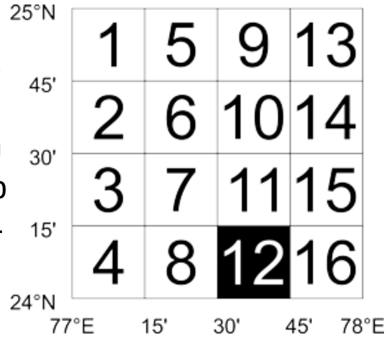
International Map of the World (IMW)



c. Each 6°×4° rectangle is further subdivided into 24 squares of 1°×1°. Each square is indicated serially by an alphabet increasing first towards east and then towards south, starting with 'A'. So sheet for Kalyanpur (77.65489°E 24.11981°N) falls within 'G-43X':



2. Each 1°×1° square is further divided into 16 squares of 15'×15' (15 minutes×15 minutes). Each square is indicated serially by a number increasing first towards south and then towards east, starting with '1' (similar to the system adopted in India and Adjacent Countries). So for the map sheet for Kalyanpur (77°39.293'E 24°7.187'N) would be 'G-43X-12':



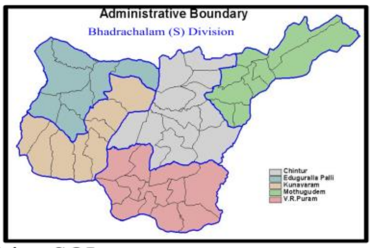
Themes in SOI maps

Like General Reference **Maps**, **Topographic Maps** are a summary of the landscape and show important physical (natural and man-made) **features** in an area. The primary difference is that they show elevation in detail. **Characteristics** of**topographic maps** include: they show elevation using contour lines.

A **'Thematic map'** is a map that focuses on a specific theme or subject area. Thematic maps emphasize spatial variation of one or a small number of geographic distributions. These distributions may be physical phenomena such as climate or human characteristics such as population density and health issues.

A thematic map shows georeferenced data, numeric or character, by colors or symbols. Specific data displayed in this manner is referred to as a theme. Different types of thematic maps, useful for showing different types of thematic variables commonly used to show natural resources, vegetation areas, population, types of soil, climate, temperature etc.,

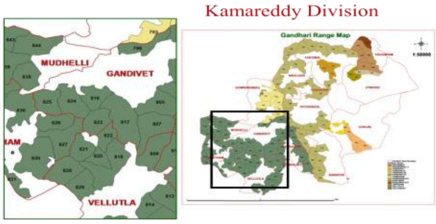
1. Range and Beat Boundaries



Using SOI topo maps.

2. Forest Block and Compartment Boundaries

Kamareddy Division



Chapter – II

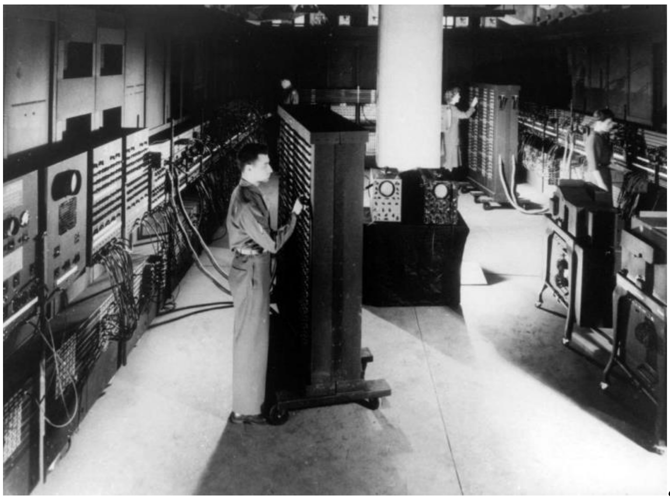
Information technology

కంప్యూటర్

3కంప్యూటర్ ఆవశ్యకత – చరిత్ర :

కంప్యూటర్ .లేదు అసత్యము లేదనుటలో ఏదియూ పని చేయని కంప్యూటర్ నేడు .వేసికొనినది పాద్దవీశ వ్యవస్థలో జీవన మానవ అనునది

కంప్యూటర్ అనగా లెక్కవేయు సాధనమువేయుట లెక్కలు అది కానీ .తో మొదలుపెట్టి కాలక్రమేణా అభివృద్ది చెంది మానవుడు చేయు పనులన్నియు చేయగల స్థితికి చేరినది . చేయుట లెక్కలు చేయునపుడు తయారు దీనిని మొదటగా, తదుపరి టైపింగ్, తదుపరి ఎకౌంట్లు, డాటాబేస్, ప్రింటింగ్, ఆడియో, వీడియో చివరకు రోబోట్లుగా అవతరించింది పరిణామములో . ఉండి పరిమాణములో భవన మొదటగా, ఇప్పుడు చేతిలో ఇమిడే ఫోనుగా మారినది సామర్థ్యము . ఉండి లలో.బి.కా మొదట, ఇప్పుడు టి వాడుటకు కూడా సామాన్యుడు అతి ఖరీదు .వచ్చినది లలోకి.బి. వాచ్ డిజిటల్ చూసుకొనే లేచినపుడు రోజు ప్రతి .కలుగుచున్నది వీలు, టి.వి., వాషింగ్ మెషీన్, మొబైల్ ఫోన్, ఏలు ఏమ్.టి., బ్యాంకులు, ఆసుపత్రి, diagnostic Centre, బి చూచుకొను షుగర్ .పి. మెషీన్లు, బస్సుటికెట్, రైల్ టికెట్, చౌకధరల దుకాణములు, ఓటరు కార్డులు, ఆధార్ కార్డులు, కరెంటు బిల్లు, టెలిఫోన్ బిల్లు చివరకు దేముని దర్శనమునకు టికెట్లు కూడా కంప్యూటర్ ఉపయోగించుచున్నారు .



ఎనియాక్)ENIAC) మొదటి కంప్యూటర్

వలన కంప్యూటరీకరణ .మెరుగైనది చాల ప్రమాణము జీవన మానవ వలన కంప్యూటరీకరణ ఈ :లాభములు కలుగు1వేగము ((Speed)2 (ఖచ్చితము (Accuracy) 3(పారదర్శకము (Transparency) 4 (స్థిరత్వం)Consistency) 5(Eye contact లేకుండా చేయుట.

1) **<u>వేగము(Speed):</u>** ఏపనినైను కంప్యూటర్ ద్వారా వేగముగా చేయవచ్చును. బ్యాంకుకు వెళ్ళి డబ్బు తీసుకొనుటకంటే ఏ.టి.ఏమ్. లో డబ్బుతీసుకొనుట వేగము, సులభము. కాంపిటీటివ్ పరీక్షల యొక్క పేపర్లు కంప్యూటర్ సహాయముతో దిద్దుటవలన తొందరగా పూర్తి అవుచున్నది. ఈమెయిల్స్ వలన పాతకాలపు టెలిగ్రాం లు కనుమరుగైనాయి. లైబ్రరీకి వెళ్ళి సమాచారము సేకరించుట కన్నా గూగుల్ లో క్షణాలలో పొందవచ్చును. డిజిటల్ ఫోటోలు, పాతకాలపు ఫోటోలకన్నా చాలా తక్కువ సమయం లో వచ్చును. పాతకాలపు టైపు మెషీన్ కంటే కంప్యూటర్ తో టైపు చేస్తే తప్పులు లేకుండా సులువుగా, వేగంగా చేయవచ్చును. ఈ విధంగా అన్ని విషయాలలో కంప్యూటర్ వలన వేగంగా పనులు పూర్తి అగును.

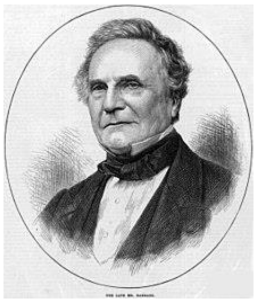
2) **<u>ఖచ్చితము (Accuracy):</u>** కంప్యూటర్ ద్వారా చేయు పనులు మనుషులు చేయుపనుల కంటే ఖచ్చితముగా పని చేయును. బ్యాంకులలో పూర్వము ఉన్న పని కంటే ఇప్పుడు ఎక్కువ పనులు జరుగుచున్నప్పటికి కంప్యూటర్ వాడుటవలన తప్పులు లేకుండా జరుగుచున్నవి. అటులనే కరెంట్, టెలిఫోన్, మొబైల్ ఫోన్ బిల్లులు వచ్చుచున్నవి. పరీక్షల రిజల్ట్స్ కూడా ఖచ్చితంగా వచ్చుచున్నవి. శరీరపరీక్షల ఫలితములు అన్నియు కంప్యూటర్లు ఉపయోగించుటవలన తొందరగా తేలికగా వచ్చుచున్నవి. ఇక పోతే అటవీశాఖలో ఉపయోగించుటకు టేపుకు బదులు లేజర్ మెషీన్ (EDM), కాలిపార్స్ కు బదులు,

Abney level కు బదులు, Compass కు బదులు క్రొత్త, క్రొత్త ఎలక్ట్రానిక్ పరికరములు వచ్చినవి. ఇవి మనుష్యులకంటే ఖచ్చితంగా పని చేయుచున్నవి.

3) **పారదర్శకము (Transparency):** పాతకాలమందు ఏ విషయము పూర్తిగా తెలిసేవి కాదు కదా, కంప్యూటర్ వాడుటవలన పారదర్శకముగా నుండును. పరీక్ష ఫలితములు గానీ, ఉద్యోగ నియామకములలో గానీ, నగదు మార్పిడి, కొనుగోళ్ళు విషయములుగాని మనము అవసరమైనచో విపులంగా చూడవచ్చును. ఇందువలననే ఇప్పుడు భారత దేశములో ప్రభుత్వం అన్ని శాఖలను, అన్ని వ్యాపార, బ్యాంకుల లావాదేవీలను కంప్యూటరీకరించుటకు నిశ్చయించినది. దీనివలన టాక్స్ ఎగవేత దారులు, బ్లాక్ మార్కెట్ వ్యవహారాలు కట్టడిలో నుండును.

4) **స్థిరత్వం (Consistency):** కంప్యూటర్లు వాడక ముందు ఒకే సమాచారము వివిధ విభాగములలో వేరు వేరుగా నుండెడిది. సమాచారము ఫారెస్టు గార్డ్ నుండి ఫారెస్టరు, రేంజి అధికారి, డివిజన్ అటవీ అధికారి, అటవీ సంరక్షణాధికారి, ముఖ్య ప్రధాన అటవీ సరక్షణాధికారి వారికి చేరునప్పటికి చాలా కాలము గడచేది. ఇందువలన సమాచారము వివిధ భాగములలో వేరు వేరుగా నుండెడిది. కాని కంప్యూటర్లు వాడుకలో ఎప్పటికప్పుడు సమాచారము అప్ డేట్ అగుచున్నది. ఇటులనే రైలు టికెట్టు ఎక్కడ కొనునప్పటికి ఖాళీ బెర్తుల సమాచారము కరెక్టుగా ఉండుటచే తేడాలు లేకుండా బుక్ చేయగలము.

5) **Eye contact లేకుండా చేయుట:** ప్రభుత్వ శాఖలలో పనులు చేయుటకు వివిధ వ్యక్తులను కలువ వలసి వచ్చేది. దీని వలన ఆవ్యక్తుల యొక్క ఇష్టా ఇష్టాలపై పనులు జరిగేవి. ఇప్పుడు కంప్యూటర్లు వాడకము వలన, వ్యక్తుల ప్రమేయం లేకుండా పనులు జరుగుచున్నవి.



ఉదాలైసెన్సులు :, పాస్ పోర్టులు, పర్మిషన్లు వగైరాలుదీ .నినే ఈ-గవర్నెన్స్ అందురు.

మనుష్యులకు చేయుటకు లెక్కలు పెద్దపెద్ద పూర్వకాలములో .పట్టేది సమయం చాలాCharles Babbage అను ఇంజినీర్ మెకానికల్ కంప్యూటర్ కనుగొనడమైనది ఎలక్ట్రానిక్స్ కాలములో తర్వాత . ట్రాన్సిస్టర్స్ నుపయోగించి, డయోడ్, ICs చిప్ సెట్స్ తో మోడరన్ కంప్యూటర్ తయారైనది

Charless Babbage

కంప్యూటర్ పని చేయు విధానము –బైనరీ కోడ్ – బిట్ – సమాచారము:

ననుసరించి వాని ఉపయోగించు .సాధనము పనిచేయు పై విద్యుత్తు ఇది అనగా కంప్యూటర్ సేకరించి సమాచారమును, పొందుపరచి విశ్లేషించి, కావలసిన రీతిలో చూపించు సాధనము ఇది . గుర్తించి గాను 0 లేనిచో గాను 1 ఉన్నచో విద్యుత్ .పనిచేయును నుపయోగించి బైనరీకోడ్, ఈ సంకేతాల సమూహములో తయారయిన భాషలో పనిచేయునులాంగ్వేజ్ మెషీన్ భాషలను ఈ ., ఎసెంబ్లీ లాంగ్వేజ్ అందురు ప్రస్తుతం .పనిచేయును రూపంలో ల బిట్ సమాచారము . తయారగుచున్న కంప్యూటర్లు వీటిని అందువలన .వాడుచున్నారు బిట్లు 64 లేక బిట్లు 32 అనియు కంప్యూటర్ డిజిటల్, ఈ కాలాన్ని డిజిటల్ యుగము అని అందురు.

కంప్యూటర్ హార్డ్వేర్ – ఇన్పుట్ డివైసెస్ – ఔట్పుట్ డివైసెస్ – సి పి యూ :

ముఖ్యముగా ను కంప్యూటర్ పర్సనల్ లేదా కంప్యూటర్ రెండు భాగములు .1 హార్డ్ . 2 వేర్. సాఫ్ట్ వేర్ .వర్గీకరించవచ్చును విభాగములుగా రెండు ను వేర్ సాఫ్ట్ మరల .1 . 2 సిస్టం ఆపరేటింగ్. అప్లికేషన్ సాఫ్ట్ వేర్కనబడు కంటికి అనగా వేర్ హార్డ్ ., స్పర్శకు అందు భాగములు .విధములు 3 ఇవి .భాగములు కనబడు పైకి .

1. **Input Devices** (ఇన్ పుట్ డివైస్) అనగా సమాచారమును లేదా ఆదేశములను కంప్యూటర్ కు ఇచ్చు భాగములు. అ) కీబోర్డు ఆ) మౌస్ ఇ) స్కేనర్ ఈ) కెమేరా ఉ) బార్ కోడ్ రీడర్ మొదలగునవి.
2. **Central Processing Unit** (సెంట్రల్ ప్రొసెసింగ్ యూనిట్) నందు సమాచారము తీసుకొనుట, నిలువ చేయుట, విశ్లేషించుట, ఫలితము ఇచ్చుట. దీనిలో అ) హార్డ్ డిస్క్ ఆ) RAM ఇ) ప్రొసెసర్ (చిప్ సెట్) ఉండును.
3. **Out put Devices** (అవుట్ పుట్ డివైస్) అనగా సమాచారము బయటకు వచ్చుట ఉపయోగపడు భాగములు అ) మోనిటర్ ఆ) ప్రింటర్ ఇ) స్పీకర్ ఈ) ప్రొజెక్టర్ మొదలగునవి ఉండును.

Input Device (ఇన్పుట్ డివైస్):

కీ బోర్డు ముఖ్యమైన ఇన్పుట్ డివైస్ఆదేశములు కు కంప్యూటర్ ద్వారా దీని ., సమాచారమును అందించవచ్చును లేనిచో .ON-SCREEN కీ బోర్డు వాడవలసి వచ్చును.

రెండవ

ముఖ్యమైన ఇన్‌పుట్ డివైస్ మౌస్. దీనితో GUI (GRAPHIC USER INTERFACE) ద్వారా కంప్యూటర్ ఉపయోగించుట సులబము .
దీనికి ప్రత్యామ్నాయము టచ్ స్క్రీన్ ఇది .
.ఉండును కూడా లలో టాప్ లాప్ కొన్ని లోనూ ల ఫోన్ స్మార్ట్ లోనూ ల టేబ్స్ స్కానర్ ల లో ఆప్టికల్, మాగ్నెటిక్, బార్ కోడ్ , QR కోడ్ రకములు కలవ .
కెమెరా ల ద్వారా ఫోటోలు వీడియోలు కంప్యూటర్ నందు పొందు పరచబడ వచ్చును.
మైక్రోఫోన్ అనునది శబ్దము ను గ్రహించి కంప్యూటర్ నందు బద్రపరచును.

<u>సి :భాగములు అందలి.యూ.పి.</u>

ఇది కంప్యూటర్ నందు ముఖ్యమైన భాగము దీనిలో . ఇది .బోర్డు మదర్ ప్రధానము పరికరాలలో డిజిటల్ అన్ని లేక ప్రాసెసర్ దీనిపై .ఉండును లోని మనిషి ఇది .ఉండును చిప్ కంప్యూటర్ .వంటిది మెదడు ఆధార దీనిపై పనితనము యొక్క సామర్ధ్యం దీని .ఉండును పడి లో హెట్ట్జ్ గిగా ప్రస్తుతం ఉన్నది .

ఎం ఏ ఆర్(రామ్ పై బోర్డు మదర్ కూడా ఇది .మెమొరీ ఆక్సెస్ రాండమ్ అనగా (అవసరార్థము ఉపయోగించువాని కంప్యూటర్ కర్తవ్యము ప్రధాన యొక్క దీని .ఉండును లేటెన్సి అప్లికేషన్ వాడుచున్న తెచ్చి సమాచారమును నుండి డిస్క్ హార్డ్ ముందుగా (డిలేద .ఉపయోగపడును లేకుండా (ీని వలన పని త్వరగా చేయుటకు వీలు కలుగును హెర్ట్జ్ గిగా ఇది . .పెంచుకొనవచ్చును అవసరమైనచో దీనిని .ఉండును లలో HD సినిమాలు గాని వీడియో గేమ్ లు చూచుటకు ఇది ఎక్కువ సామర్ధ్యము కలిగి ఉండవలెను, లేనిచో వేరేగా వీడియో కొరకు వీడియో రేమ్ అమర్చుకొన వలెను.

) ఎం ఓ ఆర్ROM) అనగా రీడ్ ఓన్లీ మెమొరీ హార్డ్‌వేర్ కంప్యూటర్ ఇది . దీనినే .వచ్చును పాటు తోBIOS (బేసిక్ ఇన్‌పుట్ ఔట్‌పుట్ సిస్టమ్ .అందురు (చేసిన ఆన్ స్విచ్ కంప్యూటర్ పని దీని అన్నీ లోని హార్డ్‌వేర్ తరువాత

ఫర్ దీనిని .చేయును ఆక్టివేట్ ను సిస్టమ్ ఆపరేటింగ్ పరచి ఉత్తేజ భాగములుమ్ వేర్ అనికూడా అందురు.

మెకానికల్ ఇది .భాగము ముఖ్యమైన తరువాత బోర్డు మదర్ అనునది డిస్క్ హార్డ్) రేకులు అయస్కాంత దీనిలో .ఉండును మందముగా ఇది .డివైస్platters) ఉండును 9600 నిమిషానికి ఇవి . అవసరమైనప్పుడు మరలా పరచి బద్ర సమాచారమును తిరుగుచు రొటేసన్స్ 12000 నుండి అందించును 500 లు డిస్క్ హార్డ్ ఇపుడు .gb 2 నుండి (బైట్ గిగా) tb (టెర్రా బైట్) వరకు లభించు చున్నవి.

ఇన్పుట్ సమాచారమును కూడా పోర్ట్లు కంప్యూటర్ .రవాణా అనగా పోర్ట్ .పంపును బయటకు నుండి డివైసెస్ ఔట్పుట్ తీసుకొని నుండి డివైసెస్VGA పోర్ట్ అనునది

CPU ను మానిటర్ కు గాని TV కు గాని ప్రొజెక్టర్ గాని కలుపుట వలన సమాచారమును స్క్రీన్ పై చూడ వచ్చును కానీ. వినుటకు ఆడియో కూడా కలుపవలసి వచ్చును .HDMI) HIGH DEFINITION MEDIA INTERFACE) పోర్ట్ కూడా చూచుటకు ఉపయోగ పదును హై ద్వారా దీని . సౌండ్ చిత్రములను క్వాలిటి ను పొంద వచ్చును పాత కానీ . కాలపుCRT (CATHODE RAY TUBE పోర్ట్ లేటెస్ట్ కంటే అన్నిటి .పడదు వీలు కలుపుటకు లకు టివి (USB) UNIVERSAL SERIAL BUS). ఈ పోర్ట్ అన్నీ డివైసెస్ లను ఇన్పుట్), ఔట్పుట్ & ఇతర పరికరాలను కూడా) గుర్తించి పని చేయును .


అమటట్ పుటట్ డివ్వైసస్)Out put Device): ముఖ్యమ్మైన అమటట్ పుటట్ డివ్వైసస్ మానిటరర్ వివిద ఇది . 1 రకములు రెండు ఇవి .ఉండును క్వాలిటి బటట్టి ఖరీదును .దొరకును లో ల స్సైజ్. CRT మానిటరర్ 2. LCD/LED మానిటరర్ ఇపుడు .CRT మానిటరర్లు వాడుక, లబ్యత తగ్గినది .LCD(LIQUID CRYSTAL DISPLAY) మానిటరర్లు LED(LIGHT EMMITTING DIOD) మానిటరర్ల కంటే చమక పెద్ద చాలా ఇవి . జనము ఎక్కువ ఇది .పనిచేయును వలె మానిటరర్ కూడా ప్రొజెక్టరర్ .లబించును కూడా లో ల స్సైజ్ .వచ్చును పనికి చూచుటకు సారి ఒకే

రెండవ అతి ముఖ్యమ్మైన అమటట్ పుటట్ డివ్వైసస్ ప్రింటరర్ .దొరకును లో ల స్సైజ్ చాలా ఇవి . ప్లాటట్టరర్ ప్రింటరర్లను పెద్ద .లభించునే ప్రింటరర్లు రకముల్లైన చాలా బటట్టి క్వాలిటిని ప్రింటరర్లు జెటట్ ఇంకక్ అవి ప్రకారము ఇందనము వాడు ఇవి .అంధురు, లేసరర్ ప్రింటరర్లు, థెర్మల్ ప్రింటరర్లు, ఫోటోగ్రాఫిక్ ప్రింటరర్లు గా వాడుకలో నున్నవి .

స్పీకరర్ ద్వారా ద్వాని వినిపించును.లభించును లో ల మోడ్ స్టీరియో మరియు మోనో ఇవి .

కంప్యూటరర్ సాఫ్టట్వేరర్:

సాఫ్టట్ వేరర్ అనగా హార్డ్ వేరర్ ను కంప్యూటరర్ ఉపయోగించు వ్యక్తిని అనుసంధాన పరచునది .రకములు మూడు ఇది .

1(BIOS (Basic Input Output System) ఇది హార్డ్ వేరర్ తో పాటు అది తయారు చేయు సంస్థ ఇచ్చు సాఫ్టట్ వేరర్) పరికరములలో కంప్యూటరర్ చిన్న చిన్న దీనినే .Firmware) ఫర్మ్ వేరర్ అందురు . మొబ్బైల్స్ :ఉదా, టాబ్, సెటట్ టాప్ బాక్సు లు మొదలగునవి .

2(ఆపరేటింగు సిస్టం)Operating System).ఎస్.ఓ కావలసి వారు ఎవరికి ఇది :(OS) వేసుకొనవచ్చును . డివ్వైసెస్ పుటట్ ఇన్ అనగా .ఉపకరించును చేయుటకు పని అన్నివిధములుగా కంప్యూటరర్ ఇది ప్రఖ్యాత .కల్పించును వీలు వాడుటకు అన్నిటిని డివ్వైసెస్ పుటట్ అమటట్ మరియు .యు.వి.సి విండోస్ లు .ఎస్.ఓ, మేకింతోష్, లీనక్స్విండోస్ . ఓ దీనిలో .వారిది మ్మైక్రోసాఫ్టట్ .ఎస్. సామర్థ్యము వేరర్ హార్డ్ .ఉండును లు వెర్షన్ చాలా, వాడుకదారుని అవసరము బటట్టి తగిన వెర్షన్ ఉపయోగించవలెను వాడుటకు దీనిని .వారిది కంపెనీ ఏపిల్ మేకింతోష్ .ఖరీదు చాలా ఇది . లీన .ఖరీదు చాలా ఇదికూడా .తప్పనిసరి కంప్యూటరర్ బుక్ మాక్క్స్ ఓ) .ఎస్.Operating System) ను ఓపెన్ సోర్స్)Open Source) సాఫ్టట్ వేరర్ అందురు .ఎస్.ఓ .ధృడమ్మైనది చాల .ఉచితము ఇది .)Operating System) తో పాటు చాలా అప్లికేషన్ స్ ఉచితంగా లభించును.

అప్లికేషన్స్ లేదా ఏప్స్)apps) ఒక నిర్ధిష్ట మ్మైన పనులకు తయారు చేయబడు ప్రోగ్రాము ముఖ్యముగా ఇవి .

1) ఆఫీసు అప్లికేషన్లు అనగా MS Word, MS Excel, MS Powerpoint, MS Access మొదలగునవి.
2) Internet Applications: ఒపేరా, ఫ్సైర్ ఫాక్స్, గూగుల్ క్రోమ్ మొదలగునవి.
3) డాటాబేస్ అప్లికేషన్స్: ఒరకిల్, డి-బేస్, ఫాక్స్ ప్రో మొదలగునవి.
4) G.I.S. Applications: ఆర్కువ్యూ ArcView, ArcInfo, Google Earth, Map Source, Erdas Imagine మొదలగునవి.
5) ప్రోగ్రామింగ్ అప్లికేషన్స్: “c”, C+, C sharp, .Net (డాటట్ నెటట్), విజువల్ బేసిక్ మొదలగునవి.

ఇంకా ఆడియో అప్లికేషన్, వీడియో అప్లికేషన్, మెసేజింగ్ అప్లికేషన్ మొదలగునవి . .రకములు 3 అప్లికేషన్స్ ఈ ఫ్రీ వేరర్ - వేరర్ షేరర్ లేక వేరర్ టట్రైల్ .లభించునవి ఉచితంగా -) డ్ ప్రైస్ .ఉచితము గాని ఫీచరర్లు కొన్ని గాని కొంతకాలముPriced) ల్సైసెన్స్ కొని వాడవలసినవి :ఉదా .MS ఆఫీసు, ArcView మొదలగునవి .

కంప్యూటరర్ నెటట్వర్క్స్:

జ. కొంతమంది మనుష్యులు గాని, రహదారులు కాని, కంప్యూటరర్లు కాని కలసి

సమాచారములేక వస్తువులను మార్చుటను నెట్ వర్క్ అందురు. నెట్ వర్క్ ఎంత పెద్దది ఉంటే అంత శక్తి వంతము. మనుష్యులకు పెద్ద నెట్ వర్క్ ఉండినచో అతని పనులు సులభముగా, త్వరగా జరుగును. అటులనే ఏ ప్రాంతమునకైనా ఎక్కువ నెట్ వర్క్ రోడ్లు ఉంటే అంత సౌకర్యముగా ఉండును. అటులనే కంప్యూటర్ ఒకటి ఎంత శక్తి వంతమైననూ, తన పరిసరాలలోని మిగిలిన కంప్యూటర్ల సముదాయమును కలిసినపుడు మరింత శక్తివంతమగును. ఇటువంటి కంప్యూటర్ల సముదాయమును కంప్యూటర్ నెట్ వర్క్ అందురు. ఇవి 3 రకములు.

1. లోకల్ ఏరియా నెట్ వర్క్ : ఒక ప్రభుత్వ కార్యాలయము నందుగానీ, ఒక వ్యాపార సంస్థ కార్యాలయము నందుగానీ, కళాశాలలో గానీ వాడుతున్న అన్ని కంప్యూటర్లను అనుసంధానించిన, దానిని లోకల్ ఏరియా నెట్ వర్క్ అందురు. వీటిని ఈథర్ నెట్ కేబుల్స్ తో కలుపుదురు.
2. వైడ్ ఏరియా నెట్ వర్క్: ఒకే వ్యవస్థ కు చెందిన వేరు వేరు ప్రదేశాలలోని అన్ని కంప్యూటర్లను కలుపు ప్రక్రియ. ఉదా: రైల్వే స్టేషన్లలోని రిజర్వేషన్ కార్యాలయాలు.
3. ఇంటర్ నెట్: పైన పేర్కొన్న “వైడ్ ఏరియా నెట్ వర్క్” లను కలుపు సముదాయమును ఇంటర్ నెట్ అందురు. (Network of Networks is called Internet). భూగోళము నందలి నెట్ వర్క్ లను కలుపు వ్యవస్థ. ఇది బ్యాండ్ విడ్త్ మరియు ఇంటర్ నెట్ ప్రోటోకాల్స్ పై పని చేయును (TCP/IP). ఈ బ్యాండ్ విడ్త్, ఇంటర్ నెట్ సర్వీసు ప్రొవైడరు ఖరీదు పై సమకూర్చును. ఈ రోజులలో వచ్చుచున్న చాలా అప్లికేషన్లు ఇంటర్ నెట్ పై ఆధారపడుచున్నవి. విండోస్ అప్ డేట్, మెసెంజర్, వాట్సప్, ఫేస్ బుక్, మొదలగునవి పని చేయును. ఇంటర్నెట్ ను కేబుల్ ద్వారాగానీ, టెలిఫోన్ లైన్ ద్వారాగానీ, వైఫై (WiFi) ద్వారా గానీ పొందవచ్చును. ఇప్పుడు మొబైల్ ఫోన్ల నుండి 4జి, LET టెక్నాలజీ తో హాట్ స్పాట్ పద్దతిలో ఇంటర్నెట్ కంప్యూటర్లకు ఇవ్వవచ్చును. కానీ, ఇది ఖరీదైన ప్రక్రియ. బి.ఎస్.ఎన్.ఎల్. బ్రాడ్ బ్యాండ్ చౌక.
4. **WWW (World Wide Web):** వరల్డ్ వైడ్ వెబ్ అనునది టిమ్ బెర్నర్స్ లీ (Tim Berners-Lee) అను కంప్యూటర్ ఇంజినీరు తయారుచేసెను. ఈ ప్రక్రియ రాక ముందు ఇంటెర్ నెట్ నుండి సమాచారము పొందుపరచిన సర్వర్ల (Servers) ను Access చేసే పర్మిషన్ లతో సమాచారము పొందెడివారు. ఇట్లు రకరకములైన సర్వర్లను వాడుకుట, సమాచారము పొందుట కష్టతరముగ ఉండేది. ఈ www వలన సమాచారము పొందుగోరు వ్యక్తికి ఆ సర్వర్లు వాడుకుటకు పర్మిషన్లు తీసుకొను పని లేకుండా బ్రౌజర్ ఇంటర్ ఫేస్ (Browser Interface) తయారుచేసెను. ఈ బ్రౌజర్లు http: (hyper text transport protocol) సాంప్రదాయముననుసరించి పనిచేయును. ఈ బ్రౌజర్లు వివిధ కంపెనీలు తయారు చేసినవి. ఉదా: గూగుల్, క్రోమ్, ఒపేరా, ఫైర్ ఫాక్స్, బింగ్ మొదలగునవి. ఇవి ఉచితము. వీటిని మొబైల్స్, టాబ్స్, కంప్యూటర్ లో కానీ డౌన్ లోడ్ చేసి కొన వచ్చును. అన్నింటిలోను వాడుటకు వీలుగా ఒకే విధముగా ఉండును. ఇవి ఇంటర్నెట్ బాండ్ విడ్త్ పై పనిచేయును. వీటికి కంప్యూటర్ సామర్థ్యముతో పనిలేదు. అతి తక్కువ సామర్థ్యము కలిగిన కంప్యూటర్లో కూడా పని చేయును. ఎందుకనగా ఇవి ఎక్కువ కంప్యూటర్ సామర్థ్యము వాడదు. ఇవి అర్థము చేసికొనుట మరియు వాడుట సులభము. వీటిలో ‘ఎడ్రస్ బార్’ ఉండును. ఎడ్రస్ బార్ నందు మనకు కావలసిన ఎడ్రస్ ను టైపు చేసినచో వాటి సర్వర్లను అనుసంధానించును. దీనినే (url) యూనివర్సల్ రిసోర్స్ లోకేటర్ అంటారు. ఒక వేళ ఎడ్రస్ తెలియనిచో వివిధ రకములైన సెర్చింజన్ల సహాయముతో మనకు కావలసిన సమాచారమును వెదికి చూచి డౌన్ లోడ్ చేసికొనవచ్చును. ఉదా: గూగుల్, యాహూ, బింగ్

Tim Berners-Lee

మొదలైనవి. ఈ బ్రౌజర్‌లలో కంప్యూటర్‌లలో చేయు అన్ని పనులను చేయవచ్చును. అనగ ఆఫీసులలో ఉపయోగించు వర్డ్, ఎక్సెల్, పవర్ పాయింట్, మెయిల్ మొదలగునవి. అంతే కాక వీడియోలు, పాటలు, మ్యాప్ లు చూడవచ్చును.

ఈ విధముగా వరల్డ్ వైడ్ వెబ్ మానవాళికి ఎన్నో విధాలుగా ఉపయోగపడుచున్నది.

ఉదా: మెయిల్స్, బ్యాంకు పనులు, చెల్లింపులు, ధరఖాస్తు ఫారాలు, పరీక్షా ఫలితాలు, రైలు, బస్సు టికెట్స్, సర్టిఫికెట్స్, ఇన్ కంటాక్స్, ఆరోగ్య విషయాలు, కావల్సిన వస్తువులు కొనుట మొదలైనవి.

<u>ఆఫీసు అప్ప్లికేషన్స్:</u>

1. ***<u>Microsoft Office Suite</u>***: అన్ని కార్యాలయముల మాదిరి ఈ శాఖలో కూడా పి.సి. వాడుట చేత దానిలో విండోస్ ఓ.ఎస్. ఉన్నది. దానిపై ఎం.ఎస్. ఆఫీసు అప్లికేషన్ సాఫ్ట్ వేర్ లోడ్ చేయడం జరిగింది. ఈ Suit లో Word, Excel, Powerpoint వాడుచున్నారు. Word ను మెమోలు, లెటర్‌లు, ఆర్డరులు మొదలగు కరస్పాండెన్సుకు వాడుచున్నారు. Excel ను సాలరీ స్టేట్ మెంట్‌లు, ఎస్టిమేట్‌లు, ప్రోగ్రెస్ రిపోర్ట్‌లు, బడ్జెట్ వివరములకు వాడుచున్నారు. Power point ను మీటింగులలోను, డిమానిస్ట్రేషన్ లకు, లెక్చర్‌లకు వాడుచున్నారు. MS Outlook ను తెలిసినవారు మెయిల్ కోసం వాడుచున్నారు.

<u>జి.ఎస్.ఐ.& జి.అప్ప్లికేషన్స్.ఎస్.వి.</u>

2. G.I.S. Softwares: G.I.S. Software లు అటవీశాఖ ప్రధాన కార్యాలయమునందు మరియు డివిజన్ కార్యాలయములందు వాడుచున్నారు. ప్రధాన కార్యాలయమునందు వాడు సాఫ్ట్ వేర్‌లు 1. Arc Info 2. ERDAS Imagine 3. Arc View డివిజనల్ కార్యాలయములందు ఆర్క్ వ్యూ వాడుచున్నారు.

   1. Arc Info: ఈ సాఫ్ట్ వేర్ ను ESRI కంపెనీ వారిది. దీనిని ఉపయోగించి మ్యాప్ లకు కావలసిన థీమ్స్ తయారు చేయవచ్చును. పాతమ్యాపులను స్కానింగ్ చేయుటద్వారా, శాటిలైట్ నుండి వచ్చిన ఇన్ఫర్మేషన్ ద్వారా లేక GPS ద్వారా వచ్చిన డాటాతో వివిధ రకములైన థీమ్స్ / లేయర్స్ తయారు చేయవచ్చును. దీనిని వాడుటకు బాగుగా తర్ఫీదు పొందిన నిపుణులు అవసరము.
   2. Arc View: ఈ సాఫ్ట్ వేర్ కూడా ESRI కంపెనీ వారిది. దీనితో G.I.S. మ్యాపులను చూచుట, కలుపుట, మ్యాపులను ప్రింట్‌లు తీయుట చేయవచ్చును. దీనికి కొద్దిపాటి శిక్షణ, Hands on Practice ఉన్న పని జరుపుకొనవచ్చును.
   3. ERDAS Imagine: ఇది ERDAS (Earth Resources Digital Analysis System) కంపెనీవారిది. ఈ సాఫ్ట్ వేర్ లో శాటిలైట్ నుండి వచ్చు డిజిటల్ ఇమేజి లను విశ్లేషించి కావలసిన సమాచారమును పొందవచ్చును. ఇది నైపుణ్యము తో కూడుకున్న పని. అటవీశాఖవారు ప్రతీ సంవత్సరం IRS IC/ID LISS IV డాటాను కొని అటవీ సాంద్రతను బేరీజు వేయుదురు. అట్టి బేరీజు వేసిన సమాచారమును మ్యాపులుగా ముద్రించి (Ground True thing) గ్రౌండ్ ట్రూతింగ్ కు అటవీ బీట్ లకు పంపుతారు. అచట కరెక్షన్ జరిగిన తరువాత అటవీ సాంద్రతను ప్రకటించుతారు.

