NETAJI SUBHAS OPEN UNIVERSITY

STUDY MATERIAL

POST GRADUATE GEOGRAPHY

PAPER - 09

GROUP : B

Remote Sensing & Geographic Information System

PREFACE

In the curricular structure introduced by this University for students of Post-Graduate Degree Programme, the opportunity to pursue Post-Graduate course in subject introduced by this University is equally available to all learners. Instead of being guided by any presumption about ability level, it would perhaps stand to reason if receptivity of a learner is judged in the course of the learning process. That would be entirely in keeping with the objectives of open education which does not believe in artificial differentiation.

Keeping this in view, study materials of the Post Graduate level in different subjects are being prepared on the basis of a well laid-out syllabus. The course structure combines the best elements in the approved syllabi of Central and State Universities in respective subjects. It has been so designed as to be upgradable with the addition of new information as well as results of fresh thinking and analysis.

The accepted methodology of distance education has been followed in the preparation of these study materials. Co-operation in every form of experienced scholars is indispensable for a work of this kind. We, therefore, owe an enormous debt of gratitude to everyone whose tireless efforts went into the writing, editing and devising of a proper lay-out of the materials. Practically speaking, their role amounts to an involvement in 'invisible teaching'. For, whoever makes use of these study materials would virtually derive the benefit of learning under their collective care without each being seen by the other.

The more a learner would seriously pursue these study materials, the easier it will be for him or her to reach out to larger horizons of a subject. Care has also been taken to make the language lucid and presentation attractive so that they may be rated as quality self-learning materials. If anything remains still obscure or difficult to follow, arrangements are there to come to terms with them through the counselling sessions regularly available at the network of study centres set up by the University.

Needless to add, a great deal of these efforts is still experimental-in fact, pioneering in certain areas. Naturally, there is every possibility of some lapse or deficiency here and there. However, these do admit of rectification and further improvement in due course. On the whole, therefore, these study materials are expected to evoke wider appreciation the more they receive serious attention of all concerned.

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Vice-Chancellor

First Edition : November, 2018

Printed in accordance with the regulations of the Distance Education Bureau of the University Grants Commission.

NETAJI SUBHAS OPEN UNIVERSITY

Post-Graduate Geography
[M.Sc]

Paper : PGGR 09

Group : B

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PGGR on Remote Sensing & Geographic Information System

UNIT:1 □VISUAL IMAGE INTERPRETATION

Structure:

1.1 Introduction

Maps are the best tools available to geographers for portraying the geographical information into graphical formats. It is said that maps should be self explanatory. But for practical purposes, it is observed that the map reader should acquire certain skill so that the map may be read at ease. More over, by interpreting the base map, variety of maps may be prepared. Now a days with the advancement of various technologies, base maps are also considered as data. Initially traditional ground survey techniques were in use to prepare topographical sheets. Now a days remote sensing products in the form of aerial photograph and satellite imagery are extensively used for preparation and revision of topographical sheets. The main advantage of the toposheet is its annotation part. Moreover, with the help of conventional symbols it is easy to read the map. On the other hand, the identification and recognition of objects from aerial photograph or satellite imagery depends upon the readers' knowledge about the characteristics of the photo/image recorded in terms of *tone, texture, pattern, shape, size, shadow, situation, resolution* and

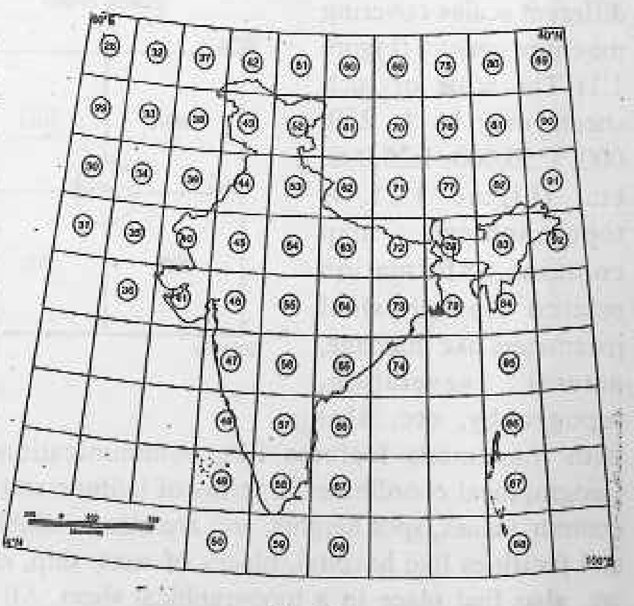


Fig. 1.1

spectral sensitivity, etc. Different colour clues are also important to open the secrecy of colour images. Repetitive coverage, synoptic view and uniform data set are the main advantages of satellite images. But spatial resolution is the main constrain for such products. Moreover, neither aerial photograph nor satellite imagery contains any annotation.

A topographical map is a map that represents the form of Earth's surface. It is available in different scales. For example, Survey of India publishes toposheets in different scales covering the entire country (Figure 1.1) The scale of such sheets may be 1: 250, 000, 1:50,000, 1:25,000. etc. (Figure 1.2). A topographical map contains information related to physical parameters like drainage, natural vegetation, topography, etc. along with man made features like communication network, settlement pattern, etc. Geographical coordinates in terms of latitude and longitude, administrative boundaries, contour values, spot heights, etc. are also available in a topographical sheet. Amenities and facilities like hospital, places of work ship, rest house and bunglow, market place, etc. also find place in a topographical sheet. All these information are represented in terms of different colours, symbols and texts (Figure 1.3). Thus to interpret a

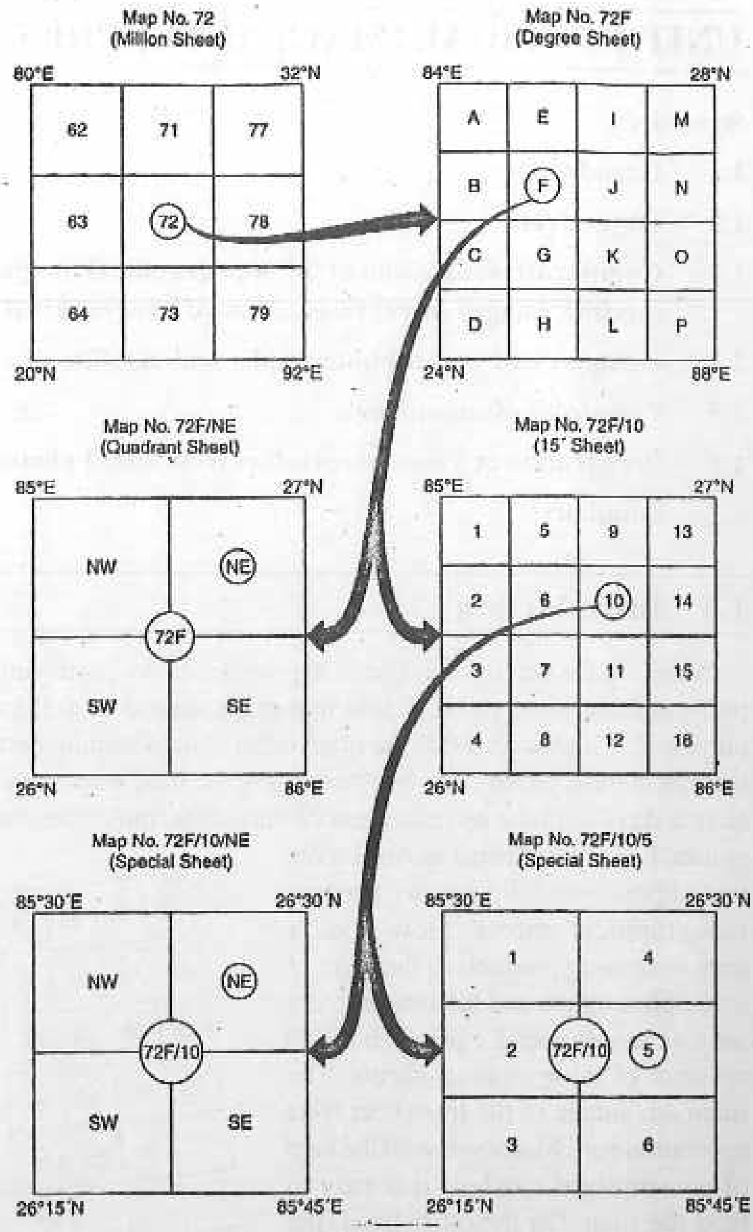
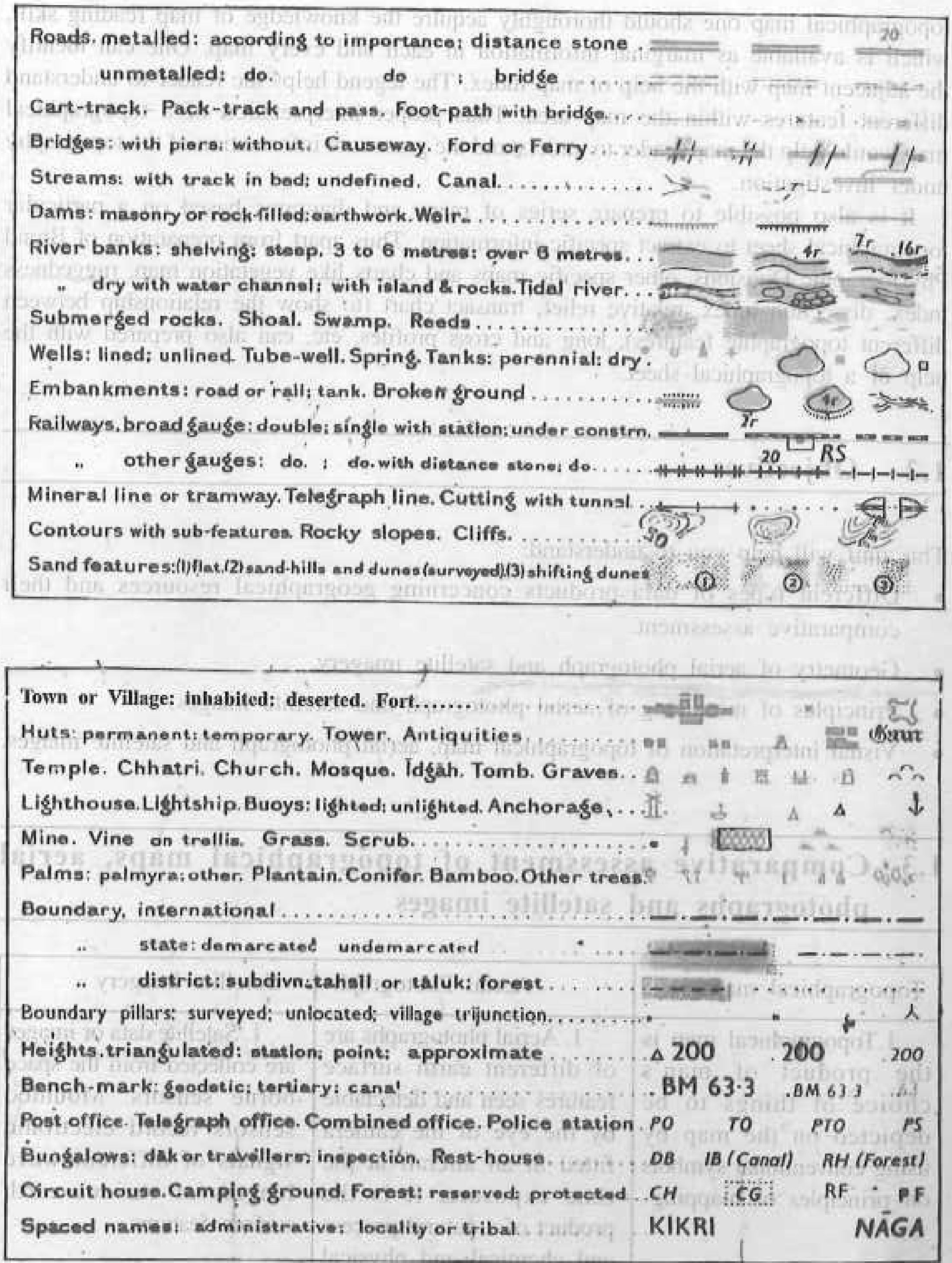


Fig.1.2


Roads. metalled: according to importance; distance stone
20
unmetalled: do. do : bridge
Cart-track. Pack-track and pass. Foot-path with bridge
Bridges: with piers; without. Causeway. Ford or Ferry
Streams: with track in bed; undefined. Canal
Dams: masonry or rock-filled; earthwork. Weir
River banks: shelving; steep, 3 to 6 metres; over 6 metres
4r
7r
16r
" dry with water channel; with island & rocks. Tidal river
Submerged rocks. Shoal. Swamp. Reeds
Wells: lined; unlined. Tube-well. Spring. Tanks: perennial; dry
Embankments: road or rail; tank. Broken ground
4r
7r
Railways, broad gauge: double; single with station; under constrn.
RS
20
" other gauges: do. ; do. with distance stone; do.
Mineral line or tramway. Telegraph line. Cutting with tunnel
Contours with sub-features. Rocky slopes. Cliffs
50
Sand features: (1) flat, (2) sand-hills and dunes (surveyed), (3) shifting dunes
1
2
3
Town or Village: inhabited; deserted. Fort
Huts: permanent; temporary. Tower. Antiquities
Temple. Chhatri. Church. Mosque. Idgāh. Tomb. Graves
Lighthouse. Lightship. Buoys: lighted; unlighted. Anchorage
Mine. Vine on trellis. Grass. Scrub
Palms: palmyra; other. Plantain. Conifer. Bamboo. Other trees
Boundary, international
" state: demarcated undemarcated
" district: subdivn., tahsil or tāluk; forest
Boundary pillars: surveyed; unlocated; village trijunction
Heights, triangulated: station; point; approximate
200
200
200
Bench-mark: geodetic; tertiary; canal
BM 63·3
BM 63·3
Post office. Telegraph office. Combined office. Police station
PO
TO
PTO
PS
Bungalows: dāk or travellers; inspection. Rest-house
DB
IB (Canal)
RH (Forest)
Circuit house. Camping ground. Forest: reserved; protected
CH
CG
RF
PF
Spaced names: administrative; locality or tribal
KIKRI
NĀGA
Fig.1.3

topographical map one should thoroughly acquire the knowledge of map reading skill, which is available as marginal information in each and every map. One can identify the adjacent map with the help of map index. The legend helps the reader to understand different features within the map area. Thus proper interpretation of a topographical map would help the map reader to understand the grass root information of the topography under investigation.

It is also possible to prepare series of maps and diagrams based on a particular topographical sheet to extract specific information. Thus apart from preparation of Broad Physiographic Divisions, other specific maps and charts like vegetation map, ruggedness index, dissection index, relative relief, transact chart (to show the relationship between different topographic features), long and cross profiles, etc, can also prepared with the help of a topographical sheet.

1.2 Objectives

This unit will help you to understand:

- Different types of data products concerning geographical resources and their comparative assessment.
- Geometry of aerial photograph and satellite imagery.
- Principles of mosaicing of aerial photograph and satellite images.
- Visual interpretation of topographical map, aerial photograph and satellite images.

1.3 Comparative assessment of topographical maps, aerial photographs and satellite images

Topographical map	Aerial Photograph	Satellite Imagery
1.Topographical map is the product of man's choice of things to be depicted on the map by using conventional symbols on principles of mapping	1. Aerial photographs are of different earth surface features seen and detectable by the eye of the camera fitted in an aircraft at the time exposure. It is the product of a natural process and chemical and physical laws of imagery.	1. Satellite data or images are collected from the space borne sensors. Mounted sensors record electronic signals of different wave lengths of various earth surface features.

2. Map distinguishes the features by various symbols, colours, annotations, etc. For artificial presentation, the differentiation of features is not clear on the map.	2.Differentiate the recorded features by the clues, e.g. tone, texture, size, shape, shadow, pattern, situation, resolution & spectral sensitivity.	2. Satellite images are also identified and dictated by the same elements. Quantitative analysis of tonal variations for image interpretation can be done which is not possible on aerial photograph.
3.Toposheet depict the average natural conditions. It is better to say that map contributes a spatial generalization of a particular place.	3. Aerial photographs are the natural image of the concern area in original, as it appreard before camera at the time of exposure.	3. Satellite remote sensing do not give natural image. It collects signals from objects belonging to several visible or pre-selected bands of EMR for distinguishing & characterizing different features.
4. In topo maps, no such features of natural & man introduced environmental hazards are depicted.	4. In aerial photo any transient things like a cloud speck, etc are found. Besides, it can assess the nature & extent of sudden changes, e.g. damages due to flood, landslide, earthquake, cyclone, etc.	4.Thermal sensing can record the images day & night long. It has the capability in delineating & detecting forest fire to assess the environmental change.
5. There is an absolute index numbering system of topographical sheets for a given map which helps to identify the different regions properly.	5. There is a task number for aerial photo which is secret & not openly available. But with the help of index map, if available, the task no, strip no and photo no can help to identify the actual area of the photograph.	5. There is international index number for satellite images. Each satellite has a separate index number. With the help of row and path, it is possible to identify the area of interest.
6. Topographical sheets represent the two dimensional reality. Heights, depths, slopes, etc. are not visualized but they can be understood by the trained & efficient interpreters.	6. Stereoscopic view of different photo pairs gives 3D impression. The three dimension impression of landscape is properly visualized on the photograph. Slopes can be determined by using parallax bar.	6. All the satellite images do not have the capability of stereo viewing. However, SPOT is the first Satellite to provide with stereo viewing. Indian satellite like IRS 1C, ID, Cartosat-1,2,2A etc. could capture stereo images.

7. The scale is constant on topographical sheets.	7. Scale of vertical photo is variable due to point displacement for height variations & tilting of the camera axis. Scale is greatly variable in oblique photo also.	7. In satellite remote sensing one of the major limitation is the poor spatial resolution or the pixel size.(e.g. 80 m for Landsat MSS, 30m for TM, 36.5m for LISS II of IRS 1A &B & 10m for SPOT PAN.)
8. Features in minute details are not found in topographical maps because these are manually produced & there is scope for manipulation.	8. All the physical & cultural features exposed to the camera may be seen in the photo, although it depends on camera angle, sunlight & atmospheric condition.	8. Where existing weather conditions restrict the use of aerial cameras for taking the photographs, RADAR sensing is used in such case to record the image of the concerned area.
9. Topographical sheets of highly inaccessible areas, e.g. mountains, oceans, etc. are not available.	9. Aerial photograph of inaccessible areas are available.	9. Satellite remote sensing is in a position to collect information from inaccessible areas.
10. Topographic surveying for the preparation of topographical maps needs a lot of survey instruments and huge technical staff.	10. Aerial survey necessitates heavy financial investment for specially designed air craft, aerial camera, photogrammetric equipment & the most efficient technical staff.	10. Satellite remote sensing is a high tech affair which also needs large amount of money & also efficient technical personnel, but it becomes cheaper in the long run for its diversified use.
11. Topographic survey is generally conducted in a long interval of time which provides all old and backdated information of a particular region.	11. Aerial survey is conducted in a comparatively short interval of time which provides more or less up to date information.	11. Satellite images of different modes and of a very short time span are available which can give changing scenes of a particular region.
12. Preparation of topographical map takes much more time.	12. It is less time consuming.	12. It saves money, time & energy than traditional maps and photographs.

1.4 Geometry of aerial photographs and satellite photo products

To know the geometry of aerial photographs, we are to know the basic concept of aerial photography, which is being described herein below.

1.4.1 Aerial Photography:

Photographs taken from an aircraft are commonly termed as aerial photographs. Aerial photographs are considered as remotely sensed data products. Remote sensing is the science and art of obtaining information about an object, area or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area or phenomenon under investigation. Thus broadly speaking both photographic as well as non photographic detectors are included with the perview of remote sensing. At this stage it is better to distinguish the difference between photographic and non photographic sensing systems. In case of an ordinary photograph, reflected energy directly acts upon the chemical emulsion producing an image of the object. On the other hand, in case of non-photographic remote sensing system, the sensed energy gives the result of the detection of emitted or reflected energy which are converted into signals in a digital recorder, which may ultimately be used for producing picture like formats known as images.

1.4.1.1 Brief History of Aerial Photography:

First photographs were taken in 1839 by Nicephore Niepce, Williams Henry Fox Talbot and Louis Jacques Mande Daguerre. In the year 1840 Argo, Director of the Paris Observatory, expressed his opinion in favour of use of aerial photography for topographical survey. The first known photograph was taken by Gasperd-felix Tournachon, a Parisian photographer, in the year 1858, known as "Nadar". Balloon was used as the platform for taking the photograph near Paris. A photograph over Boston taken from a balloon by James Wallace Black in the year 1860, is considered as the earliest existing aerial photograph. In the year 1882, kites were used to take aerial photographs, particularly for collecting meteorological data. World War I was a major impetus for development of aerial photography mainly for military reconnaissance purposes. In the mean time there were steady improvements in case of version of aircraft, camera, filter, film emulsion, etc. However, after the war the technology was in place to begin large scale aerial surveys. Moreover, the greatest stimulation to the photo interpretation occurred during World War II.

1.4.1.2 Types of photographs:

Photographs which are used for mapping and photo-interpretation can be divided into the following main classes according to the direction of the camera axis:

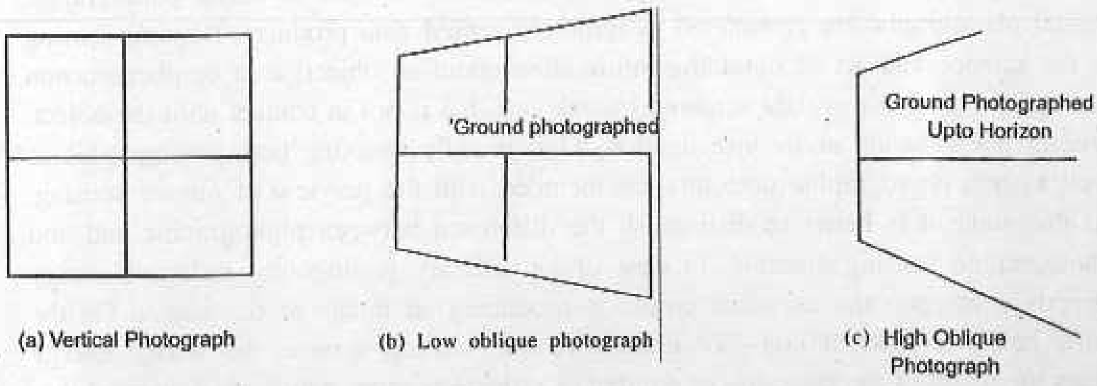
a) Vertical photographs

b) Horizontal or terrestrial photographs

c) Oblique photographs

The term 'vertical' and 'horizontal' refer to the direction in which the camera axis was pointing at the time of exposure.

Vertical Air photographs:



(a) Vertical Photograph (b) Low oblique photograph (c) High Oblique Photograph

Fig.1.4

These are taken with the axis of the aerial camera vertical or nearly vertical (Figure 1.4 a). A vertical photograph closely resembles a map and is particularly suitable for obtaining uniform coverage. As these photographs can be obtained with reasonable low tilt (tilt is deviation of the camera axis from the vertical), they are generally used for mapping and photo-interpretation works.

Terrestrial / Horizontal photographs:

These are taken with photo-theodolites from camera station on the ground with the axis of the camera horizontal and they present the more familiar elevation view. This type of photographs are used for survey of structures and monuments of architectural or archeological value. Terrestrial photographs taken with normal good cameras can also be of considerable use in supplementing photo-interpretation of vertical aerial photographs particularly so in geology and forestry, where study of a profile may be needed.

Oblique photographs: Aerial photographs taken with the optical axis of the aerial camera tilted from the vertical are known as oblique photographs. These photographs cover large areas of ground but clarity of details diminishes towards the far end of the photograph. Aerial photographs on which the horizon does not appear are known as Low Oblique (Figure 1.4b) and are, sometimes, used to compile reconnaissance map

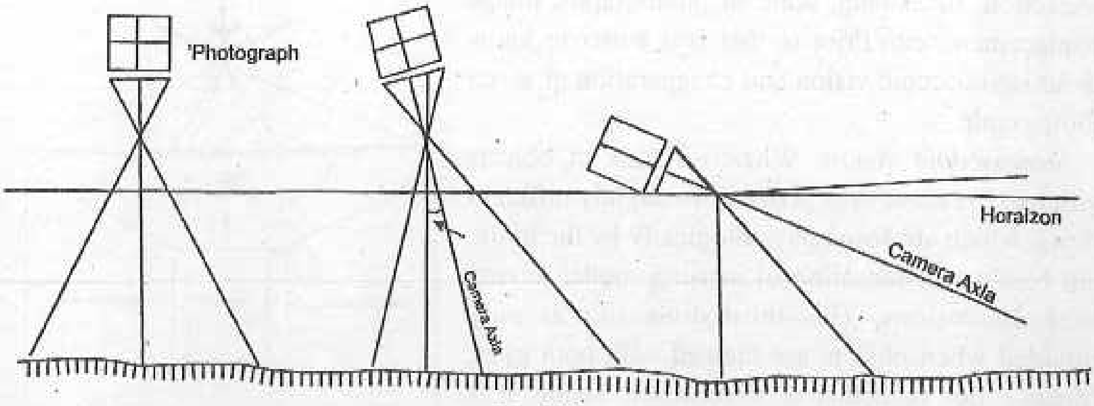


Fig. 1.4d

in inaccessible areas, High Oblique photographs (Figure 1.4c & d), which are tilted sufficient to contain the horizon, were previously used for extension of planimetric and height control, when the available ground control was insufficient to provide necessary accuracy. These have very limited use at present.

There are combinations of above types of photography taken with two or more cameras in a single camera unit in the photographic air plane.

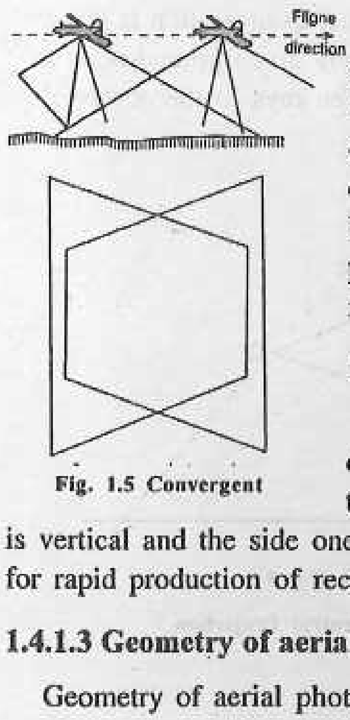


Fig. 1.5 Convergent

Convergent Photographs:

These are low oblique photographs taken with two cameras exposed simultaneously at successive exposure stations, with their axis tilted at a fixed inclination from vertical in opposite directions in the direction of the flight line so that the forward exposure of the first station forms a stereo-pair with the backward exposure of the next station (Figure 1.5). Special plotting instruments are required for compiling topographical maps from convergent photographs.

Trimetrogon photography:

Another important type of photography which is a combination of a vertical and two oblique photographs is trimetrogon photography, in which the central photograph is vertical and the side ones are oblique (Figure 1.6). This photography can be used for rapid production of reconnaissance maps on small scales.

1.4.1.3 Geometry of aerial photographs

Geometry of aerial photograph is related to different aspects of photography like, projection, tilt, swing, scale of photographs, image displacement, etc. Prior to that it is better to know about stereoscopic vision and exaggeration of aerial photograph.

Stereoscopic vision: When we look at objects with two eyes, our eyes give us two slightly different views, which are fused physiologically by the brain, and result in a sensation of sensing model having three dimensions. This third dimension is only provided when objects are viewed with both eyes. This is called binocular or stereoscopic vision. It is also possible to get a three dimensional impression if we offer to each of our eyes, instead of nature, a photograph taken from different points, a so called stereopair. For the three dimensional study of stereopairs usually stereoscopes are used.

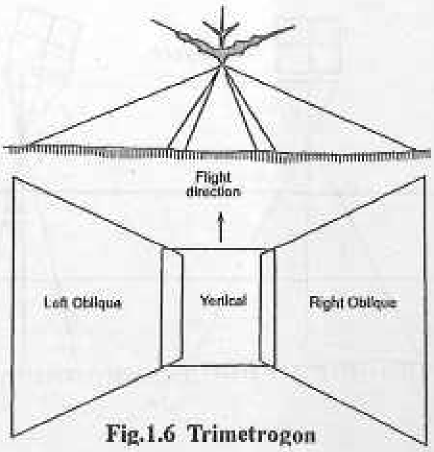


Fig.1.6 Trimetrogon

Stereoscopic exaggeration: The appearance of the stereoscopic image is that of a relied -model or stereo-model, giving the impression of solidity and depth. For vertical photos, having 60% overlap, the vertical scale of the model appears to be considerably exaggerated, and the impression of relief is far greater than that which an observer in the stereoplane would have received visually. Mountains and hills appear higher and their slopes steeper than they really are in nature. This vertical exaggeration is due to the much greater angular difference between the rays from any given ground-point to two successive exposure stations, as compared to that between rays to the observer's eyes from the same ground-point.

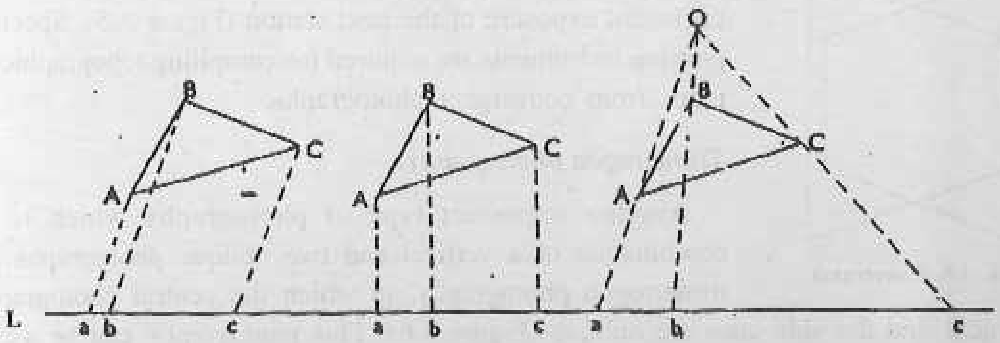


Fig. 7 (a) Parallel Projection

Fig. 8 (b) Orthogonal Projection

Fig. 9 (c) Central Projection

Projection:

In order to understand the geometric qualities of a photograph, it is necessary to understand what projection means in terms of geometry. In the example given below the triangle ABC and the line (LL_1) on which the projection is made are in the same plane.

(a) Parallel Projection:

In this projection, the projecting rays are parallel (Figure 1.7a). The triangle ABC is projected on the line LL_1. The projection of the triangle is 'abc'. The projecting rays Aa, Bb, Cc, are all parallel in this case.

(b) Orthogonal Projection:

In this case, the projecting rays are all perpendicular to the line LL_1 (Figure 1.7b). This is a special case of parallel projection. Map is an orthogonal projection of the ground on a certain scale. The advantage of this projection is that the distances, angles and areas in the plane are independent of the elevation differences of the objects.

(c) Central Projection:

In case of central projection, the projecting rays Aa, Bb, Cc pass through one point O, called the Projection Centre or Perspective Centre (Figure 1.7c). The image projected by a lens system is treated as a central projection.