<u>FMIS</u> (Forest Management Information System): అటవీశాఖ నందు TCS వారి సహకారముతో ఈ సాఫ్ట్ వేర్ ను తయారుచేసిరి) .ఎస్.ఐ.ఎం దీనిని .Management Information System) అని కూడా అందురు .G.I.S. వలె ఇది కూడా సమాచార వ్యవస్థ .ఉండమ మ్యాపులు ఇందులో కాని .M.I.S. అనునది ఈ రోజులలో అన్ని ప్రభుత్వ, ప్రైవేటు కార్యాలయాలలో ఉండవలసిన వ్యవస్థ ఈ . సాఫ్ట్ వేర్ వలన ప్లానింగ్ మరియు మోనిటరింగ్ చేయవచ్చునుబడ్జెట్ దీనిలో ., ఖర్చులు, వి.ఎస్.ఎస్., వాటి పనులు, అడమలు, ప్లాంటేషన్స్, డిపోలు, అమ్మకాలు, సిబ్బంది వారి జీత భత్యాలు, అటవీ రక్షణ, అటవీఫలసాయము మొదలగు అన్ని విషయములు సమీకరించి, క్రోడీకరించి నిర్ణయములు తీసుకొనవచ్చును)భాగములు నందు వేర్ సాఫ్ట్ ఈ .Modules)

Chapter - III

Fundamentals of Geographical Information System

3.1 Introduction:

The field of geographic information systems (GISs) is emerging as one of today's most exciting and progressive technical areas. GIS technology has evolved during the past four decades and is only now starting to penetrate major industry and service hubs. With such a wide array of new users, there exists not only considerable interest in GIS but also a fair amount of uncertainty and misunderstanding surrounding the discipline. Now it had gained widespread acceptance throughout the transportation, business, traffic control and land information system. Its origin can be traced to some geographers who thought of storing the maps in computers. In 1962 GIS came in operational mode with sponsoring of Canadian Federal government. It got a tremendous boost after personal computers came into existence in 1980's. PCs came withi n the reach of common people because of falling prices. GIS and Remote Sensing are major parts of the spatial information. Each is a means to an end neither is an end nor itself.

Now-a-days, most government departments, business and even individuals are taking GIS software like word processing etc. Over the years, the maintenance and management of utilities has been dramatically improved by the use of Geographical Information System.

3.2 Concept of GIS:

GIS is seen by many, as spatial tool information systems. Information is derived from the interpretation of data, which are symbolic representations of geographic features. The value of information depends upon many things including its timeliness, the context in which it is applied and the cost of collection, storage, manipulation and presentation. Information is now a valuable asset. It is a commodity which can be bought and sold for a high price. Information and its communication is one of the key development processes and characteristics of contemporary societies.

Geographic information systems arose from activities in four different fields:

Cartography, which attempted to automate the manually dependent map-making process by substituting the drawing work by vector digitization.

Computer graphics, which had many applications of digital vector data apart from cartography, particularly in the design of buildings, machines and facilities.

Databases, which created a general mathematical structure according to which the problems of computer graphics and computer cartography could be handled.

Remote Sensing, which created immense amounts of digital image data in need of geocoded rectification and analysis

3.3 Definition of GIS:

- **<u>Geographical</u>** *implies that locations of the data items are known, or can be calculated, in terms of Geographic coordinates (Latitude, Longitude)*
- **<u>Information</u>** *implies that the data in a GIS are organized to yield useful knowledge, often as colored maps and images, but also as statistical graphics, tables, and various on-screen responses to interactive queries.*
- **<u>System</u>** *implies that a GIS is made up from several inter-related and linked components with different functions.*

- *Thus, GIS have functional capabilities for data capture, input, manipulation, transformation, visualization, combinations, query, analysis, modeling and output.*

Other definitions of GIS

> "***A set of tools for collecting storing retrieving at will, transforming and displaying data from the real world for a particular set of purposes."***
>
> "***An organized collection of hardware, software, geographic data, and personnel designed to efficiently capture, more, update, analyze and display all forms of geographically referenced information (ESRI)."***

These are very general descriptions for such a complex and wide ranging set of tools. GIS is, in essence, a central repository of and analytical tool for geographic data collected from various sources. The developer can overlay the information from these various sources by means of themes and layers, perform comprehensive analysis of the data, and portray it graphically for the user.

Components of GIS

People, computer staff, experts from various science disciplines, GIS operators, GIS experts, applications developers;
Data, which may be of type spatial, temporal, or attribute;
Engines that perform various data storage, retrieval, analysis, reporting, and communication functions;
Interfaces such as GUIs having widgets based on toolboxes such as X-Windows or MOTIF, Microsoft Windows; and
Hardware, including workstations and networks, disk and tape storage, digitizers, plotters, and communications devices.

3.4 How GIS Works?

In a geographic information system (GIS), geographic data are transformed into geographic information. This simple transformation, however, involves a complex series of functions and processes. In a nutshell, geographic data begins as raw positional feature data holding attributes. These data are then overlaid with complementary and/or contrasting data sets, which form coincident relationships. Data and relationships are analyzed, geoprocessed, and then presented as geographic information products. These geographic information products are often interactive software applications used to help people make decisions. GISs are accessible to an array of users, from the expert GIS software developer to the GIS novice project manager, and, subsequently, offer visualization to users throughout the spectrum of skill levels. This diversity becomes a unique benefit of GIS and explains how quickly it can become visible within an organization, as well as offering project visibility to the public.

3.4.1 Flow of Information:

Geographic data originate from actual locations and physical characteristics of features on or near the surface of the Earth (or other celestial bodies such as Mars or the Moon). These raw, positional data are the start points for every GIS modeling, relationships, and analysis. Raw data can come from a range of sources, such as aerial photographs, previously digitized maps, and global positioning systems. These types of digital and nondigital geographic resources are readily available and, in many cases, are plentiful, well designed, and comprehensive. Additionally, many digital sources are free. Other more labor intensive sources are field data and measurements collected from site visits, and transformed maps, whereby old hardcopy maps are first scanned into a computer and then digitized.

In the most fundamental sense, raw data are either geographic data or are transformed into geographic data through a GIS, and are in turn used to produce geographic information products. Geographic information products are user-conceived information results created through a GIS and a user's ability to relate, manipulate, and present overlaid geographic data. These products are used to analyze data for a specific application.

The overall work of transforming data in a GIS can be summarized through its three distinct procedures:

A GIS leverages the flexibility of geographic data. Raw data are static (nonchanging) and offer only a limited amount of flexibility on real-world applications. When raw data are transformed to geographic data through a GIS, the capability for enhanced data use and analysis (i.e., data flexibility) significantly increases. At a minimum, overlaying two geographic data sources provides sufficient new information, better analytical means, and additional flexibility to not only help someone visualize the real world but also help them make an informed decision.

GIS performs functions and analysis within a single environment. These data functions are the literal "doers" of a GIS solution and are known as *geo-processing* and *spatial analysis.* These operations are available within a single GIS environment and include the generation of features, buffers, view sheds, and cross sections; the calculation of centroids, slopes, statistics, and suitability; and the manipulation of feature attributes, smoothing of lines, feature transformations, and clipping.

A GIS serves as a software application and creates useful information products. GIS environments, foremost, serve as spatially enabled enterprise data management systems and data repositories. These systems are software applications that protect the value and usefulness of the information related to your project. The end result is an information product that enables the user to better manage his or her project.

Through this procedural flow of information, geographic data are transformed into geographic information. GIS environments centralize both data collection and information management to save time, minimizes technical effort, and automates known repetitive administrative tasks.

The core data component of a GIS is often represented by a geographic data model, which is an industry or discipline-specific template for geographic data. A geographic data model offers the user flexibility in the design of the file management and database hierarchy. Geographic data models typically utilize a grid-based structure (known as raster) or a coordinate point structure (known as vector).

Facilitating the model is one or more geo-databases. A geo-database is a collection of geographic data sets, real-world object definitions, and relationships. Comparable to a Microsoft Access file, a geo-database is a collection of geographic data sets and geometric features. A geo-database furnishes the data organizational structure and workflow process model for the creation and maintenance of the core data product. In essence, the geo-database is the heart of a GIS's management capability.

3.4.2 Geographic Data

Geography is the study of the Earth's surface and climate, and is the founding science to a GIS. Geography furnishes information about the Earth and distinguishes how features upon the Earth correlate with one another. For example, a basic geographic study involves how climate and landform interrelate with inhabitants, soil, and vegetation. Data collected from this study are geographically oriented and are therefore geographic data. Any study with a geographic component, regardless of form, produces geographic data.

By their very nature, geographic data comprise the physical locations of objects on or near the surface of the Earth. Data are intimately concerned with the properties of such objects and hold attributes that can be associated to other types of geographic data. For example, a user can have two types of geographic data about a 40-acre stretch of land in New Zealand: one detailing elevation above sea level, and one detailing the various types of soil composition throughout the parcel.

Both forms of data can be combined for analysis in a GIS using the land parcel as the common link. All physical relationships between layers of geographic data are interpreted as coincident relationships, meaning that features coincide in real world space. In the above example, the elevation data and soil composition data would go on separate “layers” in the GIS.

Most standard GIS vector file formats consist of a feature file, an index file, and a linked attribute table. A *feature file* contains geographic object feature information, such as representative point, line, and polygon information. An *index file* contains unique identifiers that comprise more detailed information and help speed spatial feature queries. A linked attribute *table is* a matrixes table that contains explicative attributes for a group of spatial features.

3.4.3Geo-referencing:

Many data sources lack formal spatial referencing. Some CAD and GIS data sets are developed in a generic “design” space and have unique, often proprietary, types of referencing that simply need reinterpretation to be spatially integrated into a GIS environment. However, many of these sources are scanned raster data (digital imagery) that have only the coordinates of a raw pixel grid from an original scan. While these raster sources are often times unique and critical to a GIS project, images also need to be referenced from scratch, spatially transformed into a defined coordinate referencing system, then integrated and overlaid in a GIS environment. This process is known as *geo-referencing*.

The ability to perform accurate and timely spatial referencing adds a measure of customization to any GIS operation or project. Raster imagery, such as hardcopy maps and aerial photography, is the most popular type of data to use with geo-referencing, since it is the most commonly available type of data to use. Scanning imagery also alleviates the need to perform time-consuming and repetitive digitization efforts (i.e., transforming hardcopy to an electronic, digital file).

Geo-referencing is the art of selecting common point locations in the real world using at least two data sources: an unreferenced source (such as a raster map) and a referenced source of the same area providing positional information. Basic geo-referencing procedures involve point selection and transformation. For example, when a hardcopy map is scanned to an electronic file, it has no relationship to any real-world coordinate system. The geo-referencing process establishes (or in some cases reestablishes) the relationship between image pixel locations and real-world locations. Geo-referencing is accomplished by first selecting points on a source image (scanned raster map) with known coordinates for the real-world surface location (benchmarks, grid ticks, road intersections, and so on). These real- world coordinates are then linked to the corresponding pixel grid coordinates in the raster source image. After the image is geo-referenced, each pixel has a real-world coordinate value assigned to it.

3.4.4General Capabilities:

GIS can be used to store, display, and analyze geographic information in a spatial or “map-like” configuration in a computer. When linked to a printer or plotter, the GIS can generate top quality maps for reports, field operations or office use. Many systems will perform complex analyses, overlay various layers of maps, incorporate digital remote sensing imagery and global positioning systems data, and conduct modeling operations. The various maps stored in the GIS database can be displayed on the computer screen individually or overlaid on top of each other. By overlaying multiple layers of map information for the same area, the GIS help the analyst see relations between different aspects of the environment. Specific map elements (such as polygons or points) can also be displayed independently or in conjunction with other elements. Using the computer mouse (or cursor) map elements on the screen are selected to reveal text or statistics linked to the map elements.

3.4.5 Geo-processing:

Geo-processing is the fundamental process of creating a derived set of geographic data from various existing data sets using operations such as feature overlay and data conversion. In a typical geo-processing environment, the user applies GIS functions to a group of geographic (input) data to yield a precise output data set suitable for a particular application. Geo-processing functions run the gamut from simple spatial clipping to more complex analytic operations. These software functions can stand alone or be chained to other processes. This ultimately opens the gates for virtually unlimited sets of geo-processing models and potentially staggering sets of output data to solve specific problems.

Most professional GIS software environments include a mission-specific geo-processing interface, or “workbench,” of geospatial dialogs and tools. These software environments usually include extensible scripting tools and compilers to automate, customize, and document geo-processing workflows. The most important contribution of geo-processing to the GIS big picture is the automation of repetitive tasks. Geo-processing is an elaborate turnkey for efficient and clean geographic output.

Geo-processors come in different forms. Many geo-processing functions are embedded in a GIS environment. A GIS environment is a package of integrated GIS components: a geographic map control, a map layout designer, a data tree catalog, and so forth, of which geo-processing is a member. However, many powerful stand-alone software applications offer specific, related subsets of geo-processing functionality. Some include file format translators or spatial referencing transformation tools. Many professional GIS efforts actually require licensing these stand-alone accessories in order to reap the often-advantageous outputs of these stand-alone software applications.

Site selection is a prime example of a geo-processing application. Another is the function of batch processing in a non interactive manner. Geo-processing environments can be considered “robots” that automate geographic data processes and provide storage of geographic data models. Geo-processing is very reliable.

There are eight categories of predominant geo-processing operations, or families of operations:

Conversion: Conversion is completely an issue of formatting. File format conversions (translations) and coordinate system referencing conversions are the most common geo-processing conversion operations, and serve to characterize the conversion family.

Overlay (union, intersecting): Overlay involves superimposing two or more geographic data layers to discover relationships. In fact, overlay is intimately associated with the discipline of set

Topology: This defines the rules for valid spatial relationships between features in a geographic data layer.

Intersect*:* Geo-processing computes a geometric intersection of the input features. The resultant features or portion of features common to all layers or assigned groups of same shape type (called a feature class) will be written to the output.

Union: Like intersect, union computes a geometric intersection of the input features. All features with the overlapping attributes from the input features will be written to the output feature class.

Extraction (clip, query): Like overlay, extraction is also intimately associated with the discipline of set topology. Queries help select the geographic data to be clipped or extracted, subject to a specific group of topology rules.

Proximity (buffer): Proximity is initiated through a query that selects geographic features based on their distance or proximity from other features. Geographic features include lines, points, and polygons.

Management (copy, create): GIS data management software is generally designed to facilitate the organization of a user’s unique personal catalog (or collection) of geographic data. The intrinsic forms of all types of geographic data are accommodated by these applications.

Transformation: Typically in GIS, the term “transformation” means a spatial transformation, such as a datum transformation or reprojection. Geo-processing, however, introduces transformations of different types, such as temporal or geometric transformations. This facet of flexibility finds favor among integrated user interfaces, complementing comprehensive spatial analysis within a geo-processing software environment.

3.4.6 Queries:

Once data are adequately geo-referenced and resident in a GIS, the user can then create a query expression to find the relevant data for a specific application. A query enables the user to search geographic data to collect location, feature, and attribute information from a relational database management system or geo-database. The most fundamental test of geographic coincidence between data sources is a query by location in tandem with a targeting expression, such as *Intersection, Within distance of, Contained by, Share features with, Touch the boundary of, Are crossed by the outline of,* and *Completely in.*

Queries can also be executed on feature attribute tables and performed on specific fields. Records are selected in this manner; each record (or "row") in the table corresponds and is linked to a distinct geographic feature data set. Features conforming to certain attribute criteria can be selected and extracted using this method.

Quite simply, queries are the user's refining tool for taking the massive available data and selecting only those pieces that pertain to the application at hand. The absolute function of queries is a GIS staple. For example, population information relating to administrative units or municipalities might be sorted to show varying population densities among the municipalities. Such variations could then be shown graphically as charts or histograms on the map.

3.4.7 Quick updates:

GIS can update maps and map attributes directly onto the computerized map. A revised, updated hardcopy version of the map can then be printed quickly.

3.5 Structure of the GIS data:

Geographic data come from a variety of sources, such as digitized maps, aerial photography, GPS, and field data. Valid geographic data serve as a collective true marker as to what level of detail and accuracy a GIS can potentially attain. But, in reality, this is only a half-truth. The manipulation of this geographic data is as important and, often, more suggestive of the outcome's quality.

The appropriate structure of geographic data is considered a top reason why a GIS succeeds or fails. Inappropriate data handling or structure predictably leads to inappropriate geographic information products. To this extent, a user's grasp of the GIS application, the desired outcomes, and the geospatial system's limits are detrimental to realizing how best to treat the geographic data. Ultimately, the successful structuring of geographic data requires a combination of understanding and sound decision making.

Cartographic (Spatial) - observations on spatially distributed features, activities, or events –

Vector Data: Points, Lines (Arcs), Areas (Polygons)
Raster Data : Grid and Images

Non-Cartographic (Aspatial) - descriptive information in a database about the cartographic features located on a map.

Attributes
Attribute Values

Geographic information systems utilize two primary data models to manipulate and structure geographic data: the raster data model and the vector data model.

Raster and Vector Data Models

Like any complex data structure, raster and vector data have a myriad of different realizations that vary in complexity through use, appearance, format, and file size. Although distinctly different, these affiliate data structures share two characteristics: (1) They visually represent real-world features, and (2) they are subject to orientation within the real world. By satisfying both of these characteristics, geographic data are born and made interoperable with other geographic data sources within GIS. Before proceeding further with this discussion, let us take a small step back to reacquaint ourselves with the raster and vector data structures.

Raster Data model: Raster data structures characterize continuous data (such as imagery) and are exceptionally strong where boundaries and point information are not well defined. Raster data provide data as a pixel grid, whereby each pixel or cell is a feature capable of retaining properties and attributes. These pixels approximate pictures and images in an impressionistic way, with all of the smallish, monothematic cells contributing to a greater whole. Adding further identity, a raster image can vary in file format, color representation, resolution (size of pixels/ number of pixels per set area), and potential properties.

The raster model divides the entire study area into a regular grid of cells in specific sequence. The conventional sequence is row by row from top left corner. Each cell contains a single value.

It is space filling since every location in the study area corresponds to a cell in the raster. One set of cells and associated values is a layer, and there may be many layers in a database, e.g., soil type, elevation, land use, land cover etc.

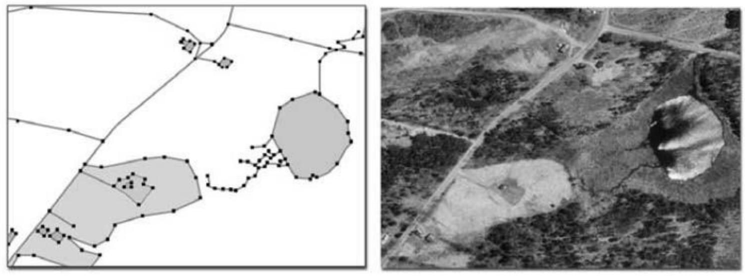
Vector Data model: Vector data are a bit different. Vector data structures characterize discrete data (such as roads, pipelines and topographic features) and are exceptionally strong where distinct boundaries and point information are well defined. This data structure is constructed on ordered two- and three-dimensional coordinates ([*x*,*y*] and [*x*,*y*,*z*], respectively). Features are represented as geometric shapes defined through single or grouped coordinates on a set grid.

It reduces the entire study area into three geographical identities – the point, polygon and the area.

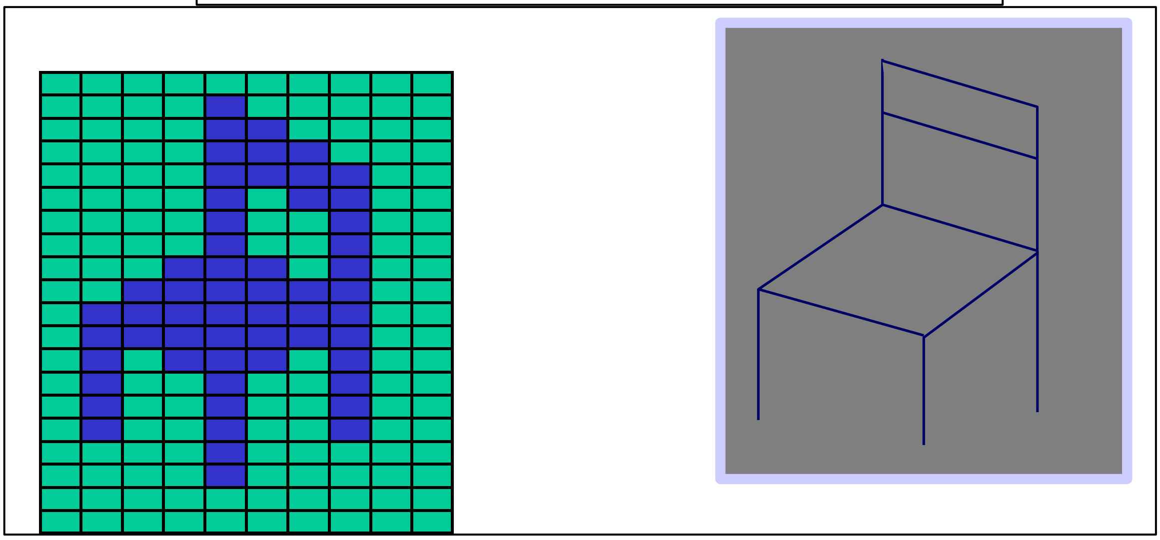
Every geographical phenomenon can be represented by point, line and polygon plus a label saying what it is. The labels could be the actual names, or they could be numbers of the cross-reference.

A map is a set of points, lines and areas that are defined both by their location in space with reference to a coordinate system and by their non-spatial attributes.

Vector objects do not necessarily fill space. Not all locations in space need to be referenced in the model.



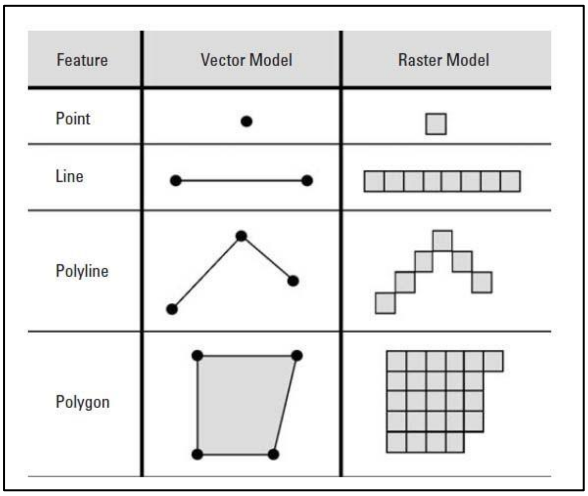
Vector Representation   Raster Satellite Image



Raster model   **Vector**
Model

Raster Vs Vector

- Question: which is better? – Answer, it depends…
- What are the requirements?
  - ➢ Raster is well suited for analysis and for displaying complex vector data for large geographic areas.
  - ➢ Vector is better suited for data collection, cartography, and applications where high accuracy is needed.



Both the raster and vector data structures have inherent advantages and disadvantages that allow GIS users a certain degree of choice. A full understanding of the native characteristics of each data model is a prerequisite for GIS success. Often certain requirements force the use of one data model rather than the other, such as the need for a better output resolution, easy image analysis, or enhanced spatial accuracy. Raster data, for example, offer a truly simple data structure that involves a grid of row and column data. This simple grid structure allows for easy raster image analysis, as well as analysis among multiple images. Raster modeling is also much easier to implement due to the single-value cell structure and relatively simple software programming. These advantageous raster capabilities are shadowed only by raster's native weaknesses. Disadvantages to raster data include general spatial inaccuracies and misrepresentations, low resolution, and massive data sets that require significant processing capability. The lack of accurate topology is also a major raster-based limitation.

Similarly, vector data offer their own variation of modeling strengths. Vector data, for instance, are spatially accurate and support a better, higher resolution than the raster data model. The ability to provide topology or feature relationships is a definite advantage, as well as the minimal data storage requirements. Although seemingly ideal, vector data have their own share of weaknesses worthy of mention. Due to the complex data structure, vector data require a greater and more powerful processing capability. With this comes the need for better, faster workstations to minimize the data processing times that typical computers face. Inevitably, the costs to run a vector GIS and expeditiously process complex geographic data sets can become highly expensive.

Needless to say, both the raster and vector data models have their own brand of geographic data expertise and capability embedded within a GIS. Nowadays, GISs are offered as raster-based systems, vector-based systems, or raster- vector capable systems. When necessary, raster-to-vector/vector-to-raster conversions can be easily accomplished through GIS or third-party conversion software. Undoubtedly, the choice of data model lies with the user and the available software/hardware.

Advantages and Disadvantages in nutshell

Vector

Advantages	Disadvantages
Precise expression	Complicated Structure
Less data volume	Difficulty in overlay
Full topology	Difficulty in updating
Fast Retrieval	Expensive data Capture
Fast Conversion	

Raster

Advantages	Disadvantages
Simple Data Structure	Large Data Volume
Easy for overlay and modelling	Low precision
Suitable for 3D display	Difficulty in network analysis

Integration of Image data	Slow conversion
Automated data capture	

3.6 Topology:

It has already been established that in a vector-based GIS, primary geometries (i.e., points, lines, and polygons) represent real-world features. The spatial relationship of these features is referred to as topology. Topology is the highest level of generalization at which geographic features can be stored. By storing information about the location of feature relative to other features, topology provides the basis for many kinds of geographic analysis without having to access the absolute locations held in the coordinate files. Topology is the set of rules through which a GIS represents features with the primary geometric shapes (i.e., point, line, and polygon). The vector data model utilizes topology to organize spatial relationships between discrete features. In essence, the main functions of topology are to define: (1) feature-to-feature locality or, simply, where a feature is in relation to another feature, (2) what is shared between different features, and (3) how features are grouped or connected within a set.

In a GIS, topology establishes geometric harmony within a geographic data set. Illustrating this precept is ESRI's *shapefile*, in which the vector feature file employs a set of natural numbers plotted and structured in binary format. This set of natural numbers delineates the boundaries and coverage of a particular feature. The simple binary structure defines a topological space for the feature and establishes continuity with other features, forming topological relationships.

Topological relationships are defined in all types of feature files and are generally categorized into the three primary functions of topology (previously mentioned):

1. Feature-to-feature locality, called a *complement;*
2. What different features share, called an *intersection;*
3. How features are grouped, called a *union.*

3.7 GIS Attribute Tables and Indices:

In order for a GIS to successfully manipulate and portray geographic data, feature files must be indexed to attributes providing more information. As detailed, most standard GIS data formats consist of a feature file, an index file, and a linked attribute table, whereby the feature file contains geographic object feature information, the attribute table (file) contains explicative attributes for spatial features, and the index file links attributes with features.

Briefly stated, index files act as attribute pointers. Indices contain unique identifiers that contain more detailed information about a specific feature. This embedded linkage helps speed up spatial feature queries within the GIS and serves as an index file's only true function.

Geospatial attribute tables, on the other hand, drive the spatially enabled database. There are various attribute field data types to handle the multitude of data, differentiated by a specific form of data and the degree of precision. To adequately handle the variants, attribute field data types signify different groupings of data bits, such as incorporating sign (i.e., "+" or "−"), binary, mantissa, and exponent bits, or signify data values, such as text, date, and object ID values. For clarity of this discussion, an *exponent* defines repeated multiplication (i.e., in $2^3 = 2 \times 2 \times 2$, the exponent is 3) and a *mantissa* is the value to the right of the decimal point in a common logarithm (i.e., in log 196 = 2.2923, the mantissa is 0.2923).

The following attribute field data types are most common and are supported in many major GIS environments:

Short Integer. A basic attribute data type that includes one signed bit and 15 binary bits.

Long Integer. A more complex form of the basic attribute type that incorporates one signed bit and 31 binary bits. As you can imagine, the *Long Integer* offers greater precision than the *Short Integer.*

Float. Contains one signed bit, seven exponent bits, and 24 mantissa bits.

Double. A more complex form of the *Float* attribute type with one sign bit, seven exponent bits, and 56 mantissa bits. As with the *Long Integer,* the *Double* attribute type holds greater precision than the *Float* attribute type.

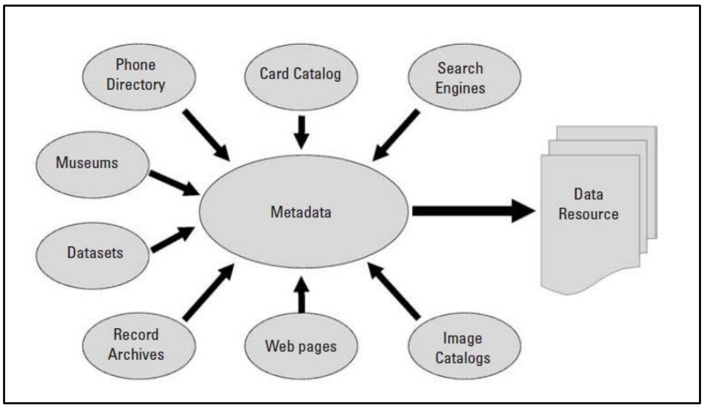
Text. Contains varying forms of data, such as numbers, letters, and symbols. The *Text* attribute type is a character string that can hold any amount of characters, but each character is stored using eight bits (called a byte). An interesting aspect to *Text* attribute data are that each text value in the same field must have the same number of characters. To achieve this, end blanks are used to fill in the empty slots.

Date. Though not apparent from the attribute data type name, a *Date* type contains date and time data. The value is based upon a standard time format and is automatically transformed into the current day and time within the system's local time zone.

BLOB. Short for *Binary Large Object*. A *BLOB* is a complex (and large) object stored in the database that may include an image, sound, video, or geometry. *BLOB*s allow users the ability to insert any type of multimedia data into the geodatabase.

GUID. Acronym for *Globally Unique Identifier*. A *GUID* is a unique 128-bit (16 byte) number that is produced to identify a particular application, file, database entry, hardware, or user. Each generated *GUID* is "mathematically guaranteed" to be unique since the total number of unique keys is colossal and the probability of generating an identical *GUID* is virtually impossible.

3.8 Metadata:



Metadata is defined as structured information that enables a resource to be easily identified, used, manipulated, and cataloged. Metadata is often identified as "data about data" and can be applied to various resources, such as images, online documents, maps, library records, data sets, or anything else inherently searchable. In simpler terms, metadata helps resources be suitably found, cataloged, and used.

The concept of metadata is nothing new. In fact, library card catalogs, which have been around since long before GIS, are a form of metadata. The older hardcopy information cards and newer online records hold a selection of basic information and identifiers for the material being sought. Typically, information supplied includes a title, author, date, ISBN or similar identifier, and a unique library location number. This library catalog card/record is identical to metadata since it is data (card information) about data (book or resource material).

3.9 Geographic Data Generalization

Geographic technologies represent the real world mainly for convenience, similar to the role played by hardcopy paper maps used by our wandering ancestors. For example, a traveler cannot simply fold up a true representation of his 100-mile route and stick it in his coat pocket. For the sake of convenience and portability, the 100-mile route is reduced to a scale of 1:100,000 (i.e., 1 inch equals 100,000 inches), which is then drawn and portrayed on paper, folded, and placed in his pocket. This diminution of scale is adequately achieved through generalization.

Generalization at its core is a method to manage and reduce unwieldy or overly numerous input data sets. Through this process of reduction, the real-world data source is rendered in less detail and, as a result, is somewhat distorted from reality. Each level of generalization introduces a greater degree of distortion; however, immediately, generalization affects the overall appearance and, even more important, the precision of the output data. All geographic data are in some way generalized. This is an inevitable, astringent process that alters the actual character of the data into a simplified and shrunken model of the real world. Ultimately, scale dictates the severity of generalization, varying in level from project to project. For instance, a map drawn to 1:100,000 scale (smaller scale) is more generalized than the same area drawn to 1:24,000 (larger scale), thus the smaller the scale, the greater the level of generalization.

3.10 Projection: Display of 3D earth surface information on 2D plane surface with user required accuracies of shape, size and distance. The idea of depicting the Earth on a flat map is easy to imagine and rather simple to understand, but the actual process of a map projection is complex. It will be discussed in detail in Chapter I.

3.11 Types of GIS:

a) **Desktop Mapping:** Though not a true GIS, these systems are useful to review map data for general planning purposes, do simple processing (such as map queries and basic statistics) and output maps and graphics for reports or meetings. They run on standard PC's with a minimum of upgrades. Many are user friendly and most useful to the non-GIS professional who routinely needs to consult geographic information or map data.

b) **Project level GIS:** The project level GIS is a true GIS with complete functionality, it usually involves a small number of users and is focused on trying to "get an answer" to a specific problem. It usually is not so concerned with issues such as standards and inter-operability between different parties. Data sets frequently have a short life in terms of their usefulness. Such a system would typically be PC based. Requirements for inputs and outputs are determined according to the need to answer the specific question that justified the acquisition of the GIS.

c) **Corporate-level GIS:** The corporate-level GIS usually serves multiple parties or an unknown number of users with diverse needs and generates data sets with a long life expectancy. Common hardware for these operations includes single workstations or multiple workstations. Input and output formats, procedures and methodology are frequently standardized and documented to assure compatibility among the various users. These characteristics make such a system complex. Consequently, it requires extensive front-end planning and consensus building among the potential users in order to determine their goals and needs for information and to define and appropriate system, data and personnel requirements necessary to achieve the goals and generate the information.

3.12 Use of GIS in simple terms:

- Though collection of data is difficult once it is collected, it can be stored safely in digital form (in computer) forever without damage, which usually happens to our maps.
- Once if a map is prepared accurately it can be printed in any scale without any redrawing.
- Large scale maps at smaller units (Beats) level can be joined for creating maps at divisions or district level, very accurately within few minutes.
- Changes can be incorporated very easily in computer and it doesn’t require any redrawing.
- Same map can be generated even after 100s of years later.
- New things can be known after overlay of different themes and a new types of maps can be generated.
- Work can be done faster than manually.
- The work of decision makers and end users will become easier.
- Map data is more secured and better organized.
- Redundancy and other problems of multiple map sets are eliminated.
- Once a map is prepared accurately it can be printed in any scale without any redrawing.
- Same map can be generated after many years.
- The work of decision-makers and end users will become easier
- Map revisions are Easier and Faster.
- Map data is easier to search, analyze and present.
- Employees are more productive.
- Mapping geographical characteristics for analysis
- Modeling alternative processes for management plans
- Managing a utility’s assets
- Monitoring changes in environmental factors

Chapter - IV
Fundamentals of Remote Sensing

4.1 Overview:

Remote sensing refers to the activities of recording, observing, and perceiving (sensing) objects or events in far-away (remote) places. In remote sensing, the sensors are not in direct contact with the objects or events being observed. Electromagnetic radiation normally is used as the information carrier in remote sensing. The output of a remote sensing system is usually an image representing the scene being observed. A further step of image analysis and interpretation is required to extract useful information from the image. In a more restricted sense, *remote sensing* refers to the science and technology of **acquiring information about the earth's surface (i.e., land and ocean)** and atmosphere using sensors onboard airborne (e.g., aircraft or balloons) or spaceborne (e.g., satellites and space shuttles) platforms.

Depending on the scope, remote sensing may be broken down into (1) satellite remote sensing (when satellite platforms are used), (2) photography and photogrammetry (when photographs are used to capture visible light), (3) thermal remote sensing (when the thermal infrared portion of the spectrum is used), (4) radar remote sensing (when microwave wavelengths are used), and (5) LiDAR remote sensing (when laser pulses are transmitted toward the ground and the distance between the sensor and the ground is measured based on the return time of each pulse).

A photograph is a good example of remote sensing. In fact on the advent of development of photography technique, people started gathering information of land surfaces with cameras, called terrestrial Remote Sensing. After invention of air crafts, aerial photography has gained much prominence in collection of data of earth is resources, though lesser effort was initiated well before with the help of Balloons. Even now aerial photography is being used in most of the places for land resources management.

The technology of remote sensing evolved gradually into a scientific subject after World War II. Its early development was driven mainly by military uses. Later, remotely sensed data became widely applied for civil applications. The range of remote sensing applications includes archaeology, agriculture, cartography, civil engineering, meteorology and climatology, coastal studies, emergency response, forestry, geology, geographic information systems, hazards, land use and land cover, natural disasters, oceanography, water resources, and so on. Most recently, with the advent of high spatial resolution imagery and more capable techniques, urban and related applications of remote sensing have been rapidly gaining interest in the remote sensing community and beyond.

The first Remote sensing satellite was launched by USA 'Landsat' in the year 1982. Since then many countries have launched different satellites with different capabilities including India. India has launched its first R.S. Satellite IRS IA in the year 1988. Since then it has launched IRC series IB, IC, ID and P series P1, P2, P3, P5, P6, Cartosat etc.