Tilt

It is the angle between the optical axis of the camera and the plumb line. It is also

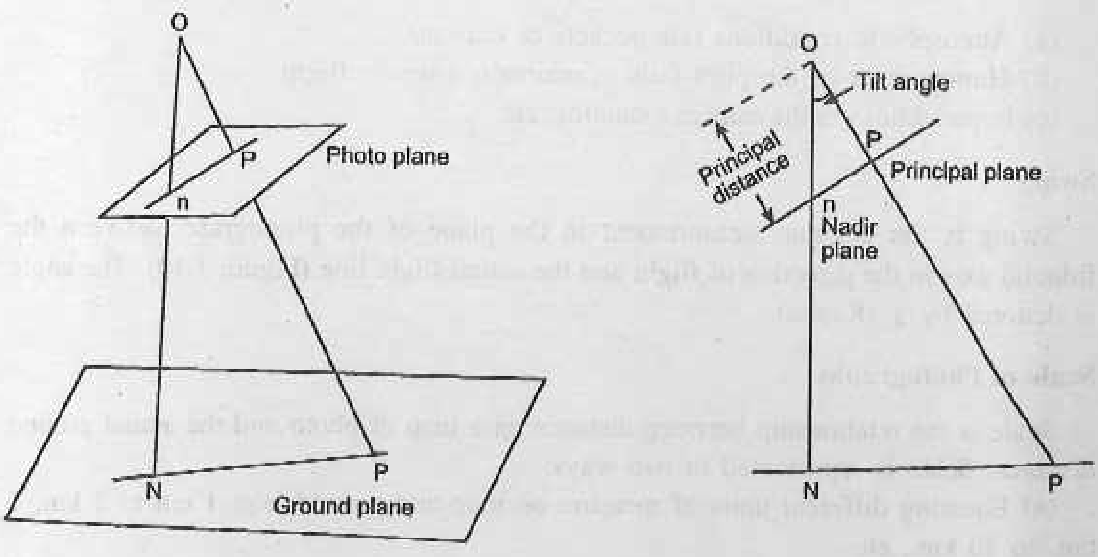


Fig.1.8

the angle between the ground plane and the photo plane. Tilt can be resolved into two components, one in the direction of flight (the X-axis) and the other perpendicular to it (the Y-axis).

The component about the Y-axis, i.e. in the direction of X is called Longitudinal Tilt or X -tilt or Fore and Aft Tilt or Tip. It is denoted by letter θ (Phi).

The component about X-axis, i.e. in the direction of Y is called Lateral Tilt or Y-tilt or simply Tilt. It is denoted by letter ω (Omega).

In Figure 1.8 the vertical ON through the perspective centre O meets the photo plane at point 'n' called the *Photo nadir point* and the ground plane at N the *Ground nadir point*. These points are also called *plumb points*.

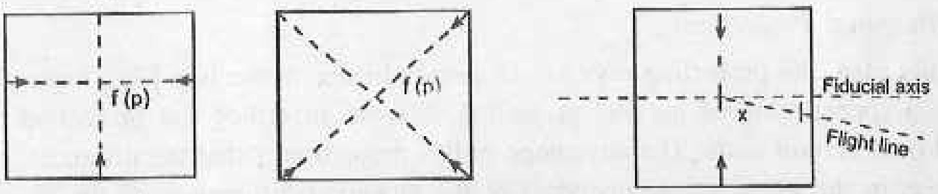


Fig.1.9

The foot of the perpendicular (p) from O on the photo plane is called the *Principal point*. The length of this perpendicular (Op) is called Principal distance.

The approximate position of the principal point of a photograph is determined by joining the opposite fiducial marks (Figure 1.9). The point of intersection of the fiducial axis is called fiducial centre (f) and is coincident with the principal point (p).

Reasons for Photo Tilt:

(a) Atmospheric conditions (air pockets or currents).

(b) Human error of the pilot fails to maintain a steady flight.

(c) Imperfections in the camera mounting, etc.

Swing

Swing is the angular measurement in the plane of the photograph between the fiducial axis in the direction of flight and the actual flight line (Figure 1.10). The angle is denoted by χ (Kappa).

Scale of Photographs:

Scale is the relationship between distance on a map or photo and the actual ground distance. Scale is represented in two ways:

(a) Equating different units of measure on map and ground, e.g. 1 cm to 2 km, 1 cm. to 10 km., etc.

(b) As R.F. (representative fraction) in which the numerator is unity, e.g. 1:10,000 or 1/10,000 which means 1 unit on the map or photo represents 10,000 units on the ground.

Methods of scale determination:

There are three methods to determine scale of aerial photographs:

(i) *By establishing the relation of photo to ground:*

If the distance between the same two points on the photo as well as on the ground can be measured, R.F. can be set up:

$$\text{R.F.} = \frac{\text{Photo distance}}{\text{Group Distance}}$$

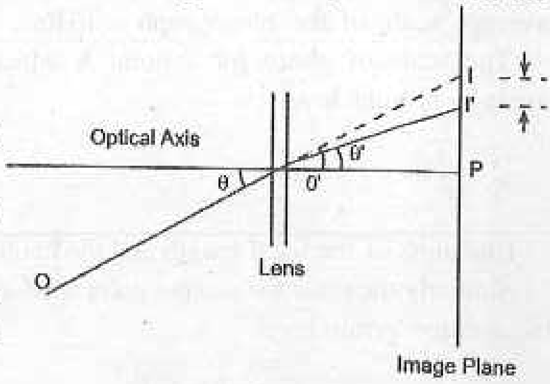


Fig. 1.11 Lens Distortion

(ii) *By establishing the relation of photo to ground with the help of a map:*

If the distance between two points on a photo which can be located on the map as well, is measured, the horizontal measurements of these distances form a ratio, which when multiplied by the R.F. of the map gives the R.F. of the photo. If g be the ground distance between two points, m the map distance and p the photo distance then R.F. of map is m/g and R.F. of photo is p/g.

$$\frac{\text{R.F of photo}}{\text{R.F of map}} = \frac{p/g}{m/g} = \frac{p}{m}$$

$$\therefore \text{R.F. of photo} = \frac{p}{m} \times \text{R. f. of map.}$$

(iii) *By establishing the relation between focal length of the Camera and flying altitude:*

In a true vertical photograph of flat terrain the scale of photograph is the ratio f/H. In figure 11 (a) distance 'AB' is imaged as 'ab' on the photo.

$$\text{Scale of the photo} = \frac{\text{Photo Distance}}{\text{Group Distance}}$$

$$= \frac{ab}{AB}$$

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

If the terrain is not flat, the scale of the photograph is not uniform. In Figure 11 (b) Hm is the flying height above the average height of the terrain photographed. Then the average scale of the photograph = f/Hm.

The scale of photo for a point A which is at a height of h' metre/ft, above the average ground level

$$= \frac{f}{H_{m-h}}$$

(the units of the focal length and the height being in the same terms)

Similarly the scale for another point B which is at a vertical distance 'd' meters/ft, below the average terrain level.

$$= \frac{f}{H_{m+h}}$$

Thus the scale of a photograph is not uniform if there is irregular terrain. We can determine either the average scale of the photograph as a whole or the scale of the photograph at a particular point or elevation.

It should be noted here that the scale of aerial photograph changes irregularly due to height differences in the terrain but continuously due to inclination of the camera axis.

Image Displacement:

On a planimetric map all features are shown in their correct horizontal position on a certain scale. This is not so in the case of aerial photographs due to image displacement or distortion. A disturbance of the principle of geometry is called distortion. There are three major sources of distortion which are due to Optical or photographic deficiencies, i.e. lens distortion and aberration, relief variation of the object photographed and tilt of the camera axis at the moment of exposure.

(a) Lens distortion:

Figure 1.11 shows distortion due to a lens. Object point O is imaged at 1 instead of its correct position I on the image plane. Δd is the image displacement in this case. In a modem aerial lens this type of distortion is negligible.

(b) Image displacement due to relief:

Relief is the most significant source of image displacement. In Figure 1.12 O is the camera station. NA is a flat plain on which stands a tower AB with its base at B. The image of B on the truly vertical positive photographic plane is b. This is the correct planimetric position (orthogonal) of the image of the tower AB. Top A is imaged as 'a'.

The image of A is thus displaced from its correct planimetric position b, as 'A' is vertically above 'B', on the photograph. This shift of'a' from 'b' represented by distance ba is called *relief displacement.*

(c) Image displacement due to tilt:

In case of flat terrain, for example in case of Figure 1.13, let O be the perspective centre and 1 and II be the positive planes for a truly vertical and tilted photographs respectively. The figure shows a cross-section in the principal plane. For a point 'A', which appears at a' in I and at a in II, the displacement is equal to 1a`–'2a.

1.4.2 Geometry of satellite images:

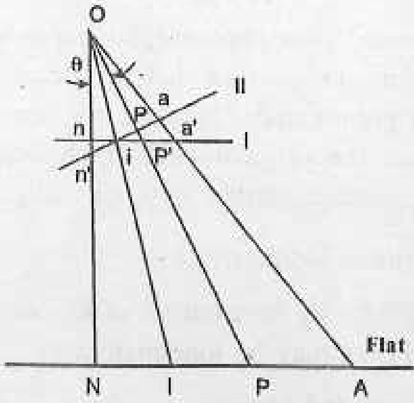


Fig. 1.13

Images from across-track scanning systems exhibit two main types *of geometric distortion.* They too exhibit relief displacement, similar to aerial photographs, but in only one direction parallel to the direction of scan. There is no displacement directly below the sensor, at nadir. As the sensor scans across the swath, the top and side of objects are imaged and appear to lean away from the nadir point in each scan line. Again, the displacement increases, moving towards the edges of the swath. Another distortion occurs due to the rotation of the scanning optics. As the sensor scans across each line, the distance from the sensor to the ground increases further away from the centre of the swath. Although the scanning mirror rotates at a constant speed, the IFOV of the sensor moves faster (relative to the ground) and scans a larger area as it moves closer to the edges. This effect results in the compression of image features at points away from the nadir and is called *tangential scale distortion.*

All images are susceptible to geometric distortions caused by variations in platform stability including changes in their speed, altitude, and attitude (angular orientation with respect to the ground) during data acquisition. These effects are most pronounced when using aircraft platforms and are alleviated to a large degree with the use of satellite platforms, as their orbits are relatively stable, particularly' in relation to their distance from the Earth. However, the eastward rotation of the Earth, during a satellite orbit causes the sweep of scanning systems to cover an area slightly to the west of each previous scan. The resultant imagery is thus skewed across the image. This is known as *skew distortion* and is common in imagery obtained from satellite multispectral scanners.

The sources of geometric distortion and positional error vary with each specific situation, but are inherent in remote sensing imagery. In most instances, these distortions may be removed, or at least reduced, but they must be taken into account in each instance before attempting to make measurements or extract further information.

1.5 Principles of mosaicing

Mosaicing means joining together, the exercise may be related to either aerial photographs or satellite images.

1.5.1 Mosaicking of Aerial photographs:

A *mosaic* is a photographic reproduction of a series of aerial photographs put together in such a way that the detail of one photograph matches the detail of all adjacent photographs. Mosaics are, for the most part, reproduced at a much smaller scale than the original photography, and consist of three main types: *uncontrolled mosaics, semi-controlled mosaics* and *controlled mosaics.*

Uncontrolled Mosaics

- Prints are laid out so as to join together in a "best fit" scenario.
- Prints may be tone-matched.

Semi-Controlled Mosaics

- The prints used in the mosaic are tone-matched but not rectified.
- Prints are laid down to fit a map base of the same scale.
- A title and scale may be added.

Controlled Mosaics

- For controlled mosaics the base map with minimum of three (3) ground control points per print need to be provided with.
- Prints are tone-matched and rectified to fit the map base.

1.5.2 Mosaicking of satellite images:

Mosaicking is joining together several overlapping images to form a uniform image as shown in Figure

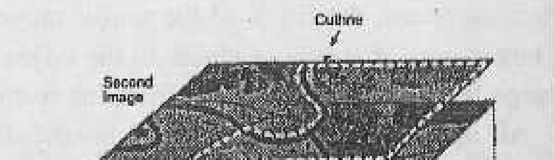


Fig. 1.14

1.14. Basically, it is similar to creating a jigsaw puzzle with your images, and then making the joints disappear.

For the mosaic to look like one image instead of collage of images, it is important that the images fit well together. You will achieve better results if you orthorectify your images. Using a rigorous math model ensures the best fit not only for the individual images, but for all the images united as a whole.

Starting a Project to Mosaic Raw Images:

Since raw (unreferenced) images contain the distortions inherent to the sensor, it is unlikely that features will align well in the overlapping areas without compensating for these distortions. If you are lacking the ground control needed to correct your images, you can adjust the alignment of the features in the raw images by building a math model based on images (pixel and line) coordinates.

To create a mosaic with raw images, you have to build a project using polynomial or Thin Plate Spline math model, collect ground control points, geometrically correct the images, and then mosaic them.

To start the Project in Geometica :

- On the *OrthoEngine* window in the *File* menu, click *New*
- On the *Project Information* window in the *Filename* box, type a file name for your project. This will be the name used when you save your project
- In the *name* box, type a name that you want to appear on the title bar of the *OrthoEngine* window.
- In the *Description* box, type a description of the project that will help you to identify its contents
- Under *Math Modelling Method,* click *Polynomial* or *Thin Plane Spline.*
- Click *OK*

Starting a Project to Mosaic Existing Georeferenced Images:

Instructions would be as above, excepting under *Math Modelling Method,* click *None (mosaic only)* instead of *Polynomial* or *Thin Plane Spline.*

Defining a Mosaic Area:

The Mosaic Area determines the extents of the mosaic file. The images are added to the Mosaic Area like pieces of a puzzle. On the *Define Mosaic Area* window, the footprints of the images in your project are displayed as they overlap. The crosshairs represent the principal point of each image. Click one of the crosshairs to reveal the footprint of an individual image. The background value of the Mosaic Area is zero by default.

To open the Define Mosaic Area window:

On the OrthoEngine window in the Processing step list, select Mosaic
Click the Define mosaic icon

To define the Mosaic Area:

By default the bounds of the Mosaic Area are the maximum extents of the images in the project.

You can:

Place the cursor over the side or corner of the frame and move it to change its size and shape. In the list under Mosaic Extents, click UL & LR corner. Type new x and y coordinates for the upper left and lower right corners of the frame.

In the list under Mosaic Extents, click UL & Size. Type new x and y coordinate for the upper left corner of the frame. Type the number of pixels in X Size and the number of lines in Y Size to specify the size of the frame.

In the list under Mosaic Extents, click Centre & Size. Type new x and y coordinates for the centre of the frame. Type the number of pixels in X Size and the number of lines in Y Size to specify the size of the frame.

In the list under Mosaic Extents, click Centre & Size. Type new x and y coordinates for the centre of the frame. Type the number of pixels in X Size and the number of lines in Y Size to specify the size of the frame.

Click Select Existing Mosaic File to open an existing mosaic file.

Under Mosaic File Information in the Channels list, click any of the following:

8 Bit Unsigned
16 Bit Signed
16 Bit Unsigned
32 Bit Real

If you select None (Mosaic only) when you set up the project, Input Image Background Value becomes available. Type the background value of the images that you want to mosaic or click to clear the check mark if the background value is zero.

Click Create Mosaic File
Click Close.

Mosaicking Images Automatically:

Although you can create your mosaic one image at a time by using Manual Mosaicking, most of the time you will use Automatic Mosaicking to do the bulk of the work, and you will use Manual Mosaicking to edit portions of the mosaic file.

To open the Automatic Mosaicking window:

On the OrthoEngine window in the Processing step list, select Mosaic.
Click the Automatic mosaicking icon

To automatically mosaic your images:

In the Automatic Mosaicking window, click in the Use column to select or clear the images. The images with check marks in the Use column will be mosaicked. You can also use the Orthos in mosaic button to select or clear the images,

Click: All to select all the available images. Gray check marks indicate images outside the difined mosaic area. None to clear all the images selected in the Use column

All in mosaic to select only the images that appear in the region that you set in Define Mosaic Area

Normalization is used to even out the brightness in the images to achieve a more pleasing mosaic. You can select Regenerate offline orthos to generate orthorectified images with a Stale or Offline status

Clear mosaic file before mosaicking deletes existing data from the mosaic file.

In the Starting Image list, select the corrected image on which you want to build the mosaic, the colour balancing, and the cutline selection.

In the Color balance list, select a method (for example None, Entire image or Overlap area)

In the Trim histogram (%) box, type a number representing the percentage or mention default 2 percent, which is recommended for most data sets

Select the Ignore pixels under bitmap mask check box to disregard the pixel values under the mask when calculating the colour balancing histogram

Cutlines are drawn in areas where the seams are the least visible based on the radiometric values of the overlapping images. Select an appropriate method

If you want to use existing or imported cutlines, select Use existing cutlines

In the Preview file box, type the path and file names

In the box under Directory files, type the path for the temporary working files

Under Generate Start Time, click Start now or start at specific time

Click Generate Preview

Click Generate Mosaic

1.6 Preparation of Thematic overlays from aerial photographs and satellite images

In the following paragraphs examples regarding preparation of thematic overlays from aerial photographs and satellite images are described in brief.