4.2 Definitions:

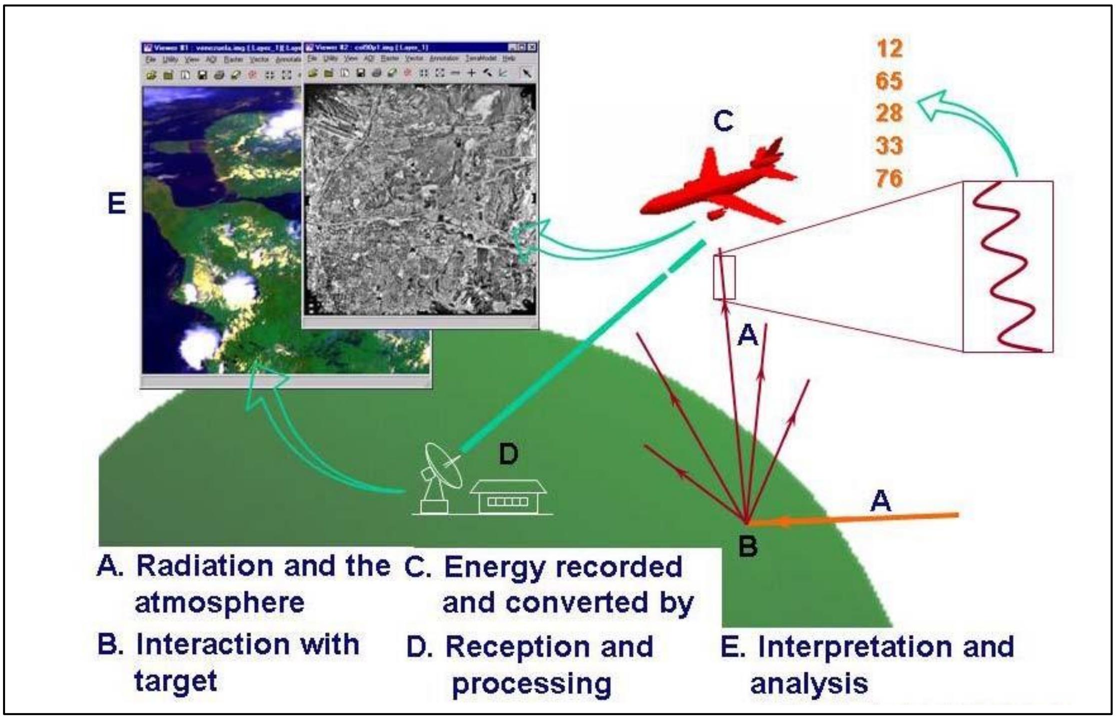
Collection of information about on object without actually being in contact with it is called Remote Sensing.

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 being in contact with the object, area, or phenomenon under the investigation.

> *"Remote sensing refers to gathering and processing of information about earths environment and its natural and cultural resources through Aerial photographs and satellite scanning"*

4.3 Process of Remote Sensing:

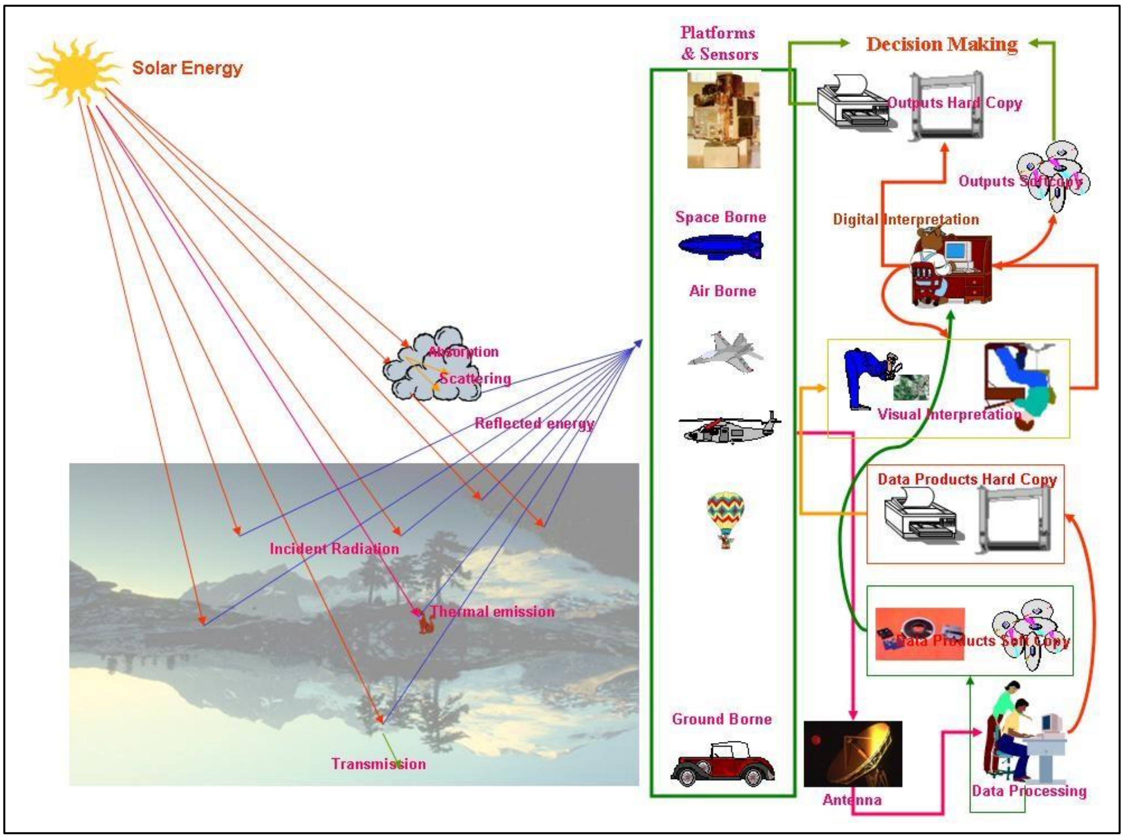
Solar energy as Sunlight passes through atmosphere and reaches the earth surface after some filtering. Objects on the earth's surface may absorb or transmit or reflect part or whole of the energy received depending upon its constituency. This reflected energy will be sensed by sensors fitted in cameras on board of satellite. Sensor is fitted with an array of CCD (charge couple devices). Each CCD is responsible for sensing reflection of a particular area on earth's surface. Thus this array scans the earth's surface like push broom along the path of the satellite. Each camera is fitted with a lens designed in such a way that it will only allow the reflected energy pertaining to a part of electromagnetic spectrum. Thus each camera will give information for a particular band. The information (reflectance value) in stored as digital number depending upon its calibrated levels (2,8,16…256, 1024).



4.4 Principles of Electromagnetic Radiation:

Remote sensing takes one of the two forms depending on how the energy is used and detected. Passive remote sensing systems record the reflected energy of electromagnetic radiation or the emitted energy from the earth, such as cameras and thermal infrared detectors. Active remote sensing systems send out their own energy and record the reflected portion of that energy from the earth's surface, such as radar imaging systems.

Electromagnetic radiation is a form of energy with the properties of a wave, and its major source is the sun. Solar energy traveling in the form of waves at the speed of light (denoted as *c* and equals to 3 x 10^8 ms–1) is known as the *electromagnetic spectrum*. The waves propagate through time and space in a manner rather like water waves, but they also oscillate in all directions perpendicular to their direction of travel. Electromagnetic waves may be characterized by two principal measures: wavelength and frequency. The wavelength λ is the distance between successive crests of the waves. The frequency μ is the number of oscillations completed per second. Wavelength and frequency are related by the following equation: $C = \lambda \times \mu$



The electromagnetic spectrum, despite being seen as a continuum of wavelengths and frequencies, is divided into different portions by scientific convention. Major divisions of the electromagnetic spectrum, ranging from short-wavelength, high-frequency waves to long-wavelength, low-frequency waves, include gamma rays, x-rays, ultraviolet (UV) radiation, visible light, infrared (IR) radiation, microwave radiation, and radiowaves.

The visible spectrum, commonly known as the *rainbow of colors* we see as visible light (sunlight), is the portion of the electromagnetic spectrum with wavelengths between 400 and 700 billionths of a meter (0.4–0.7 μm). Although it is a narrow spectrum, the visible spectrum has a great utility in satellite remote sensing and for the identification of different objects by their visible colors in photography.

The IR spectrum is the region of electromagnetic radiation that extends from the visible region to about 1 mm (in wavelength). Infrared waves can be further partitioned into the near-IR, mid-IR, and far- IR spectrum, which include thermal radiation. IR radiation can be measured by using electronic detectors. IR images obtained by sensors can yield important information on the health of crops and can help in visualizing forest fires even when they are enveloped in an opaque curtain of smoke.

Microwave radiation has a wavelength ranging from approximately 1 mm to 30 cm. Microwaves are emitted from the earth, from objects such as cars and planes, and from the atmosphere. These microwaves can be detected to provide information, such as the temperature of the object that emitted the microwave. Because their wavelengths are so long, the energy available is quite small compared with visible and IR wavelengths. Therefore, the fields of view must be large enough to detect sufficient energy to record a signal. Most passive microwave sensors thus are characterized by low spatial resolution.

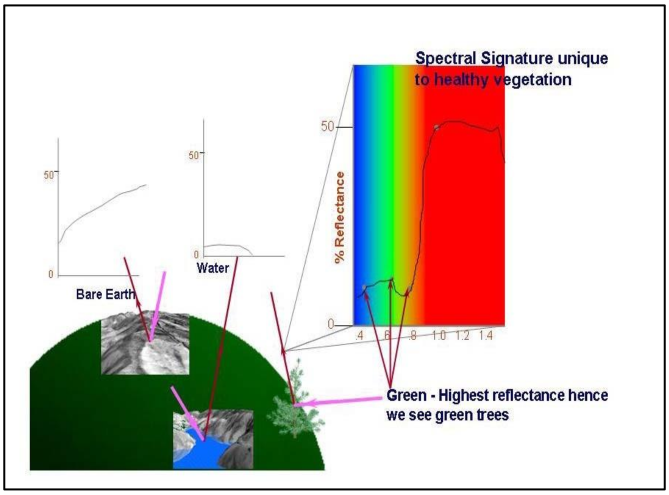
Active microwave sensing systems (e.g., radar) provide their own source of microwave radiation to illuminate the targets on the ground. A major advantage of radar is the ability of the radiation to penetrate through cloud cover and most weather conditions owing to its long wavelength. In addition, because radar is an active sensor, it also can be used to image the ground at any time during the day or night. These two primary advantages of radar, all-weather and day or night imaging, make radar a unique sensing system.

The electromagnetic radiation reaching the earth's surface is partitioned into three types by interacting with features on the earth's surface. *Transmission* refers to the movement of energy through a surface. The amount of transmitted energy depends on the wavelength and is measured as the ratio of transmitted radiation to the incident radiation, known as *transmittance.* Remote sensing systems can detect and record both reflected and emitted energy from the earth's surface. *Reflectance* is the term used to define the ratio of the amount of electromagnetic radiation reflected from a surface to the amount originally striking the surface. When a surface is smooth, we get *specular* reflection, where all (or almost all) of the energy is directed away from the surface in a single direction. When the surface is rough and the energy is reflected almost uniformly in all directions, *diffuse* reflection occurs. Most features of the earth's surface lie somewhere between perfectly specular or perfectly diffuse reflectors. Whether a particular target reflects specularly or diffusely or somewhere in between depends on the surface roughness of the feature in comparison with the wavelength of the incoming radiation. If the wavelengths are much smaller than the surface variations or the particle sizes that make up the surface, diffuse reflection will dominate. Some electromagnetic radiation is absorbed through electron or molecular reactions within the medium. A portion of this energy then is reemitted, as *emittance,* usually at longer wavelengths, and some of it remains and heats the target.

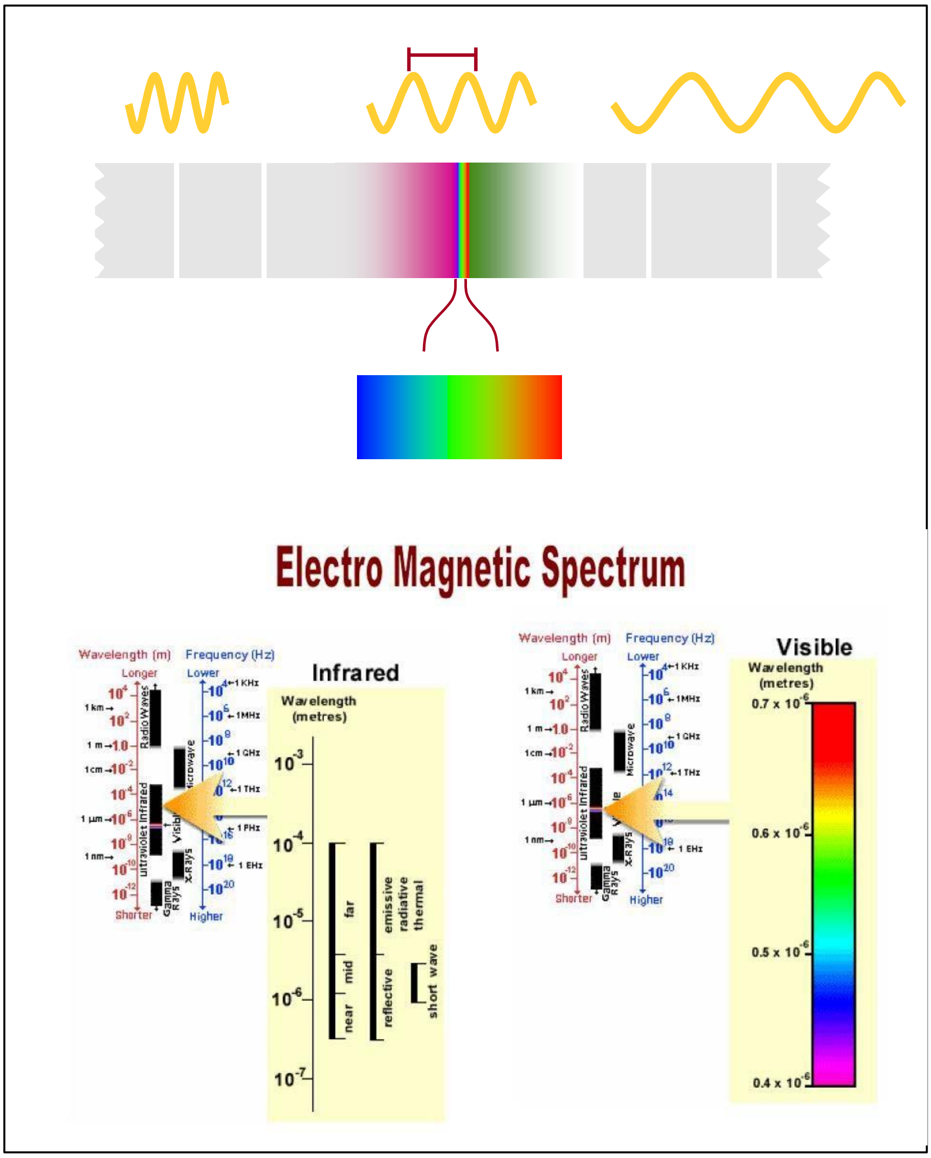
Electro Magnetic Spectral Regions

Region	Wavelength	Remarks
Gamma ray	<0.03 um	Incoming radiation is completely absorbed by the upper atmosphere and is not available for Remote Sensing.
X – Ray	0.03 to 3.0 um	Completely absorbed by atmosphere, not employed in Remote Sensing.
UV	0.03 to 0.4 um	In coming wavelengths less than 0.3 um are completely absorbed by ozone in the upper atmosphere
Photographic UV band	0.3 to 0.4 um	Transmitted through atmosphere. Detectable with film and Photo detectors, but atmospheric scattering is serving.
Visible	0.4 to 0.7 um	Imaged with film and photo detectors includes reflected energy Peak of earth at 0.5 m intention with matter varies with wavelength atmospheric transmission windows are separated by absorption bands
Reflected	0.7 to 0.3 um	Reflected solar radiation that contains information about thermal properties of materials. The from 0.7 to 0.9 mis detectable with film and is called the photographic IR band
Thermal band	3 to 5 um 8 to 14 um	Principle atmospheric windows in the thermal region. Images at these wavelengths are acquired by optical mechanical scanners and special vidicon systems but not by film.
Microwave	0.1 to 30 cm	Longer wave lengths can punctuate clouds, fog and rain; images may be acquired in the active or passive mode.
Radar	0.1 to 30 cm	Active form of microwave Remote sensing Radar images are acquired in various wavelength bands
Radio	>30 cm	Longest wavelength portion of electromagnetic spectrum, some classified radars with very long wavelength operate in this region.

For any given material, the amount of solar radiation that reflects, absorbs, or transmits varies with wavelength. This important property of matter makes it possible to identify different substances or features and separate them by their spectral signatures (spectral curves). Figure illustrates the typical spectral curves for three major terrestrial features: vegetation, water, and soil. Using their reflectance differences, we can distinguish these common earth-surface materials. When using more than two wavelengths, the plots in multidimensional space tend to show more separation among the materials. This improved ability to distinguish materials owing to extra wavelengths is the basis for



multispectral remote sensing.



4.5 Characteristics of Remote Sensing Data:

Regardless of passive or active remote sensing systems, all sensing systems detect and record energy “signals” from earth surface features and/or from the atmosphere. Familiar examples of remote sensing systems include aerial cameras and video recorders. More complex sensing systems include electronic scanners, linear/area arrays, laser scanning systems, etc. Data collected by these remote sensing systems can be in either analog format (e.g., hardcopy aerial photography or video data) or digital format (e.g., a matrix of “brightness values” corresponding to the average radiance measured within an image pixel). Digital remote sensing images may be input directly into a GIS for use; analog data also can be used in GIS through an analog-to-digital conversion or by scanning. More often, remote sensing data are first interpreted and analyzed through various methods of information extraction in order to provide needed data layers for GIS. The success of data collection from remotely sensed imagery requires an understanding of four basic resolution characteristics, namely, spatial, spectral, radiometric, and temporal resolution.

Spatial Resolution:

Spatial resolution is a measurement of the minimum distance between two objects that will allow them to be differentiated from one another in an image and is a function of sensor altitude, detector size, focal size, and system configuration (Jensen, 2005). For aerial photography, spatial resolution is measured in resolvable line pairs per millimeter, whereas for other sensors, it refers to the dimensions (in meters) of the ground area that falls within the instantaneous field of view (IFOV) of a single detector within an array or pixel size (Jensen, 2005). Spatial resolution determines the level of spatial details that can be observed on the earth's surface. Coarse spatial resolution data may include a large number of mixed pixels, where more than one land-cover type can be found within a pixel. Whereas fine spatial resolution data considerably reduce the mixed-pixel problem, they may increase internal variation within the land- cover types. Higher resolution also means the need for greater data storage and higher cost and may introduce difficulties in image processing for a large study area. The relationship between the geographic scale of a study area and the spatial resolution of the remotesensing image has been explored (Quattrochi and Goodchild, 1997). Generally speaking, on the local scale, high spatial-resolution imagery, such as that employing IKONOS and QuickBird data, is more effective. On the regional scale, medium-spatial- resolution imagery, such as that employing Landsat Thematic Mapper/Enhanced Thematic Mapping Plus (TM/ETM+) and Terra Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data, is used most frequently. On the continental or global scale, coarse-spatial-resolution imagery, such as that employing Advanced Very High Resolution Radiometer (AHVRR) and Moderate Resolution Imaging Spectrometer (MODIS) data, is most suitable.

IRS 1C/1D PAN 5.8 Mt, WiFS 188.3 Mt, LISS III 23.5 & 70.5 Mt; Cartosat 1 2.5 m
NOAA AVHRR 1.1 KM at nadir and 2.4 & 6.9 KM offnadir; etc

Spectral Resolution:

Spectral resolution of a sensor refers to the number and size of the bands it is able to record (Jensen, 2005). Spectral resolution is defined as the specific wavelength intervals in the electromagnetic spectrum that a sensor can record or Refers to the band width and the no. of bands used for collecting the data. For example band 1 of the IRS-IC, LISS III sensor records energy between 0.52 to 0.59 µm in the visible spectrum.

Wide intervals in the electromagnetic spectrum are referred to as coarse spectral resolution and narrow intervals are referred to as fine spectral resolution. For example the IRS – IC, PAN sensor is considered to have coarse spectral resolution because it records electromagnetic range between 0.5 to 0.75 µm. On the other hand, band 3 of IRS-IC LISS III Sensor has fine spectral resolution because it records electromagnetic range between 0.62 to 0.68 µm. AVHRR, onboard National Oceanographic and Atmospheric Administration's

(NOAAs) Polar Orbiting Environmental Satellite (POES) platform, collects four or five broad spectral bands (depending on the individual instrument) in the visible (0.58–
0.68 μm, red), near-IR (0.725–1.1 μm), mid-IR (3.55–3.93 μm), and thermal IR portions (10.3–11.3 and 11.5–12.5 μm) of the electromagnetic spectrum.

Temporal Resolution:

Temporal resolution refers to the amount of time it takes for a sensor to return to a previously imaged location. Therefore, temporal resolution has an important implication in change detection and environmental monitoring. Many environmental phenomena constantly change over time, such as vegetation, weather, forest fires, volcanoes, and so on. Temporal resolution is an important consideration in remote sensing of vegetation because vegetation grows according to daily, seasonal, and annual phenologic cycles. It is crucial to obtain anniversary or near-anniversary images in change detection of vegetation. Anniversary images greatly minimize the effect of seasonal differences (Jensen, 2005).

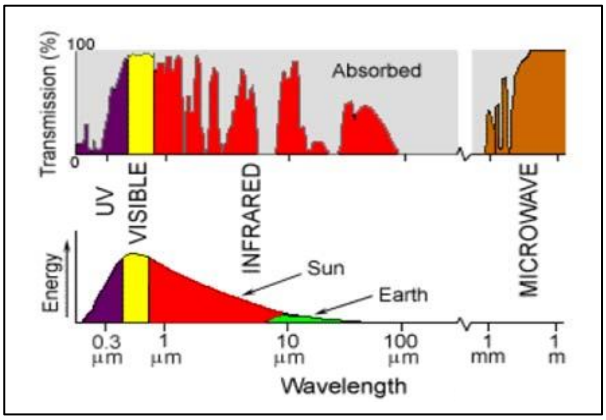
IRS 1C/1D PAN 5Days, LISS III 24 Days; NOAA AVHRR half day for TIR, one day for Visible; MOS 1 &1a MESSR, VTIR and MSR 17 Days; Geostationary Operational Environmental Satellite (GOES), 0.5/h;and Meteosat first generation, every 30 minutes etc.

Radiometric Resolution:

Radiometric resolution refers to the sensitivity of a sensor to incoming radiance, that is, how much change in radiance there must be on the sensor before a change in recorded brightness value takes place (Jensen, 2005). Refers to the no. of quantization levels into which the radiant flux reflected from the scene elements is recorded. This is referred to by the number of bits into which the recorded energy is divided for instance, in 8 bit data file values range from 0 to 255 for each pixel, but in 7 bit data the data file values for each pixel range form 0 to 127. The total intensity of the energy from 0 to the maximum amount the sensor measures is broken down into 256 brightness values for 8 bit data and 128 brightness values for 7 bit data.

Coarse radiometric resolution would record a scene using only a few brightness levels, that is, at very high contrast, whereas fine radiometric resolution would record the same scene using many brightness levels. *IRS 1C/1D PAN* 6 *Bits, LISS III 7 Bits; Landsat 7 ETM+ 8 Bits; SPOT* 4*&5 MLA 8 Bits; AVHRR 10 Bits etc.*

Atmospheric Effects: The earth's atmosphere absorbs energy in the gamma ray X-ray and most of the UV region; therefore, these regions are not used for Remote Sensing. Remote sensing records energy in the microwave, infrared and visible regions, as well as the long wave length portion of UV region. Wavelength regions with high transmission are called **atmospheric windows** and are used to acquire Remote Sensing Images.



4.6 Platforms and Sensors:

Platform – the device to which the sensor is attached e.g. Indian Remote Sensing Satellite

Sensor – the device that actually gathers the remotely sensed data e.g. LISS (4 bands) and PAN (1 band) sensors

Ground borne: *Van, Tripod etc. - Capability to view object from different angles*

Air borne: Balloons - *Tethered and Free; Aircraft - DAKOTA, AVRO, CESSUA, CANBERRA.*

Space borne: *Satellites and Space Stations*

4.7 Satellites:

Geo stationery Satellites:

- Fly at 35000 KM altitude, move with respect to sun i.e., relatively in constant position over equator
- Continuous sensing of the Earth and covers 1/3 of earth i.e., 3 satellites are required to entire earth at a time
- Orbit is circular, no inclination
- Stationary relative to the Earth's surface as speed match the rotation of the Earth
- Low spatial but high temporal resolution
- Used for meteorological, communication, natural resource assessment etc.
- INSAT series, GEOS etc.

Polar Orbiting or Sun Synchronous Satellites:

- Fly at altitudes ranging from 200 KM to 950 KM and continuous imaging of earth surface in specified paths and rows.
- Satellite passes over each area of the Earth's surface at a constant local time of day
- High spatial but low temporal resolution

- Orbital period approximately 102 to 105 min.
- Revisit the same area at specified intervals e.g. IRS 1C/1D 24 days etc.
- Generally inclined at 990 to withstand gravitational pull & more coverage
- Used for natural resource assessment viz.., Forestry, Geological, Soil, Hydrological, Oceanographic, Agricultural etc., applications etc.
- IRS 1A/B, 1C/D; LandSat 1:7, SPOT 1:5, NOAA 1:12, MOS 1&1A etc.

Other Satellites: *Spy Satellites, Candors, Iridium, Constellation of GPS Satellites etc.*

4.8 Sensors:

Passive systems: A **passive sensor** is a device that detects and responds to some type of input from the physical environment. **Passive sensor** technologies gather target data through the detection of vibrations, light, radiation, heat or other phenomena occurring in the subject's environment.

photographic camera, television camera, return beam vidicon (RBV), electro- optical scanner

Active systems: An **active sensor** is a **sensing** device that requires an external source of power to operate; **active sensors**contrast with passive **sensors**, which simply detect and respond to some type of input from the physical environment.

RADAR, microwave, photographic camera with flash light

a) **Photographic camera**
   Metric camera
   Strip camera
   Multiband camera
b) **Television camera**
c) **Electronic scanner**
d) **Thermal scanner**
e) **Imaging spectrometer**

4.9 Satellite Coverage:

Remote sensing satellite roams around earth from pole to pole with an inclination angle of 5 degrees, which may take 104 minutes for one round. The area covered in one round is called path. The width of this path is called swath width and is varied from satellite to satellite and camera to camera in the same satellite. Due to earth's rotation on its polar axis the path of the satellite changes from round to round, thus it covers the entire area in 24 days (IRS IC). Adjacent scenes from different paths are called Rows. The demarcation of coverage of earth as path & Row varies from satellite to satellite.

4.10 Scanning System:

A scanning system employs single detector with a narrow field of view which sweeps across the terrain to produce an image. When photons of electromagnetic energy radiated or reflected from the terrain encounter the detector, an electrical signal is produced that varies in proportion to the number of photons. The electrical signal amplified, recorded on magnetic tape, and played back later to produce an image. All scanning systems sweep the detectors field of view across the terrain in a series of parallel scan lines.

Across-track scanner or Whisk-broom scanner

- Consists of a single detector and a rotating mirror
- Mirror is oriented in such a manner that, after one complete rotation, the detector beam sweeps a straight line on the surface of the Earth across the track of the satellite
- Scan lines are at right angles to the flight line
- Data collected within an arc below the aircraft typically of 900 to 1200
- Series of contiguous or just touching narrow strips of observation

Along-track scanner or Push-broom scanner

- Consists of thousands of equally-spaced detectors (CCD) which together act as a linear camera, recording one entire line
- Size of the detectors determines the size of each ground resolution cell
- All scan lines in an array viewed simultaneously

IRS-P5 or CARTOSAT-1 – 2 Panchromatic solid state cameras *(for generation of stereoscopic images of the area along the track)* working on the '**push broom scanning**' concept

IRS P-6 or RESOURCESAT-1 – 3 solid state cameras (LISS-III &V and AWiFS) working on the
'**push broom scanning**' concept

Multi-spectral System:

The framing and scanning systems said above, record a single image that represents a single band. For many Remote Sensing applications it is essential to record a scene with multi-spectral images. Multiple images acquired at different spectral bands. Multi-spectral images may be acquired by several methods. Multiple Cameras or vidicons may be mounted together and aligned to photograph the same area. The shutters are linked together and triggered simultaneously. A typical cluster of four multi- spectral Cameras records three visible bands (blue at 0.4 to 0.5 µm, green at 0.5 to 0.6 µm and red at 0.6 to 0.7 µm).

4.11 Indian Satellites – IRS Series:

The IRS IA/IB satellites have a nominal altitude of 904 Km and an orbital inclination of 99 degrees which makes them nearly polar. They are in sun synchronous orbit which means that the orbit plane passes about the same angular radii that the earth. This enables the spacecraft to cross the equator at the same local time (10 to 10.30 am) every day. The orbital period is about 103 minutes and the satellite completes 14 orbits per day. It takes 22 days to complete one cycle of the globe in 308 orbits.

IRS – IC and P Series:

The IRS –IC/ID and P Series satellites are placed in a polar sun synchronous orbit with ascending mode of 817 km with the local time of equator crossing at 10.30 hrs. The satellite takes 101.35 min to complete one revolution around the earth and completes 14 orbits a day. The entire earth is covered by 341 orbits during a 24 day cycle.

IRS- IC/ID and P Series offers the Remote sensing community a unique combination of 3 cameras, one operating in the panchromatic and the other two in multi-spectral bands. These payloads that operate in push broom scanning mode using charge coupled devices (CCD) as detectors are unique in terms of their resolution revisit period and application potential.

These satellites have following sensors.

Panchromatic Camera (PAN):

The Panchromatic Cameras enables the acquisition of images at resolution of 5.8m which is the highest spatial resolution being offered by any civilian Remote Sensing Satellite presently orbiting the earth. The Pan Camera operates in the spectral range of 0.5-0.75m and provides a ground average of
70km. The camera has off nadir viewing capability with a visit frequency of 5 days, which can provide stereo image.

Linear Image self scanner (LISS-III):

The 4 band multi spectral camera LISS-III provides the data of the earth’s surface in the short- wave IR region besides visible and near IR regions of the electromagnetic spectrum. LISS-III has a resolution of 23.5mts each in the visible and near IR bands and 70mts in the short-wave-IR bond. The swath in the visible and near IR bands in 141kms while the short-wave-IR has a swath of 148kms.

Wide field sensor (WiFS):

Wi FS is a 2-band camera, which enables the dynamic monitoring of natural resources, and observes the same region once is every 5 days. The 2 bands operates is the visible and near IR region with a spatial resolutions of 188.3mts and a wide swath of 810 kms.

Advanced Wide field sensor (AWiFS):

AWiFS is a 2-band camera, which enables the dynamic monitoring of natural resources, and observes the same region once is every 5 days. The 2 bands operates is the visible and near IR region with a spatial resolutions of 56.25 m.

4.12 Hard copy: Output of an image on paper is called hard copy.

4.13 Soft copy: Output of an image in digital form is called soft copy. The digital file format in important criteria as it requires a specific software to view and analyze it. Secondly the out put has to be loaded on one of the media suitable for users' hardware. Ex: Floppy, IO mega diskette, CD Rom, DAT, CCT, etc.

4.14 False Color Composite: It is a standard & universally accepted hard copy format of output of multi-spectral data. The output will be generated by assigning Blue color to green band, green color to Red band and Red color to Infra red band. The concept behind this assignment of color is most of the information of earths surface reflects in IR, where as blue band reflects much less. Secondly, human eye can distinguish more tones of red than other the any other color. Hence it is assigned to more informative bond IR. That is how it is called false color composite. It can also be generated by assigning derived bands using band algebra in place of various bands.

4.15 Data Formats:

Digital image analysis is usually conducted using raster data structures – each image is treated as an array of values. Additional spectral channels form additional arrays that register to one another. Each pixel is treated as a separate unit, which can always be located within the image by its row and column coordinates. **Raster data structures** offer advantages for manipulation of pixel values by image processing systems, as it is easy to find and locate pixels and their values. The advantages are usually apparent only when we need to represent not the individual pixels but areas of pixels as discrete patches or regions. Then the alternative structure **– vector format –** becomes more attractive. ***Vector format*** uses polygonal patches and their boundaries as fundamental units for analysis and manipulation. The vector format is not appropriate for digital analysis of remotely sensed data, although sometimes we may wish to display the results of our analysis using a vector format. Equipment and software for digital processing of remotely sensed data almost always must be tailored for raster format.

Digital remote sensing data are often organized using one of the three common formats used to organize image data. Consider an image consisting of four spectral channels, which can be visualized as four superimposed images, with corresponding pixels in one band registering exactly to those in the other bands.

Band Interleaved by Pixel (BIP)
Band Interleaved by Line (BIL)
Band Sequential Format (BSQ)

The “best” data format depends on immediate context, and often the specific software and equipment available. In general, however, the analyst must be prepared to read the data in the format that they are received, and to convert them into the format most convenient for use at a specific laboratory.

Data compression reduces the volume of data required to store or transmit information by exploiting redundancies within the data set. Because remotely sensed images require large amounts of storage, and usually contain modest redundancies, data compression is of significance for storage, transmission, and handling of digital remote sensing data. Compression and decompression are accomplished by running computer programs that receive, for example, compressed data as input and produce a decompressed version of the same data as output.

4.16 Advantages and Limitations:

Limitations:

- Different types of land use may not be distinguishable on images.
- Small areas survey, the cost of mobilizing a Remote Sensing mission may be uneconomical.
- Identifying & classifying multiple uses occurring on a single parcel of land will not be so easy.
- Similar spectral response of two different objects sometim es creates confusion to the interpreter in image analysis.
- Cloud cover in optical sensors.

Advantages	Limitations
Real time	Cloud free data availability
Cheaper	Limitations in mapping smaller areas
Different scales	Cumbersome processing
Accurate if processed properly	Can not hold attributes
Easy updation, more analytical themes	Needs conversion to vector
More analytical themes	

CHARACTERISTICS OF REMOTE SENSING SYSTEMS									
Name / characteristic	**Altitude in km**	**Orbital Period in min**	**Temporal resolution (days)**	**Sensor**	**No. Of bands and region**	**Spatial resolution in mt**	**Quantiz ation (bits)**	**Swath in km**	**Off-nadir Viewing**
IRS 1A/1B, (1988/1991)	904	103.2	22	LISS I lISS II	4; Visible, NIR 4; Visible, NIR	72.5 36.25	8 8	148 75	No No
IRS 1C/1D (1994/1997)	817	101.35	24	PAN lISS III WiFS	1; Visible 4; Visible, NIR, SWIR 2; Visible, NIR	5.8 23.5,B2:4 & 70.5, B5 188.3	6 7 7	70 & 90 141,B2:4 & 148,B5 810	Yes No No
Landsat 4&5 (1982/1984)	705	103	16	MSS TM	4,Visible, NIR 7,Visible,NIR,SWIR, TIR	82 30 for B1-5&7 120 for TIR	6 8	185 185	No Yes
Landsat 7 (Proposed)	705	103	16	ETM HRMSI	6, Visible,NIR,MIR, 1TIR, 1 PAN 1 PAN, 4Visible,NIR	30,60,15 5 10	8 6 8	185 185	No Yes No
SPOT 1,2,3 (1986,90,93)	832	101	26/5 26/5	PLA MLA	1,PAN 3,Visible,NIR	10 20	6 8	60 117	Yes Yes
SPOT 4&5 (Proposed)	832	101	26/5 26/5 26/1	PLA MLA VMI	1,PAN 4,Visible,NIR,MIR 5,Visible,NIR,MIR	10 20 1000	6 8 8	60 117 2000	Yes Yes
NOAA 6:12	833	102	1/2	AVHRR	5,Visible,NIR, MIR,TIR	1100,nadir 2400& 6900	10	2400	Yes

Image Processing

Inherently the data received from satellite, which is called raw data, consists of many errors. Removing the errors and preparing the data for use in applications is called image processing.

4.1 Image Pre - Processing / Restoration

Images rectification and image restoration techniques are used to correct image data for distortions, noise reduction, or data reconstruction. Data reconstruction is necessitated by the design of the sensor system, by the limitations of one or more of its components, or by the malfunction of components. Because rectification and restoration techniques are often followed by other image processing techniques, they are commonly referred to as *preprocessing* techniques.

It involves those operations that are normally required prior to the main data analysis and extraction of information. Generally grouped as **radiometric** or **geometric corrections**

4.2 Sources of Errors - Internal & External

- Internal - Due to Sensor effects and determined from Pre-launch measurements - Predictable & Unpredictable
- External - Due to Platform Perturbations, Atmosphere; variable in nature and determined from GCPs and Tracking data

4.3 Errors in imageries: Primarily the errors are of two types:

4.3.1 Radiometric errors: The scanners on satellite platform will have areas of CCDs. Each CCD is responsible for recording the reflections of a particular area on earth's surface, which is also called as instantaneous field of view (IFOV). The width of the IFOV is termed as its spatial resolution. The reflections will be recorded as a digital number depending upon its (CCDs) radiometric resolution. As per example IRC IC camera is of 7-bit type i.e. it can differentiate the spectral reflection in 128 levels where 0 represents absolute black (total absorption) 127 represents total reflection i.e. pure white. Errors in this phenomenon are again of 3 types.