1.6.1 Preparation of Thematic overlays from aerial photographs

For preparation of thematic overlays from aerial photographs, it is essential to know about characteristics of photo images, which is being described herein below.

Fig. 1.14 (a) Tone

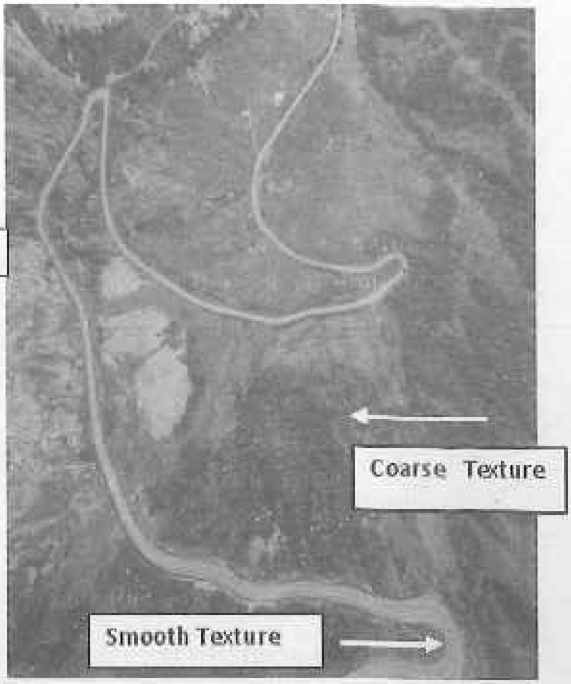


Fig. 1.14 (b) Texture

1.6.1.1 Characteristics of photo images:

The identification and recognition of objects are helped by a knowledge of the characteristics of the photo-image as recorded by black and white panchromatic film. Most important characteristics are : *tone, texture, pattern, shape, size, shadow, situation and resolution & spectral sensitivity.*

Tone:

Tone means the black and white range (i.e. grey scale variation) of a (panchromatic) photograph. The grey tone of a particular object depends on how much light is reflected from it into the camera, and thus onto the film. The more light that is reflected, the lighter the tone on the photograph. Some of the clues are as follows:

Water surfaces usually have a fairly dark tone (Figure 1.14a), but if the water contains much sediment, the tone becomes more light.

Un-vegetated dry sand is usually light.

Surfaced roads are generally light.

Railways are normally dark,

It may be noted here that generally these are the examples - there will always be exceptions.

Moreover, different prints of one photograph are not always identical to another in tonal density, due to differences in film processing and printing.

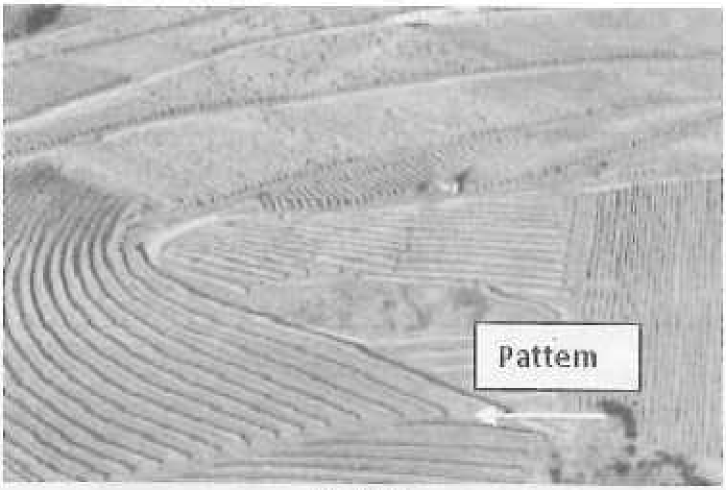


Fig.1.4(c)

Texture:

Texture may be defined as the product of an aggregates of uniform features which are too small to be clearly discerned individually. Texture will be depicted as a repetition of tonal changes. Forest is the best example in this regard, e.g., in large scale photographs the big trees appear in a coarse texture, whereas in case of small scale photographs they appear as fine texture (Figure 1.14b).

Fig. 1.14 (d)

Pattern:

Pattern stands for the spatial arrangement of objects in a repeated sequence and / or in a characteristics order. Examples are: orchards, where trees are planted in lines (Figure 1.14c) or drainage patterns like dendritic, radial, etc.

Shape:

Shape is defined as the form or topographic expression of an object as can be observed in the two-dimensional photo-image. Rectangular shaped houses, circular shaped water tank, typical shape of a stadium (Figure 1.14d) is best example in this regard.

Size:

Size means the volume dimension of an object as may be observed in the three-dimensional

Fig. 1.14 (e)

(stereo) photo-model. Dwelling houses, school, factory, office building, etc. can be identified in terms of size differences (Figure 1.14e).

Shadow:

Shadow is the obscurity within an area from which direct rays, from a source of light, are excluded by an interposed opaque body. Shadow can be very important to the interpreter by giving clues as to the profile or shape of an object (e.g. a building bridge or tree) through the shadow it casts on the ground (Figure 1.14f).

Situation:

Situation means the location of one place, relative to the location of other places, e.g. building beside a railway line generally represents the railway station. The runway and standing aircrafts signifies the airpor (Figure 1.14g)

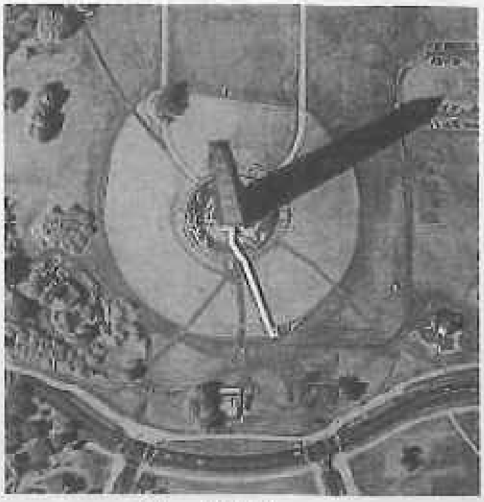


Fig. 1.14 (f)

Resolution and spectral sensitivity of film types:

Recognition of features' quality depends on the type of photographic film. Film emulsions like panchromatic, infra-red, etc. have different spectral sensitivity.

Resolution or resolving power refers to the sharpness of detail afforded by the combination of film quality and the camera lens system. It is subjective measure of the image "sharpness", expressed as the maximum number of lines per millimetre that can be resolved or seen as individual lines. The net effect of a low resolving power is a loss of detail. Small objects cannot be distinguished individually anymore.

Films may be made with several types of emulsions. These emulsions are sensitive for different wavelengths of the spectrum: each different emulsion has its own spectral sensitivity.

Fig. 1.14 (g)

In aerial photography normally two types *of black and white films* are used:

a) Panchromatic film: Sensitive for all wavelengths of the visible spectrum. This type of film is mostly used for aerial mapping and interpretation. Panchromatic photos show varying shades of grey, with each tone comparable to the density of an object's colour as seen by the human eye. Panchromatic film is superior for distinguishing objects of truly different colours, but its lack of high sensitivity to green light makes separation of vegetative types (e.g. tree species).difficult.

b) Infrared film: Sensitive to violet, blue and red light of the visible spectrum in addition to infrared.

It has been generally assumed that the grey tones on infrared film result from the degree of infrared reflectiveness of an object rather than from its true colour. According to this theory, broad-leaved vegetation is highly reflective and therefore gives light tones on the photographs; coniferous or needle-leaf vegetation tends to absorb infrared radiation and consequently gives much darker tones.

Bodies of water absorb infrared light to a high degree and usually give quite dark tones on the film (unless the water bodies are heavily silt laden). This characteristic is useful for determining and mapping the extent of river tributaries, tidal marshes, shorelines and canals. On the other hand, the dark tone often prevents detection of such underwater hazards as reefs, shoals, and channel obstructions, which are visible on panchromatic film.

Infrared film is also useful in detecting variations in moisture contents of soils; the higher the moisture content, the darker the tone.

Another advantage of infrared photography is the fact that it normally penetrate haze better than panchromatic photography, but it will not penetrate extremely dense haze or moist cloud. Clear photographs can be obtained when conventional photographs are obscure.

Colour film: Although black and white panchromatic film has long been the standard film types for aerial photography, many remote sensing applications currently involve the use of colour film. The major advantage to the use of colour is the fact that the human eyes can discriminate many more shades of colour than it can to with tones of gray.

Colour infrared film: In contrast to "normal" colour film, colour IR film is manufactured to record green, red, and the panchromatic portion (0.7-0.9 μ m) of the near -IR scene energy in its three emulsion layers. The dyes developed in each of these layers are again yellow, magenta, and cyan. The result is false colour film in which blue images result from objects reflecting primarily green energy, green images result from objects reflecting primarily red energy, and red images result from objects reflecting primarily in the near IR portion of the spectrum.

1.6.1.2 Visual Interpretation of Aerial Photograph:

In the following paragraph a model interpretation of aerial photograph has been presented.

The given aerial photographs bear numbers $\frac{518A}{287-29}$, $\frac{518A}{287-30}$, & $\frac{518A}{287-31}$

The middle photograph, (Figure 1.16) i.e. $\frac{518A}{287-30}$ is to be interpreted. The

Fig. 1.16

interpretation of photographs can be seen as a process that can be divided into number of phases. For all purpose we can say that it is a three phase operation.

Firstly, the examination of the photographs.

Secondly, the identification of objects or features.

Thirdly, the classification of objects identified.

Procedure:

1) Placing photographs under the stereoscope with overlapping parts of the photographs next to each other.
2) Locating & marking of principal point on each of photograph. This is done by aligning opposite sets of fiducial marks with a straight edge & the intersecting point is considered as principal point
3) Transferring of principal point from the adjacent overlapping photograph with the help of a mirror stereoscope. By connecting the principal point & the transferred principal point the flight line may be obtained.
4) Placing the stereoscope over the stereo pair in such a way that the line joining the center of the stereoscopic lenses is parallel to the flight line.
5) Although the photographs should be seen three dimensionally now, a little adjustment in distance between the photographs may still be necessary. So the photographs may be moved side ways until the spacing between the corresponding images produce comfortable stereoscopic viewing.

Reference Data:

Survey of India topographical sheet number 73E/15 & 73I/3 with scale of 1: 50,000 have been used as reference data.

Administrative Index:

From the topographic maps & the photo index it is known that the area under investigation covers parts of Puruliya district of West Bengal and Ranchi District of Jharkhand.

Scale : The scale of the photograph is 1:60,000

Landforms:

So far as the broad physiographic unit is concerned, the area covered by photograph belongs to Ranchi Plateau. Except the narrow strip of land along the both sides of river Subarnarekha, the entire region is a plateau fringe. Based on image characteristics the following landforms can be identified in the photographic region (Figure 1.17).

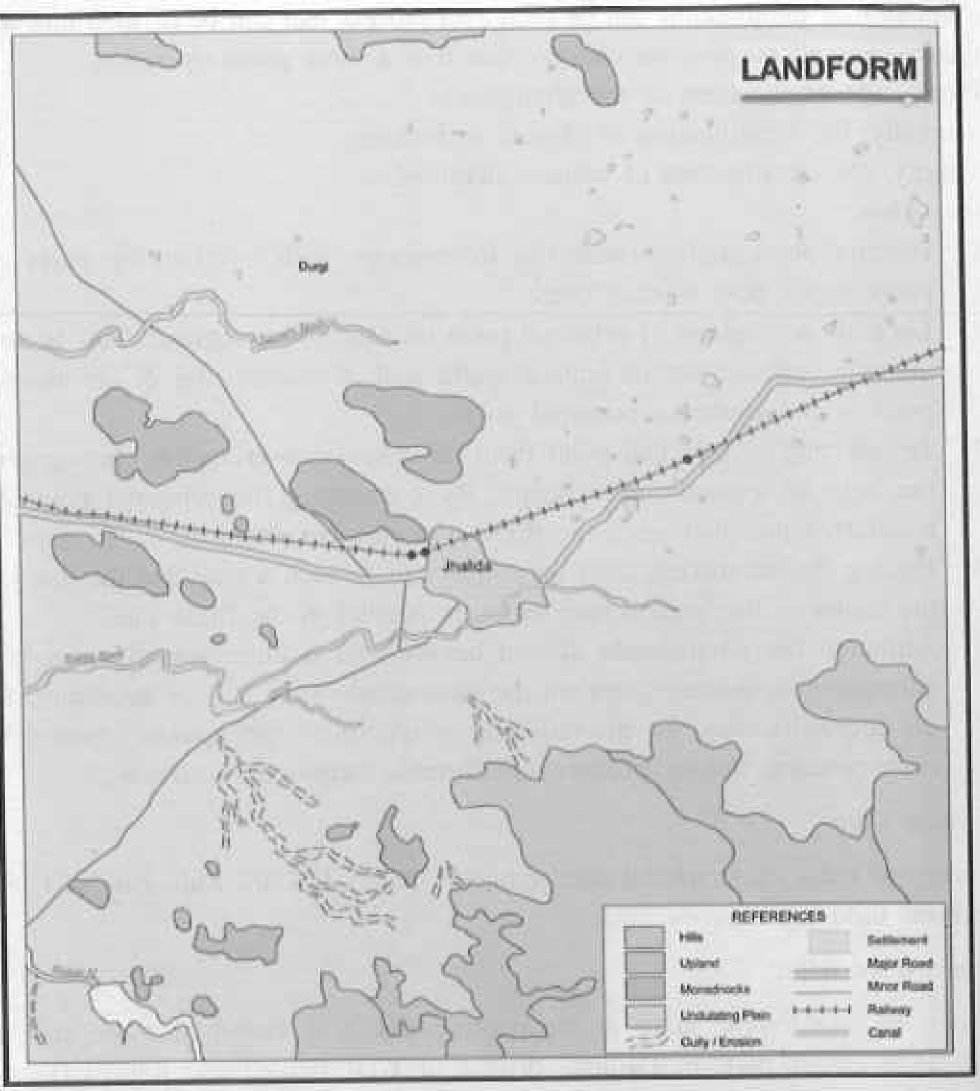


Fig. 1.17

1) *Hills,* 2) *Monadnocks,* 3) *Uplands,* 4) *Undulating Plains* and *5)Gully.*

1. ***Hills :*** The hilly areas are well marked in the north western part and also in the south, south eastern part . In the north west there is a dome shaped hill with appreciable height. In the southern and south eastern portion there are hilly areas characterized by appreciable length and height. It appears that constituent hard rocks resisted erosion thus ultimately isolated the area from the surrounding erosional landscape.
2. ***Monadnocks*** : Maximum number of monadnocks are found in the central portion of the mapped area. According to Davisian concept of cycle of erosion,

the monadnocks are residual parts of hard rocks which were influenced by fluvial action. They are the remnants of peneplain formation.

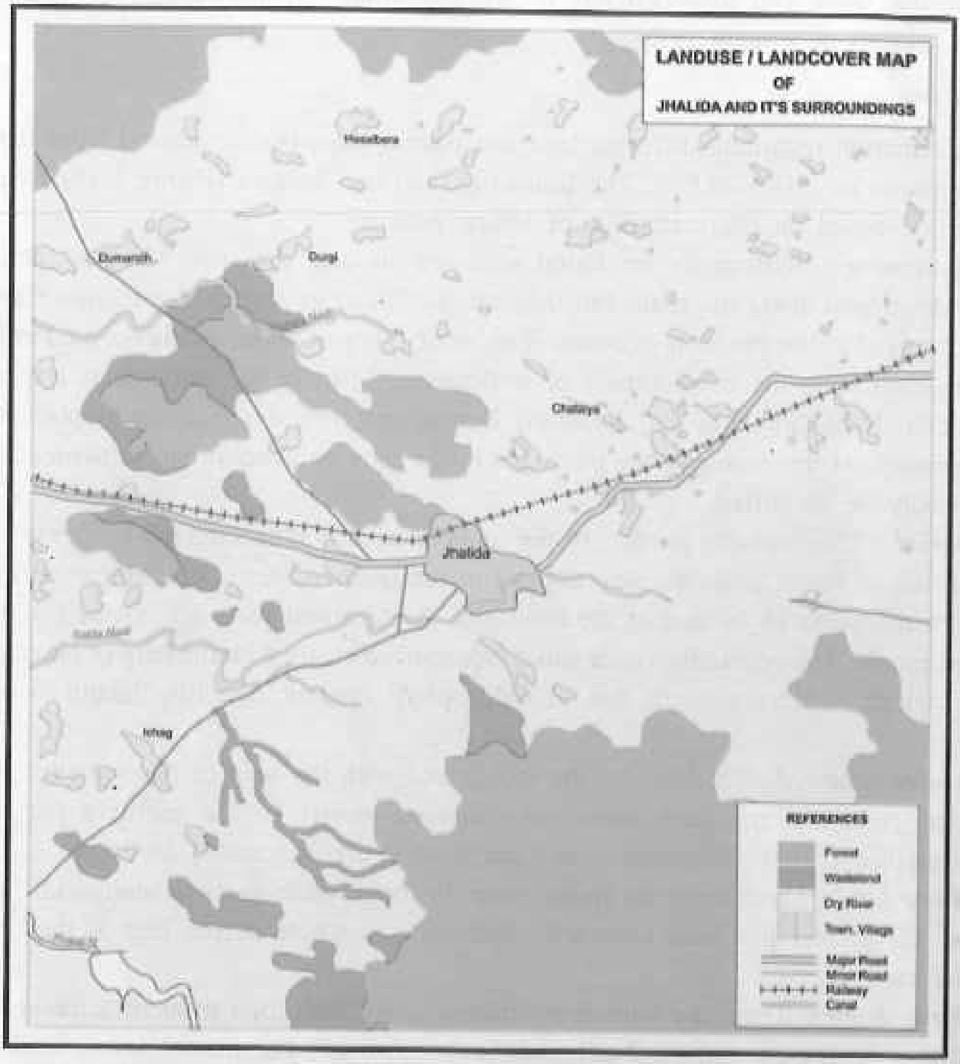


Fig. 1.18

3. ***Upland*** **:** The areas which are higher in elevation but the surface is not plain is upland. This landform is the result of fluvial erosion conducted by *Salda Nadi* and its tributaries. The area is almost covered by hard rocks.
4. ***Undulating Plain*** **:** Major part of the photograph is covered by undulating plains. This region is characterized by uneven plain topography which is rolling in nature.

5. ***Gully :*** Particularly in the north and central part of the map where the 1[st] order streams have been originated, such landforms may be identified. The topography has been well dissected due to erosion. Small streams follow the direction of slopes in straight fashion.

Land use :

Information regarding different land use pattern have been extracted from the same photograph, i.e. 518A/287:30. The following land use features (Figure 1.18) have been identified based on characteristics of image pattern.

Settlement : Settlements are found scattered all over the area. Most of them have been developed along the roads but they are not linear in pattern. Sometimes they have been formed at the junction of roads. The availability of water is also a predominating factor controlling the development of settlements. Most of the settlements are rural in character. Patjhalida. Masina, Khatjuri, Bengo, etc. are some of the important rural settlements. At the center of the photograph, the only compact urban settlement Jhalida can easily be identified.

Forest : The southern portion of the mapped area is characterized by dense forests. Extension of forest areas are also noticed in the north western part. Moreover, isolated hills or monadnocks located at the central or west central parts are covered with open mixed jungle. The vegetative cover can be recognized easily with the help of photographic tone, which is dark enough due to chlorophyll content denoting health vegetative cover.

Arable land : Arable land can be recognized with the help of photographic tone as well as field pattern. Such areas are confined mostly to the northern part of the photographic region. At places, tanks are used to irrigate arable land.

Waste land: Waste lands are found either in rocky waste parts or along gully erosion areas. The former has been caused by deforestation where as the later is the result of fluvial erosion.

Water bodies: There are numerous streams along with their tributaries traversing the photographic region. Sapahi Nadi and Salda Nadi are the major rivers, which flow almost parallel to each other. Both of them originate from the east and ultimately join Subarnarekha River further south (out side the photographic area). Scattered tanks are found in different parts of the area. It may be mentioned here that water bodies are recognized with the help of dark tonal expression of the photo image.

Communication systems: Communication network in the form of railway and road traverse the photographic region. They may be recognized by means of tonal variations along with geometric shape. South eastern railway passes along the central part of the photograph, parallel to the main highway.

1.6.2 Preparation of Thematic overlays from satellite images

For preparation of thematic overlays from satellite images, it is essential to know about basic concept of remote sensing, which is being described herein below. Brief history of the evolution of remote sensing technology has also been discussed.

1.6.2.1 Remote Sensing: The Basic Concept:

Lillesand defines remote sensing is the science and art of obtaining information about an object, area or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area or phenomenon under investigation. Thus broadly speaking both photographic as well as non photographic detectors are included with the perview of remote sensing. At this stage it is better to distinguish the difference between photographic and non photographic sensing systems. In case of an ordinary photograph, reflected energy directly acts upon the chemical emulsion producing an image of the object. On the other hand, in case of non-photographic remote sensing system, the sensed energy gives the result of the detection of emitted or reflected energy which are converted into signals in a digital recorder, which may ultimately be used for producing picture like formats known as images.

Electromagnetic Radiation:

The earth receives the solar energy in the form of insolation and again radiates it back to the atmosphere. An object can be visualised because of the existence of light. When there is no light, i.e. in complete darkness, nothing can be visualised. Due to illumination and casting of shadow, information regarding object's size, shape and texture can be recognised. On the other hand, object's brightness and colour can be distinguished due to reflection and absorption of light as acted upon.

Electromagnetic Energy:

Each photon, i.e. quantum of electromagnetic energy, has a unique pair of electrical and magnetic field. They vibrate at right angles to each other to the direction in which they travel (Figure 1.19). The vibration can be recognised by means of wave length or frequency. Wave length stands for the distance between two successive peaks in the electromagnetic fluctuations, whereas frequency means the number of wave that pass a point in a particular time span. Thus shorter the wave length, higher the frequency or vice versa.

Normal human eyes are sensitive to only some of the electromagnetic energy, emitted and reflected by objects. The visible spectrum is confined within the wavelength ranging between 0.4-0.7 μm, which is almost equally divided into blue (0.4-0.5 (μm), green

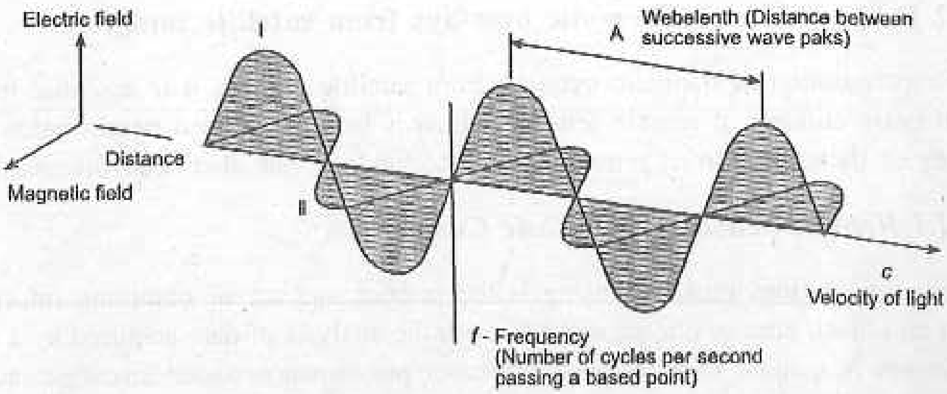


Fig. 1.19

(0.5-0.6 µm) and red (0.6-0.7 µm) spectral ranges. By mixing these primary colours additively (i.e. by throwing beam of light), any other colour including white can be created. However, visible spectrum occupies only a very small part of the entire electromagnetic spectrum. Atom, gama ray, x ray, ultraviolet ray are shorter wave lengths compared with visible spectrum, whereas infra-red (which may either be divided into reflected infra-red and thermal infra-red or near infra-red, middle infra-red and far infra-red) thermal (heat), micro-wave, etc. are the much longer wave lengths (Figure: 1.20). All these energies are included within electromagnetic spectrum because they are

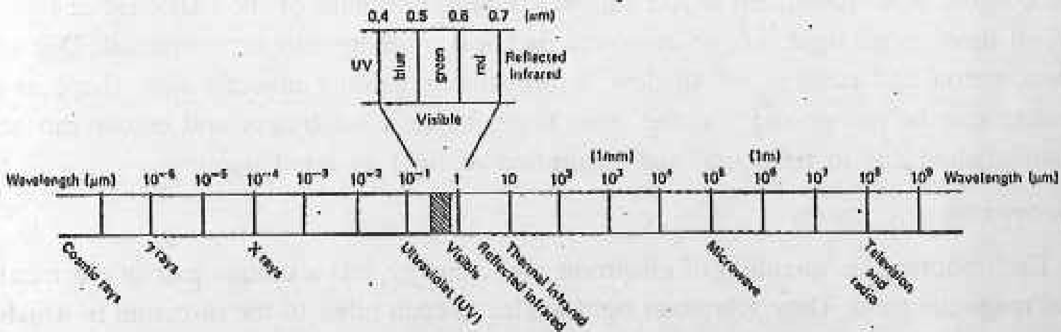


Fig.1.20

basically similar in nature and radiate energy in accordance with the basic principle of wave theory. It may be mentioned here that electromagnetic energy travels in a harmonic, sinusoidal fashion at the velocity of light.

Scattering and absorption of light in the atmosphere:

All materials at temperature above absolute zero (0° K = -273°C) emit electromagnetic radiation. A hypothetical black body, which is an ideal radiator, that totally absorbs and re-emits all energy, is considered as standard to compare emittance of radiation (Figure

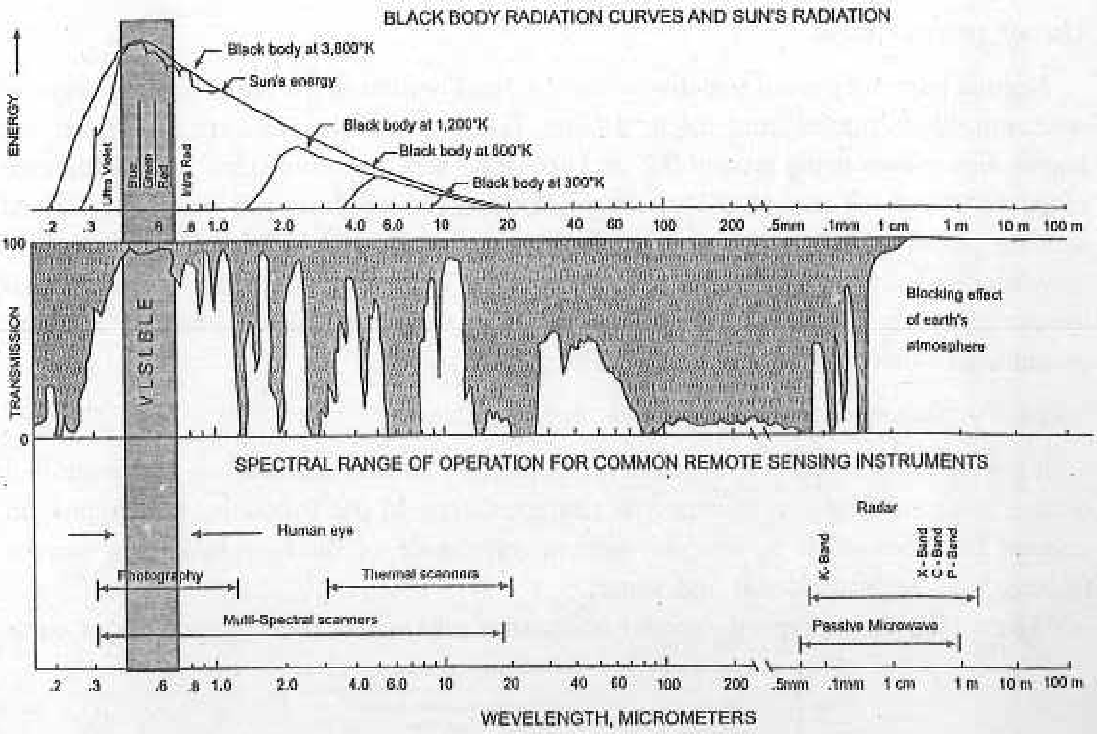


Fig. 1.21

1.21). But the amount of available energy may be affected due to various factors including atmospheric conditions causing scattering and absorption. Molecules and other tiny particles which are smaller in dimension than the wavelength of the interacting radiation cause Rayleigh scattering. It is one of the reasons for causing haze, which diminishes the contrast in the imagery. Mie scattering results due to existence of water vapour or dust in the atmosphere, the dimension of the particle size being equal to the energy wave lengths being sensed. Overcast is the result on the imagery. Non-selective scattering is caused due to existence of different sizes of particles like water droplets, the diameter being much larger than the energy wave length to be sensed. The resultant effect is fog or cloud which appear as white patch in the imagery.

On the other hand, different elements are responsible for atmospheric absorption resulting effective loss of energy to atmospheric constituents. Water vapour, carbon dioxide, ozone, etc. are the important absorbers of solar radiation.

Atmospheric window:

Due to such blocking effects of the earth's atmosphere, it is not possible to use the entire electromagnetic spectrum for remote sensing purposes. Actually the bands of the spectrum i.e. the wavelength ranges, where the atmospheric attenuation is slight, are known as Windows. These are the regions used for remote sensing purposes.

Use of spectral band:

Normal human eyes are sensitive to only a small portion of the entire electromagnetic spectrum which ranges from 0.4 to 0.7 µm. Gama rays and x rays are very short, the length dimensions being around 0.2 µn Ultraviolet sensitive emulsions react within the range of 0.3 to 0.4 µm of the electromagnetic spectrum. Infra-red emulsions extend sensing possibilities up to 1.2 µm. Thus photographs are in a position to record wavelengths from 0.2 to 1.2 µm, i.e. three times more than the range of the normal human eyes can visualise. However, to sense wavelengths longer than 1.2 µm, instruments other than photographic cameras are in use.

Spectral reflectance of different earth surface features:

It has been observed that different types of earth surface features may be identified on the basis on their specific spectral characteristics. In the following paragraphs, an attempt has been made to analyse spectral reflectance of three typical earth surface features, i.e. vegetation, soil and water.

Figure 1.22 shows typical spectral reflectance curves for three basic types of earth

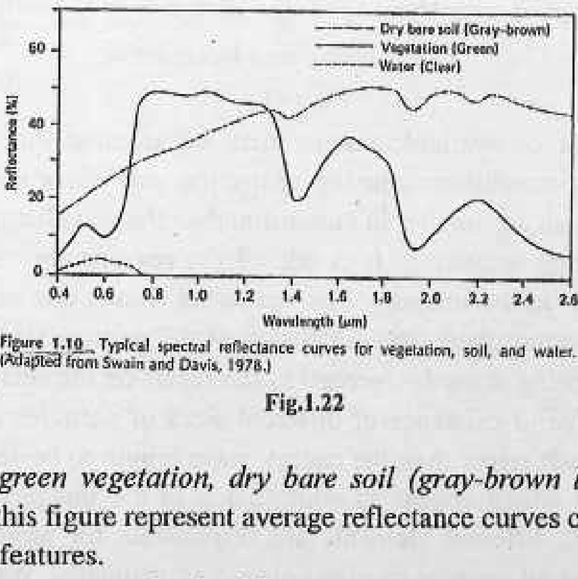


Figure 1.10 Typical spectral reflectance curves for vegetation, soil, and water. (Adapted from Swain and Davis, 1978.)

Fig.1.22

features : *healthy green vegetation, dry bare soil (gray-brown loam), and clear lake water.* The lines in this figure represent average reflectance curves compiled by measuring a large sample of features.