1) ***Calibration errors: -*** *Recording* the reflection in improper DN values instead of its assigned range will cause the data un-usable. However every camera will have Calibration correction system, which will be programmed in such a way that periodical refinement is carried. In NRSA the 7 bit (128 levels) data of IRS IC, ID is being converted to 8 bit (256 levels) data as standard format of popular image processing software.

2) ***Pixel dropouts: -*** *The* CCD array is a line of CCDs that are equal to the swath width of the camera divided by its spatial resolutions. For example IRS IC PAN will have 71000mts / 5.8mts = 12241 nos. Sometimes during scanning process, one or few CCDs may not function properly for an instant or for sometime, which may result in empty DN value for that pixel. These spots are called pixel dropouts.

3) ***Bad Lines: -*** *When* the CCD array totally fails to record for an instance or a single CCD fails to record continuously lines of missing data appears in imagery.

Most of the calibration errors will be rectified by the NRSA during generation of data, for all standard products. In precision product even the pixel dropouts, Bad lines will also be removed for extra price.

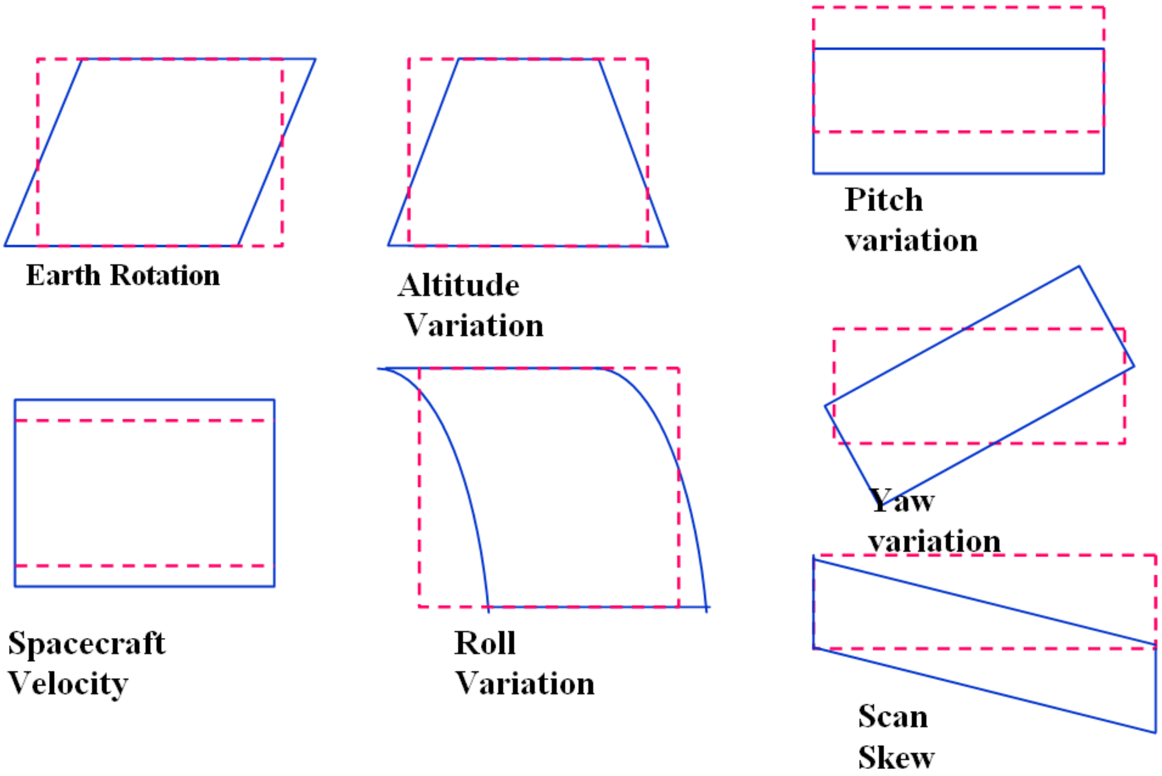
4.3.2 Geometric Errors: Errors relating to geometry of the features in image due to various factors are called geometrical errors. Sources of these errors are as follows:

a) ***Earth's Curvature: -*** Surface of earth is curvaceous, so the features in the center will be scanned true to scale, where as the borders will be reduced to smaller scale progressively from center to periphery.

b) ***Undulations an earth's surface:*** **-** Though the elevation differences of earth surface are negligible, when scanning from long distance they induce errors to some extent.

c) ***Central Perspective Projection:*** **-** As the scanners are designed on camera principles, errors of central perspective projection i.e. increase of distortion towards edges are induced in imagery.

d) ***Satellite positional errors: -*** As a moving object satellite is subjected to have positional errors like Pitch, Roll & Yaw, which results in tilting of camera angle, thus causes greater distortion in image.



No corrections will be made by NRSA in standard products; geometric corrections will be carried in geo-coded products. All corrections will be made in standard products. The cost of the product will increase from standard to geo-coded to precision product. It is always economical to go for standard products, as they are very cheap compared to other products.

4.4 Corrections of Errors:

4.4.1 Need for Image Correction

To Compensate for Sensor errors and to achieve proper conditions to support image-data analysis and interpretation

Ensuring High Geometric accuracy / Fidelity for Cartographic applications

Registering multiple Images of like geometry and same geographic area coincident with respect to another

For Mosaicking multiple scenes covering adjacent and overlapping spatial regions

For removing the errors caused by Sensor defects and Improper Calibration data

For determining Calibration parameters to establish relation between Detector output and Scene Radiance

1) Radiometric errors are corrected through re-sampling. DN values for the missing pixels will be calculated by averaging the DN values of surrounding pixels, with the logical assumption, that a pixel will not have strange DN value than that of its surrounding pixels.

2) Geometrical errors will be removed by rectifying (warping) with the help of good ground control points (GCP). G.C.P. is the feature identified both on image and map. The rectification software will take the relational distances between GCPs from Map and rubber sheet the imagery. Quality of rectification depends upon the quality of GCPs like permanent features, no. of GCPs and their distribution. The map used for this purpose should be of good quality and fresh. In India Survey of India toposheets are best used for this purpose. Accuracy of the rectified image is proportional to the scale of the map. Large-scale maps will give more accuracy.

4.5 Image Rectification

Raw data from Data production centre is supplied as scenes with reference to path and raw. There is no correlation between S.O.I grid and Path & Row. For a particular area of interest, we may have to join more scenes and at the portion we need. Secondly the feature on the image doesn't have any reference to real world co-ordinates. We have to correlate the image to user specified referencing system with projection. These processes are detailed below:

Geo-referencing: Correlating the image to the real world co-ordinates with a specific projection and specified units is called geo-referencing. Unless until images are geo-referenced, they cannot be arranged sequentially or overlaid one upon another for any further analysis. Rough geo-referencing can be done with the help of addresses (Lat, Long) given in the accompanied data of image for 4 corner pixels and 1 central pixel. For refined geo-referencing, a projected map can be used while rectification (warping) of image and can be transformed specific projection of that map with specific datum and units.

Image rectification techniques are very similar to or identical to the techniques that are used to register vector or raster data layers to real world coordinate systems by converting existing coordinates to coordinates that are tied to a mapping coordinate system. Therefore, they are also referred to as *geometric transformation techniques*.

Image - to - Map Rectification

It is the process by which image is made planimetric, required when accurate area, direction and distance measurements are made - For thematic overlay

Image - to - Image Registration

Positions two images of like geometry and same geographic area coincident with respect to one another - For Change detection

4.7 Contrast Enhancement techniques:

Before using the images for a particular analysis the information in the images can be improved by further processing.

Causes for low Contrast in Images

Low Contrast ratio in the Scene itself

Atmospheric Scattering

Poor Sensitivity of the Detector to detect and record the contrast

Need for Contrast Enhancement

- To improve the quality of the image
- To enable to discriminate different objects
- To Emphasize areas of interest
- To utilize the entire brightness range of the display

Histogram equalization: *The* process of redistributing pixel values in proportion to their frequency so that there are approximately the same no. of pixels with each value with in a range. This result is a nearly flat histogram.

Contrast Stretch: *Transformation* of data file values into brightness values is called contrast stretch. A contrast stretch is a simple way to improve the visible contrast of an image. It is often necessary to contrast stretch raw image data, so that they can be seen on the display. Mostly raw data, the data file values fall with in a narrow range – Usually a range much narrower than the display device is capable of displaying. You can expand that range to utilize the total range of the display device.

Data scaling: Whenever an 8 bit data is opened, the variation of Image value in Histogram ranges from 0-255. In order to get a particular range of pixel values in image, then the data scaling can be done. It is useful for removing low frequency pixel values.

Spatial Filtering

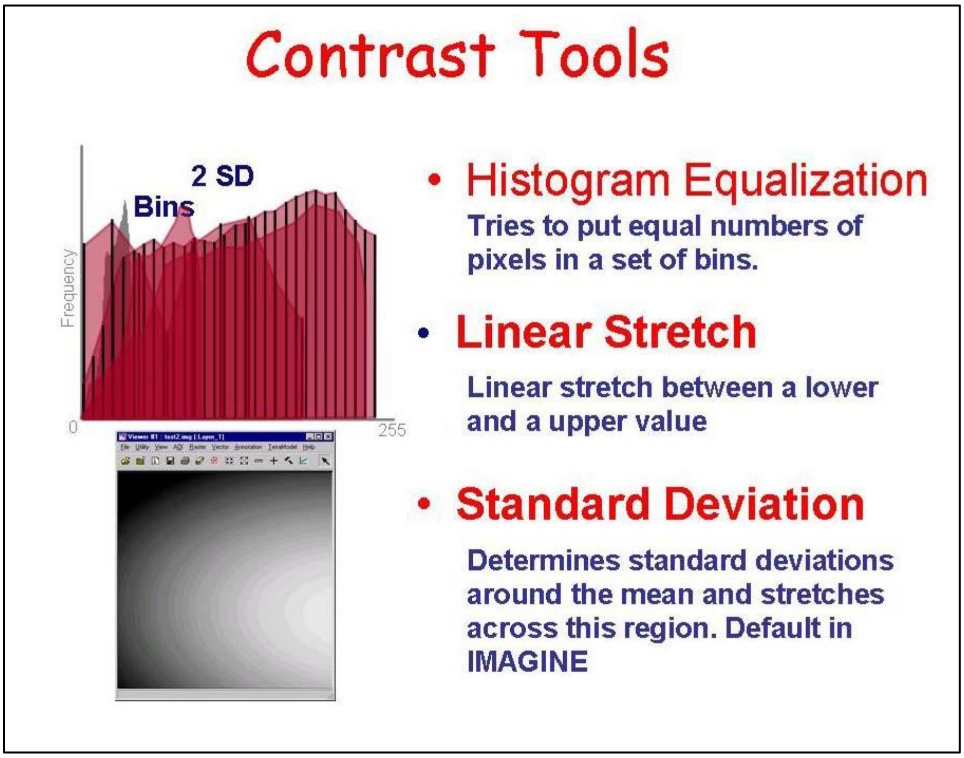
Frequency – the number of changes in the brightness values. If the there are few changes in brightness values in a particular area in the imagery then it is referred to as a low frequency area and vice versa. The spatial frequency may be enhanced using spatial convolution filtering or subdued using special transformations

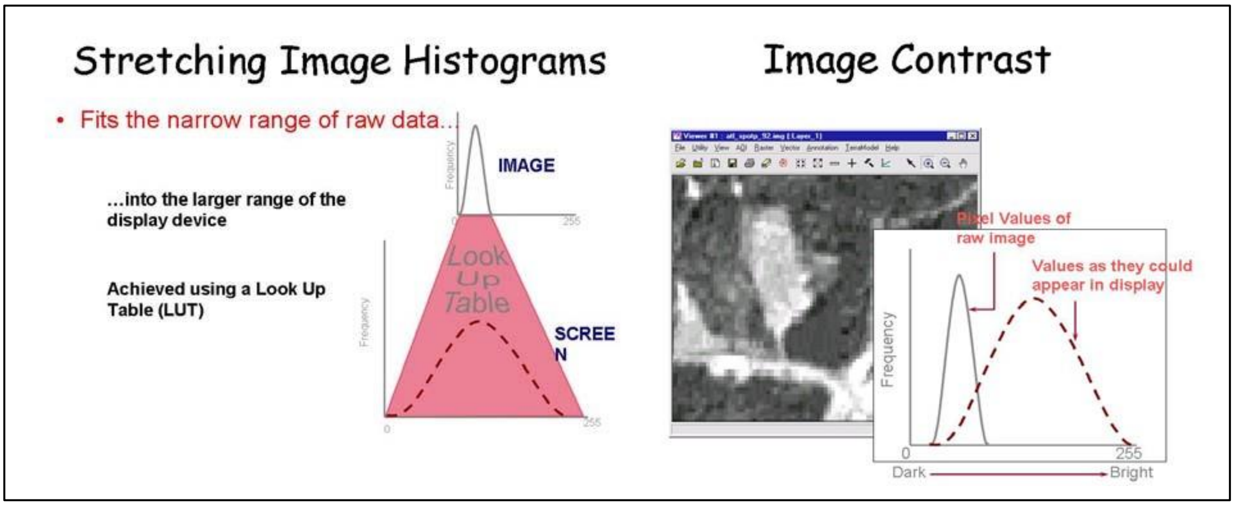
1. Low Pass Filtering: Low Pass filter decreases spatial frequency. The resulting image looks smoother or more blurred which can be eliminated by giving unequal weightages. It is being used for removal of noise. Examples are Mean, Median, Mode, Min / Max, Olympic etc but it blurs the imagery at edges

2. High Pass Filtering: It has the effect of increasing spatial frequency i.e., the difference between the highest and lowest values of a continuous set of pixels. High pass filter serve as edge enhancer / edge detector.

3. Edge Enhancement: *A* high frequency convolution kernel that brings out the edges between the homogeneous groups of pixels. This process highlights edges. It doesn’t suppress other features.

E.g.: It is used for delineating linear features like roads, faults etc.





4.8 Utility process:

1. ***Mosaicking:*** If the area of interest exists in more than one image, we have to join the images after geo-referencing them. Rectification can be done to original images either before mosaicking or to the mosaicked image afterwards. Whatever the case may be one should be continuous in edge matching particularly in mosaicking side scenes, as they come from different paths and time.
2. ***Subsetting:*** Depending upon the camera and satellite, the area, width of the scene (swath) will change. Accordingly NRSA data center produces the square of swath as full scene. i.e. 70 km^2 for PAN, 140 km^2 for LISS-III. A full scene is divided into 9 sub scenes. Cutting of image from a scene is called subsetting.
3. ***Data Merging:*** Panchromatic data of IRS IC has 5.8mts. Spatial resolution with which we can see the information clearly up to 1:10000 scale. As the information in this data is from wide band of visible region, it cannot be used individually for any analysis. Like wise LISS III multi-spectral data has 4 bands, but with poor spatial

resolution i.e. 23.5mts. Upon data merge we can obtain an image of 4 bands with the spatial resolution of PAN 5.8mts. Different software use different algorithms for this purpose.

4. ***Analytical Process:*** The object of Remote Sensing is to gather information about earth for resource management. Unless until the images of Remote Sensing are analyzed, the purpose of Remote Sensing cannot be achieved. Depending upon the requirements of specific users the analytical process differs. As an example, a forester is interested in analysis of vegetation for different cover types, vegetation types, bio-mass calculations etc., where as a geo-morphologist is interested in identifying faults, dykes, drainage pattern etc. A watershed manager looks for land use land classes' information, where as an agro-economist looks for crop patterns and crop estimates. Depending upon the need, the images are subjected to different analytical processes. Few of the processes are discussed below:

4.9 Band Rationing: IRS IC LISS-III image consists of 4 bands, out of which 3 bands i.e. green, red, near infrared are important for any analysis. Vegetation is more pronounced in NIR and Red. If rationing is done among these bands most of the information can be brought out as a single bond, which is termed as vegetation index.

a) *R.V.I. (Ratio Vegetation Index):* Deduction of Red band from Infra red band is called R.V.I. R.V.I. = (IR-R).

b) *VI Vegetation index = IR/R*

c) N.D.V.I (Normalized Difference Vegetation Index): Fractionalization of RVI with (IR+R) to get a decimal number for better delineation of index, NDVI formula is used.

$$NDVI = \frac{IR-R}{IR+R}$$

4.10 Principal Component Analysis: Principal Component analysis (or PCA) is often used as a method of data compression, it allows redundant data to be compacted into fewer bands – that is, the dimensionality of the data is reduced. The bands of PCA data are non-correlated and independent, and are often more interpretable, than the source data.

4.11 Classification: Segregating the information in an image basing on its color, tone, texture, shape, DN values and with the help of ground truthing is called classification. Classified images will give clear- cut information of resources (Thematic maps), which can be quantified.

4.12 AP Forest Department: APFD has procured multi-spectral data for entire state of Andhra Pradesh for the years 1988 (LISS-II – 36.0mts resolution), 1996 (PAN – 5.8mts) & 1996 (LISS-III – 23.5mts) 1998 (LISS-III), 1999 (LISS-III), 2000(LISS III), 2001(LISS III), 2002 (LISS III)&(PAN), 2003 (AWiFS), 2004 (LISS III), 2005 (LISS III), 2006 (LISS III), 2007 (LISS III), 2008 (LISS III), and Cartosat Stereopair 2005-2009

Object of the data procurement is to create 1:50000/1:10000 databases for vegetation cover and types to use them in planning process; detecting the change in vegetation from 1988 to 1996 and subsequently every year.

Image Classification

Classification is the process of categorizing (information in an image into land cover classes or themes) the remotely sensed data into land cover classes or information.

5.1 What Is Image?

Image is the copy of object or landscape captured by scanner or photographic materials using the Electro Magnetic Spectrum (energy) reflections from the object. It may be in analogue form like photograph or digital form as in the case of remote sensing imageries. **There are two types**.

Hard Copies: Which are produced generally in photography through chemical process ex: Arial photography. The digital data also can be converted into analog form to produce hard copies. Advantages of hard copies are, they can be usually interpreted without the need of computers for small jobs ex: Satellite imageries – FCC's.

Soft Copies: These are the digital form of imagery. The information is stored in pixels (picture element) arranged in rows and columns. Each pixel will have a value assigned to it, which can be displayed on computer with a color or grey scale. The scalar differentiation will give an impression to the viewer. The advantage of digital image over analogue image is that the DN (Digital Number) values can be modified as per user's interest for evolving more information. Another advantage of soft copy is, we can combine more images, captured from different cameras having difference bands, so that more understandable image can be displayed which will be useful for digital analysis for different classification which is also called as digital interpretation.

5.1 Necessity of classification:

Quantification of features is another important aspect of classification. Ex: Area of vegetation water, wastelands etc.

It is also useful in finding out new feature classes, which are unheard of in particular locations with the help of ground truthing. Ex: Insect attacks, fire, etc.

Change detection of a particular area over a period of time. Requires classification of Images of different people.

Classification is necessary for understanding different features, more than what human eye can perceive.

In general human eye can at the best distinguish very few colors/tones from an image, through the interpretation keys like shape, size tone, texture, association, colors pattern help in distinguish different features, they are not sufficient to exactly delineate different types of features, as the modern R.S. cameras are using 8 bit cameras (256 tones in each color)

5.3 Image interpretation Strategies:

a) **Field Observation:** Field observations, as an approach to image interpretation, are required when the image and its relationship to ground conditions are so imperfectly understood that the interpreter is forced to go to the field to make an identification.

b) **Direct Recognition:** Direct recognition is the application of an interpreter's experience, skill, and judgment to associate the image patterns with informational classes. The process is essentially a qualitative, subjective analysis of the image using the elements of image interpretation as visual and logical clues.

c) **Interpretation by Inference:** Interpretation by inference is the use of a visual distribution to map one that is not itself visible on the image. The visible distribution acts as a surrogate, or proxy (i.e., substitute) for the mapped distribution.

d) Deterministic Interpretation: Deterministic interpretations are based on quantitatively expressed relationships that tie image characteristics to ground conditions. In contrast with the other methods, most information is derived from the image itself. Photogrammetric analysis of stereo pairs for terrain information is a good example.

e) **Collateral Information:** Collateral, or ancillary, information refers to non-image information used to assist in the interpretation in the form of everyday experience and also formal training. In its narrower meaning, it refers instead to the explicit, conscious effort to employ maps, statistics, and similar material to aid in analysis of an image. In the context of image interpretation, use of collateral information is permissible, and certainly desirable, provided two conditions are satisfied.

f) **Interpretive Overlays:** Often in resource-oriented interpretations it is necessary to search for complex associations of several related factors that together define the distribution or pattern of interest. For example, soil patterns may often be revealed by distinctive relationships between separate patterns of vegetation, slope, and drainage. The interpretive overlay approach to image interpretation is a way of deriving information from complex interrelationships between separate distributions recorded on remotely sensed images. From the information presented by several patterns, the interpreter can resolve information not conveyed by any single pattern.

g) **Photomorphic Regions:** In the first step the interpreter delineates regions of uniform image appearance, using tone, texture, shadow, and the other elements of image interpretation as a means of separating regions. In the second step the interpreter must be able to match photomorphic regions to useful classes of interest to the interpreter. Delineation of photomorphic regions do not always correspond neatly to the categories of interest to the interpreter. The appearance of one region may be dominated by factors related to geology and topography, whereas that of another region on the same image may be controlled by the vegetation pattern. And the image appearance of a third region may be the result of the interaction of several other factors.

5.3 Types of Classification:

1. Visual Interpretation
2. Digital Interpretation

5.6.1 Visual Interpretation:

It is generally done for small areas where time and money is the constraint. It has to be done only on hard copies. Interpretation skill is absolute necessary for this work.

Image Interpretation Technique:

Image interpretation is defined as the act of examining images for identifying objects and judging their significance. Interpreters study remotely sensed data and attempt through logical processes in detecting, identifying, classifying, measuring and evaluating the significances of physical and cultural objects, their patterns and special relationship. Image interpretation is a complex process of physical and psychological activities occurring in a sequence of time. The sequence begins with the detection and identification of images and later by their measurements. The various aspects of image interpretation are listed below.

a) **Detection:** It is a process of “picking out” an object or element from photo or through interpretation techniques. It may be detection of point or line locations e.g. agricultural field or small settlement.

b) **Recognition and Identification**: It is a process of classification or trying to distinguish an object by its characteristics or patterns which are familiar on the image. Sometimes it is also termed as photo reading e.g. water features, streams, tanks, sands, etc.

c) **Analysis:** It is a process of resolving or separating a set of objects or features having similar set of objects and the degree of reliability of these lines can also be indicated, e.g. sands as that of rivers.

d) **Classification**: It is a process of identification and grouping of objects or features resolved by analysis.

e) **Deduction**: It is a process where references are drawn about the objects based on direct or indirect evidence of the information or phenomena under study. Deductions may be firmly confirmed by ground checks to avoid misclassification.

f) **Idealization**: It is a process of drawing ideal or standard representation from what is actually identified and interpreted from the image or map e.g. set of symbols or colors to be adopted in wasteland maps etc.

Elements of Image Interpretation:

a) **Color:** Color is an important factor in classification of broads themes ex: blue-water, Red- vegetation, grey-habitations, white-Barren lands, exposed clouds, sand, and Black-deep water/wet soils.

b) Tone: Tone within a color will give further differentiation among features ex: Deep red thick vegetation, bright red – agriculture, Deep blue deep water, light blue – shallow water etc.

c) **Texture**: Different textures will give finer classes like smooth light red – Agriculture, coarse red – Scrub forest; smooth white – clouds, course white – exposed sand etc.

d) **Shape**: With shape, one can differentiate man made tanks with natural tanks Agricultural lands with scrub forest, Parks and Grounds with wastelands, Roads with Rivers.

e) **Size:** Size will also delineate specific features like encroachments, habitations, and tanks with reservoirs.

f) **Pattern**: Pattern will give information about features as in the case of clouds, waves in sea etc.

g) **Association**: Shades of clouds can be distinguished from dark tones with the help of its association with clouds, like wise streams can be identified with its association of valleys and tanks etc.

h) **Shadow:** They are cast due to Sun’s illumination angle, size and shape of the object or sensor- viewing angle. The shape and profile of shadows help in identifying different surface objects e.g. clouds, nature or hill slopes aspect etc. They also help in arriving at tree heights or building heights on aerial photos.

i) **Location:** The geographical site and location of the object often provide clue for identifying objects and understanding their genesis e.g. salt affected land-inland river/desert plains etc.

Advantage of Visual Interpretations:

i. It is very useful for smaller jobs as there is no need of other peripherals

ii. As it is done with human knowledge, differentiation of physical themes like roads, rivers, tones, clouds, and shades is better delineated.

iii. Generalization is possible for quantification, which will give polygons of minimum mapping quality.

Disadvantages of Visual Interpretation:

i. This cannot be done for large areas, as the availability of skilled manpower is difficult to get.

ii. Due to limitations of human vision, finer classification is not possible.

iii. Quantification of interpretation needs conversion to vector format, for which again computers are necessary.

iv. Due to ever increasing spatial resolutions, generalization of features is becoming difficult.

v. Information available in different bands cannot be analyzed.

5.6.2 Digital Interpretation:

Image classification is the process of categorizing (all pixels in an image into land cover classes or themes) the remotely sensed data into land cover classes or information. Normally, multi-spectral data are used to perform the classification i.e., different feature types manifest different combinations of (DNs) digital numbers based on their inherent spectral reflectance and emittance properties. Spectral pattern recognition refers to the family of classification procedures those utilizes this pixel-by-pixel spectral information as the basis for automated land over classification.

Supervised Classification:

In this classification the image analyst “supervises” the pixel categorization process by specifying, to the computer algorithm, representative sample sites of known cover type, called training areas, as used to compile a numerical “interpretation key” that describes the spectral attributes for each feature type of interest. Each pixel in the data set is then compared numerically to each category in the interpretation key and labeled with the name of the category it “looks most like”.

For example we are dealing with analysis of four channel (LISS III) data. For each of the pixels shown along this line, the LISS III has measured scene radiance in terms of DNs recorded in each of five spectral bands of sensing; Green, Red, Near-infrared, shortwave infrared. Below the scan line, typical DNs measured over six differently land over types are shown. The vertical bars indicate the relative gray values in each spectral band. These five outputs represent a coarse description of spectral response patterns of various terrain features along the scan line. If these are distinct for each feature type, they may form the basis for image classification.

Basic steps involved in supervised classification.

The analyst identifies representative training areas and develops a numerical description of the spectral attributes of each land cover type of interest in the stage.

Each pixel in the image data set is categorized into the land cover class, it most closely resembles. If the pixel is insufficiently similar to any training data set it is usually labeled
'unknown'.

Being digital in character, the results may be used in a number of different ways. Out products are thematic maps; tables of full scenes or sub scene are a statistics for the various land cover classes, and digital data files amenable to inclusion in a GIS. In the latter case the classification "output" becomes a GIS input.

The training stage: The training effort required in supervised classification is both an art and science. It requires close interaction between the image analyst and the image data. It also required substantial reference data and a thorough knowledge of the geographic area to which the data apply. Most importantly the quality of the training process determines the success of the classification stage and therefore the value of information generated from the entire classification effort.

The over all objective of the training process is to assemble a set of statistics that describe the spectral response pattern for each land over type to be classified in an image.

Unsupervised Classification:

The fundamental difference between these techniques is that supervised classification involves a training step followed by a classification involves a training step followed by a classification step. In the unsupervised approach the image data are first classified by aggregating them into the natural spectral groupings or clusters present in the scene. Then, the image analyst determines the land cover identity of these spectral groups by comparing the classified image data to ground reference data.

Unsupervised classifiers do not utilizes training data as the basis for classification. Thus family of classifiers involves algorithms that examine the unknown pixels in an image and aggregate them into a number of classes based on the natural groupings or clusters present in the image values. The basic premises is that values within a given cover type should be close together in the measurement space, whereas data in different classes should be comparatively well separated.

The result from unsupervised classification is spectral classes. Because them are based solely on the natural groupings in the image values, the identity of the spectral classes will not be initially known. The analyst must compare the classified data with some form of reference data (such as larger scale imagery or maps) to determine the identity and informational value of the spectral classes. Thus, in the supervised approach we define useful information categories and then examine their spectral seperability; in the unsupervised approach we determine spectrally separable classes and then define their informational utility.

Basic Steps

- Specify the no. of classes
- Specify the convergence threshold
- Specify the accuracy level
- Specify the algorithm
- Specify the no. of iterations
- Regroup the nearly similar classes
- Assign colors
- Ground Truthing
- Refinement
- Ground Checking & Accuracy assessment
- Generation of Statistics, Maps & Reports

Advantages of Digital Classification:

i. Each and every pixel in the image can be classified basing on its DN values.

ii. Any number of Band combinations can be used for delineating required features using complex algorithms.

iii. Work can be done faster.

iv. Classification can be done number of times using different combination of algorithm. v. Computation of results is easy.

vi. Conversion of Data into vector form after generalization is easy.

Disadvantages of Digital Classification:

i. As the human involvement is reduced in delineation of features, unusual results may results. ii. Needs good image processing software with skilled personnel.

iii. Needs generalization before conversion to vector, which may result in increase of error.

5.4 Ground Truthing / Ground Checking

Process of establishing correlation between spectral signatures and ground information. Ground truthing in remote sensing is the ground investigation that is carried out to give the sensing investigator or operational user a realistic portrait of the target and also necessary in research and operational applications. The ground observations can be obtained from regularly collected or already available data sometimes, but often a ground investigation data collection program must be specifically designed for the RS mission. Because the ground investigations are very costly, it is essential to determine which info is required to meet the needs of a particular activity. After the RS mission or operational period, the utility of the ground investigation data should be carefully examined, to determine whether the results of the ground investigation were compromised because of inadequate data, or whether the same conclusions would have been reached with fewer ground investigation.

5.4.1 Uses of ground truth data: The main uses of ground truth data are

- calibrating the radiometers, Spectrometers etc.
- Interpretation of properties
- Training sets
- Verification

5.4.2 Test sites

Test sites are the small selected areas in which the necessary ancillary data will be collected to gain the knowledge of the area that can be used to aid the interpretation of the entire area under question. The physical and biological characteristics of these sites shall be extensively studied, and a variety of RS data shall be tested over them. It is always advisable to choose the site for which already extensive field data is available, and if new site is to be chosen it should be easily accessible.

Ground investigation involves two kinds of observations i.e., Visual and Spectral measurements depending upon the objective to be achieved. The visual ground truth involves observation such as color, shape, size, texture, temperature of the object of interest. The spectral observation involves measurement of spectral reflectance of a particular object, in-situ using specially designed equipment for this purpose.

5.4.3 Spectral signature

It can be defined as any remotely sensed parameter which directly or indirectly characterizes the nature and/or condition of the object under investigation. This can be defined as a unique pattern of wavelengths radiated by an object. These are

Spectral variation – Variation in reflectivity and emissivity as a function of wavelength.

Spatial variation – Variation in reflectivity and emissivity with spatial position (shape, size, texture of the object).

Temporal variation - of reflectivity and emissivity like that in diurnal and seasonal cycle.

Polarization variation – which are introduced by the material in the radiation reflected or emitted by it.

Each of these four features of EMR may be independent at different times or different spectral bands. A measure of these variations and correlating them with the known features of an object provides signature of the object concerned. The knowledge of the state of polarization of the reflected radiation in addition to the spectral signatures of various objects in RS adds another dimension in interpretation of RS data. The degree of polarization and Stoke’s parameter are extremely useful in providing valuable data in discriminating the objects.

Verification of accuracy of classification is called ground truthing. It has to be done in the following steps.

i. Identifying different classes
ii. Selection of points in different classes either systematically or randomly with ratio suitable to time, money and accuracy available.
iii. Collection of location of the selected points with references.
iv. Field work
v. Recording the findings in field
vi. Computerization & finding accuracy.

It can be done any number of times depending upon the accuracy needs. In APFD the ground truthing is done by the people acquainted with the area (usually Beat officers), which is being used by the project scientists as training sets. Further the classified outputs are being sent to field for accuracy assessment.

5.4.4 Accuracy Assessment:

Accuracy Assessment is the quantitative identification and measurement of map error. There is no simple, standardized, generally accepted methodology for determining classification accuracy. The two of the most commonly employed approaches an from a digital classification t the "known" identity of land cover in test areas derived from reference data. One or combinations of the following, typically represent the test areas.

1. Homogeneous test areas selected by the analyst.
2. Test pixels or areas selected randomly.

Test areas are areas of representative, uniform land cover that are different from, and considerable more extensive than, training areas. They are often located during the training, stage of supervised classification by intentionally designating more candidate training areas than are actually needed to develop the classification statistics. A subset of these may then be withheld for the post classification accuracy assessment, again using a contingency table to express the results (Table-I). The accuracies obtained in these areas represent at least a first approximation to classification performance throughout the scene. However, being homogeneous, test areas might not provide a valid indication of classification accuracy at the individual pixel level of land cover variability.

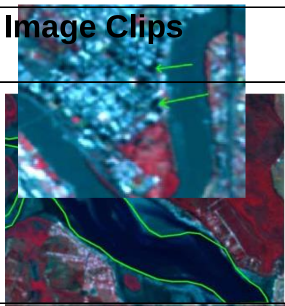
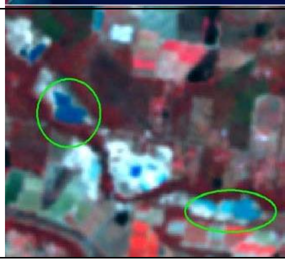
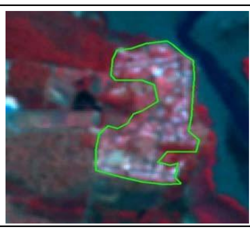
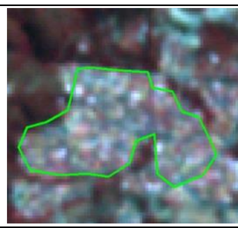
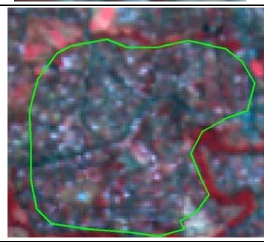
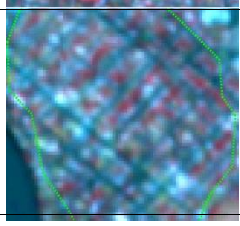
Table.1 Contingency Table Resulting from Classifying Test Area Pixels

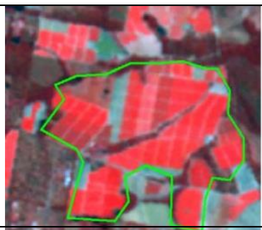
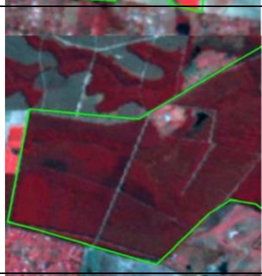
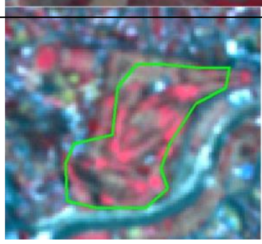
Known Category Type	**Number of Pixels**	**Percentage correct**	**Number of pixels classified into category**					
			1	**2**	**3**	**4**	**5**	**6**
1	5352	97	5165	0	42	44	53	21
2	328	66	0	216	0	108	4	0
3	4284	84	0	0	3599	16	482	187
4	945	42	12	92	228	397	132	84
5	2380	80	0	9	28	78	1904	361
6	3048	72	8	0	48	18	779	2195

Over all classification performance: 82.6% (total correct pixels/total pixels) Average performance by class: 73.5% (average of category accuracies).

1-Water, 2-Sand, 3-forest, 4-Urban, 5-Corm, 6-Hay

Interpretation Process:

Code	Class Name	Image Clips	Cod e	Class Name	Image Clips
1	River		5	Open	
2	Lakes		6	Quasi open(0pen with vegetation and small built up area)	
3	Sea		7	Forest Low Density	
4	Seasonal Water bodies		8	Forest High Density	
9	Village/Town		12	Suburban with few vegetation	
10	Low Intensity Residential		13	Suburban with dense vegetation	
11	High Intensity Residential		14	Commercial	 

Code	Class Name	Image Clips	Code	Class Name	Image Clips
15	Skyscrapers/ High Rise Buildings		19	Agriculture/ Cropland	
16	Industrial zone		20	Plantation	
17	Open in urban		21	Low tree Density	
18	Airport		22	Park/Recreational land	
23	Grasslands				
24	Paved/Major Roads				
25	Marsh				

Data Browsing

Data browsing is one of the important aspects in creation of data base as per the user specifications. Earlier the browsing was done at NRSA Data Center (NDC), NRSA, Blanagar, Hyderabad, now these browsing facility is also available through the Internet at **http://www.nrsa.gov.in**

The satellites revolve round the earth in predefined orbits and accordingly the Remote Sensing data will be collected and organized at NDC with separate indexing called Path and Rows. IRS 1A/1B is defined with same kind of Path and Rows as per the configuration of the satellites. Where as the indexing pattern of the satellites of IRS1C/1D is entirely different from the indexing of the satellite series 1A/1B.