Spectral reflectance curves for *healthy green vegetation* almost always manifest the "peak-and-valley" configuration. The valley in the visible portion of the spectrum are directed by the pigments in plant leaves. Chlorophyll, for example, strongly absorbs energy in the wave length bands centered at about 0.45 and 0.67µm (often called the "chlorophyll absorption bands"). Hence our eyes perceive healthy vegetation as green in colour because of the very high absorption of blue and red energy by plant leaves and the very high reflection of green energy. If a plant is subject to some form of stress that interrupts its normal growth and productivity, it may decrease or cease chlorophyll production. The result is less chlorophyll absorption in the blue and red bands. Often, the red reflectance increases to the point that we see the plant turn yellow (combination of green and red).

As we go from the visible to the near - IR portion of the spectrum at about 0.7 μm, the reflectance of healthy vegetation increases dramatically. In the range from about 0.7 to 1.3μm, a plant leaf typically reflects 40 to 50 percent of the energy incident upon it. Most of the remaining energy is transmitted, since absorption in this spectral region is minimal (less than 5 per cent).

The *soil* curve in the figure shows considerably less peak- and - valley variation in reflectance. That is, the factors that influence soil reflectance act over less specific bands. So of the factors affecting soil reflectance are moisture content, soil texture, surface roughness, presence of iron oxide, and organic matter content. These factors are complex, variable and interrelated. For example, the presence of moisture in soil will decrease its reflectance. Soil moisture is strongly related to the soil texture : Coarse, sandy soils are usually well drained, resulting in low moisture content and relatively high reflectance; poorly drained fine-textured soils will generally have lower reflectance.

Considering the spectral reflectance of *water*, probably the most distinctive characteristic is the energy absorption at near - IR wavelengths and beyond. Clear water absorbs relatively little energy having wavelengths less than about 0.9μm. High transmittance typifies these wavelengths with a maximum in the blue-green portion of the spectrum. However, as the turbidity of water changes, transmittance - and therefore reflectance - changes dramatically. For example, water containing large quantities of suspended sediments resulting from soil erosion normally has much higher visible reflectance than other *clear* water.

Remote sensing platform:

Platforms refer to the structures or vehicles on which the sensing instruments are mounted, e.g. pigeon, kite, balloon, rocket, aeroplane, space shuttle, satellite, etc. The platform on which a particular sensor is housed determines a number of attributes, which may dictate the use of particular sensors. These attributes include: distance the sensor is from the object of interest, periodicity of image acquisition, timing of image acquisition, and location and extent of coverage. There are three broad categories of remote sensing platforms: ground based, air borne and space borne.

Ground based — A wide variety of ground based platforms are used in remote sensing. Some of the more common ones are hand held devices, tripods, towers and cranes. Instruments that are ground-based are often used to measure the quantity and quality of light coming from the sun or for close range characterization of objects. For example, to study properties of a single plant or a small patch of grass, it would make sense to use a ground based instrument.

Laboratory instruments are used almost exclusively for research, sensor calibration, and quality control. Much of what is learned from laboratory work is used to understand how remote sensing can be better utilized to identify different materials. This contributes to the development of new sensors that improve on existing technologies.

Field instruments are also largely used for research purposes. This type of remote sensing instrument is often hand-held or mounted on a tripod or other similar support.

Permanent ground platforms are typically used for monitoring atmospheric phenomenon although they are also used for long-term monitoring of terrestrial features. Towers and cranes are often used to support research projects where a reasonably stable, long-term platform is necessary. Towers can be built on site and can be tall enough to project through a forest canopy so that a range of measurements can be taken from the forest floor, through the canopy and from above the canopy.

Airborne — Airborne platforms were the sole non-ground-based platforms for early remote sensing work. The first aerial images were acquired with a camera carried aloft by a balloon in 1859. Balloons are rarely used today because they are not very stable and the course of flight is not always predictable, although small balloons carrying expendable probes are still used for some meteorological research.

At present, airplanes are the most common airborne platform. Nearly the whole spectrum of civilian and military aircraft are used for remote sensing applications. When altitude and stability requirements for a sensor are not too demanding, simple, low-cost aircraft can be used as platforms. However, as requirements for greater instrument stability or higher altitudes become necessary, more sophisticated aircraft must be used.

Aircraft are divided into three categories (low, mid, and high) based on their altitude restrictions. In general, the higher an aircraft can fly, the more stable a platform it is, but correspondingly more costly to operate and maintain.

Low altitude aircraft typically fly below altitudes where supplemental oxygen or pressurization are needed (12,500 feet above sea level). They are good for acquiring high spatial resolution data limited to a relatively small area.

Helicopters are usually used for low altitude applications where the ability to hover is required. Helicopters are quite expensive to operate and they are typically used only when needed. Ultra-light aircraft are a class of aircraft that is gaining popularity. These small, often portable, aircraft are inexpensive and are able to take off and land where larger aircraft cannot. They are limited to flying at lower elevations and at slow speeds.

Mid-altitude aircraft have an altitude limit under 30,000 feet above sea level. This class of airplane is used when stability is more important and when it is necessary or desired to acquire imagery from a greater distance than available from low altitude aircraft. These aircraft can obtain greater areal coverage more quickly than low altitude platforms.

High altitude aircraft can fly at altitudes greater than 30,000 feet above sea level. This class of airplane is usually powered by jet engines and is used for specialized tasks, such as atmospheric studies, research to simulate satellite platforms, and other applications where a high altitude platform is required. High altitude aircraft are good for acquiring large areal coverage with typically lower spatial resolutions.

Another class of aircraft that has been in use for many years is remote control aircraft, or drones. Remotely controlled aircraft are often used for conditions when it may be too hazardous to fly. They have been used extensively by the military.

Space borne— The most stable platform aloft is a satellite, which is space borne. The first remote sensing satellite was launched in 1960 for meteorology purposes. Now, over a hundred remote sensing satellites have been launched and more are being launched every year. The Space Shuttle is a unique spacecraft that functions as a remote sensing satellite and can be reused for a number of missions.

The payload for remote sensing satellites can include photographic systems, electro-optical sensors, microwave or lidar systems. For applications benefiting from simultaneous coverage by different sensors, more than one sensing system can be mounted on a single satellite.

Fundamental Sensor Types:

Sensor means the sensing or recording device. There are several broad categories of basic sensor system types such as passive vs. active, and imaging vs. non imaging. Passive vs. active refers to the illumination source of the system; imaging vs. Non imaging refers to the form of the data. A variety of different sensors fit in these categories, which are not mutually exclusive.

Passive vs. active sensors— Passive sensors measure light reflected or emitted naturally from surfaces and objects. Such instruments merely observe, and depend primarily on solar energy as the ultimate radiation source illuminating surfaces and objects. Active sensors (such as radar and lidar systems) first emit energy (supplied by their own energy source) and then measure the return of that energy after it has interacted with a surface. Use of data collected by passive sensors often requires accurate measurements of solar radiation reaching the surface at the time the observations were made. This information allows for the correction of "atmospheric effects" and results in data or images that are more representative of actual surface characteristics.

Imaging vs. Non imaging sensors — Remote sensing data are the recorded representation of radiation reflected or emitted from an area or object. When measuring the reflected or emitted energy, either imaging or non imaging sensors can be used. Data from imaging sensors can be processed to produce an image of an area, within which smaller parts of the sensor's whole view are resolved visually. Non imaging sensors usually are hand held devices that register only a single response value, with no finer resolution than the whole area viewed by the sensor, and therefore no image can be made from the data. These single values can be referred to as a type of "point" data, however some small area is typically involved depending on the sensor's spatial resolution.

Image and non image data each have particular uses. Non-image data give information for one specific (usually small) area or surface cover type, and can be used to characterize the reflectance of various materials occurring in a larger scene and to learn more about the interactions of electromagnetic energy and objects. Image data provide an opportunity to look at spatial relationships, object shapes, and to estimate physical sizes based on the data's spatial resolution and sampling. Image data are desirable when spatial information (such as mapped output) is needed.

Images produced from remote sensing data can be either analog (such as a photograph) or digital (a multidimensional array or grid of numbers). Digital data can be analyzed by studying the values using calculations performed on a computer, or processed to produce an image for visual interpretation. Image interpretation is used to decipher information in a scene. In the past, image interpretation was done largely using subjective visual techniques, but with the development and ongoing advancement of computer technology, numeric or digital processing has become a powerful and common interpretation tool.

In many cases, image interpretation involves the combination of both visual and digital techniques. These techniques utilize a number of image features including tone and color, texture, shape, size, patterns, and associations of objects. The human eye and brain are generally thought to more easily process the spatial characteristics of an image, such as shape, patterns and how objects are associated with one another. Computers usually are better suited for rapid analysis of the spectral elements of an image such as tone and color. Sophisticated computer software that can perform like the human eye and brain may be more commonly available in the future.

Passive Sensors

Passive sensors are the most common sensor type for vegetation related remote sensing. This is not only because passive sensor systems are generally simpler in design (built only to receive energy) but also because portions of the solar spectrum provide very useful information for monitoring plant and canopy properties.

A major limitation of passive systems is that in most cases they require sunlight in order for valid and useful data to be acquired. Consequently, deployment of or data acquisition by passive sensors is very dependent on lighting (time of day, time of year, latitude) and weather conditions, since cloud cover can interfere with the path of solar radiation from the sun to the surface and then to the sensor.

The signals detected by passive sensors can be greatly altered due to atmospheric effects, especially in the shorter wavelengths of the solar spectrum that are strongly scattered by the atmosphere. These effects can be minimized (but not eliminated) by collecting data only under very clear and dry atmospheric conditions. Sophisticated atmospheric correction routines now exist to remove atmospheric effects from data acquired by passive sensors.

Photographic — The most common sensor system is the photographic camera — a simple passive sensor. Many of the historic developments in remote sensing were directly related to the development of photographic systems. Camera systems are similar in design to the human eye. Both have a lens at one end of an enclosed chamber and a light-sensitive material (film for a camera and the retina for an eye) at the other. In both systems, an iris is used to control the amount of light that can strike the film/retina. In a camera, a shutter is placed between the lens and film to control how long the light can strike the film. Filters can be attached in front of a lens to restrict the wavelength of light permitted to strike the film.

There are three basic elements of photographic systems — optics, film, and filters. Optics refer to lenses and the geometry of light retrieval in a camera. The lenses in a camera are responsible for focusing and zooming on an object. Before light reflected from an object strikes the film, it must pass through one or more lenses. As light passes through a lens, it is bent to focus the imaged object on the film. To minimize distortions associated with the use of single lenses, most camera lenses are actually composed of multiple lenses that work in concert to form an image onto the film.

The amount of image detail that can be recorded on film is directly related to the distance between the lens and the film, referred to as the focal length. As the focal length increases, the detail that can be seen on the film increases. Increasing the focal length is commonly called zooming in on an object.

Film in a camera is used to record the image that passes through the lens. Photographic film is composed of a durable base, which is coated with a light-sensitive layer know as the emulsion. During the short time that a shutter is open, light strikes the film and leaves a latent image on the emulsion. This image can be made visible by the process of developing and printing.

Emulsions are made of materials sensitive to particular regions of the electromagnetic spectrum. For example, some film is only sensitive to visible light, whereas other film is sensitive to near-infrared light. In color film, the emulsion is composed of three layers, with each being sensitive to different wavelengths of light, normally blue, green and red light. With black and white film, the emulsion is sensitive to a broad spectrum of light. Film emulsions are generally limited to recording wavelengths between 0.4 to

0.9 micrometers. Black and white film sensitive to visible light and black and white film sensitive to infrared wavelengths can also be used for remote sensing purposes.

Film speed is another quality of emulsions that is important for aerial photography. Film speed refers to the quantity of light than is needed to expose the emulsion. Fast film requires less light than slow film to record the same image. If the camera platform is moving, one would want to use a high speed film to reduce the blurring effects of the moving camera.

In many remote sensing applications, it is important to restrict the light entering the camera by the use of filters. Color filters work by absorbing a range of wavelengths while allowing other wavelengths to pass through. Another filter type, known as neutral color filters, do not alter the spectral composition of light, but instead reduce the amount of light of all wavelengths that pass through.

Perhaps the most common color filter is an antihaze filter. These are clear or yellow filters, which absorb out the shorter ultraviolet and blue wavelengths that are substantially scattered by particulates in the atmosphere. Another filter used for monitoring vegetation is an infrared filter, which absorbs visible light and only allows infrared light to pass through.

Aerial photography is one of the oldest forms of remote sensing and it is still used extensively today. It is usually the choice if great spatial detail is needed. For example, photography can be used to identify individual tree species (based on the shape of individual trees) and measure tree heights using special photographic techniques. Because of the detail that can be discerned on a photograph, aerial photography is used extensively for mapping vegetation classes.

Aerial photography is also used as a reconnaissance tool to provide overview information for a particular area. For instance, if there has been an outbreak of a disease that is killing a certain tree or agricultural species, aerial photography using infrared film (to locate trees that are being stressed) can monitor areas for signs and extent of the disease.

Electro-optic radiometers — A radiometer is an instrument designed to measure the intensity of electromagnetic radiation in a set of wavebands ranging from the ultraviolet to microwave wavelengths. Radiometers are similar in design to a camera in that they have an opening for the light to enter, lenses and mirrors for the light to pass through, but instead of film, they have an electronic detector to record the intensity of electromagnetic energy. As energy hits the detector, a signal proportional to the incoming irradiance is processed to either a digital or analog output that can be recorded.

Detectors for radiometers have been devised to measure wavelengths from 0.4 to 14 micrometers. Although some radiometers can detect this entire range of wavelengths, most only measure selected wavebands in this range. Radiometers that measure more than one waveband are called multispectral radiometers. For this type of radiometer, the light must be separated into discrete wavebands so that multiple waveband or multichannel readings can be taken. This separation can be done using filters, prisms or other sophisticated techniques.

Non imaging radiometers are commonly used as research tools to better understand how light interacts with objects, for spectral characterization of a variety of surfaces, and for atmospheric measurements. Another common use is to measure the quantity and quality of solar energy. These measurements can in turn be used to correct other imaging and non imaging measurements for atmospheric effects.

Passive microwave systems — Passive microwave systems are based on a type of radiometer that detects wavelengths in the microwave region of the spectrum. Because of the nature of microwave radiation, optical systems cannot be used for the detection of this range of wavelengths. As with optical systems though, both non imaging and imaging systems are available. The components of a microwave radiometer are an antenna, receiver, and recording device. Microwave energy emitted from Earth's surface is collected by an antenna, converted by a receiver into a signal, and recorded.

The features of electromagnetic energy measured by microwave radiometers are polarity, wavelength, and intensity. These properties provide useful information about the structure and composition of an object. Most of the applications of passive microwave radiometers have been in the fields of atmospheric and oceanographic research. It has also proven to be an effective tool for the measurement of soil moisture, an important parameter in studying vegetation.

Visible, infrared, and thermal imaging systems— By combining a number of detectors or radiometers into detector arrays, it is possible to create a sensor that can acquire a 2D image of an area. There are three basic designs for imaging sensors: frame, pushbroom, and mechanical scanner.

The first two designs are similar. The frame sensor is a 2D array of detectors that acquires an entire image in one exposure similar to the way a camera captures an image on film. A *push broom sensor* is a 1D array that obtains an image one line at a time. Each new data line is added as the platform moves forward, building up an image over time. In a mechanical scanner system the sensor acquires only one or several pixels in any given instant, but since the scanner physically sweeps or rotates the sensor (a radiometer) or a mirror back and forth, an image is produced.

This category of sensor (passive visible, infrared and thermal imaging systems) contains numerous instruments that have been deployed on a wide variety of platforms and used for many applications. Most modern imaging systems are multispectral (acquiring data for more than one limited spectral area). The recording of each discrete spectral sampling is referred to as an image band or channel. Using image processing techniques, multiple (usually three) bands selected from a multispectral image database can be combined to make a single color composite image.

Active Sensors

Active systems supply their own illumination energy which can be controlled. Some advantages active systems have over passive sensors are they do not require solar illumination of surfaces or perfect weather conditions to collect useful data. Consequently they can be deployed at night or in conditions of haze, clouds, or light rain (depending on the wavelength of the system).

Radar — Radar *(radio detection and ranging)* systems use microwaves (wavelengths ranging from 1 millimeter to 1 meter). Microwave pulses are transmitted at a target or surface, and the timing and intensity of the return signal is recorded.

Transmission characteristics of radar depend on the wavelength and polarization of the energy pulse. Common wavelength bands used in pulse transmission are K-band (11-16.7 mm), X-band (24-37.5 mm), and L-band (150-300 mm). The use of letter codes to designate the wavelength range for various radar systems originated when radar was being developed during World War II.

Information about the structure and composition of objects and surfaces can be detected with radar. Radar has been used in a number of fields, including geology, snow and ice studies, oceanography, agriculture, and vegetation studies. Radar has been especially useful in areas with nearly constant cloud cover.

Lidar — Lidar *(light detecting and ranging)* systems use laser light as an illumination source. A short pulse of light is emitted from a laser and a detector receives the light energy (photons) after it has been reflected, or absorbed and remitted, by an object or surface. Lidar systems emit pulses at specific, narrow wavelengths that depend on the type of laser transmitter used. The possible wavelengths range from about 0.3 to 1.5 micrometers, which covers the ultraviolet through near-infrared spectral range. The simplest lidar systems measure the round trip travel time of a laser pulse, which is directly related to the distance between the sensor and the target. Basic distance measuring lidars are often referred to as rangefinders or as laser altimeters if deployed on an aircraft or spacecraft. These systems typically measure elevation, slope, and roughness of land, ice, or water surfaces.

More advanced lidars measure the received intensity of the backscattered light as a function of travel time. The intensity of the signal provides information about the material that reflected the photons. Such backscatter lidar systems are often used for atmospheric monitoring applications concerned with the detection and characterization of various gases, aerosols and particulates. Lidar methods have recently been adapted to measure tree heights and the vertical distribution of canopy layers with great accuracy and precision. Lidar instruments have flown on the Space Shuttle, and Vegetation Canopy Lidar (VCL) and Ice, Cloud, and land Elevation Satellite (ICESat).

Lidar systems can also make fluorescence measurements. Fluorescence refers to the process where a material absorbs radiant energy at one wavelength and then emits it at a different wavelength without first converting the absorbed energy into thermal energy. The wavelengths at which absorption and emission occur are specific to particular molecules. Fluorescence data can identify and quantify the amount of plankton and pollutants in the marine environment. Leaf fluorescence can also help to identify plant species.

Orbiting satellites

Satellites can be classified by their orbital geometry and timing. Three orbits commonly used for remote sensing satellites are *geostationary, equatorial* and *Sun synchronous.* A *geostationary satellite* (Figure 1.23) has a period of rotation equal to that of Earth

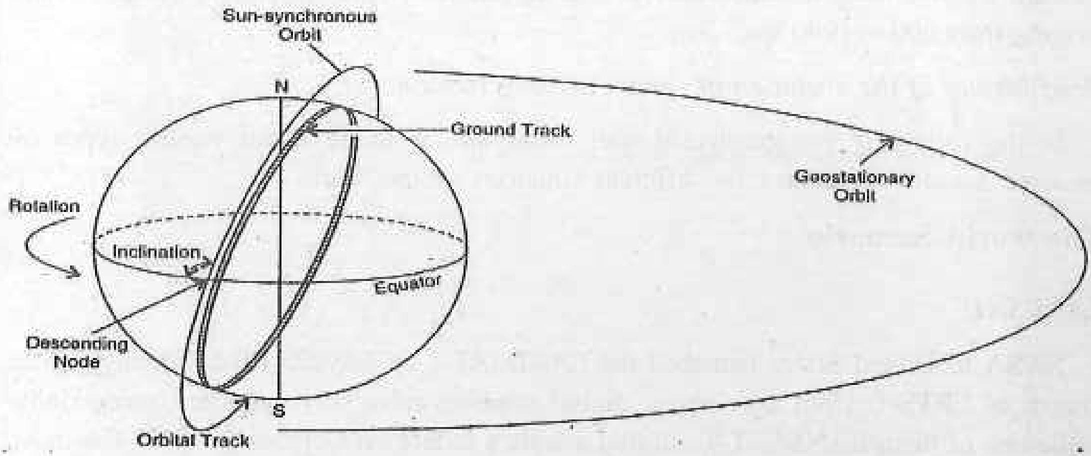


Fig.1.23

(24 hours) so the satellite always stays over the same location on Earth. In other words, Geostationary orbit means an orbit at an altitude of 36,000 / 40,000 km above the surfac of the earth in the direction of the earth's rotation, which matches the speed so that a satellite remains over a fixed point on the earth's surface. Communications and weather satellites often use geostationary orbits with many of them located over the equator. INSAT is an example of Geostationary satellite.

In an *equatorial orbit,* such a satellite circles Earth at a low inclination (the angle between the orbital plane and the equatorial plane). The Space Shuttle uses an equatorial orbit with an inclination of 57 degrees.

Sun synchronous satellites (Figure 1.23) have orbits with high inclination angles, passing nearly over the poles. Orbits are timed so that the satellite always passes over the equator at the same local sun time. In this way the satellites maintain the same relative position with the sun for all of its orbits. Many remote sensing satellites are Sun synchronous which ensures repeatable sun illumination conditions during specific seasons. Because a Sun synchronous orbit does not pass directly over the poles, it is not always possible to acquire data for the extreme polar regions. The frequency at which a satellite sensor can acquire data of the entire Earth depends on sensor and orbital characteristics. For most remote sensing satellites the total coverage frequency ranges from twice a day to once every 16 days. These satellites are placed at an altitude ranging from 600 to 800 kilometres. LANDSAT, SPOT, IRS, etc. are examples of sun synchronous satellite.

Another orbital characteristic is altitude. The Space Shuttle has a low orbital altitude of 300 km whereas other common remote sensing satellites typically maintain higher orbits ranging from 600 to 1000 km.

Brief history of the evolution of remote sensing technology:

In the following paragraphs, a brief discussion is made about various types of resource satellites launched by different countries of the world.

The world Scenario

LANDSAT:

NASA of United States launched the LANDSAT-1 on July23, 1972. Initially it was known as ERTS-1. Until now seven landsat satellites have been launched successfully while one of them LANDSAT-6 suffered a launch failure on October 5, 1993. The most recent being the LANDSAT-8 launched on February 11, 2013.

The series Landsat 1,2,3 orbited the earth in sun synchronous orbit at a height of about 900 km. After every 18 days it passed over the same place on earth to provide repetitive coverage. Landsat 4,5 were at an altitude of 700 km with a revisit period of 16 days.

The Landsat programme is the oldest Earth observation programme. It started in 1972 with the Landsat-1 satellite carrying the MSS (Multispectral sensor). After 1982, the Thematic Mapper (TM) replaced MSS sensor. In April 1999 Landsat-7 was launched carrying the ETM+ scanner.

There are many applications of Landsat Thematic Mapper data : land cover, mapping, land use mapping, soil mapping, geological mapping, sea surface temperature mapping, etc. Landsat Thematic Mapper is the only non-meteorological sensor that has a thermal infrared band. Thermal data are required to study energy processes at the Earth's surface, for instance, the crop temperature variability within irrigated areas.

A number of sensors have been put onboard Landsat series satellites, which include

Return Beam Vidicon (RBV), Multispectral Scanner (MSS), Thematic Mapper (TM), Enhanced Thematic Mapper (ETM), etc. Each of these sensors collected data over a swath of 185 km. MSS had 4 spectral bands at spatial resolution of 80 m and a radiometric resolution of 6 bits. TM sensors has an improvement over MSS in terms of resolution. TM has 7 bands. For six bands the spatial resolution is 30 m and it has a thermal band at 120 m resolution. ETM has 8 bands.

SPOT:

SPOT stands for *Systeme Pour la Observation de la Terre*. SPOT is owned by a consortium of French, Swedish and Belgium governments. SPOT-1 was launched on 22 February, 1986. At that time, the 10 m panchromatic spatial resolution of SPOT-1 was unprecedented. Spot-2 was launched on 22 January, 1990; SPOT-3 was launched on 26 September, 1993. On 24 March 1998 a significant improved SPOT-4 was launched: the HRVIR sensor had 4 instead of 3 bands and the VEGETATION instrument was added. VEGETATION was designed for frequent (almost daily) and accurate monitoring of the globe's landmasses.

SPOT-5 is the fifth satellite in the SPOT series which has successfully been placed in the orbit on 4 May, 2002 from Guiana Space Centre, Kourou, French Guyana. The new *SPOT-5* satellite offers improved ground resolutions of 10 metres in *multispectral mode* and 2.5 to 5 metres in *panchromatic* and *infrared* mode. Higher 2.5 metre resolution is achieved using an innovative sampling concept called *supermode*.

SPOT-5 also features a new a *HRS* instrument *(High Resolution Stereoscopic)* operating in *panchromatic* mode and able to point forward and aft of the satellite. In a single pass, the forward-pointing camera acquires images of the ground, then the rear ward- pointing camera covers the same strip 90 seconds later. *HRS* is thus able to acquire *stereopair* images almost simultaneously to map relief and also produce *Digital Elevation Models (DEMs)* of wide areas.

SPOT-6 and SPOT-7 were launched on 9 September 2012 and 30 June 2014 respectively.

IKONOS:

The *IKONOS* satellite is a high resolution satellite operated by *GeoEye*. *IKONOS-1* failed during launch on 27 April, 1999. However *IKONOS-2* was delivered to *Space Imaging* (now *GeoEye)* on 24 September, 1999 and was successfully placed in the orbit at an altitude of 681 kilometre. Its capabilities include capturing a 3.2 metre *multi-spectral, Near-Infrared (NIR)* and also 0.82 *metre panchromatic* resolution at nadir. The swath of the satellite is 11.3 km at nadir and 13.8 km at 26° off-nadir. The satellite provides with 11 bit data in terms of radiometric resolution. The spectral resolutions of *panchromatic* mode is 450-900 nanometre, whereas the same for *multispectral* mode is

445-516 nm *(Blue)*, 506-595 nm *(Green)*, 632-698 nm *(Red)* and 757-853 nm *(NIR)*. The revisit period of the satellite is 3 days whereas the operating life is more than 7 years. Its applications include both urban and rural mapping of natural resources and of natural disasters, tax mapping, agriculture and forestry analysis, mining, engineering, construction and change detection. In addition to mapping of small to medium scale mapping, IKONOS data can also be used for updating existing topographic maps. It can yield relevant data for nearly all aspects of environmental study. *IKONOS* images have also been produced by *SIC* for use in the media and motion picture industries, providing aerial views and satellite photos for many areas around the world. Its high resolution data makes an integral contribution to homeland security, coastal monitoring and facilitates 3D Terrain analysis.

QuickBird:

The highest resolution satellite imagery currently available to the public is provided by *QuickBird-2*. It may be mentioned here that *QuickBird-1* failed to attain earth orbit during the 22 November, 2000 launch. However, launched on 18 October, 2001 *QuickBird-2*, operated by *DigitalGlobe*, is one of the first commercial remote sensing satellites capable of gathering *sub-metre* resolution data over a very wide swath. The orbital altitude of the satellite is 450 km and is expected to operate for seven years long with revisit time of 1 to 3.5 days with up to 30° off-nadir viewing. The *QuickBird* satellite incorporates on ITT designed and built sensor subsystem, consisting of the focal plane array, image compression and electronics. The subsystem captures 0.61 metre spatial resolution panchromatic imagery and 2.4 metre multispectral imagery. The swath of the satellite is 16.5 km with radiometric resolution of 11 bits per pixel. It produces 11x11 km snapshots to 11x225 km strip maps. In addition to green, red and near-infrared wavelengths, the multispectral sensor can also process a blue channel enabling true colour imaging from space. *QuickBird's*, global collection of *panchromatic* and *multispectral* imagery is designed to support applications ranging from map publishing to land asset management to insurance risk assessment.

Orbview:

Orbview-3 has been successfully launched on 26 June, 20003 by *Orbimage* (now *GeoEye)*, U.S.A. It is the third space born satellite that provides imagery products up to a spatial resolution of 1 metre in the *panchromatic* channel. The system can also provide *multispectral images* with a spatial resolution of 4 metres.

Orbview-3 collects one metre *panchromatic* and four metre *multispectral* imagery at a swath width of 8 km. One metre imagery enables the accurate viewing and mapping of houses, automobiles and aircraft and make it possible to create highly precise digital maps. Four metre *multispectral* imagery provides colour and infrared information to further characterize cities, rural areas and undeveloped land from space. The satellite revisits each location on earth in less than three days with its ability to collect data up to 50 degree off-nadir. *Orbview-3* provides imagery products useful for a variety of applications such as utilities, telecommunications, oil and gas, mapping, surveying, agriculture, forestry, security, etc. It may be mentioned here that *Orbview-4* failed to orbit on 21 September, 2001.

EROS:

EROS (Earth Remote Observation Satellite), is an Israeli commercial/military photo-imaging satellite. Successfully launched on 5 December, 2000, *EROS A* has been commercially operated since 1 January, 2001. However on 25 April, 2006 *ImageSat* launched the second very high resolution satellite in the *EROS* family, *EROS-B*, the launch took place at the cosmodrome in Svobodni, Siberia by a *Start* launcher. The satellite is expected to provide services for 8-10 years. It has larger camera of *CCD/TDI (Charge Coupled Device/Time Delay Integration)*, with *standard panchromatic* resolution of 0.70 metre at an altitude of 500 km.

Resurs:

Resurs-DKl was launched from Baykonur launch area on June 15, 2006 with Soyz carrier vehicle. The 6570 kg satellite was placed into elliptical orbit at an altitude of 360-604 km. With 6 days revisiting frequency, the satellite is having a life span of 5 years. It is able to collect 1 m spatial resolution imagery in panchromatic mode.

The major tasks of the satellite include data supply for resource management and economical activity including inventory of natural resources, topographic and thematic mapping, etc. Moreover the sensors attached to the satellite are in a position to monitor the pollution sources of the atmosphere, water and soil with the view of providing Federal and regional environmental authorities with the relevant information to management decisions. It is also possible on-line monitoring of man-caused and natural emergencies for the purpose of effective planning and timely performing of measures to eliminate damages.

Ofek:

Ofek-7, also known as Ofeq-7, is part of the ofeq family of earth observation satellites designed and built by Israel Aerospace Industries (IAI) for the Israel Ministry of Defence. The first Ofek-7 was launched by a Shavit space launch on June 11, 2007. Equipped with advanced technology and a series of new enhancements to provide improved imagery, it is placed into an elliptical orbit of 300 x 600 kilometres. Three days after its launch, IAI/MBT Space Division received the first image taken by the satellite. The Ofek-7 is a follow-on spacecraft to Ofek-5 that was placed into orbit in

2002. The latest Ofek-7 was launched on September 17, 2007 from Palmahim Air Force Base atop a Shavit missile. It's elliptical orbit reportedly takes it over Iran, Iraq and Syria every 90 minutes. It has an expected life of four to six years. Ofek-7 contains notable improvements over the Ofek-6 satellite, which crashed into the Mediterranean shortly after launch in 2004. Defense officials of Israel said that the new satellite was by far the most advanced satellite the country has ever launched into space. It is further stated that the satellite was superior to the Eros-B, which has the ability to identify objects on the ground as small as 70 centimetres.

World View:

WorldView-1 was successfully launched into orbit on 18 September, 2007. It is a high resolution imaging satellite launched and operated by *DigitalGlobe,* has reached its operational state. The satellite has met all requirements and is delivering imagery to the US *National Geospatial-Intelligence Agency (NGA)* as part of its Nextview programme. Following a controlled rollout with *NGA, DigitalGlobe* began taking orders for *WorldView-1* imagery on 3 January, 2008. The majority of the imagery captured for the *NGA* will also be available for distribution through *DigitalGlobe's ImageLibrary.* The deployment of this satellite frees capacity on the company's *QuickBird* satellite to meet growing commercial demand for multi-spectral geospatial imagery.