The IRS 1C/1D is a three body stabilized satellites designed and launched in a polar sun synchronous orbit at an altitude about 800kms. Each path is repeated after a period of 24 days.

The referencing scheme of LISS III consists of 341 paths numbered from west to east. Each path consists of 141 rows. Each LISS III scene covers an area of 141X141kms. The referencing scheme of LISS III over an India is shown here.

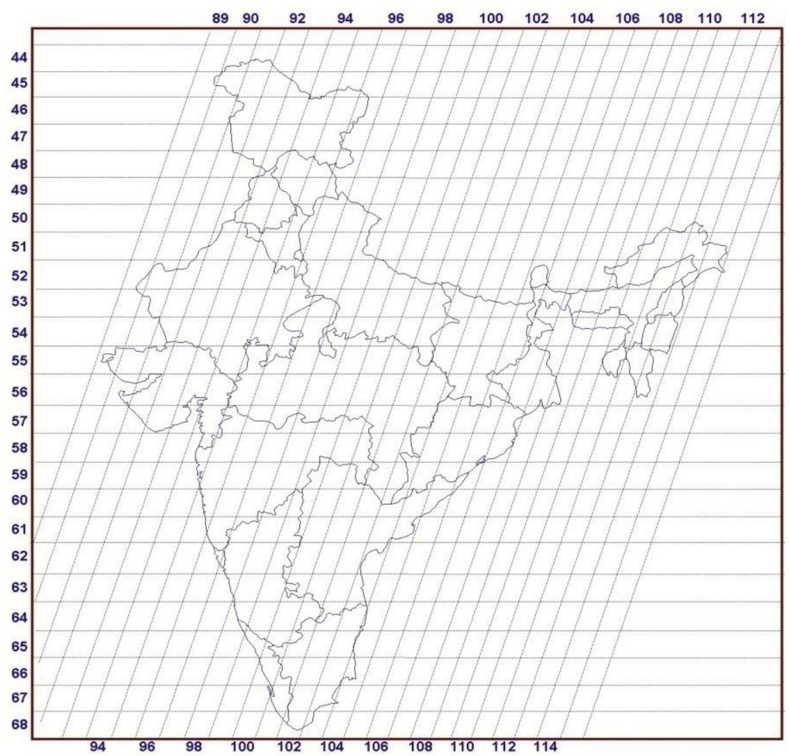


Fig: Path and Row scheme of IRS 1C/1D LISS III sensor over India

The referencing scheme of PAN has been evolved around the LISS III scene center. A PAN full scene is consist of 70X70kms and four PAN full scenes are fitted in a LISS III scene. A LISS III scene is divided into four parts which are designated as A, B, C and D and PAN scene will be referred to by the same path and row numbers as that of LISS III along with suffixes A, B, C and D.

The referencing scheme of LISS III and PAN sensors are shown here over Andhra Pradesh with index numbers.

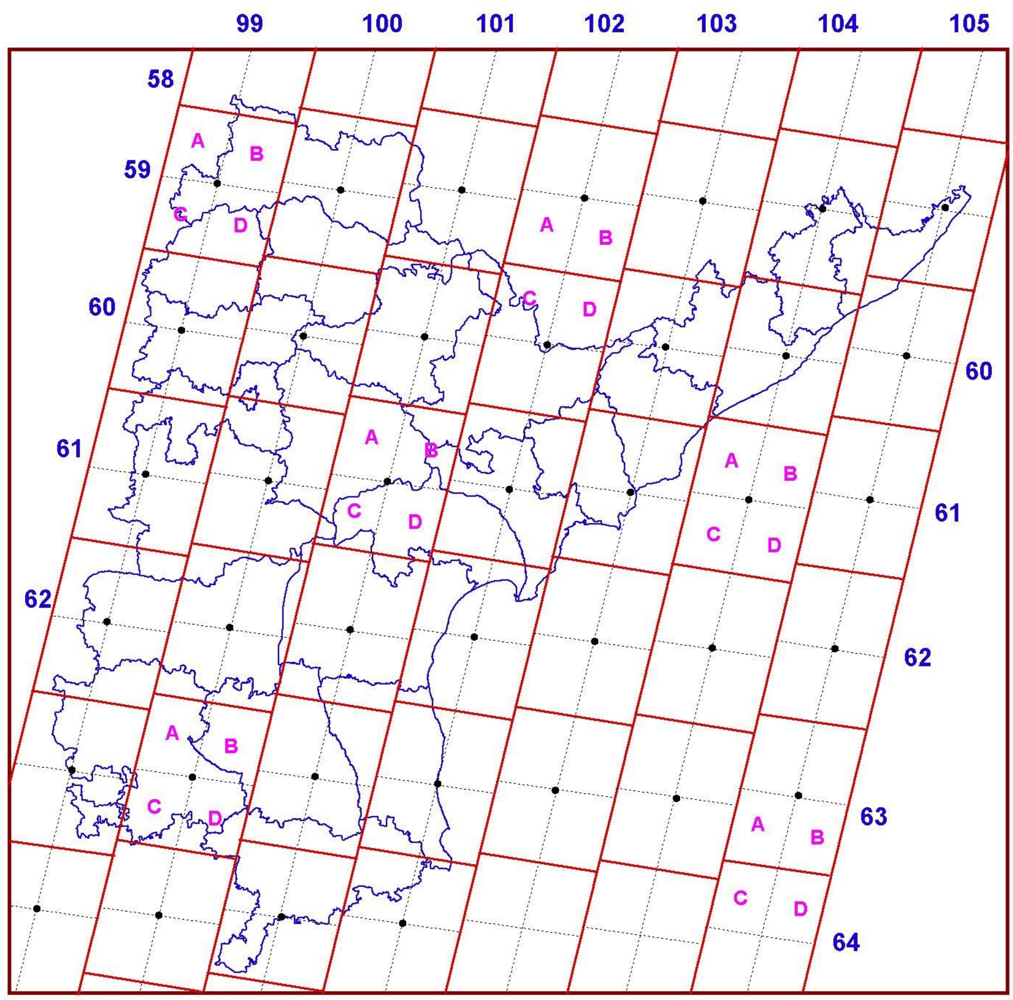
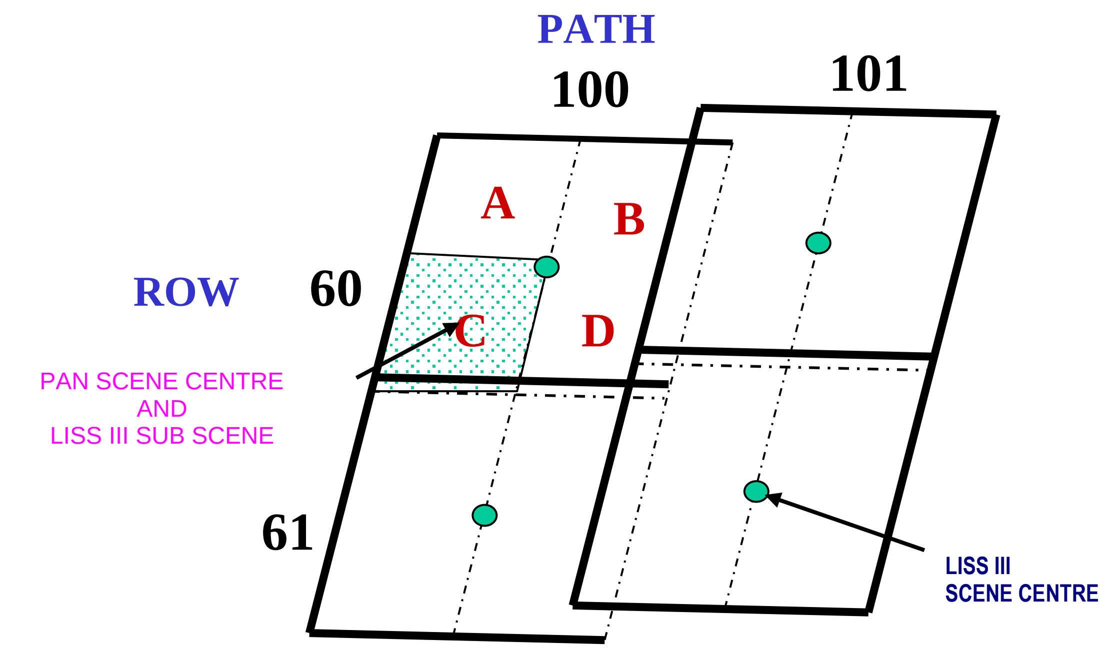
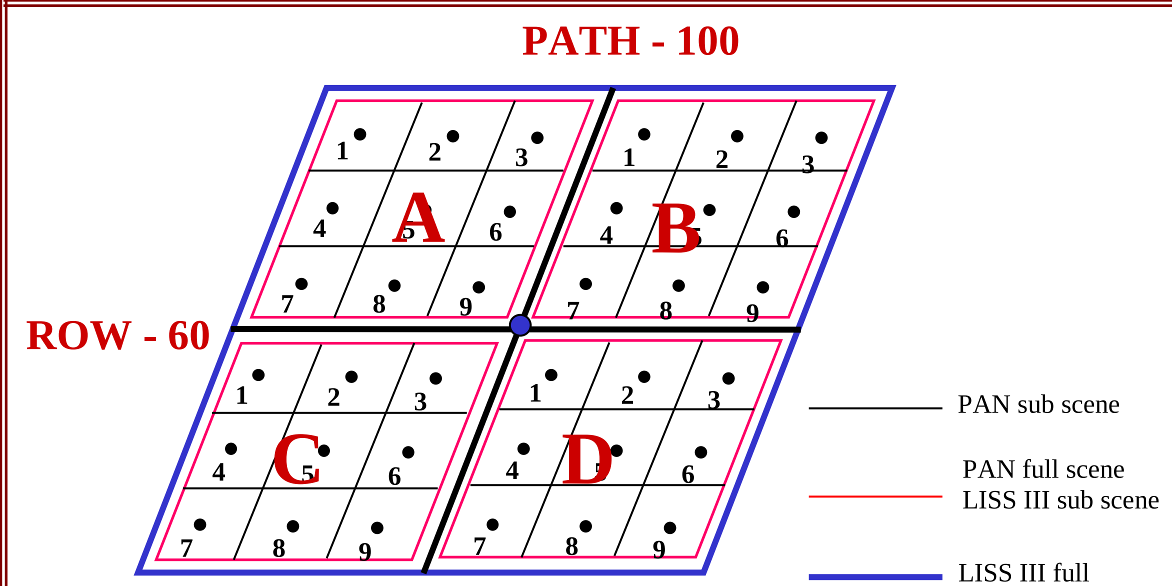


Fig: Path and row map of Andhra Pradesh for LISS III and PAN sensors

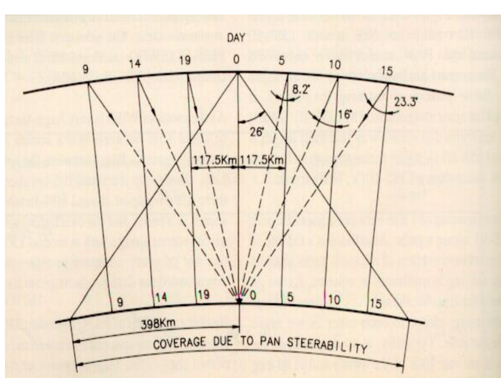
Andhra Pradesh state requires about 30 IRS 1C/1D LISS III scenes and 100 Pan Scenes to cover entire. Each path is revisited at an interval of 24 days. IRS 1C and 1D is designed with same configuration and scan the images with the same path and rows as a result the revisited period is reduced to 12 days. Hence the availability of scope of data is increased for the end users. Even after these circumstances it is very difficult to procure data for a small span of period over large areas.



LISS III and PAN full scenes index



LISS III and PAN sub scenes index



PAN Off-nadir Viewing

Plate - 4

6.1 PRODUCTS AVAILABLE AT NRSA

1. Hard copies
2. Soft copies

1. HARD COPIES:

a. Standard Products
b. Georeferenced Products (topo index based)

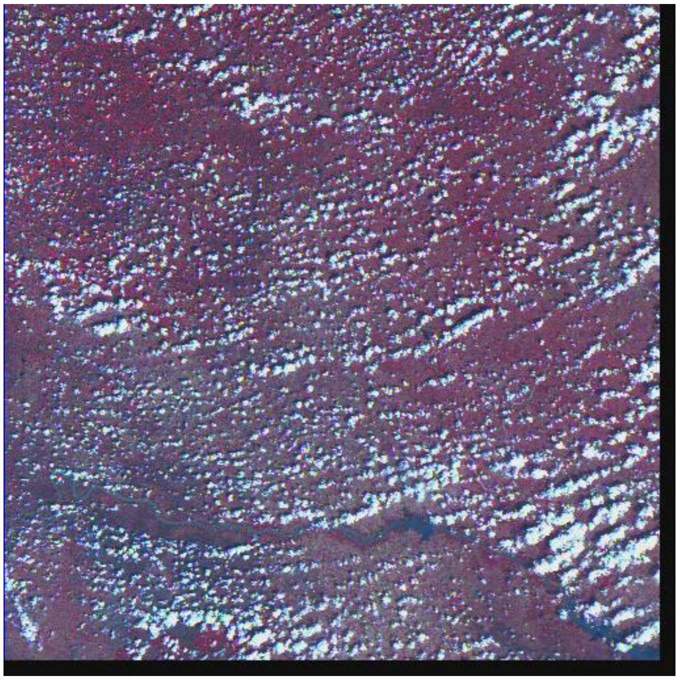
2. SOFT PRODUCTS:

a. Standard Products
b. Georeferenced Products (topo index based)

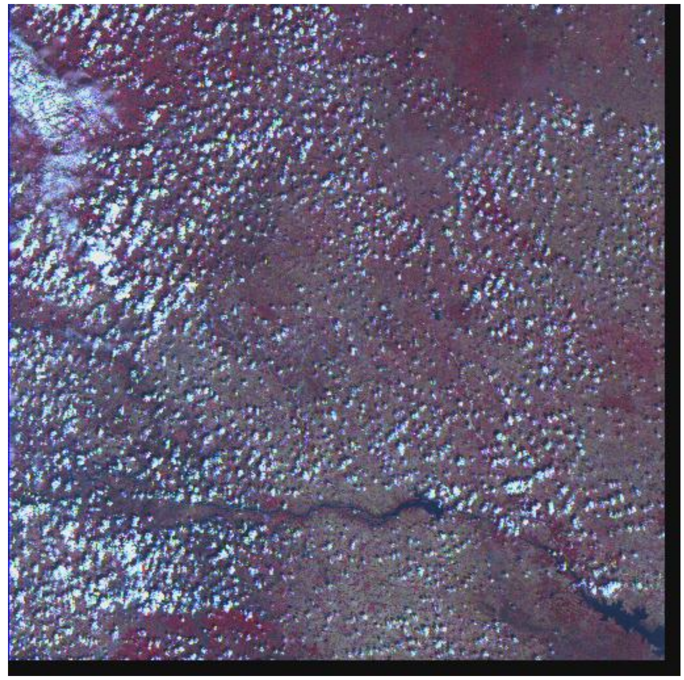
6.2 For IRS Series

Sensor	Product	Scene
Pan	Standard	• Full Scene • Quadrant • Sub scene
Pan	Geocoded	• 1:25,000 (14kmX14km) • 1:12,500 (9kmX9km)
LISS III	Standard	• Full Scene • Sub scene
LISS III	Geocoded	• 1:50,000 (28kmX28km) • District Geocoded

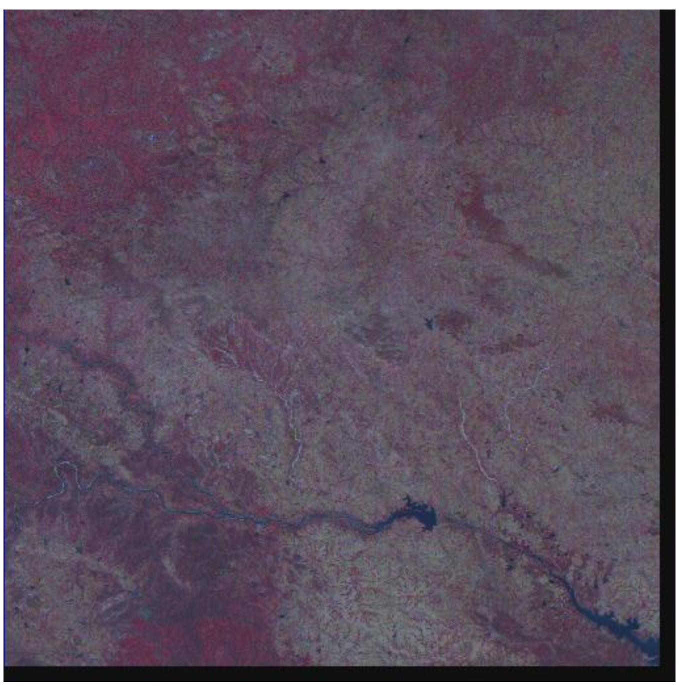
Only some of the products most demanded by users commonly are given. Numerous products from other Indian satellites are also available at NRSA. These all are some of the basic required data for most of the users. NRSA is also sponsoring the special products based on the requirement of the user. A special order has to be placed for procurement of specific data. Apart from the Indian satellites data NRSA is also supplying some other countries satellites of LANDSAT, SPOT, Radarsat etc data to the users as per the requirement. Browsing of data can be done at NDC directly as per the user specifications. Now this browsing facility is also available in the internet at the following site.



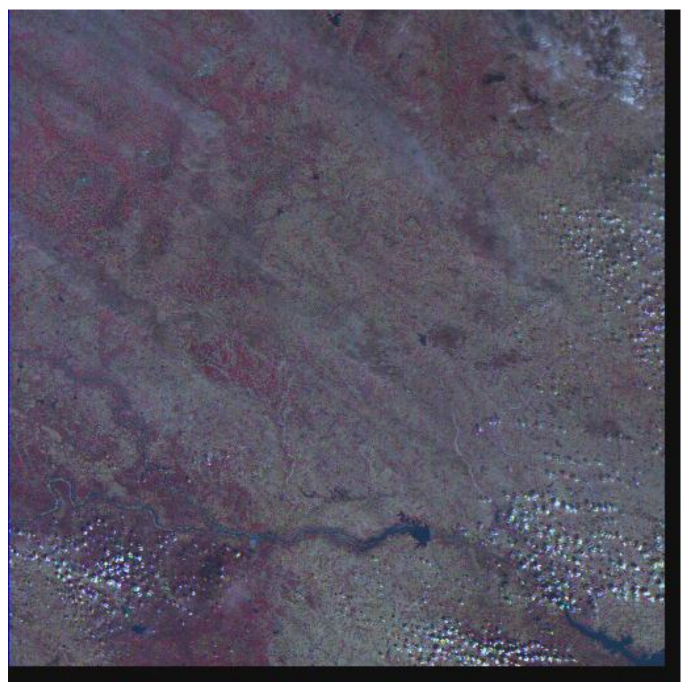
14th Oct 99



7th Nov 99



1st Dec 99



25th Dec 99

Plate - 5

The maps (See plate – 4) are some of the samples of data which are downloaded from Internet from the above mentioned website.

This is 99-61 path and row of IRS 1C scenes scanned at different dates (See Plate – 3)

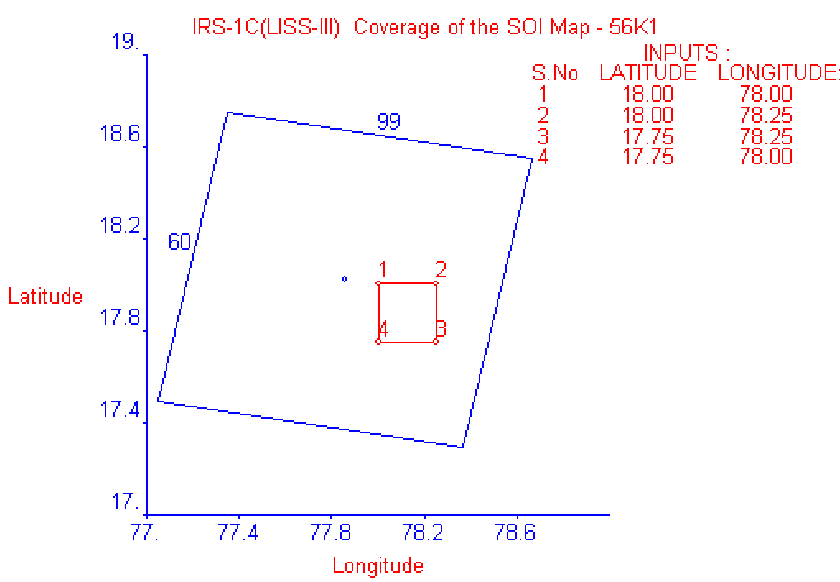
From the above given maps it is easy to decide that which scene is suitable for the data analysis as per the user requirement. Accordingly order can be placed at NRSA for the procurement of data.

Conversion of topo index into path and row reference scheme:

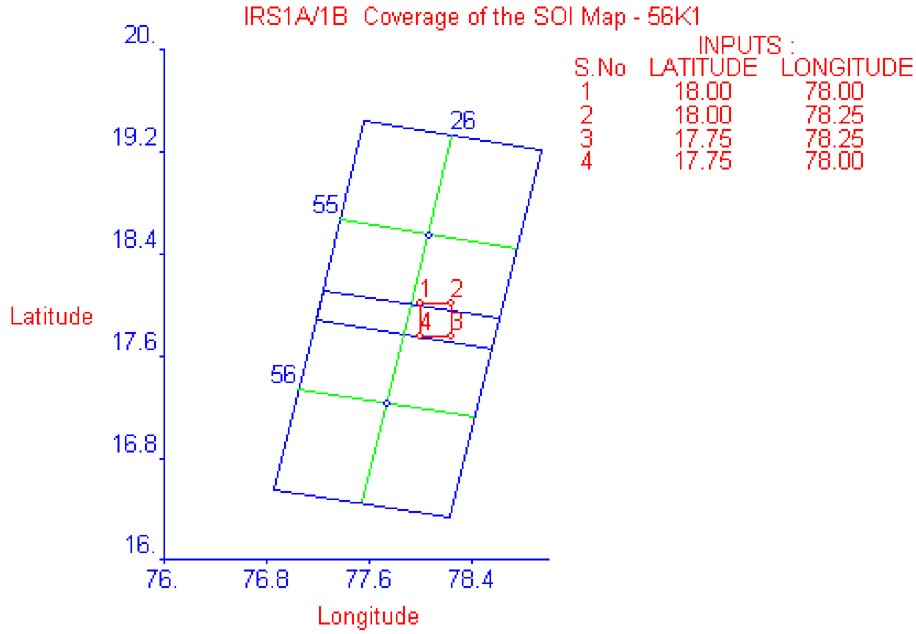
Most of the users are well aware of the Survey of India index pattern because all the Govt. and Private organizations are using Survey of India sheets for regular usage. Satellite index and Survey of India index are entirely different but users need to place the order as per the SOI index. To solve this problem NRSA is developed a small package called Integrated Digital Reference Scheme (IDRS). From this package it is very easy to know the path and row of any satellite data for a given topo index map. This package is freely available at NRSA for the users to facilitate to browse the data in a easy way. This is very small package and can be copied in a floppy.

We can identify the path and rows of any of the sensor by giving directly latitude and longitude co-ordinates of the project area in this software.

Following map is an example for identifying path and row of 56k/1 topo map.



As per above map it is very clear that the topo map area of 56k/1 is falling in 99 – 60 path and row of IRS 1C/1D of LISS III sensor.



From the above map it is showing the required path and rows of IRS1A/1B of LISS II sensor for 56k/1 topo index map.

6.3 Data availability:

Availability of cloud free data for a given period of time to cover entire Andhra Pradesh is difficult with the present available satellite technology, though temporal resolution for IRS1C/1D satellites is 24 days. In case of PAN data still it is very difficult to get total cloud free data for entire state even with in a span of 5months period. Because of these reasons some times it is becoming very difficult to analyze the data for various purposes over a given period of time.

To solve the cloud problem up to some extent some of the alternatives could be

If the cloud is out side the area of interest then remove the cloud part and analyze the rest of the area as per the specifications.

If the cloud is partly covered in one pass and other pass is free with cloud, where the other pass is covered with cloud and vise-versa. In this situation user can order both the passes of the same scene and with the help of these two passes can be generated total cloud free data.

To procure the data from NRSA user must open his account at NDC and after browsing data properly user can place order through a prescribed form supplied by NDC. Payment has to made advance before placing the order then only user order processed accordingly.

Chapter – V

Global Positioning System

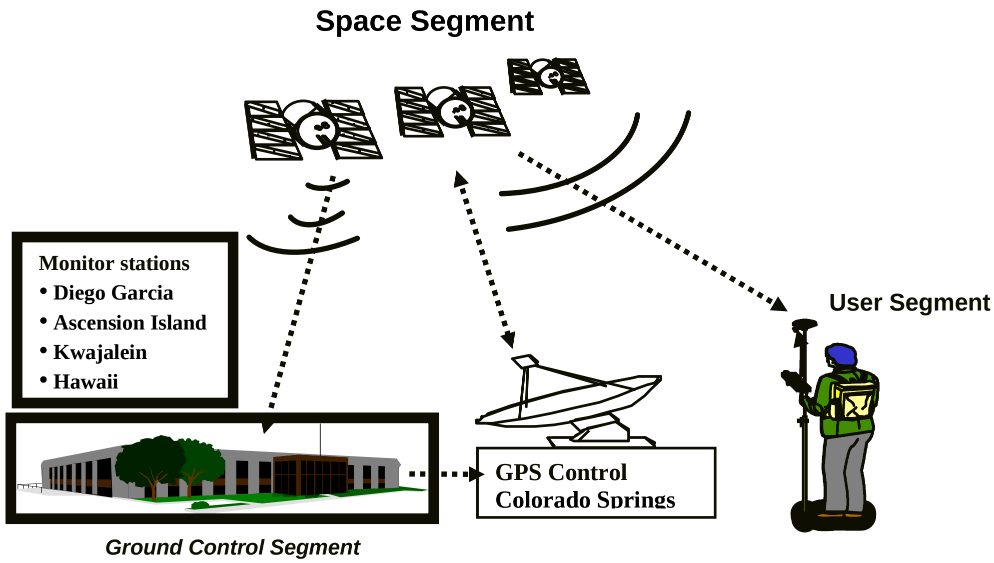
5.1 Introduction

The Global Positioning System (GPS) is a satellite-based radio-navigation system established by the U.S. Department of Defense for military positioning applications and as a by-product, has been made available to the civilian community. Navigation, surveying and integration with Geographic Information Systems (GIS) are just a few of the fields which have seen the successful application of GPS Technology.

GPS is a complex system which can be used to achieve positional accuracies ranging from 10 m to a parts per million (ppm) depending on the equipment used and procedures followed. In general, higher accuracies correspond with higher costs and more complex observation and processing procedures. Therefore it is important for users to understand what techniques are required to achieve desired accuracies with the minimal cost and complexity.

5.2 System Description

The Global positioning System (GPS) consists of 1) a constellation of radio-navigation satellites, 2) a ground control segment which manages satellite operation and 3) users with specialized receivers who use the satellite data to satisfy a broad range of positioning requirements. The system was established by the United States Department of Defense (DoD) to fulfill defense positioning needs and as a by-product, to serve the civilian community.



Three segments of GPS

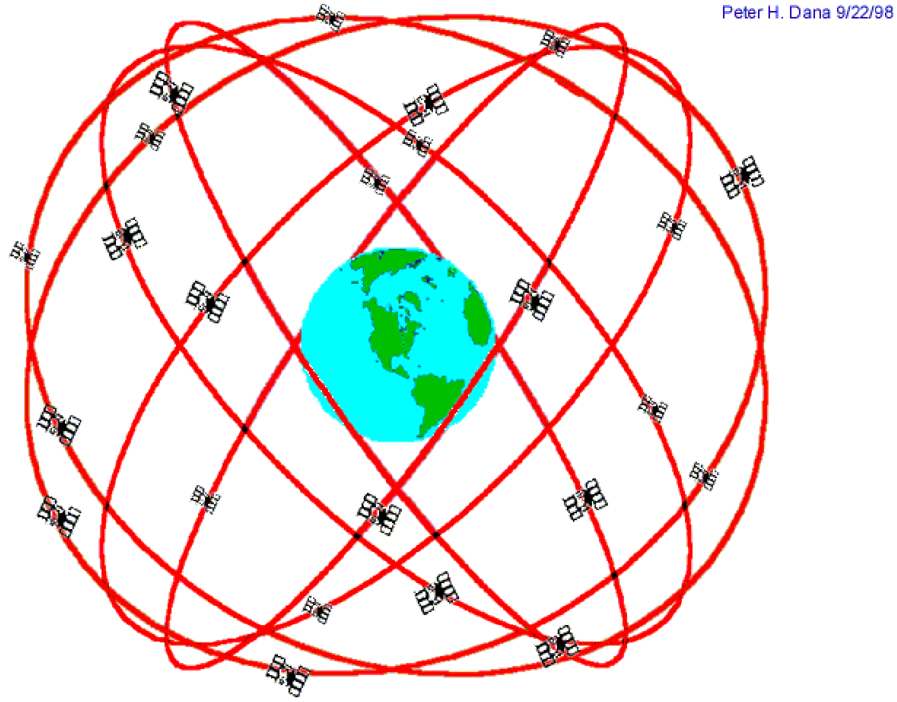
GPS Satellite constellation

The satellite constellation, which was fully operationalised at the end of 1993, consists of 24 satellites (See Plate – 6) and three active spares positioned 20,200 km (about three times the earth's radius) above the earth. The satellites were distributed in a manner that ensures at least four satellites are visible almost anywhere in the world at any time. Each satellite receives and stores information from the control segment maintains very accurate time through on board precise atomic clocks and transmits signals to the earth.

The Ground control segment operates the satellite system on an on-going basis. It consists of five tracking stations distributed around the earth of which one, located in Colorado Springs, is a Master Control Station. The control segment tracks all satellites, ensures they are operating properly and computes their position in space.

If a satellite is not operating properly the ground control segment may set the satellite "unhealthy" and apply measures to correct the problem. In such cases, the satellite should not be used for positioning until its status is returned to "healthy". The computed positions of the satellites are used to derive parameters, which in turn are used to predict where the satellites will be later in time. These parameters are uploaded from the control segment to the satellites and are referred to as broadcast *Ephemerides.*

The user segment includes all those who use GPS tracking equipment to receive GPS signals to satisfy specific positioning requirements. A wide range of equipment designed to receive GPS signals is available commercially, to fulfill an even wider range of user applications. Almost all GPS tracking equipment have the same basic components: an antenna, an RF (radio frequency) section, a microprocessor, a control and display unit (CDU), a recording device, and a power supply. These components may be individual units, integrated as one unit, or partially integrated. Usually all components, with the exception of the antenna, are grouped together and referred to as a receiver. Some GPS receivers being marketed now in fact only consist of computer cards which may be mounted in portable computers or integrated with other navigation systems.



GPS Nominal Constellation
24 Satellites in 6 Orbital Planes
4 Satellites in each Plane
20,200 km Altitudes, 55 Degree Inclination

Picture - 1

DGPS system **Handheld GPS**

Plate - 6

5.3 GPS signals:

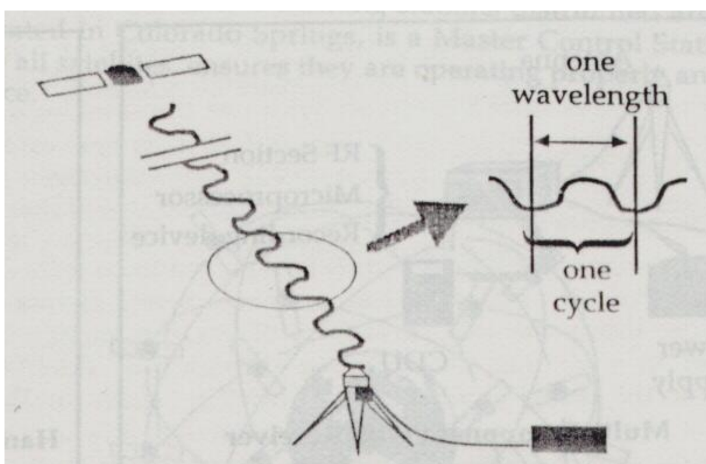
Each GPS satellite continuously transmits signals which contain a wealth of information. Depending on the type and accuracy of positioning being carried out, a user may only be interested in a portion of the information included in the GPS signal. Similarly, a given GPS receiver may only enable use of a portion of the available information. It is therefore important for users to understand the content and use of GPS signals. The information contained in GPS signals includes the carrier frequencies, Coarse Acquisition (C/A) and precise (P) codes and the satellite message. Description of each of these signal components is as follows.

5.4 Carrier Measurements:

Signals from GPS satellite are continuously transmitted on two carrier frequencies, 1575.42 MHz and 1227.60 MHz, and are referred to as L1 and L2 respectively. Since radio waves propagate through space at the speed of light, the wavelengths of the GPS carrier signals are computed as

Equation: $\lambda = c/f$ (1)

Where λ is the wavelength (i.e. the length of one cycle) in meters, c is the speed of light (approximately 3x10 m/s) and f is the carrier frequency in Hz (i.e. cycles per second). A snapshot of one section of carrier transmission which illustrates the definition of wavelength and cycles is shown below.



5.4.1 Carrier

The frequency and wavelength of the L1 and L2 carries (computed using above equation) are given in Table.

GPS receivers which record carrier phase, measure the fraction of one wavelength (i.e. fraction of 19 cm for the L1 carrier) when the receiver first locks onto a satellite and continuously measure the carrier phase from that time. The number of cycles between the satellite and receiver at initial startup (referred to as the ambiguity) and the measured carrier phase together represent the satellite receiver range(i.e. the distance between a satellite and a receiver). In other words,

Measured carrier phase = range + (ambiguity X wavelength) + errors

Or

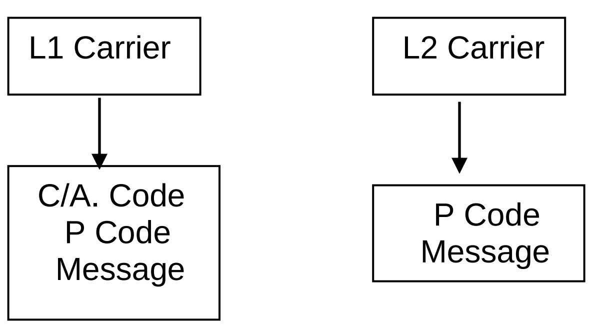
$$\mathbf{O = P + N\,\lambda + Errors} \qquad \mathbf{(2)}$$

Where O is the measured carrier phase in meters, P is the satellite-receiver range in meters; N is the ambiguity (i.e. number of cycles) and λ is the carrier wavelength in meters.

Carrier Frequencies and Wavelengths

Carrier	**Frequency (f)**	**Wavelength (λ)**
<u>L1</u>	**1575.42 MHz**	**19cm**
<u>L2</u>	**1227.60 MHz**	**24 cm**

Code and satellite messages are piggy –backed on the carrier signal through modulation. The L1 carrier is modulated by a coarse acquisition code referred to as the C/A code, a precise code referred to as the P code and the satellite message. The L2 carrier is modulated by the P code and the satellite message.



Information Modulated on Each Carrier

5.4.2 Code Measurements

It is the code measurements (also referred to as pseudo range measurements) that enable instantaneous position determinations using GPS satellites. The code is composed of a series of chips, which have values of 1 or 0. The C/A code has a frequency of 1.023 MHz (i.e. 1.023 million chips per second) and the P code has a frequency of 10.23 MHz.

The chip lengths of 293 m and 29.3 m for the C/A code and P code respectively were computed using equation (1), letting λ be the chip length. Although the P code is generally ten times more accurate than the C/A code, it is expected to be unavailable for civilian use in 1993 when the full GPS constellation was complete. Meaning only C/A code is worthy of consideration for civilian GPS applications.

Code measurements are the difference in time between when the code is transmitted from a satellite and received at a GPS receiver, multiplied by the speed of light. That is,

Measured code = speed of light x (reception time – transmission time)

OR

$$P = C\,(t \;\; - t_{t)} \qquad (3)$$

Where P is the measured code, C is the speed of light, t_t is the signal reception time and t_t is the signal transmission time. The code measurement is actually a direct measurement of satellite – receiver range (P) , i.e.:

Measured code = range + errors

Or

$$\mathbf{P = P + Errors} \qquad \mathbf{(4)}$$

Comparison of Code (Pseudo-range) and Carrier Measurements:

At this point it is possible to make some brief comparisons of code and carrier measurements. Carrier wavelengths (19cm for L1) are much shorter than the C/A code chip length (293 m) and consequently can be measured more accurately and used to achieve much higher positional accuracies than code measurements. Indeed the best relative accuracies achieved using code measurements are usually a few meters, and using carrier measurement are usually a few centimeters.

The problem with using carrier observations instead of code observations is evident upon comparison of equations (2) and (4). With code observations a direct measure of the satellite–receiver range is attained. With carrier observations the ambiguity term (number of whole cycles) must be estimated before one may take advantage of the carrier accuracy. Ambiguity estimation leads to complexities in the use of carrier phase observations which do not exist with code observations. The advantages and disadvantages of code and carrier observations are summarized in Table below

5.4.3 Key Advantages and Disadvantages of Code and Carrier Observations

	Code	**Carrier**
Advantages	Non-ambiguous simple	High accuracy potential
Disadvantages	Low accuracy	More complex

5.5 Satellite message:

The satellite message, which is modulated on both L1 and L2 frequencies, contains among other information, satellite broadcast ephemeredes and health status. The ephemeredes include the parameters necessary to compute a ***satellite's position in space for a given time*** and the health status indicates if a satellite is healthy. Almost all receivers use the broadcast ephemeredes in conjunction with code observations, carrier observations or both to solve for a GPS receiver's position in space.

5.6 Types of GPS positioning

Up to this point, the three segments of GPS have been described and the components of signals broadcasted by the satellites have been explained. Major types of possible positioning methods may now be defined. Note that only broad definitions are presented here, while specific GPS positioning methods are addressed in detail in several publications.

5.6.1 Single Point versus Relative Positioning:

Positioning with GPS may take the form of single point positioning or relative positioning. In single point positioning coordinates of a receiver at an "unknown" point are sought with respect to the earth's reference frame by using the "known" positions of the GPS satellites being tracked. Single point positioning is also referred to as absolute positioning, and often just as point positioning. In relative positioning the coordinates of a receiver at an "unknown" point are sought with respect to a receiver at a "known" point.

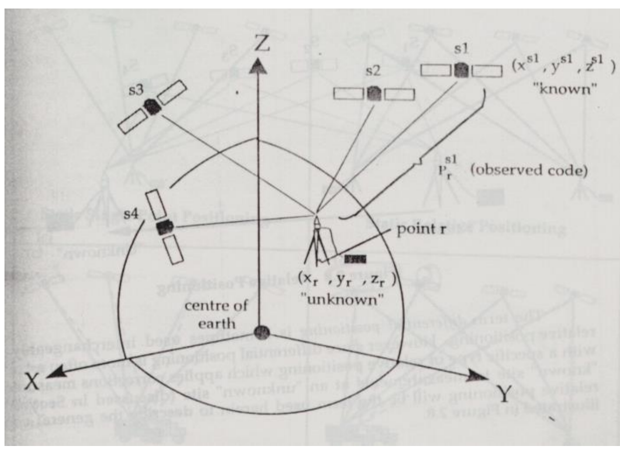
The concept of single point positioning is illustrated in Fig. below using the broadcast ephemeredes; the position of any satellite at any point of time may be computed.

In the Fig. s1, s2, s3 and s4 represent four different satellites being tracked. The positions of these satellites are referenced to the centre of the earth in the (x, y, z) coordinate frame. The coordinates for s1 are shown as (X^{s1}, Y^{s1}, Z^{s1}). The coordinates of r, the unknown point, as referenced to the centre of the earth, are (X_r, Y_r, Z_r)

The observed code, P_r^{S1} , relates the known coordinates of satellite 1 with the unknown coordinates of the receiver shown in Fig. below using the equation for a line in three – dimensional space. That is,

$$P_r^{S1} = (x^{s1}-x\lambda)^2+(Y^{s1}-Y\lambda)^2+(Z^{s1}-Z\lambda)^2+\text{errors}$$

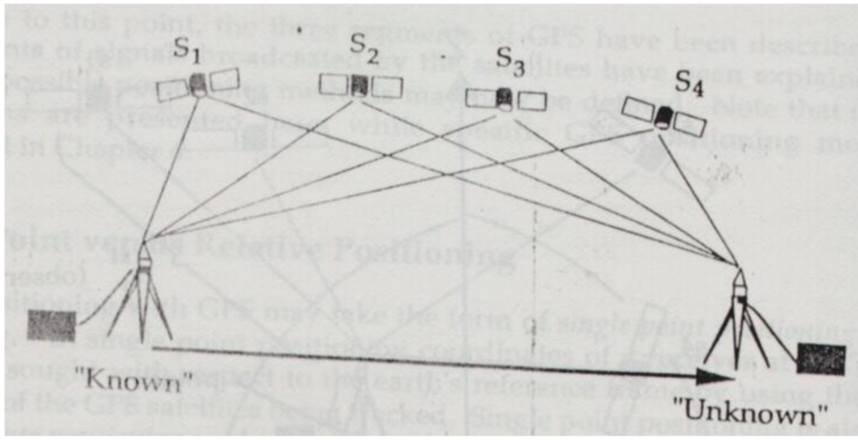
The same equation showing the relation between satellite 1 and the receiver may be formed for all satellites tracked. With at least four satellites all the unknowns (X, Y , Z) and a clock time which forms part of the errors) may be computed.



Single Point Positioning

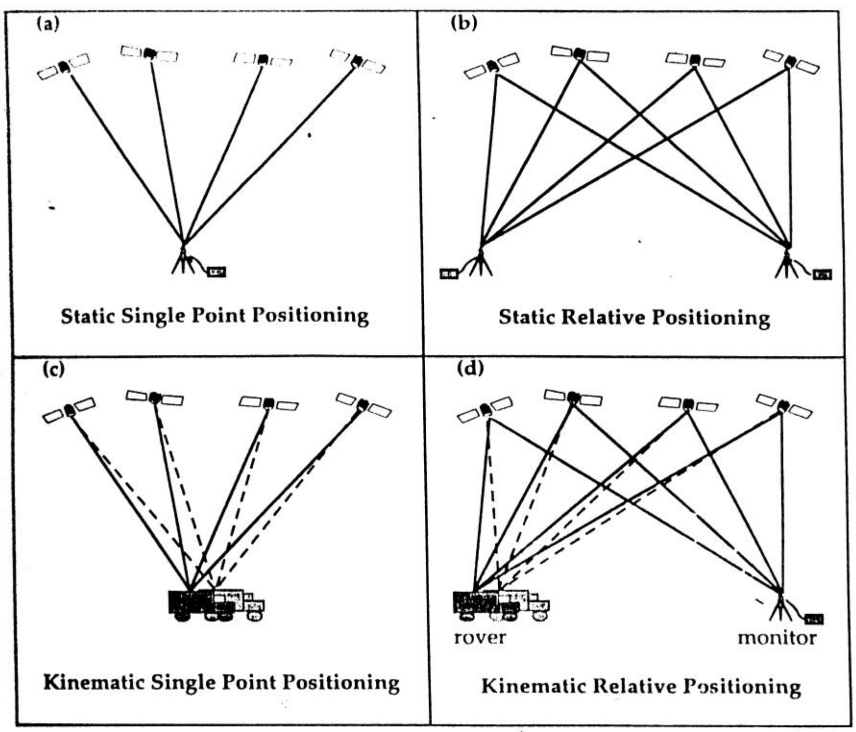
5.6.2 Relative Positioning

The concept of relative positioning is illustrated in Fig. below. Instead of determining the position of one point on the earth with respect to the satellites (as done in single point positioning), the position of one point on the earth is determined with respect to another “known” point. The advantage of using relative rather than single point positioning is that much higher accuracies are achieved because most GPS observation errors are common to the known and unknown site and are reduced in data processing.



The term differential positioning is sometimes used interchangeably with relative positioning. However since differential positioning is more often associated with a specific type of relative positioning which applies corrections measured at a "Known" site to measurements at an "unknown " site relative positioning will be the term used herein to describe the general concept illustrated in Fig.2.8

5.6.3 Static versus Kinematic Positioning



GPS positioning may also be categorized as static or kinematic. In static positioning, a GPS receiver is required to be stationary whereas in kinematic positioning a receiver collects GPS data while moving. The concepts of static and kinematic positioning for both single point and relative positioning cases are illustrated in fig below. Note that for kinematic relative positioning one receiver, referred to as a monitor , is left stationary on a known point while a second receiver, referred to as a rover, is moved over the path to be positioned.

5.6.4. Real –Time versus Post-Mission

GPS positions may be attained through real-time or post-mission processing. In real –time processing, positions are computed almost instantaneously, on site. In post –mission processing, data is combined and reduced after all data collection has been completed. Real –time relative positioning requires a data link to transmit corrections from a monitor receiver at a known point to a rover receiver at an unknown point. Post –mission processing for relative positioning requires physically bringing together the data from all receivers after an observation period. Even with real-time point positioning, for many GPS applications it is still necessary to download data and enter it in a database specific to the user's application.

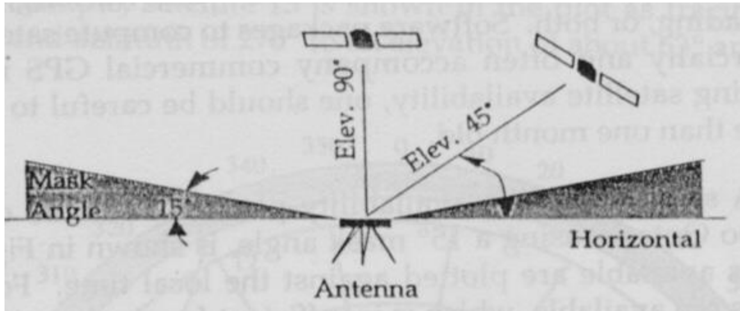
Very low accuracy code single point positioning is usually computed by GPS receivers in real-time, whereas very high accuracy carrier relative positioning is almost always dependent on post-mission processing. Real-time and spot –mission processing options exist for methodologies which yield accuracies between these two extremes.

All GPS positioning may be classified as static or kinematic, single point or relative, and real-time or post-mission. All users of GPS, no matter what the positioning type used, must be aware of the best times for data collection, which brings about discussion of satellite visibility and availability.

5.7. Satellite visibility and availability

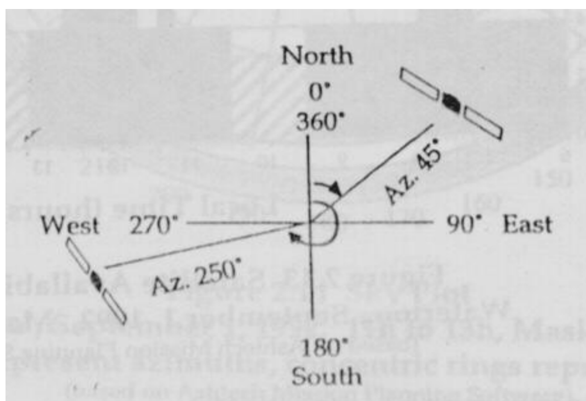
Users of GPS must know where, when and what satellites should be tracked to attain the best results. Terms used to describe satellite visibility are described, followed by a discussion of satellite geometry, satellite azimuth and elevation, selective availability and anti-spoofing.

The location of satellites with respect to a specific point on the earth is described in terms of elevation angle and azimuth. The elevation angle is the angle from the antenna between the horizontal and the line of sight to the satellite.



Elevation and Mask angles

The azimuth is the clockwise angle from north to the location of the satellite in the sky. GPS receivers, processing software, or both may have a option to set a specific mask angle (also referred to as cutoff angle). The mask angle refers to the elevation angle below which GPS signals will not be recorded. A satellite is said to be visible if it is above the specified mask angle for the time and location of interest assuming no obstructions are present.



Azimuth

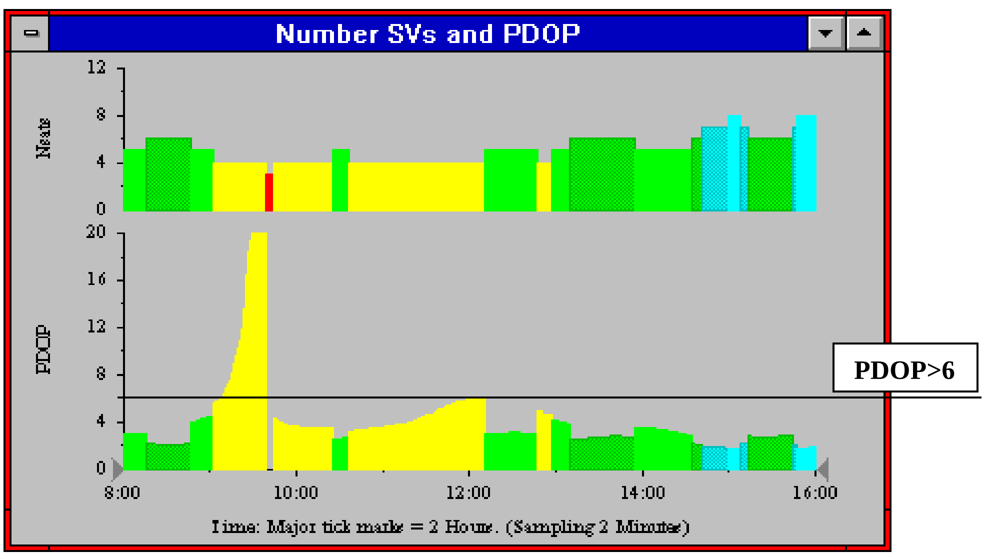
Obstructions are objects which block the path between a satellite and receiver. For example, if a desired satellite is at an elevation of 20 degrees and azimuth of 70 degrees and a building is located at the same elevation and azimuth, the satellite signal will obstructed. The avoidance of obstructions is very important to the successful application of GPS positioning.

For any given location on the earth, and any given date and time, it is possible to predict which satellites will be available and their location in the sky. This is accomplished by using almanac files which contain satellite orbit parameters in conjunction with software designed to use almanac files to compute satellite visibility. Current almanac files are available from the GPS Information Center and Hollman GPS Bulletin Board service. Many receivers display satellite availability information while tracking, provide almanac files for downloading, or both. Software packages to compute satellite visibility are available commercially and often accompany commercial GPS receiver software. When computing satellite availability, one should be careful to use only recent almanacs, no more than one month old.

A sample satellite availability plot for 12 hours on September, 1st 1992, at Waterloo Ontario using a 15 degree mask angle, is shown in Figure below. The number of satellites available is plotted against the local time. For two periods only three satellites are available, which is insufficient for single point positioning. For a short period (between 7 and 8 hours) six satellites are available, which is favorable since in general the more satellites, the better the chance of success with GPS positioning.

5.8. Satellite Availability Plot:

Satellite coverage repeats itself from day to day, but appears four minutes earlier. This means the satellite visibility plot for September 2 would be identical to that for September 1 but shifted four minutes to the left. The satellite visibility plot for September 8 (one week later) would be shifted about one half hour to the left, and for October 1 (one month later) would be shifted about two hours to the left.

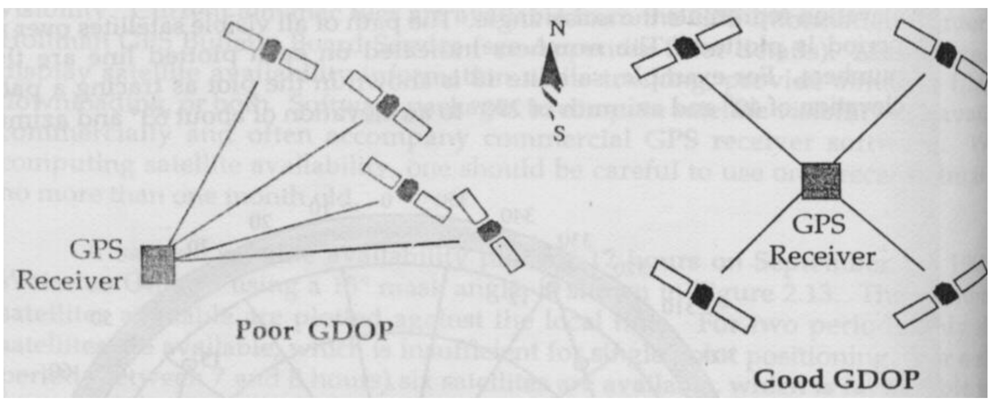


5.9 Satellite Geometry:

Sometimes sky plots, as illustrated in Fig. below are used to represent satellite visibility. To interpret such plots one must imagine being situated at the centre of the plot. Each concentric ring represents an elevation angle, while each radiating line represents an azimuth. In figure, the shaded area, below 15 degrees elevation represents the mask angle. The path of all visible satellites over a two-hour period is plotted. The numbers indicated on each plotted line are the satellite numbers. For example, satellite 13 is shown in the plot as tracing a path from an elevation of 40 degrees and azimuth of 270 degrees to an elevation of about 63 degrees and azimuth of 10 degrees.

Satellite geometry has a direct effect on positioning accuracies. The best single point positioning accuracies are achieved when satellites have good spatial distribution in the sky (e.g. one satellite overhead and the others equally spread horizontally and at about 20 degrees elevation). Sub- optimal geometry exists when satellites are clumped together in one quadrant of the sky. The geometry of satellites, as it contributes to positioning accuracy, is quantified by the geometrical dilution of precision (GDOP) . Satellite configurations exemplifying poor and good GDOP are illustrated in Fig. below.

Poor and Good GDOP



By multiplying all errors expected in single point positioning (referrred to as the user equivalent range error (UERE)) with GDOP one arrives at an estimate for the combined accuracy of the four components estimated in single point positioning (three coordinates and time). Other types of DOPs, when multiplied by the UERE yield accuracy estimates for positional, horizontal and height estimates as summarized in Table below.

Types of DOPs

Acronym	**Type**	**Position Component(s)**	**Unknowns**
GDOP	Geometrical	3 D Position and time	X, Y, Z & Time
PDOP	Positional	3D position	X, Y, Z
HDOP	Horizontal	2D horizontal position	X, Y
VDOP	Vertical	1D height	Z

Most GPS software packages include the ability to compute DOPs before an observation period. The information needed to compute DOPs is the same as that required to compute the satellite availability and sky plots of Figures shown (i.e., a recent almanac file, approximate latitude and longitude, the date and the time period). Figure below shows PDOPs which correspond to the same time and location as the plot for the number of available satellites in Figure shown for waterloo. Note there is a general tendency for low PDOPs with an increased number of satellites and vice versa.

5.10 PDOP Plot:

For GPS positioning the lower PDOP gives better accuracy. A PDOP below 5 or 6 is generally the recommended upper limit for positioning, particularly for short occupation times (eg. few minutes). In (Figure 8) PDOPs over 6 are shaded out, showing time periods which are not well suited for GPS observations. For example, for the day and location shown in the figure, one would observe from 7 to 8 hours instead of from 8 to 9 hours due to the favorable PDOP in the earlier time period. For static relative positioning over long time periods,(e.g. more than one hour) the PDOP is not quite as critical since one benefits not only from the geometry of satellite configuration, but also from the geometry of the path the satellites trace in the sky over time.

5.11 Selective Availability and Anti-Spoofing:

Two terms often associated with GPS status are selective availability (SA) and anti-spoofing (AS). Both refer to techniques to limit the accuracies achievable for civilian users. Selective availability consists of the degradation of the broadcast orbit (i.e. the accuracy of the satellites “known” position in space) and dithering of the satellite clocks. SA is currently being implemented. As a result of SA, single point positioning accuracies are limited to 100m horizontally and 256m vertically at the 95% confidence level instead of the 20-30 m and 30-45 m possible without SA. However the SA is now completely removed form May 2000.

Anti –spoofing is the denial of access of the P code to civilian users (except those with special authorization from the U S DoD) and is implemented. The P code is replaced with a Y code on the L1 and L2 carries. This Y code has similar properties to the P code but is unknown to unauthorized users.

5.12 Errors

It is important for application oriented users to understand the basic errors which affect GPS observations, since they have direct implications on the methods which should be used to achieve desired accuracies. Errors cause the measured satellite – receiver range to differ from the true satellite-receiver range, hence the inclusion of the error terms in the basic carrier and code measurement equations. Details on types of errors in GPS observations, and how they may be handled are described in several publications and are briefly discussed here.

Errors, which influence GPS range measurements, are illustrated in Figure below. The orbital error refers to the difference between the satellite position as calculated using the broadcast ephemeredes and the “true” position of satellite in space. Nominally these errors range from 5 to 25m, but have been degraded to as much as 100m through selective availability. Satellite clock errors are about 10m assuming clock corrections made available in the satellite message are used.

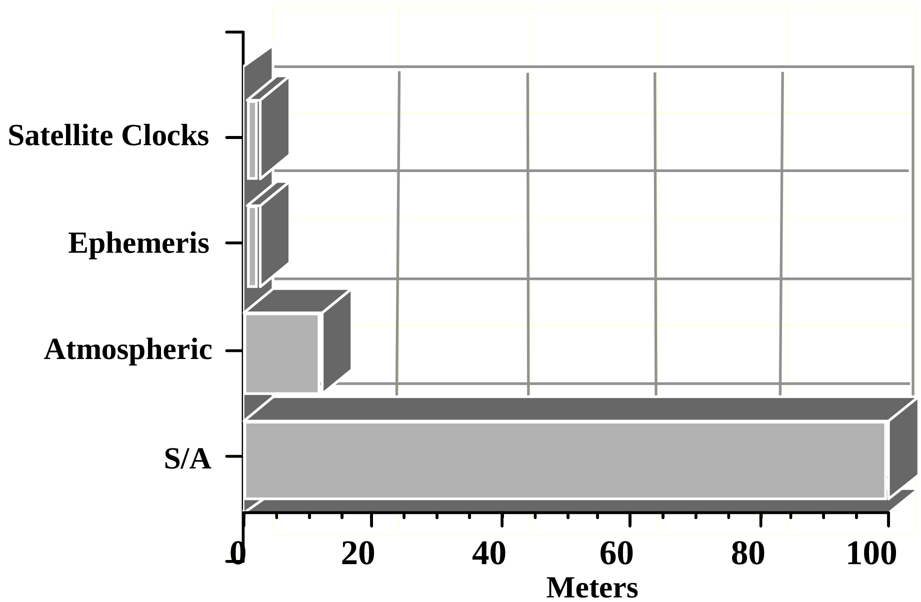
All discussions up to this point have assumed GPS signals travel at the speed of light. Two sections of the atmosphere defy this assumption: the layer of free electrons ranging from about 50 to 1000 km above the earth referred to as the ionosphere, and the layer up to 80 km above the each referred to as the troposphere. Ionospheric errors range from 50 m at zenith (i.e. when the elevation angle is 90^0) to 150m at the horizon (i.e. when the elevation angle is 0^0). Tropospheric error ranges from 2 m at zenith to about 20 m at 10^0 elevations. The errors for satellites at low elevation angles are greater because they have longer paths through the atmosphere and ionosphere.

Receiver clock errors may range from 10m to 100 m depending on the quality of the receiver clock. In positioning, this clock error is estimated along with coordinates and so does not greatly affect achievable accuracies.

Multi-path errors occur when signals received directly, combine with signals reflected off nearby objects such that the true signal is corrupted by interference from the reflected signal. Receiver noise is a function of how well a GPS receiver can measure code or carrier observations. The magnitude of both multi-path and receiver noise errors is proportional to the chip length and wavelength of the code and carrier measurements respectively. For C/A code measurements, multi-paths can 5cm. Receiver noise for code and carrier measurements are typically at the few meter and few millimeter levels respectively. Both receiver and antenna design may influence multi-path and measurement noise.

The magnitude of errors as they affect a single satellite-receiver range is summarized in Table below. All the errors presented in Table below, when combined using scientific laws of error propagation, form the user equivalent range error. It is this value, which when multiplied by the DOP (dilution of precision), yields an estimate of achievable accuracies for single point positioning.

GPS errors component wise



Error	Magnitude*
Satellite	**10 m (assuming broadcast corrections used)**
Orbital	**100 m (S/A active)** 5 to 25m (S/A inactive)
Ionospheric	**50 m (at zenith)**
tropospheric	**2 m (at zenith)**
receiver clock	**10 to 100 m (depends on type of receiver oscillator)**
Multipath **C/A code** Carrier	 50 cm to 20 cm (depends on GPS equipment and site) up to a few cm (depends on GPS equipment and site)
Receiver noise **C/A code** Carrier	 10 cm to 2-3 m (depends on receiver type) 0.5 mm (depends on receiver type)

An error unique to carrier phase observations is the cycle slip. Recall from the discussion preceding the carrier equation, that carrier phase is measured continuously, but has an ambiguity term at the time of initial satellite lock. The failure to maintain continuous lock on a satellite causes cycle slips, in which an integer number of wavelengths may be lost. Cycle slips must be corrected through data processing if carrier measurements are to be used to achieve sub-decimeter accuracy.

The wide range of accuracies and positioning techniques with GPS are a result of the type of observations used (code, carrier or both) and the means for handling the errors listed in Table above. When accuracies better than the 100 m achievable with single point positioning are required, relative positioning should be employed. In relative positioning most of the orbital, tropospheric and Ionospheric errors along the satellite-receiver path are common to both sites and consequently their influence on the relative positions is small. The closer the GPS receivers are to each other, the more common are these errors and the greater the accuracy achieved through relative positioning. Accordingly, the further apart the GPS receivers are far from each other, the less common are these errors and the less accurate the relative positioning.

For precise static relative positioning, sophisticated means for handling errors are employed which include combining observations through double differencing techniques and using advanced modeling and estimation. Dual frequency receivers may be used to almost totally remove errors due to the ionosphere in relative positioning over long baselines.

List of Global Navigation Satellite Systems currently operational and in development

1 – GPS of the United States of America

GPS (Global Positioning System) is the United States system that uses 32 satellites that are in medium Earth Orbit. They are placed in six distinct orbital planes, and older satellites are constantly replaced by new ones. It has been in operation since 1978 and it is the most used navigation system that incorporates satellites.

2 – GLONASS of Russia

GLONASS or Global Navigation Sputnik System is a Russian satellite navigation system that is used for civilian operations. It makes use of radio navigation satellites and is also utilized by the Aerospace Defence of the Russian Forces. It consists of 24 full orbital constellations of satellites that allow for global coverage.

3 – Galileo of the European Union

Galileo is the European Union satellite navigation system introduced in 2002. The European Space Agency also makes use of this system and is used as an alternative to the United States GPS. It makes use of 30 satellites that are in medium Earth orbit. It has been designed to be compatible with the GPS system of US and receivers can make use of combined signals from GPS and Galileo, mainly to increase the level of accuracy.

4 – BeiDou of People's Republic of China

China has been using the system BeiDou for its military and civilian navigation purposes. It is currently in the second generation and was formerly known as COMPASS, and serves the Asia-Pacific region in addition to China. It makes use of 30 Medium Earth Orbit Satellites and 5 satellites that are in geostationary orbit.

5 – IRNSS or NAVIC of India

IRNSS (Indian Regional Navigation Satellite System) or NAVIC (Navigation with Indian Constellation) is the satellite navigation system used by the Indian Space Research Organization, which is directly controlled by the Indian Government. It consists of 7 satellites out of which 3 are placed in geostationary orbit while the other four are in geosynchronous orbit. It has a very large signal footprint in comparison to the number of satellites in operation. All satellites in the constellation have been launched from within India, and the system will be fully operational in 2016.

6 – QZSS of Japan

The Quasi-Zenith Satellite System (QZSS) is a proposed three-satellite **regional time transfer system** and enhancement for GPS covering Japan. The first demonstration satellite was launched in September 2010.

Difference between GNSS and GPS

- GNSS stands for Global Navigation Satellite System, and is an umbrella term that encompasses all global satellite positioning systems. This includes constellations of satellites orbiting over the earth's surface and continuously transmitting signals that enable users to determine their position.
- The Global Positioning System (GPS) is one component of the Global Navigation Satellite System. Specifically, it refers to the NAVSTAR Global Positioning System, a constellation of satellites developed by the United States Department of Defense (DoD). Originally, the Global Positioning System was developed for military use, but was later made accessible to civilians as well. GPS is now the most widely used GNSS in the world, and provides continuous positioning and timing information globally, under any weather conditions.

- Besides GPS, the GNSS currently includes other satellite navigation systems, such as the Russian GLONASS, and may soon include others such as the European Union's Galileo and China's Beidou.
- GNSS is used in collaboration with GPS systems to provide precise location positioning anywhere on earth. GNSS and GPS work together, but the main difference between GPS and GNSS is that GNSS-compatible equipment can use navigational satellites from other networks beyond the GPS system, and more satellites means increased receiver accuracy and reliability. All GNSS receivers are compatible with GPS, but GPS receivers are not necessarily compatible with GNSS.
- Both GPS and GNSS consist of three major segments: the space segment (satellites), the ground segment (ground control stations), and the user segment (GNSS or GPS receivers), and the exact location of each satellite is known at any given moment. Satellites are continuously sending radio signals toward earth, which are picked up by GNSS or GPS receivers. The ground control stations that monitor the Global Navigation Satellite System continuously track satellites, update the positions of each and enable information on earth to be transmitted to the satellites.
- Currently, GNSS/GPS is being used in a variety of fields where the use of precise, continually available position and time information is required, including agriculture, transportation, machine control, marine navigation, vehicle navigation, mobile communication and athletics.

5.13 GPS Technology in Forest Department:

1. Navigational GPS are required for use in forests for ground truthing, locational search in Forest Inventory and for general perambulation. Here accuracy of 10mts is good enough for the purpose. Hand held GPS equipment is best suited for this purpose and was procured.

2. Surveying GPS are the differential GPS meant for accurate measurements (Sub-meter accuracies). These are useful in demarcating Forest Block, surveying plantations, Mining areas, Compensatory areas and encroachments, where accuracy is of importance for this purpose APFD has procured two models i.e., Trimble and CMT. The Trimble model can be effectively used to achieve the 3-D accuracy.

Now time has come to every forest officer to learn about the use, need and intricacies of GPS technology to deploy it in their day-to-day for better management of Forests.

Chapter – VI

Geomatics Applications

Watershed management

6.1 Introduction:

The “Water” is one of the five basic elements of life out of ***pancha bhuta*** i.e. air, water, earth, fire and sky on the earth is the most essential element of life. Earth has water covering about 3/4th of the total surface area but sufficient water is not available both for drinking and irrigation in several parts of the world. India is being one of them. Over the centuries population explosion, urbanization, conversion of forests to agriculture, have multiplied the demand for water. Fresh water problem is not limited to the arid climatic regions, even in areas with good supply the access to safe water is becoming a critical problem. Water on earth goes through a gigantic cycle of conversation to gaseous form by evaporation and coming down again to earth as rainfall. For masses the main source of water is the surface water that flows in streams, rivers and ground water which are highly influenced by the adjoining forests.

In the India Rain water is the most important factor in Indian Agricultural production. 75% of the total cropped area is under rain fed/ un-irrigated and account for about 42% of the total food grain production. More than 78% of cotton; 82% of oil seeds 96% of sorghum; 98% of the millets and as much as 62% of the rice and 38% of wheat of the country are grown under rain fed conditions. Therefore country’s Development lies in the improvement in the productivity of these crops. Since water is the major limiting factor for the production of rain fed crops and precipitation is the only source of water in most of rain fed regions, effective rain water management is vital to increase and stabilized their yields. To effectively manage rain water forests play a vital role. Scientific investigations onto forest – water relations began around the turn of the 20th century. It is proven after intensive research that

1. Reduction of forest cover increases water runoff
2. Establishment of forest cover in sparely vegetated land decreases water yield.
3. Response to treatment is highly variable and for the most part, unpredictable.

In the areas where forests and agriculture are coexisting the influence of the forest cover has great influence on the adjoining agriculture by way of regulating the streams and long duration of the flow; reducing the silt yield, increasing the ground water recharge. The dependence of the neighboring villages on forests for several purposes and ever increasing populations has led to the degrading of forest. In this complex situation classical management did not yield expected results. Therefore the Government had started to find out suitable alternate management techniques and culminated in joint forest management.

The location of the tank should essentially be at the lowest point of the catchment. Remote Sensing, GIS and GPS technology will provide much information and can be used in selecting suitable sites for structures and prioritization according to criteria and budget availability.

6.1.1 Concepts of watershed

A watershed is an area that drains water and other substances to a common outlet as concentrated drainage. Other common terms for a watershed are: basin, catchment, or contributing area. This area is normally defined as the total area flowing to a given outlet, or pour point. The boundary between two watersheds is referred to as a watershed boundary or drainage divide.

An outlet or pour point is the point at which water flows out of an area. This is the lowest point along the boundary of the watershed. Source cells may be features such as dams or stream gauges, for which you want to determine characteristics of the contributing area.

Runoff is an important hydrologic variable in water resources application and Management of Watersheds. Watersheds should be properly managed through scientific planning

i) to prevent loss of top soil and water that results in low productivity,
ii) to prevent land from deterioration
iii) to mitigate flood hazards in the downstream reaches
iv) to prevent rill/gully formations even at low rainfall events etc.

This can be achieved by adopting suitable soil and water conservation measures

i) To intercept and reduce runoff, and induce larger and extensive adoptions of rain water
ii) To trap eroded material and thus reduce sediment transport into streams and in turn into reservoirs
iii) To restore/reclaim degraded lands into productive lands
iv) To increase total productivity and provide a stabilized environment

Remote Sensing provide a source of basic input data to estimate the runoff or used as an aid for estimation of equation coefficients and model parameters. RS is used in both the methods i.e. Rational & Curve number methods runoff estimation. Satellite data can be interpreted to derive a number of thematic information in land use, soil, vegetation, surface water, snow cover, stream network, land form, erosion intensity etc, which combined with conventionally measured climatic parameters (temp, precipitation, evaporation etc) and topographic parameters (height contour, slope) should provide the necessary inputs to the models, both empirical and conceptional, are in practice reliable and timely estimation of runoff.

The various watershed characteristics are size, shape, relief, drainage, geology, soil, climate, surface condition and land use, ground water, social and legal status of which some of them are generated using the aerial photographs, satellite images.

6.1.2 Water resources & Watershed Management

GIS, RS, GPS and various analytical tools associated with them, are proven to be capable providing sources of data and means of manipulating data appropriate for large scale management of natural resources i.e. forests, water, soil etc and appropriate planning on sustainable basis. GIS in conjunction with various hydrological simulation modeling techniques used to assess the time varying distribution of non permanent surface water and possible to estimate the possible patterns of redistribution that might arise from drainage or consolidation GIS can be used for acquiring, collating, storing and displaying the data, that is needed for simulation models to define the geometry of the surface water flow that is controlled by surface topography and the timing flow and magnitude of water accumulation in depressions which is related to soil, climate and land cover characteristics in addition to geometric form, as well as for displaying and outputting the results. Remote Sensing can be used to determine runoff, sediment yield and the ground water potential zones, and also to determine the changing location and extent of surface water bodies above a given minimum size depending upon the resolution of the satellite sensor, and also determine patterns of flow and interconnection between depressions.

Site suitability analysis for Water Harvesting Structures - Geomatics Approach

6.1.3 Objectives:

The objective of the present study area is

1. To identify suitable sites for water harvesting structures (WHS) for effective soil and moisture conservation works
2. To prioritize WHS with respect to their feasibility and local importance
3. To assess the impact of the watershed management practices

Future Objectives:

4. To find out the runoff at each point in the range area for a given rainfall event
5. To estimate the submergence area, surface area, and storage capacity of a proposed WHS

Suitability criteria for Checkdams and Percolation tanks

Rank	Slope classes (%)	Density Classes
Highly Suitable	< = 3	Blanks & Scrub
Moderately Suitable	< = 3	Open forest
Least suitable	< = 3	Dense forest

- Streams : 2nd and 3rd ordered streams are considered.
- The minimum catchment area for check dams should be 25 ha and percolation tanks should be 40 ha

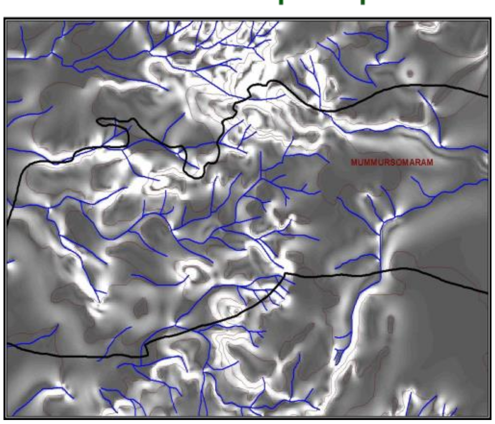
Suitability criteria for Continuous/Staggered contour trenches

Rank	Slope classes (%)	Density Classes
Highly Suitable	>3 and <= 10	Blanks
Moderately Suitable	>3 and <= 10	Scrub forest
Least suitable	>3 and <= 10	Open forest
	> 10 and < 25	Blanks & scrubs
MPTs and SGPs	>3 and <= 10	Dense Forest
	> 10 and < 25	Open and Dense forest

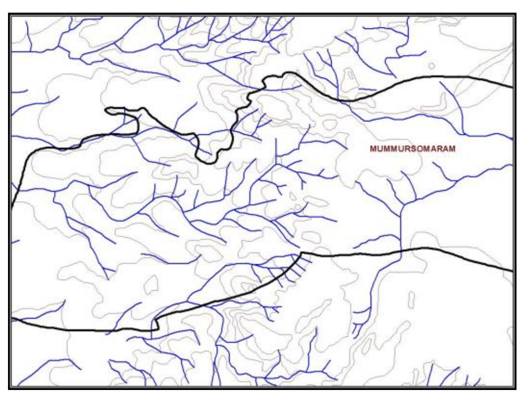
- All other areas are treated as unsuitable for any WHS.

Thematic layers used:

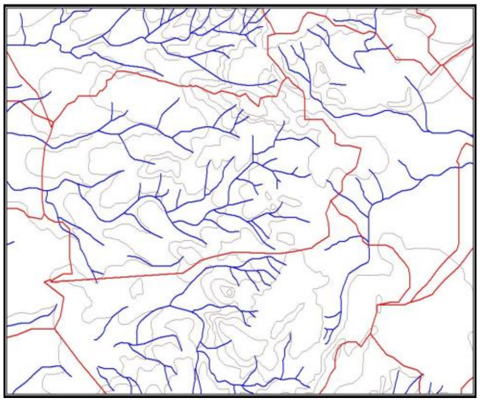
1. Continuous Slope Map



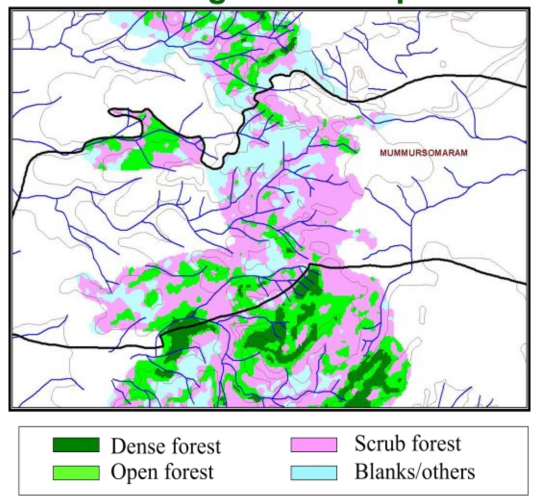
2. Stream network



3. Watershed Boundary



4. Vegetation Map



4.Vegetation - Satellite imagery will be used to classify the vegetation into various canopy density classes that are followed

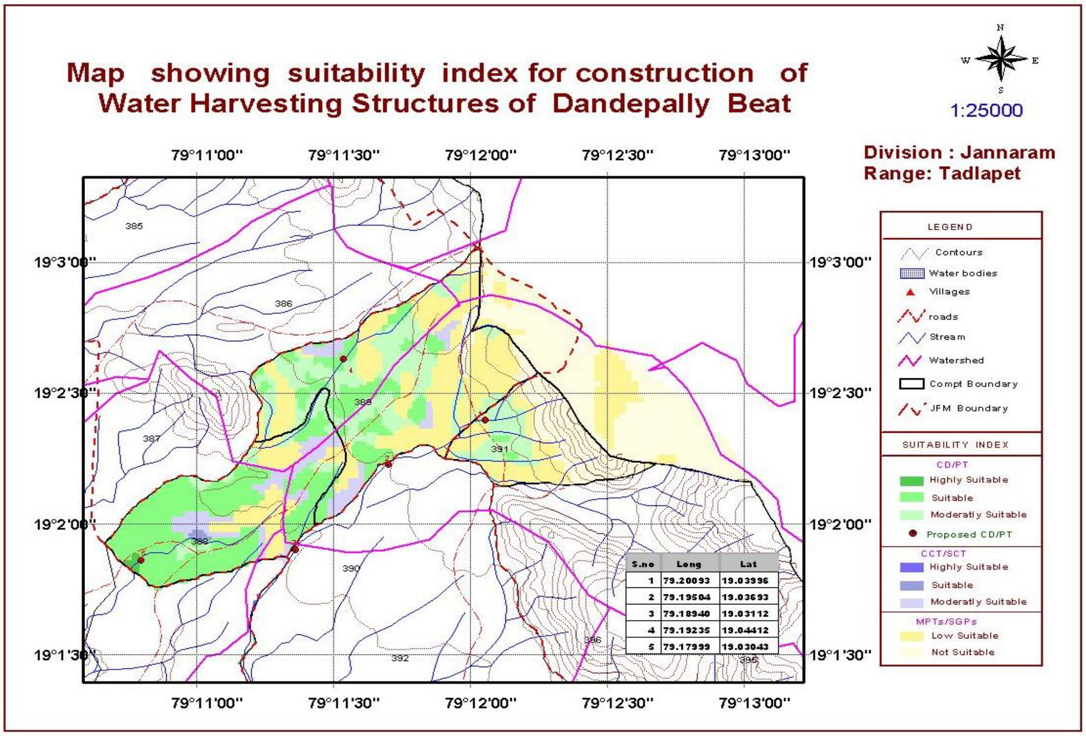
Dense Forest	**> 0.4 canopy density**
Open forest	**0.1 – 0.4 canopy density**
Scrub forest	**<0.1 canopy density**
Blanks/Others	**Areas devoid of vegetation**
Water bodies	

Analysis and final output preparation

- The layers will be integrated using above criterion and the points will be selected for construction of check dams and percolation tanks
- The maps will be composed beat wise with appropriate legend at 1:25000/50000 scale as per the requirement

The final output map contains

- suitability index for various SMC structures
- administrative, compartment, JFM boundaries
- drainage network and contours
- roads and villages
- watershed boundary
- any other topo features if required the serially numbered points showing the suitable locations for various Structures for which the latitude and longitude will be given in a separate Sheet or on map



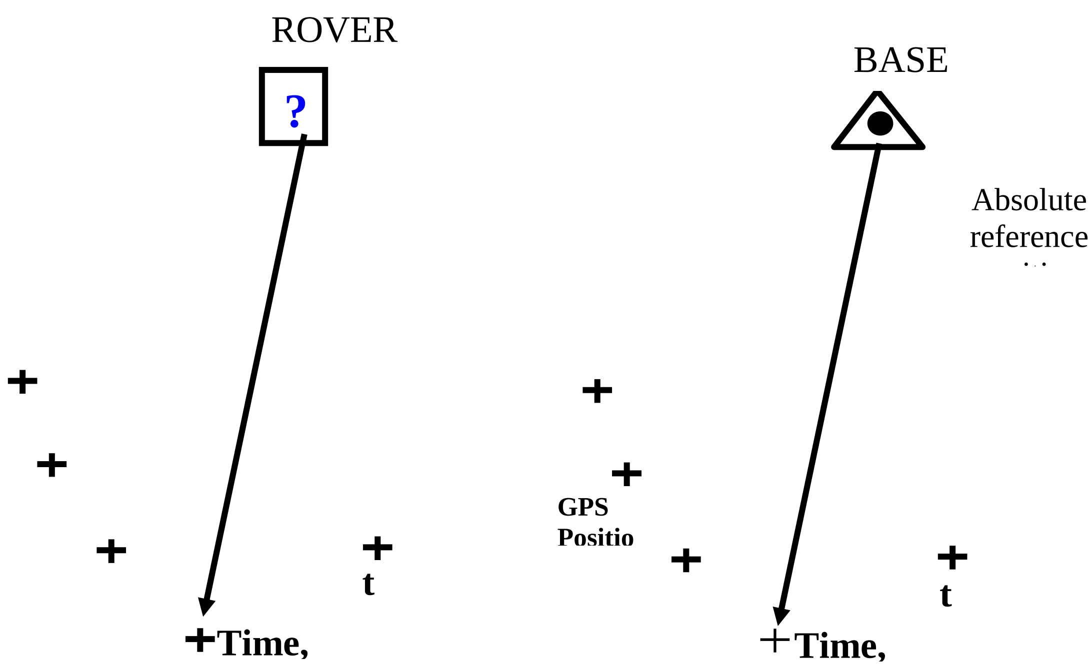
Identification of the points in the field

- The points can be navigated using GPS to its nearest locality.
- It is required to study the physical characteristics of the surrounding area up to 100 mts, to decide the exact location of structure.
- If any structure is already made in its vicinity under any scheme the areas may not be considered, except if they are drained from different catchments.
- The catchments of the check dams and percolation tanks are to be studied and the proposals for mini structures like MPTs, SGPs, RFDs etc are to be submitted in quantity.
- If any other structure can be made in the priority areas other than the proposed structures, such locations have to be submitted with its latitude and longitude.

Site suitability analysis for WHS in Dullapally Reserve Forest – A Geomatics Approach (Use of DGPS)

6.1.4 Concept of Differential Global Positioning system:

DGPS (Differential Global Positioning System) is very useful instrument for generating contours even at 10cms interval. In the normal GPS survey we will get the positional accuracy with in the range of $\pm$ 5 to 10mts. In this study area, the DGPS technology was used for generating the contours at 1mt interval. The DGPS technology consists of a base station and a rover. Base station is static whose coordinates are known in a reference frame and continuously records its position (x, y, z, and t) and rover will collect the information in the field. Base station position will be known and with reference to this known position it will calculate the error at every instant of the time. Same time rover will collect the information from the field. Same error that is calculated at the base station will be applied to the rover files for the same time.



Error removed (δx, δy and δz) — Error calculated as (δx, δy and δz)

Satellite used: 1,2,3,4 — Satellites seen:1,2,3,4,5,6,7,8

6.1.5 Principle: At the same time, the errors occurring at one location (Base station) are occurring everywhere (Rover) within the same vicinity.

6.1.6 Differential correction:

- Base Station generates corrections for all satellites in view.
- Roving GPS receiver uses these corrections to remove correctable errors.
- Differential correction can be performed in either real-time or post processed mode.
- Differential correction will be done using Pathfinder Office Software for Trimble DGPS.

6.1.7 Dullapally reserve forest

The project area Dullapally Reserve Forest is situated on the ring road joining NH7 and Medak state Highway in near by Dullapally village of Rangareddy District (See Plate–13). This forest block is very near to Hyderabad city so that it is having an importance in maintenance in environmental balance. It has an area of 526.6Ha approximately. The area lies between 17°33'34'' - 17° 31'56'' North latitude and 78° 26'26'' - 78°27'55'' East longitude. The surrounding areas of this block are maximum extent polluted by discharging waste chemicals and releasing CO_2 etc.

6.1.8 Climate: The climate is generally hot. The average maximum temperature in the summer months generally varies from 35° to 42°C. The average minimum temperature during winter varies from 10° to 22° c.

6.1.9 Rainfall: The District is generally deficient in rainfall. A major part of the district is declared as the Drought prone area and schemes such as; Drought Prone Area Program is intensively taken up in the district. The area receives rainfall mainly from south west monsoon and partly from north east monsoon during the period June to September rains received from SW monsoon and balance from N-E monsoon during October to December. The average rainfall of the area is about 600mm in the recent past.

6.1.10 Vegetation type: The forests occurring in the study areas posses general characteristics of tropical thorny scrub forests as per Champion & Seth revised classification of forest. All along the main stream which is passing through is having close cover of density. The total area is fenced and protecting from grazing so that existing root stock is coming up well.

Project area

Part of the Reserve Forest area is taken up for the treatment of Water Harvesting Structures and area is about 277Ha.

6.1.11 Methodology:

The entire project work was carried out in 2 phases.

Phase I : GPS field and post processing work

Phase II : GIS for preparing base and final results.

Phase I: GPS Field and Post processing work:

a. Preliminary Reconnaissance Survey:

The total area is perambulated and prepared rough map with all the features and elevation details before going for the actual field work. Total reserve forest area is given to different organizations and these boundaries information also recorded roughly on the map. Simultaneously while doing Reconnaissance survey prepared rough plan for DGPS surveyed paths. Since the area is not having too many undulations, the interval between the paths taken approximately 100mts apart on both the directions in such a way that to cover all the elevation points in the study area. Same paths, which are prepared for field work is roughly demarcated in the field to avoiding confusion during the field work.

b. Field work:

Actual fieldwork has started after completion of Reconnaissance survey. Since the importance is to find out the elevations so that it is essential to do differential corrections. Before going to the field it has been started the base station which is arranged at AP Forest Academy.

In the first stage it has been surveyed all the areas for demarcation which are handed over to the different organizations. As per the demarcation done in the field during the Reconnaissance survey accordingly DGPS survey has been completed by taking line feature and keeping interval between two readings as 10sec. During the DGPS survey **Carrier phase** has been put it on to get maximum accuracy 3D positions along with the elevations. About 60% of the area is got the readings with **Carrier phase** rest of the area is done with the **Code** processing mode.

c. Post processing:

Every day after completion of field work immediately downloaded the rover files and done the differential corrections using base files which are collected at the base station. Total field work has been taken about 4days to complete the area. All the rover files were downloaded and done the differential corrections using DGPS software, Pathfinder Office.

In the nest stage all unwanted points which are identified as clusters were edited in the software to avoid error in generation of contour and then other related themes. All the files that are created everyday were grouped into a single file after completion of the editing. From this final grouped file it will show the distribution of points, and the areas which are not covered with elevation points were demarcated on map and identified in the field. The elevation points were taken in these areas with DGPS as a final field collection data. This final collected field points added in to the grouped file. The final grouped file was exported only positions with elevations into GIS platform i.e. ARC/INFO coverage using different filters in the Pathfinder software to avoid maximum extent of errors. The distributions of field-collected positions are shown in the plate.

GIS for preparing base and final results

Generation of contour layer:

The point cover that is exported from pathfinder office is again converted in to TIN (Triangular Irregular Network) model using ARCTIN command in ARC/INFO software. From TIN model it can be generated contour network at the specified interval by using TINCONTOUR command in ARC/INFO contours are generated directly from the tin within its zone of interpolation. The zone of interpolation is defined by the convex hull, and/or the CLIP and ERASE features incorporated when building the tin (See Plate-14).

Site suitability for water harvesting structures

The rainfall in the district is only seasonal. The S.W. monsoons contribute 2/3 of the total (June to September) and the balance from N.E. monsoon (October to December). The rainfall is erratic and long dry spells occur in between high intensity rains. In the Nallamalai Hills this causes not only crop failure but also aggravated erosion. Suitable sites are to be located in the up stream side to protect the crops from drought and check soil erosion. This also increases the life of downside structures by arresting silt.

Criteria's for selecting suitable sites for conserving water is given in the Integrated Mission for Sustainable Development (IMSD); and the guide lines are given by the Indian National Committee on Hydrology. The guidelines are given in the Hand Book of Watershed, Govt of Andhra Pradesh. Drought prone area program to select sites for water conservation are discussed here.

Rock Fill Dams:

In general rock fill dams are constructed at first and second order streams where the initial water flow starts by accumulating water from the plain areas. In this study area it is proposed RFD's by considering the following criteria's.

Minimum distance between two RFD's has been considered as 25mts.

Almost at every 1mts. elevation i.e. vertical height has been proposed for two successive RFD's.

Check Dams:

In general these are constructed in lower order streams up to 3rd order with medium slopes. These are proposed where water table fluctuations are very high and the streams are influent and/or in internally effluent. A minimum catchment area of 25 ha should be there. The upstream slope of the area should be flat to gentle so as to retain maximum quantity of water with less height of check dam (which is cost effective too). The parameters to be considered are slope; rock type, thickness of watershed strata; fracture; depths to bed rock, side slopes for economy of structures. The water stored can be used for life saving irrigation by gravity irrigation. Proximity for village and road is also considered.

Gabion structure:

In the study area along the main stream it has been proposed to construct Gabion structures. The parameters that are considered for proposing these structures are as follows.

Along the main stream the depth of the nala is little bit high so that the water flow at this main stream is high. To retain the water flow in between the Check dams it has been proposed for Gabion type structures all along the main stream in between to the Check dams.

Percolation Tanks/Nala Bunds:

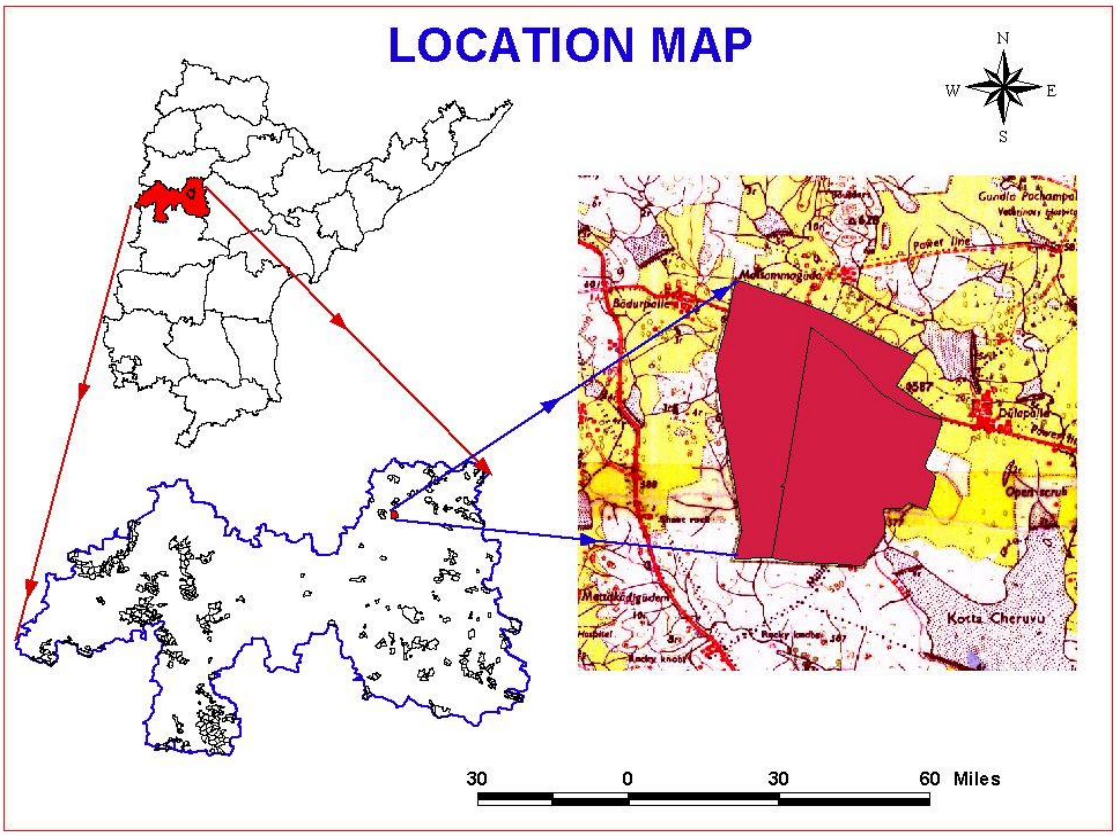
Nala bunds and percolation tanks are structure constructed across nalas (streams) for checking velocity of runoff, increasing water percolation and increasing soil moisture regime. Nala bunds are less expensive, smaller in dimension and constructed using locally available material where as percolation tanks are large and more expensive.

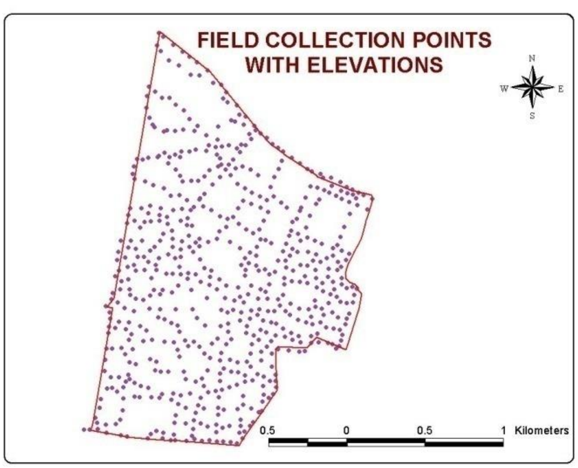
These are constructed to collect surface runoff coming from the catchment and facilitate percolation of stored water into the soil substrata with a view to rise groundwater level in the zone of influence of the nala bund/percolation tank to arrest sediment yield which would otherwise reach the multipurpose reservoirs and reduce their useful life. The sites should be selected in a relatively flatter nala reach; the slope of the nala should not be more than 2 percent. As far as possible, the catchment area of the percolation tank should not be less than 40 ha. There should be proper site for construction of emergency spillway by the side of the tank. The nala bed should have soils with adequate permeability and good fracture development to facilitate good groundwater recharge.

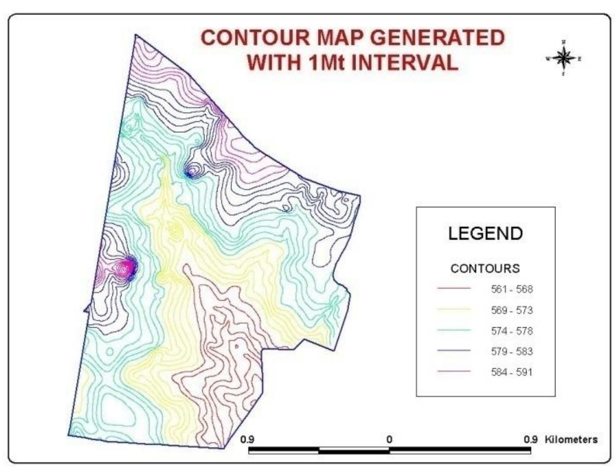
The final action plan:

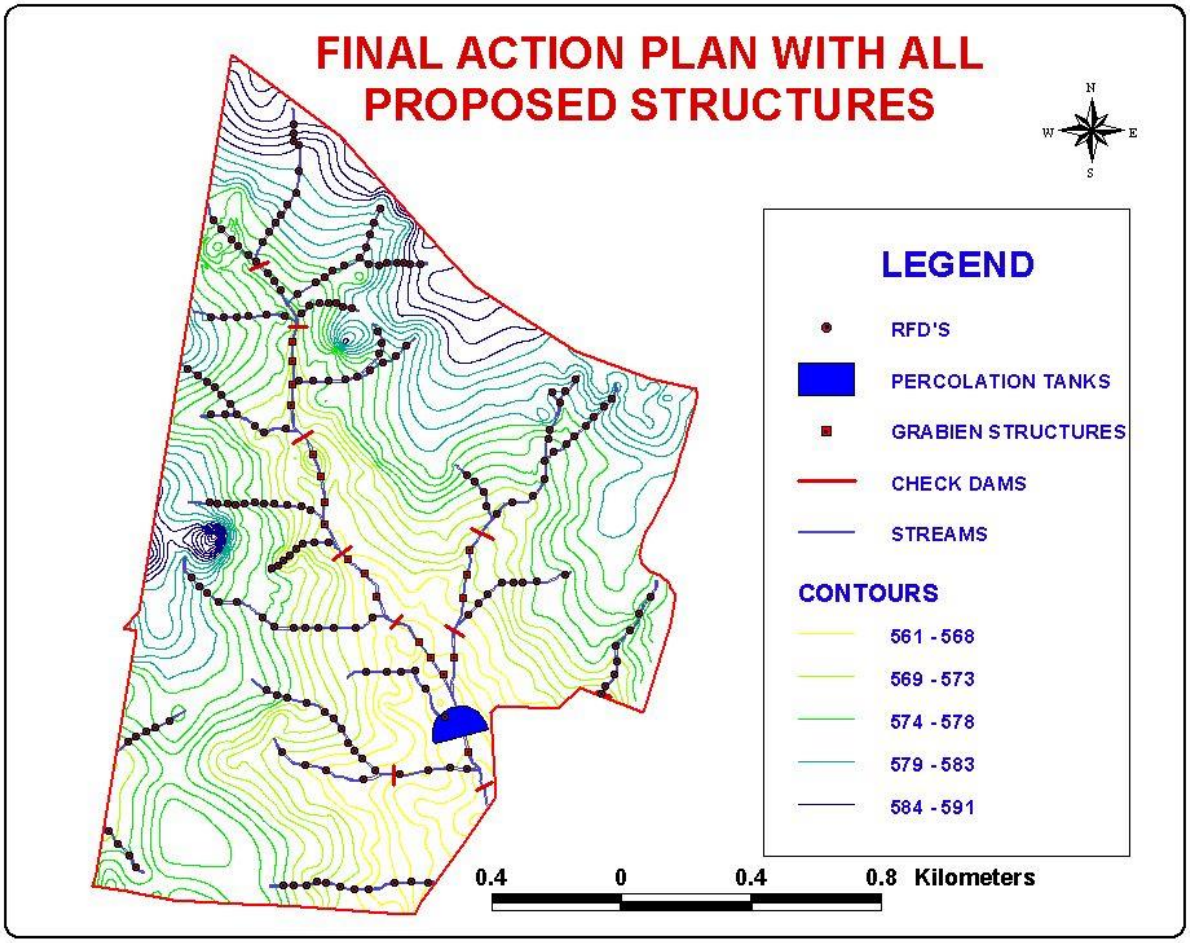
The final action plan is prepared with all the proposed structures in showing on the map. The following table showing the different structures quantity wise.

S. No.	Structure	Quantity in number
1	Rock Fill Dams	189
2	Check Dams	10
3	Grabien Structures	19
4	Percolation Tanks	1









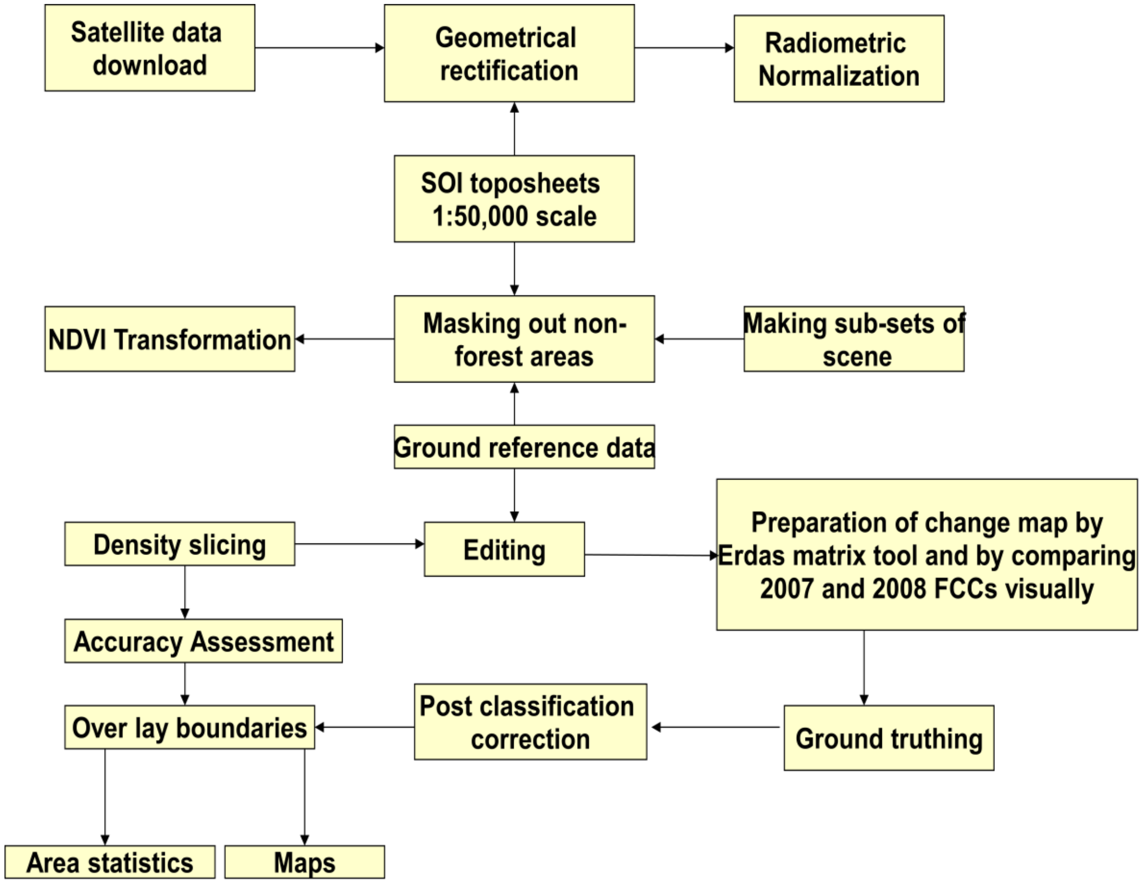
6.2 Vegetation Cover Mapping

Vegetation plays a key role in reducing ambient temperature, moisture and pollutant capture, energy use and subsequent ground level ozone reduction. In recent years vegetation mapping has become increasingly important, especially with advancements in environmental economic valuation. The spatial information from the remote sensing satellites enables researchers to quantify and qualify the amount and health of vegetation. Significance of remote sensing in the vegetation mapping of Telangana region using satellite imageries from LISS III and LISS IV. NDVI slicing cum editing, unsupervised classification, Supervised maximum likelihood classification was implemented in our approach. The final classification product provided identification and mapping of dominant land cover types, including forest types and non forest vegetation. Remote sensing data sets were calibrated using a variety of field verification measurements. Field methods included the identification of dominant forest species, forest type and relative state-of-health of selected tree species. Ground truth information was used to assess the accuracy of the classification. The vegetation type map was prepared from the classified satellite image. The dry deciduous forests constitute major portion of the total forest area. The application of remote sensing and satellites imageries with spatial analysis of land use land cover provides policy and decision makers with current and improved data for the purposes of effective management of natural resources

6.2.1 Vegetation Cover & type Mapping (Methodology)

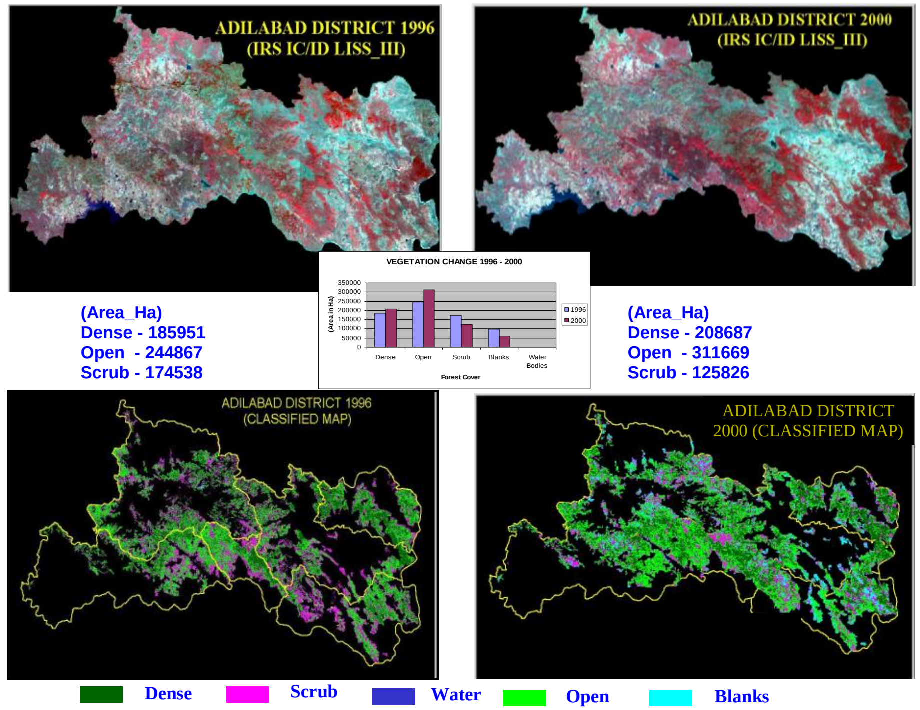
It is very crucial to monitor every Hectare of the forest land, whether it is improving or depleting. The synoptic view of satellites provides an opportunity to do that. The LISS-III images of 23.5 meter pixel size of IRS P6 satellite are very ideal to do it. Forest cover Monitoring is taking place in AP since 1996. Earlier to 2007, the forest was classified taking canopy of more than 0.4 density as a single class as dense forests. But in 2007, the forest is classified taking an extra class of VDF and 2008 image is compared to localize the changes. Repeated classification is avoided in the process and only changes are vectorised/ polygonised. These changes apart from areas of different classes in 2007 and 2008 are brought out.

The satellite data were rectified using scanned toposheets on 1:50,000 scale and then for all districts NDVI slicing cum editing, unsupervised classification, Supervised maximum likelihood classification were used to get the classification giving the best result. It was found out that in many cases NDVI slicing cum editing was giving equal or superior result and so for many districts NDVI slicing and editing was adopted. The brief technique adopted for image processing & change detection between 2007 & 2008 is given schematically below.



Class	**Canopy Density**	**Remarks**
Very Dense Forest	0.7 and above	
Dense forest	0.4-0.7	
Open forest	0.1-0.4	
Scrub forest	<0.1	
Water bodies		Streams, ponds and lakes, waterlogged
Blanks/others		Areas devoid of vegetation, fallows, etc.
Mangrove forest		Land covered with mangrove vegetation

Canopy Density Status in various seasons of Adilabad District

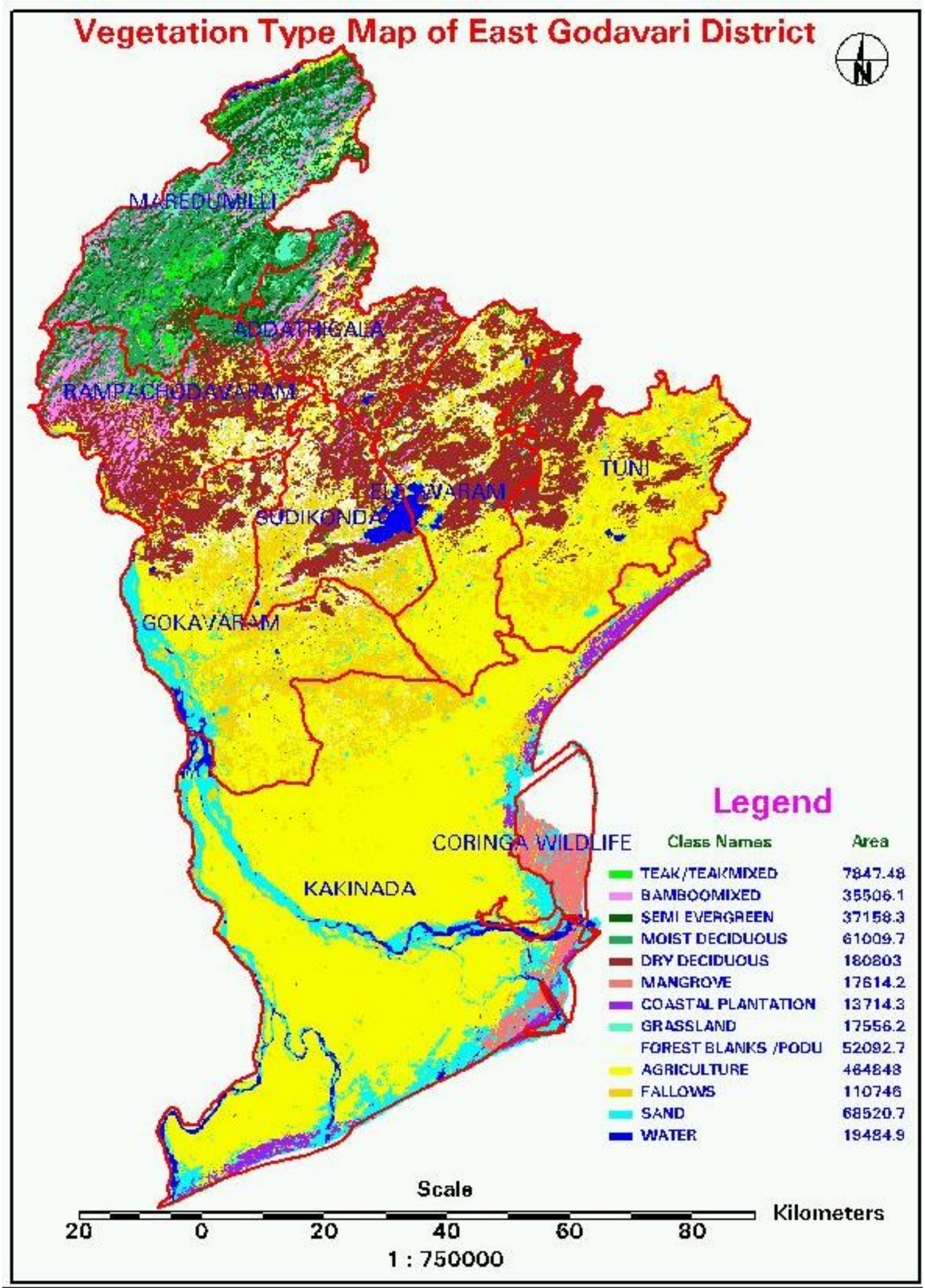


6.2.3 Vegetation Type Mapping:

The type map can be generated by adopting appropriate classification (specific to area) scheme is as under (for East Godavari District)

Bamboo mixed
Semi evergreen
Dry Deciduous
Mangrove
Coastal Plantation
Grassland
Forest Blanks / Podu
Agricultural
Fallows
Sand
Water
Moist Deciduous
Teak / Teak mixed

The classification can be performed using neural networks / semi-supervised techniques. The ground inventory data for which the sampling points will be generated using probability proportionate stratified random sampling will be analyzed using primary and secondary analysis of vegetation to estimate various indices. This data can be inputted to Satellite imagery and the type map can be generated.



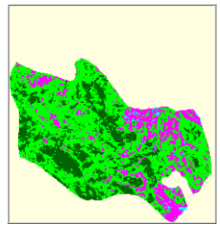
VEGETATION CHANGE IN SINGLE VSS

AMEENGUDA - 1996

DATE OF PASS: 3rd Nov'96

DENSE – 239.90
OPEN – 774.49
SCRUB – 466.10
BLANKS – 37.79

AMEENGUDA - 1998

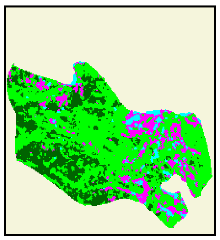


DATE OF PASS: 11th Dec'98

Area in Ha

DENSE – 367.20
OPEN – 884.62
SCRUB – 249.24
BLANKS – 17.22

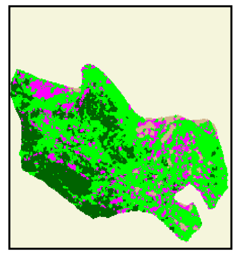
AMEENGUDA 1999



DATE OF PASS: DEC'99

DENSE	341.22
OPEN	900.05
SCRUB	194.74
BLANKS	71.36

AMEENGUDA 2000



DATE OF PASS: 6th Nov'2k

DENSE	380.79
OPEN	842.63
SCRUB	235.29
BLANKS	53.97

Forest Fire Risk Zonation Mapping

6.3 Introduction

Forest is one of the most important renewable natural resources and has significant role in the human life and environment. Forest not only produce wood, both commercial timber and fuel wood, but they also protect wildlife and give them suitable environment, maintain the watershed balance and groundwater content, protect the soil fertility, and absorb carbon and another pollutant gasses from the atmosphere. All of these forest functions influence to the continuity of life and has a global aspect. Due to natural causes and human activity forest has been degrading, both forest area degradation and forest condition and quality. Forest area decreased in huge number annually. Forest quality degrades on its productivity, degrade in biodiversity, and degrade on its capability to fulfill the forest function. One of the main causes that responsible to forest degradation is forest fire. Roughly 175 million acres of forest and grassland are burned each year worldwide. Due to large-scale human deforestation activities, grassland fires, and naturally occurring wild fires around the world, biomass burning is a major source of greenhouse gases and aerosols (tiny liquid or solid particles suspended in the atmosphere). These "emission products" significantly impact atmospheric chemistry, clouds, and the Earth's atmosphere.

Forest fires are a calamity for forests of temperature climate zones in view of the fact that the damage they cause to the forest economy is considerably greater than all the damage caused by harmful insects and diseases of wood taken together. Forest fires retard the vital activity of forest crops, subsequently encouraging the multiplication of pests and fungal diseases. Fire destroys not only greenwood and harvested timber, but also construction material in the forest many species of animals and edible birds as well as fodder grown for domestic animals, etc. Forest fires destroy the raw material resources of the timber industry, causing untimely closure of industrial bases or their transfer to the other regions. In case of large fires which acquire the character of natural calamity, the extent of atmospheric smoke content can be so high that water and air transport come to a standstill for long periods.

In spite of the development of many fire control methods and techniques, large forest fires continue to remain a common phenomenon. Therefore, the problem of controlling forest fires has been and remains a most urgent issue in the forest economy of our country.

A study made by the Forest Survey of India reveals that 51% of the forest area in Assam and Gujarat, 93% in Arunachal Pradesh, 67% in Bihar, 69% in Himachal Pradesh, 46% in Jammu and Kashmir, 76% in Madhya Pradesh, 94% in Meghalaya and Orissa, 87% in Nagaland, 58% in Uttar Pradesh and 33% in West Bengal is subject to repeated annual fires.

In Andhra Pradesh 23% of geographical area is covered under forest which is very vital for maintaining the ecological balance of state. Forest consists of basically Southern Dry mixed Deciduous type with species like Teak, Terminalia, Anogeissus, Bamboo, Dalbergia, Lannea etc., The leaf fall starts towards the end of the December and along with dry grass it forms a highly combustible material for forest fires. Fire takes place due to natural and anthropogenic activities.

6.3.1 Forest Fire – Main causes:

The causes of the forest fires can be classified in three main categories

i) Natural
ii) Intentional/deliberate due to man and
iii) Unintentional/accidental due to man.

6.3.2 *Natural:*

Natural fires occur mainly due to lightning or sometimes due to rolling stones and rubbing of dry bamboos with each other in the strong wind. Nothing can be done to avert such fires.

6.3.3 *Intentional/Deliberate:*

Intentional/deliberate are the ones most commonly reported. Fires are set in forests for inducing luscious growth of grass for better grazing. Villagers sometime set fire to drive away the game destroying their crops and to catch the wild animals running away. The enmity with forest staff is also responsible for incendiary activities in forest areas by neighboring rural population. Fires are also caused by villagers for collecting minor forest produce (MFP) like honey, mahua, flowers etc. that fall on the ground. Sparks from coal-fired railway locomotives may also cause forest fires. Nothing much can be done to prevent a fire if it is a willful act on the part of local dwellers. However, occurrence of the fire can be averted if it is the result of unintentional activities of the innocent tribal or the natural factors.

6.3.4 *Unintentional/Accidental:*

Unintentional/accidental fires occur in a forest due to careless throwing of match-sticks and burning ends of cigarettes/bidis carrying of naked fire by people passing through forests, spread of fire from labor camps and recreation or picnic sites. These are the factors governed by parameters like vicinity to settlements and distances from roads. For any area to be prone to fire depends on many factors such as vegetation type/density, soil type, humidity of the area, vicinity to settlements, distances from roads and the host of others. While it is not possible to account the natural occurrences or the deliberate attempts, the areas prone to accidental fires can be mapped.

6.3.5 Factors influencing forest fires:

To ignite a fire there are three prerequisites 1.Fuel 2. Heat and 3. Oxygen. All these elements have to be present for a fire to start and continue burning. Fire basically, depends on fuels (type, quality etc.) than on any other factor. Forest fuels can be classified into three categories i.e. ground fuels, surface fuels and aerial fuels. Ground fuels include duff, decayed wood & humus. A surface fuel consists of loose litter like freshly filled foliage, twigs, etc. It also includes herbaceous plants and low shrubs. Aerial fuels include the under story and upper canopy.

The prominent among the possible factors leading to accidental fires are

- ***Vegetation type/density***:

Dry and dense vegetation is obviously more susceptible to fire than the moist and sparse one. Vegetation with less than 10% moisture content ignites readily, while the moist take time in igniting/burning.

- ***Climatic factors:***

Of the four environmental factors viz., climatic, edaphic, physiographic and biotic, climatic factors influence fires the most. The climatic regime determines the vegetation in a region and hence plays dominant role in ascertaining the fire-prone sites. Drier the climate, more prone would be the site.

- ***Physiographic factors***:

Physiographic factors, viz., altitude, aspect and topography, influence climatic conditions, and therefore, indirectly affect the vegetation. Aspect plays vital role in spreading of the fire. Southern slopes exposed to direct rays of Sun are more vulnerable to catching fire.

The physical shape and the features also contribute a lot to the stating and spreading of fire. On a upward slope warm air raises & cause, preheating of the fuel, because of which fire moves faster on upward slope than on flat ground or down ward slope. An upward slope also provides the connectivity of the flames to the fuels and fire moves faster upwards. It is seen through number of observations that slope can be more important than wind in determining the rate of fire spread.

The aspect determines how much sunlight it receives. In India Southern & Western aspect receive most sunlight and so they are much warmer and drier than northern aspects, which get least sunlight. Northern aspects have also more moisture and they stay green for longer period. Southern and western aspects have a longer fire seasons, and longer burning period per fire incidence than northern aspects.

- ***Edaphic factors***:

Soil and vegetation are mutually dependent on each other. If soil influences growth of plants, vegetation adds to richness of soil and thus is an important factor.

- ***Distance from roads:***

The man, animal and vehicular movement and activities on the road provide enough scope for accidental/man-made fire. Nearer the roads would be the chance of fire.

- ***Vicinity to settlements***:

The areas near to the habitats/settlements are more prone to fire since the habits/cultural practices of the inhabitants can lead to incidental fire.

6.3.6 Fire and Deforestation

In India about 2-3% of forest areas are affected annually by fire and on an average over 34000 ha forest areas are burnt by fire every year. (Anon, 1991) Continuous fire can charge the composition of species in vegetation, which may slowly give way for more fire resistant and scrub type of forests which may further lead to total opening of the area leading to soil erosion etc.

6.3.7 Study of forest fire using Remote Sensing and GIS

Remote Sensing and GIS technologies can be effectively used to

1. *Mapping of fire burn areas*
2. *Fire prone area zonation*

Satellites like Indian Remote Satellite (IRS), Land sat, Spot, and NOAA are highly useful in monitoring changing earth environment and its natural resources by providing a synoptic view of large area in multi-spectral and multi-temporal domains. The Vegetation type and density maps can be prepared from RS Data.

Satellite borne sensors have borne effectively and extensively used for providing information on natural calamity like floor, earthquake, and drought and of course forest fires.

The risk of forest fire is pressing problem in Indian subcontinent because of presence of various types of forest and particularly extensive presence of Dry deciduous, and moist deciduous forests, both tropical & subtropical zones. The presence of longer dry period from winter to summer makes the forests more vulnerable for fire accident.

The evaluation of this risk is therefore of primary important in the context of environment & forest management. Remote Sensing helps in providing a number of layers of thematic information required for interactive the analysis through Geographical Information System (GIS).

6.3.8 Need of present study

The study area Bhadrachalam south Division in Andhra Pradesh is dominated by Southern dry mixed deciduous forests with lot of grass as under story hence highly vulnerable for fire incidences. The areas of semi evergreen / moist mixed forests are relatively less vulnerable to fires but the influence from adjoining areas may ignite fire. Every year the forests are burnt due to number of causes. In this background the area has been selected for this particular study to evaluate the fire prone areas and study the influence of different parameters affecting the fire.

6.3.9 Description of study area

Name of the Study area	Bhadrachalam South Division
Forest Division	Bhadrachalam South Division
Forest Circle	Khammam
Revenue district	Khammam
State	Andhra Pradesh
Location	between 81.096^{1} N to 81.813^{1} N Latitude and 17.462^{1}E to 17.901^{1}E Longitude
Area	173924 Ha (Geographic Area) 128634 Ha (Forest Area)

6.3.*10 Topography:*

The terrain of the district is generally undulating, and intercepted with hills and hill locks. There are few minor isolated lines of hills which traverse the central and eastern parts of the district. The range of hills stretches from parkal (Warangal district) and singareni to Aswaraopeta in south east bounding the lower Godavari valley. The most important hills in the district are marrigutta, rajugutta and yerragutta. At some places the district encounters with isolated perks and rocky clusters. The elevation varies from about 12 meters in the plains to about 1220 meters above mean sea level in rekapalli hills in bhadrachalam south division.

6.3.*11 Drainage – Rivers:*

The important rivers, which drain the district are the godavari, the sabari mumeru, kinnersani (Kinnarasani) paler, Akher and wyra (wira). Godavari enters the district near channapalli village in nagur taluk. After traveling a distance of 181 Kms. In south eastern direction, it leaves the district at Kollur village of bhadrachalam taluk at papi hills.

6.3.*12 Geology and Rock:*

Khammam district is endowed with the most various types of rocks and mineral deposits. A rare type of under saturated alkaline rock known as Nepheline Syenite is found in this district only. As regards the mineral wealth, it is rich in coal deposits and has considerable reserves of iron – ore, marble, lime stone and dolamite, in addition to several other minerals such as copper ore, chromite, galena, graphite, Barytes, Coruudum, Kyanite, Garnet and Mica which are available in less quantities. The two heart spring known from the state are situated in Bhadrachalam division. Considering the entire above aspects khammam district can appropriately be called as the nature's Geological museum of Andhra Pradesh.

6.3.*13 Soil Type:*

6.3.*14 Sandy Soils:*

They are derived from Ground Water formation inter mingned with patches of other types of soils, are of variable depths and are poor and infertile as they are derived of nutrients and cementing material. Percolation is good in these soils. These soils are mostly found in Khammam and Kothagudem divisions.

6.3.*15 Black Soils:*

Black soils are fertile. Due to expansion and contraction large cracks occur in dry weather. They contain lime, magnesium, Iron, Aluminum, Potash but poor in Nitrogen, Organic matter and Phosphoric acid. These soils are found in a belt blonmking the Godavari in reserves and unreserves in Bhadrachalam North ,Bhadrachalam South and Paloncha divisions. They are found in same places in madhina taluk also.

6.3.*15 Brown Earths*

They differ from black soil in colour proportion of organic matter in the humus layer. The rainfall is usually less in these areas. They are found in the Bhadrachalam North ,Bhadrachalam South and Paloncha divisions.

6.3.*16 Red Loamy Soils:*

They are derived from the metamorphic rocks and found all over the area in patches with variable depths. The solis on the whole are deficient organic matter, Nitrogen Phosphate and other plant Nutrients. These soils are found in patches all over the circle.

6.3.*17 Skeletal Soils:*

These are mostly found in hilly slopes and devoid of vegetative growth. The soils occur all over the circle at varying extent.

6.3.*18 Climate:*

The climate of the circle is characterized by hot summer and good seasonal rainfall. The summer season is from about middle of February to about first week of June. April and May are the hottest months in the year. The high hills experience less temperature due to their elevation. Hot and strong winds blow in the afternoon from March. Occasionally dust forms in the hot weather are common factor; occasionally shower occurs in hot weather sometimes becoming heavy storms. The south west monsoon season which follows lasts up to end of the September. It is generally hot in summer touching the mercury up to 122°F and cold in winter, minimum reaching 45°F. October and November months constitute the post monsoon or retreating monsoon season. The average rainfall in Khammam district is 1081.1mm which is highest in Telengana, Kunavaram, Bhadrachalam, Nugur and Burgampad are frequently affected by floods in rainy season because of fury of the river Godavari and Sabari. The weather is generally pleasant and fine from November to middle of February.

6.3.19 *Water Supply:*

The position in regards to drinking water in the district or circle is on the whole satisfactory. Generally wells constitute the chief sources of water supply. In recent years bore wells are established at many places and they are sources of drinking water when in good condition. In some areas the taluks of Kothagudem, Nugur, Badrachalam and Burgampadu people in the riparian villages resort to rivers and streams. Water table generally ranges from 25` to 30` (7.62 – 9.14m) in Khammam, Madhira and Burgampadu taluks. In some areas rocky soils render digging of wells difficult. The wells drying in summer completing the villages to fall back on rivers and streams for there supplies.

6.3.20 *Vegetation:*

The area is dominated by southern dry mixed deciduous forests mainly teak and bamboo, semi evergreen and moist mixed forests with rich understorey.

Objective: To develop fire hazard rating index and to map fire burnt areas.

Materials and Methods

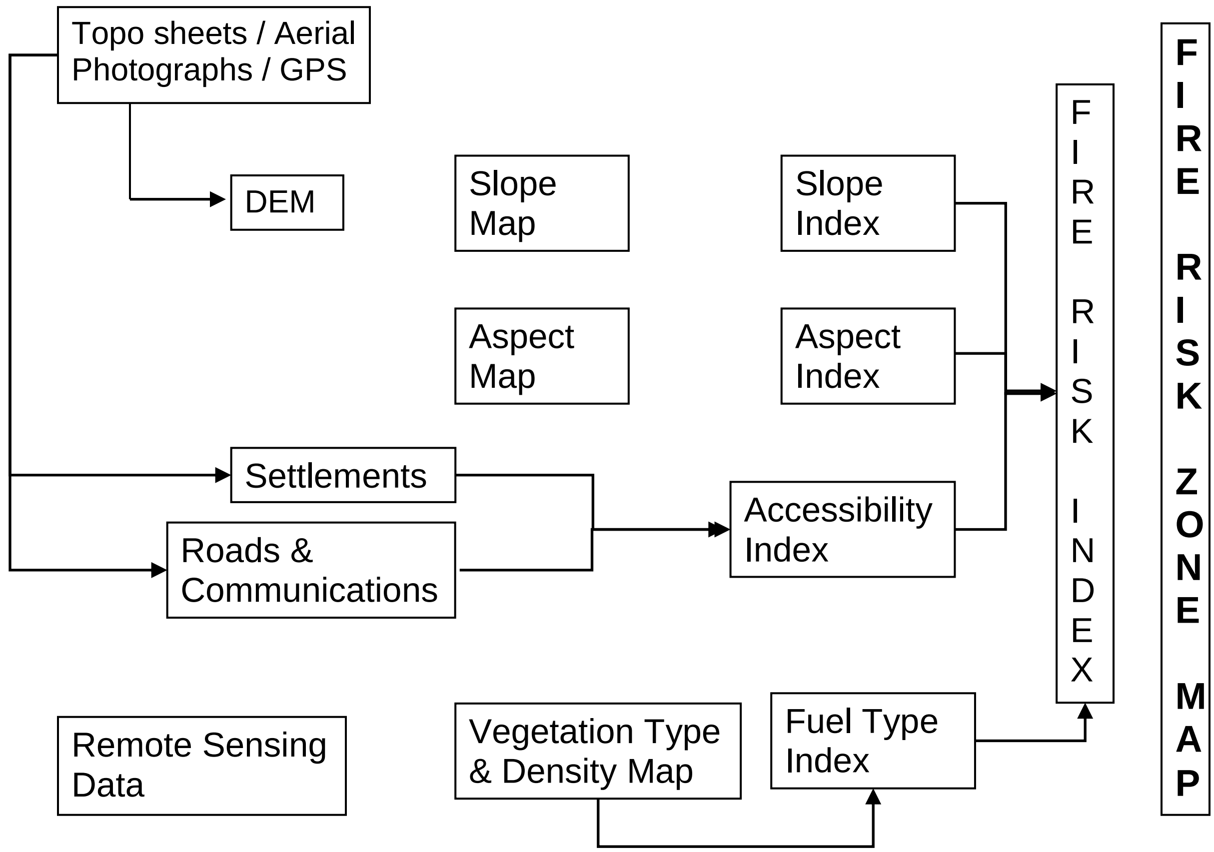
Data

Satellite data	IRS IC/ID LISS III FCC December 2000, May 2001
Ancillary Data	❖ Survey of India (SOI) topo sheets of 1:50000 Scale, to prepare base map, road map, settlement map, DEM map and also for field work and ground truth verification. ❖ Forest working plans from forest department ❖ Demographic data from revenue department. ❖ Meteorological data from dept of meteorology

Systems and Software:

1. Arc/Info 8.0.2 NT WorkStation.
2. ArcVeiw 3.2(a).
3. ERDAS Imagine 8.5.1
4. Pentium III PC
5. Windows NT operating system
6. Laser Printer, Plotter and other required material

Methodology:



Modeling*:* The various spatial data layers vegetation layer, slope layer, aspect layer, road layer can integrated for modeling the fire risk zone. Integration of these layers will be done in a hierarchical scheme. Different layers have different degree of influence on fire. According to field observation, past fire data, vegetation characteristics the variables will be weighted in the following order vegetation, aspect, slope and road. Rankings are to be given to each variable as per their influence. The weight factor contributes to the degree of influence in the modeling. The rankings to vegetation type can be given basing on the fuel content found in each type.

The slope rankings will be given basing on the fact that higher slopes are more prone to fire as well as fire spread is very fast.

South and South-West and west aspects will be assigned the highest rankings because of the fact that they receive the maximum sunlight and are warmer, making the fuel dry and providing the heat to ignite the fire. A comprehensive list of weightages assigned to various parameters is given in below tables.

The above layers will be overlaid basing on various variables-classes and its values and its corresponding weightages described as under.

TableNo.1

Sl No	Variable	Weightage	
1	Vegetation Type	7	10
2	Canopy Density	1	2
3	Slope	1	2
4	Aspect	1	2
5	Villages	2	3
6	Roads	2	3

Table No.2

Variable	**Class**	**Ranking**	**Fire sensitive**	**Value**
1. Vegetation Wt. 7	Pure Bamboo	5	Highest	100
	Grass lands Bamboo Mixed Pure Teak	4	Higher	90 87 85
	Teak Mixed Red Sanders Mixed Teak	3	High	80 70 67
	Mixed / Miscellaneous Miscellaneous scrub Sal Mixed	2	Moderate	60 50 35
	Coastal Plantations Semi evergreen Moist Mixed Mangroves Water body	1	Low / No Risk	10 3 3 1 1
2.canopy	**Class**	**Rankings**		**Value**

Density	Dense Canopy	4	High	100
Wt.1	Open canopy	3	Moderate	90
	Scrub	2	Low	50
	Blanks/Others	1	Low	5
3. Slope	**Class in degrees**	**Rankings**		**Value**
Wt. 1	0-5	1	Very Low	20
	5-15	2	Low	40
	15-30	3	Medium	60
	30 and above	4	High	100
4. Aspect	**Class**	**Rankings**		**Value**
Wt. 1	N, N/E	1	Low	40
	E, S/E	2	Medium	60
	N/W,S	3	High	80
	W, S/W	4	High	100
5.Road	**Class (Buffer)**	**Rankings**		**Value**
Wt. 2	2500-1500 mt	1	Low	25
	1500-500 mt	2	Medium	45
	500-0 mt	3	High	100
6.Villages	**Class (Buffer)**	**Rankings**		**Value**
Wt. 3	2500-2000 mt	1	Low	30
	2000-1500 mt	2	Medium	45
	1500-1000 mt	3	High	55
	1000-500 mt	4	High	100
	500-0 mt	5	High	75

A typical equation for fire hazard zonation will be

$$FR = \sum Wij(Vi) * wi$$

Where FR is Fire Risk Index

V_i is the Variable

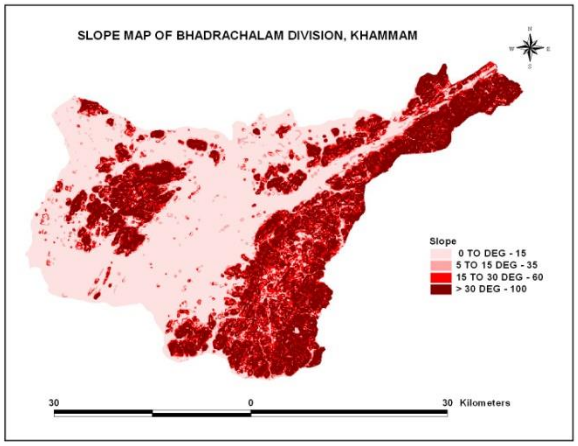
W_{ij} is the Weightage of the j^{th} class of a variable Vi

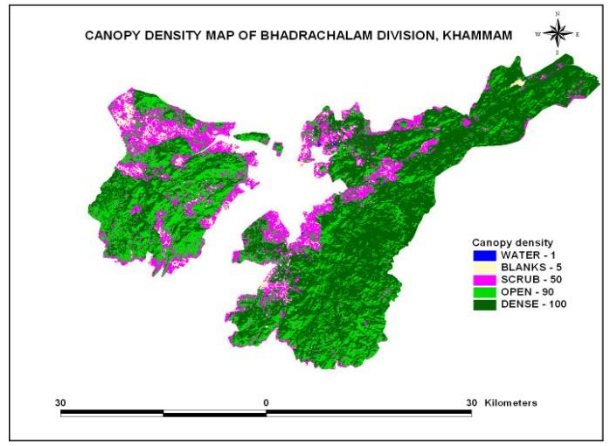
w_i is the individual weightage value to a particular variable Vi

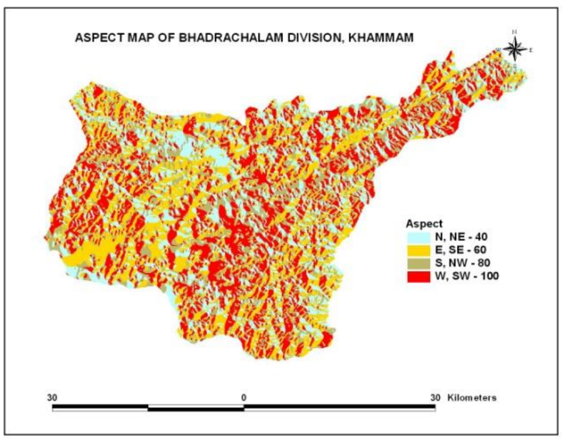
(Or)

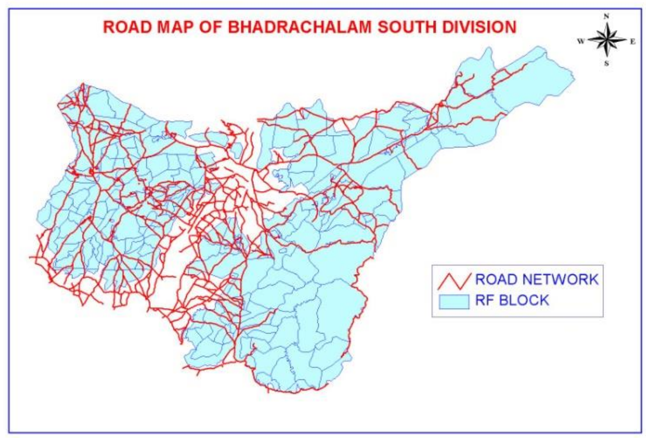
FR = w_a * Aspect + w_d*Density + w_t * Type + w_s * Slope + w_v * Village + w_r * Roads

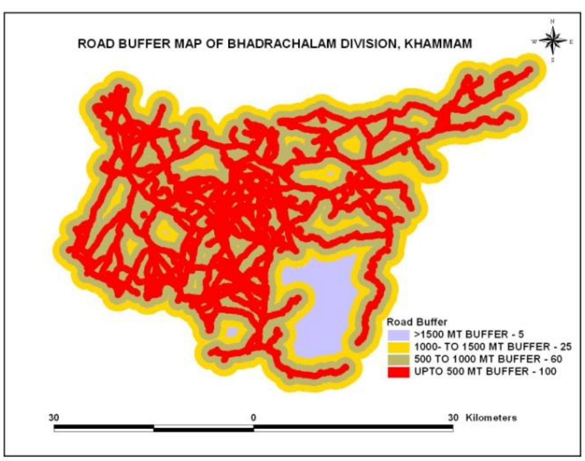
The modeling can be performed using either vector or raster overlay. The output obtained will be generalized with respect to the fire index and minimum area criteria and Fire hazard-rating map will be generated.

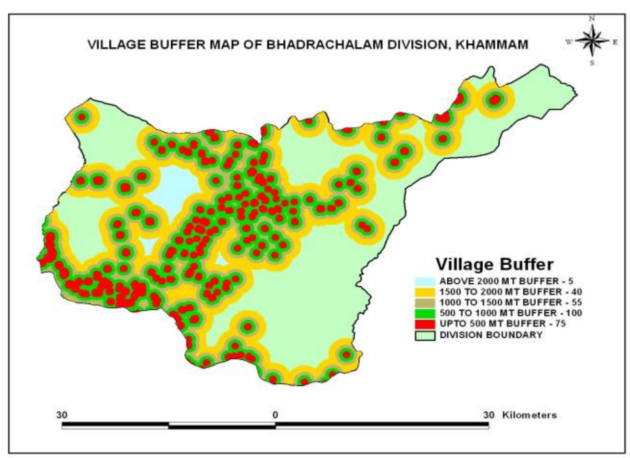

SLOPE MAP OF BHADRACHALAM DIVISION, KHAMMAM
Slope
0 TO DEG - 15
5 TO 15 DEG - 35
15 TO 30 DEG - 60
> 30 DEG - 100
30
0
30 Kilometers

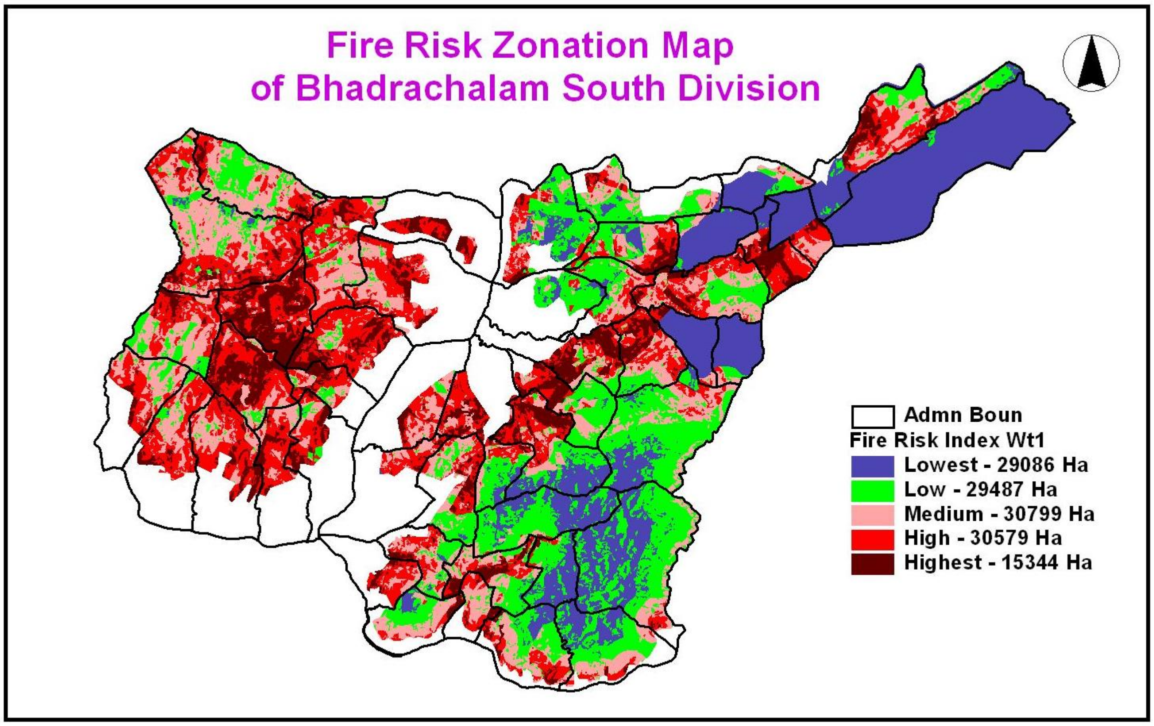

CANOPY DENSITY MAP OF BHADRACHALAM DIVISION, KHAMMAM
Canopy density
WATER - 1
BLANKS - 5
SCRUB - 50
OPEN - 90
DENSE - 100
30
0
30 Kilometers


ASPECT MAP OF BHADRACHALAM DIVISION, KHAMMAM
Aspect
N, NE - 40
E, SE - 60
S, NW - 80
W, SW - 100
30
0
30 Kilometers


ROAD MAP OF BHADRACHALAM SOUTH DIVISION
N
W
E
S
ROAD NETWORK
RF BLOCK


ROAD BUFFER MAP OF BHADRACHALAM DIVISION, KHAMMAM
Road Buffer
>1500 MT BUFFER - 5
1000- TO 1500 MT BUFFER - 25
500 TO 1000 MT BUFFER - 60
UPTO 500 MT BUFFER - 100
30
0
30 Kilometers


VILLAGE BUFFER MAP OF BHADRACHALAM DIVISION, KHAMMAM
Village Buffer
ABOVE 2000 MT BUFFER - 5
1500 TO 2000 MT BUFFER - 40
1000 TO 1500 MT BUFFER - 55
500 TO 1000 MT BUFFER - 100
UPTO 500 MT BUFFER - 75
DIVISION BOUNDARY
30
0
30 Kilometers



WILDLIFE HABITAT MAPPPING

Introdution

The conservation of wildlife species is an important issue. GIS and Remote Sensing Technology plays a vital role in the wildlife analysis. Spatial ecology is the study of patterns and processes occurring in a geographic space or landscapes that influence characteristics of plant and animal populations such as densities, distributions and movements (Clark et al. 2008). Remote Sensing techniques and use of GIS for mapping the endangered species can be conducted to help in understand the environmental factors (including land, soil, climatic condition) responsible for the extinction of species.

When two or more larger areas of similar wildlife habitat join, it creates a linkage of wildlife habitat, generally native **vegetation known as** a Wildlife Corridor. The allowance for the movement of animals and continuation of viable populations make corridors critical for the maintenance of ecological processes. Corridors can enable migration, colonization and interbreeding of plants and animals by providing landscape connections between larger areas of habitat. Across the landscape a sequence of stepping stones (areas of habitat such as paddock trees, wetlands and roadside vegetation are discontinuous), lineal strips of vegetation and habitat are continuous (e.g., riparian strips, ridge lines), consist corridors which may be parts of a larger habitat area which has been selected for its nature or likely importance to local fauna.

The two main contributors which continue in the decline of biodiversity across the landscape are habitat loss and fragmentation. An extremely important role in the maintenance of biodiversity is played by the corridors, but they can only partly compensate for the overall habitat loss produced by the fragmentation of the natural landscape. Therefore, it is important, for the maintenance of the vegetation remnants and vegetated corridors for enhanced network across all lands both private and public. In this way private landscapes can contribute to wider landscape conservation efforts by enhancing and linking existing reserves and conservation networks.

Objective: The objective of wildlife habitat mapping is to provide input to land-use planning by providing estimated habitat values for wildlife species of management concern.

The evolution of GIS, the Global Positioning System (GPS), and Remote Sensing (RS) technologies has enabled the collection and analysis of field data in ways that were not possible before the arrival of computers (Sonti 2015). An analysis of the complex inter relationship among the various environmental factors existing over a geographical area involves us in **the study of wildlife habitat suitability**. In order to identify the most suitable and moderately suitable habitats, each model of GIS should be applied.

Each model involves a study of life consisting requisite factors

- food and cover including forest type,
- topography,
- water resource,
- distance from human activity center and other factors

Data required

- Field investigations with GPS
- Satellite imagery (Type, Density can be derived)
- SOI topographic maps
- Thematic layers includes
    - Water resources
    - Slope and aspect
    - Road network
    - Village locations

The GIS database can be integrated in a complex GIS environment to generate the suitable habitat maps. Suitability is the ability of the habitat in its current condition to support a particular species. The GIS model is used to generate a habitat map by assigning ratings to different habitat types, based on the needs of the species for particular life requisites. These kinds of maps are very useful in obtaining a clear idea about habitat suitability for animal species and wild life corridors.

Habitat-rating schemes for different knowledge levels of habitat requirements

<table>
<tr><td>Percent of Local Benchmark</td><td colspan="2">I-class(Substantial Knowledge of Habitat Use)</td><td colspan="2">III-class (Intermediate Knowledge of Habitat Use)</td><td colspan="2">V-class (Limited Knowledge of Habitat Use)</td></tr>
<tr><td></td><td>Class</td><td>Rank</td><td>Class</td><td>Code</td><td>Class</td><td>Code</td></tr>
<tr><td>76 - 100 %</td><td>High</td><td>1</td><td>High</td><td>H</td><td rowspan="3">Habitat Useable</td><td rowspan="3">U</td></tr>
<tr><td>51 - 75 %</td><td>Moderately high</td><td>2</td><td rowspan="2">Moderate</td><td rowspan="2">M</td></tr>
<tr><td>26 - 50 %</td><td>Moderate</td><td>3</td></tr>
<tr><td>6 - 25 %</td><td>Low</td><td>4</td><td rowspan="2">Low</td><td rowspan="2">L</td><td rowspan="3">Likely no value</td><td rowspan="3">X</td></tr>
<tr><td>1 - 5 %</td><td>Very Low</td><td>5</td></tr>
<tr><td>0%</td><td>NIL</td><td>6</td><td>Ni</td><td>N</td></tr>
</table>

Wildlife Habitat Mapping:

A final habitat ratings table was developed after field inspections and after a final list of ecosystem units was developed. Values are assigned using information from the species accounts, including assumptions, and from the wildlife report generated from field data. We generated wildlife habitat maps by applying the ratings table values for each map theme (i.e. habitat use / life requisites for each species) onto the spatial and non-spatial data.

Multiple map themes were displayed on the habitat-use map for some species, using a hierarchy of critical habitat requirements and life requisites. As habitat uses may overlap, we ensured that the most critical habitat uses overlaid less critical habitat uses. Each map was assigned a set of colours that identify the theme and values mapped. Ratings were assigned to polygons with multiple ecosystem units using one of the following three methods;

- **Highest-value method** – the highest rating within each polygon is displayed, regardless of the area it represents. The highest-value method exaggerates the amount of high value habitat because the whole polygon may be colored high even if only a small part of it is actually high value. This method is used to highlight areas that have potential for high value habitat.

- **Averaged method –** the average rating within each polygon is displayed. Some parts of a polygon may be colored as having some value, even if those parts have little or no habitat value. Similarly, some parts of a polygon may be rated as having low value, although the habitat in those parts has high value.

- **Largest Area –** the rating for the ecosystem unit that covers the largest area of a polygon is displayed. We used buffers around specific habitat features to eliminate areas that would not be used because they are too far from another essential habitat.