GeoEye-1:

GeoEye-1 was launched on 06 September, 2008, which provided with the highest spatial resolution of any commercial imaging system during that time by acquiring imagery with a ground resolution of 41 cm and 1.65 metre in panchromatic mode and multi-spectral mode respectively. It makes 12 to 13 orbits per day flying at an altitude of 684 kilometres with an orbital velocity of about 7.5 km/sec. In the panchromatic mode *GeoEye-1* is capable of collecting up to 700,000 sq kilometres per day, and in the multi-spectral mode 350,000 sq kilometers per day. This capacity is ideal for large-scale mapping projects. *Geo-Eye-1's* optical telescope, detectors, focal plane assemblies and high-speed digital processing electronics are capable of processing 700 million pixels per second. The satellite's agile camera allows for side-to-side extensions of the camera's 15.5 kilometres swath width or multiple images of the same target during a single pass to create stereo picture. It may be mentioned here that *GeoEye-1* customers have a choice of ordering basic, ortho-rectified, or stereo imagery as well as imagery-derived products, including Digital Elevation Models (DEMs), large area mosaics and feature maps. The satellite provides with 11 bit data in terms of radiometric resolution and the expected life span of the satellite is around 10 years.

The Indian Scenario:

In the area of resource satellite based remote sensing in India, the first generation satellites *IRS-1A* and *1-B* were designed, developed and launched successfully during 1988 and 1991 equipped with two Linear Imaging and Self Scanning sensors (LISS-I and LISS-II) on board for providing data in four spectral bands (visible and near infra red regions) with skatial resolutions of 72.5 m and 36.25 m. These satellites were launched on 17 March 1988 and 29 August 1991 respectively.

Subsequently the second generation remote sensing resource satellite *IRS-IC* and *1-D* with improved spatial resolutions of 70 m in multi-spectral and 5.8 m in panchromatic mode and a Wide Field Sensor (WiFS) with 188 m resolution with a wide ground swath of 810 km have been developed and successfully launched on 29 December, 1995 and 29 September, 1997 respectively. It may be mentioned here that *IRS-IC* was launched from Baikonur whereas *IRS-1D* was launched from Sriharikota with the help of PSLV. The specifications for both the satellites were more or less the same. Placed onto a 817 km orbit, *IRS-IC* used to take only 93 minutes to go round the earth and surveying the whole surface of the earth in just 24 days. The PAN was designed to provide data with a very high spatial resolution of 5.8 m and a ground swath of 70 km. The sensor used to collect data in the visible region (0.50-0.75 micron). The added advantage of the PAN camera is its steerability. The camera can be steered to $\pm$ 26 degree which in tern increases revisit capability to 5 days. The LISS III sensor provides multispectral data collected in four bands, two in the visible (0.52-0.59 and 0.62-0.68 microns), one in the near infra-red (0.77-0.86 micron), and one in shortwave infra-red (1.55-1.70 microns) regions of the electromagnetic spectrum. While the spatial resolution and swath in case of visible and near infra-red regions are 23.5 m and 141 km respectively, they are 70.5 m and 148 km for the data collected in shortwave infra-red region. The LISS-1V is a high spatial resolution multi-spectral camera operating in three bands (B2, B3, B4). LISS-IV provides a ground resolution of 5.8 m which can be operated in either single band mono mode or multi-spectral mode. In the multi-spectral mode (MX), a swath of 23 km (selectable out of 70 km total swath) is covered in three bands, while in mono mode (Mono), the full swath of 70 km can be covered in any one single band, which is selectable by a ground command (B3-Red band). The LISS-IV camera can be tilted up to $\pm 26°$ in the across track direction thereby providing a revisit period of 5 days and 70 x 70 km stereo pairs.

The WiFS collects data in two spectral bands, visible (0.62-0.86 microns) and near infrared (0.77-0.86 microns). It may be mention here that to prepare a FCC with the help of WiFS data, one is the repeated one of the two bands to generate RGB colour separates.

These satellites have become the principle components in the National Resource Management System and the data have been used in various applications, viz. agriculture and soil, land form and land use studies, water resource, forestry, drought and flood monitoring, cartography, town planning and coastal zone monitoring. Specially *IRS IC* and *ID* data have been used for cartographic and town planning applications up to

1:10,000 scale. These satellites also provide stereo pairs of imageries to get height information to an accuracy of approximately 10 meters. It may be mentioned here that between 1995 and 1999 i.e. till the launch of *IKONOS*, this was the highest spatial data available in civilian domain in global perspective:

IRS-P-4, also known as Oceansat-1, was launched successfully into the space on 26 May, 1999 by PSLV-C2. It has a Multi-frequency Scanning Microwave Radiometer (MSMR) and a nine band Ocean Colour Monitor (OCM). The resolution of the satellite is 250 metres at nadir with a swath width of 1500 km. The main applications of this is for gathering information related to water vapour and carrying out ocean colour monitoring. The data collected from ocean colour monitoring are used for conducting fisheries survey and also for development of fisheries forecast model based on the data. Oceansat-2, also known as IRS-P-4 was launched on 23 September, 2009, which is a continuation of Oceansat-1

RESOURCESAT-1 (also known as *IRS-P6)*, has been launched from Satish Dhawan Space Centre-SHAR on 17 October, 2003 with the help of PSLV-C5. The sensors onboard include besides the improved LISS-III, newly designed LISS-IV and uniquely designed AWiFS to provide the data in a better way. With the unique combination of cameras providing imageries with high spatial, spectral, temporal and radiometric resolutions, *RESOURSESAT-1* aims at continuity to the existing data with superior capabilities and also to provide better application possibilities related to agriculture, land and water resource and disaster management. RESOURCESAT-2 has been launched on 20 April, 2011.

The AWiFS (Advanced Wide field Sensor) camera is an improved version compared to the WiFS camera mounted in *IRS-1C/1D*. AWiFS operates in four spectral bands identical to LISS-III, providing a spatial resolution of 56 m and covering a swath of 740 km. It provides enhanced capabilities compared to WiFS onboard *IRS-1C/1D*, in terms of spatial resolution (56 m Vs 188 m), radiometric resolution (10 bits Vs 7 bits) and spectral bands (4 Vs 2). The spectral bands of AWiFS are the same as those of LISS-III. The availability of AWiFS data with improved spatial and spectral resolution help in better classification accuracy of all agricultural related applications. It is a unique sensor with its high resolution and large swath, enabling monitoring of large areas for flood inundation, vegetation stress, etc. which are very much essential for a country like India.

CARTOSAT:

Cartosat-1 is a state of the art remote sensing satellite built by *ISRO* and is mainly intended for cartographic applications. It is the eleventh satellite built by *NRSA* satellite series. *Cartosat-1* has been launched on 5 May, 2005 into a 618 km high polar sun-synchronous orbit by *PSLV-C6*. The satellite carries two state of the art *panchromatic (PAN)* cameras that take black and white stereoscopic pictures of the earth in the visible region of the electromagnetic spectrum. The swath covered by the high resolution *PAN* camera is 30 km and their spatial resolution is 2.5 metre. The cameras are mounted on the satellite in such a way that near simultaneous imaging of the same area from two different angles is possible. This facilitates the generation of accurate three dimensional maps.

So far as different applications of *Cartosat-1* data are concerned, the unique high resolution along track stereo imaging capability carried out for the first time anywhere in the world, enables generation of *Digital Elevation Models (DEM)* and other value added products. The data from *Cartosat-1* is expected to provide enhanced inputs for large scale mapping applications and stimulate newer applications in the urban and rural development, land and water resources management, disaster assessment, relief planning, and management, environment impact assessment and various other *GIS* applications. The data can be used for updating topographical maps, besides generation of large scale topographical maps.

Cartosat-2 was launched into the intended 639 km high polar obrit by PSLV-C7 from Satish Dhawan Space Centre (SICS), SHAR, Sriharikota on 10 January, 2007. This is an advanced remote sensing satellite capable of providing scene specific spot imagery. The *panchromatic (PAN)* camera on board the satellite can provide imagery with a spatial resolution of better than one metre and a swath of 9.6 km. It carries two *PAN* cameras to acquire two images simultaneously. The *PAN fore* (looking forward) mounted within a tilt +25° and the *PAN aft* mounted with a tilt of -5° to generate stereoscopic images. The data from the satellite can be used for detailed mapping and other cartographic applications at cadastral level, urban and rural infrastructure development and management, as well as applications in *Land Information System (LIS)* and *9IS.*

Cartosat-2A, first dedicated military reconnaissance satellite of India, has been launched on 30 April, 2008. CARTOSAT-2A with a single panchromatic camera capable of providing scene specific spot imageries for cartographic applications, have high agility with capability to steer along and across the track up to + 45 degrees. It has been placed in a sun-synchronous polar orbit at an altitude of 630 km. It has a revisit period of 4 days, which can be improved to one day with suitable orbit manoeuvres. The panchromatic camera is design to provide better than 1 m spatial resolution imagery with a swath of 10 km.

Cartosat-2B, Cartosat-2C and Cartosat-2D have been launched on 12 July, 2010, 22 June, 2016 and 15 February, 2017 respectively.

It may be mentioned here that satellite imagery consists of images of Earth or other planets collected by satellites. Satellite images have many applications in meteorology, oceanography, fishing, agriculture, biodiversity conservation, forestry, landscape, geology, cartography, regional planning, education, intelligence and warfare. Images may be acquired from visible spectrum or from any other part of the electromagnetic region. There are also elevation maps, usually made by radar images. Interpretation and analysis of satellite imagery is conducted using specialized remote sensing applications.

In the following table, a comparative statement has been presented regarding various high resolution resource satellite systems.

Table: 1.1 Major High Resolution Earth Observation Satellites

Organisation	Digital Gobe (Earth Watch) USA	ORBIMAGE, USA	Sapce Imaging USA	Imagestal International (West Indian Space), Isreal	IRSO, India	CNES, France
System	QuickBird 1 &2	Orb View 3 & 4	IKONOS 1 & 2	EROS-A & B	Cartosal 1&2	SPORQT 5A
On-Orbit Date	QB 1-Nov 2000 QB 2-Oct 2001	OV -End 1999 OV 4-Sep 2000	1-1 Arp 1999 1-2 Sep 2000	A:#-Dec 2000 # 2-Sep 2000 B: #3-#8 Dec 02-Dec '04	#2003-04 #2-2004	May 2002
Spatial Resolution (Meters)	0.61 PAN 2.50Ms	OV-3&4 1.0 PAN OV-3&4 4.0 MS OV-4 8.0 HS	1.0 PAN 4.0 MS	#A. 1.8 PAN #B 0.82 PAn 3.28 MS	#C1-250 PAN #C2-1.0 PAN	2.5 PAN 10 HRG 20 SWIR
Revisit Interval	1-3.5 Days	Less than 3 days	1-3 days	3 days	#1-5 days #2-4 days	5 days
Altude (km)	600	470	680	480 & 600	#2-600	
Septral band Width, urn	0.45- PAN | 045-0.52 0.52-0.60 0.90 0.76-0.89 MS	0.45- 0.90 | 0.45 0.90 | 200 bands 2.50 80 bands 3.0-5.0	0.45-0.9 PAN | 0.45-052 0.5200.60 0.63-0.69 0.76-0.89 MS	A & B PAN 0.5-0.9 | #B-MS 3bands or more	PAN 05.-07	PAN 051-0730
Imaping System	Pushbroom	Pushbroom	Pushbroom	Pushbroom	CCD	NA
Swath Width (km)	16.5	8.0 Pan 5.0 Hs	11-11.0 12-12.6	EROS A-12.6 EROS B-16.4	#C1-30 #C2-10	60
System Life	5 yrs	5 yrs	7 yrs	#A-4 yrs #B-6 yrs	5yrs	5yrs
Stereo	Along & Across. ±38° & ±30°	Along & Across. ±45° & ±45°	Along & Across. ±45° & ±45°	Along ±45°	#1-Along +26°%5° #2-Along & Across ±45°	Across ±26°

(Source: Geospatial Today, Vol.1, Issue 2, 2002)

1.6.2.2 Preparation of Thematic overlays from satellite images

Visual Interpretation of Satellite imagery:

The satellite imagery under investigation is a typical geo-coded image (Figure 1.24) which has been generated matching with Survey of India topographical Map No. 73M/7. It is a merged data of SPOT (PAN) and Landsat-5 TM where high degree of spatial resolution of SPOT (PAN) has been merged with Landsat TM's colour mode, thus different object's spatial detail can be visualized in false colours. Here it may be mentioned that Landsat TM's Band 2,3, and 4 have been viewed with the help of blue, green and red colours respectively.

Fig. 1.24

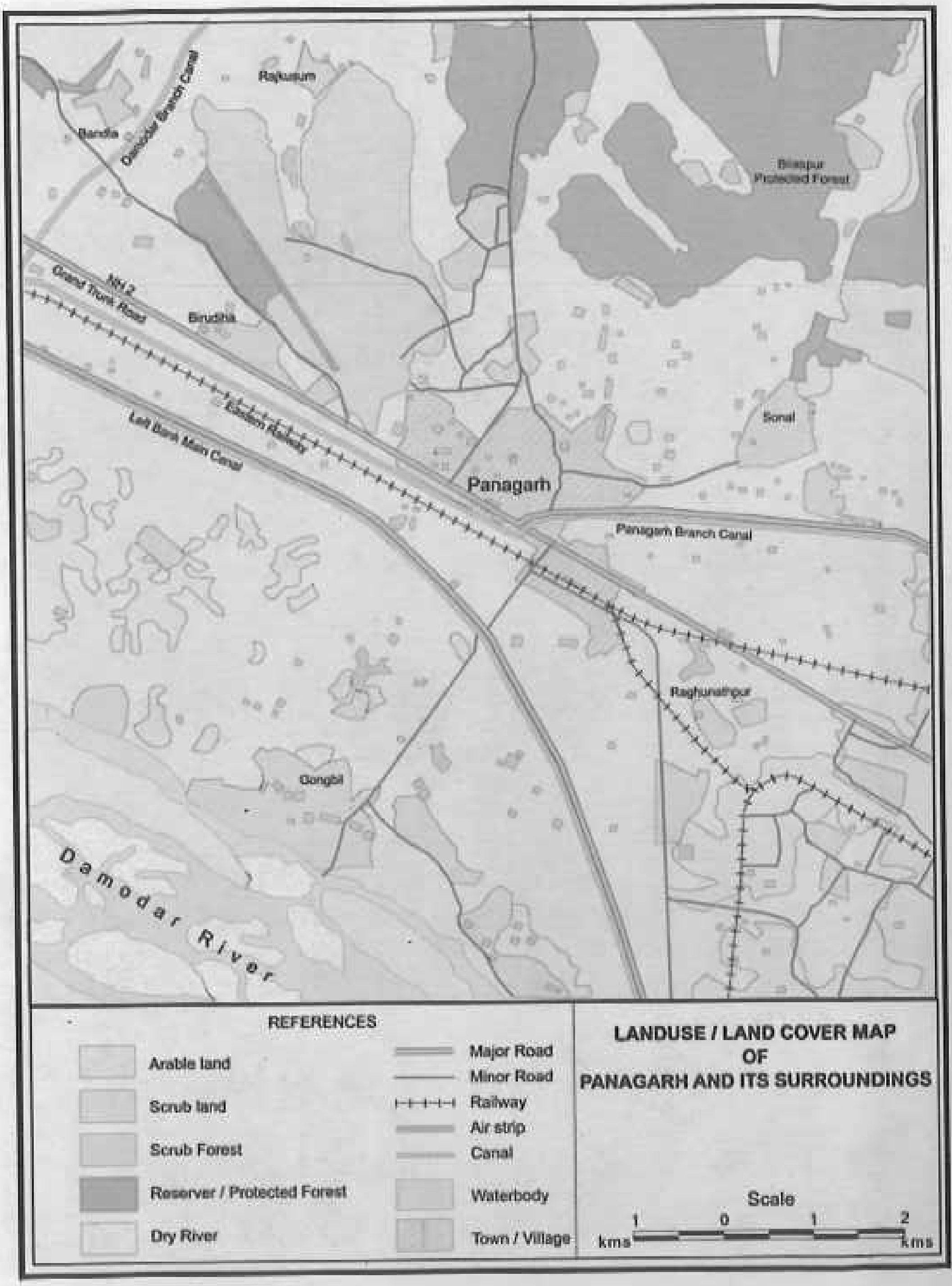

Rajkusum
Damodar Branch Canal
Bilaspur
Protected Forest
NH 2
Grand Trunk Road
Eastern Railway
Left Bank Main Canal
Panagarh
Panagarh Branch Canal
Raghunathpur
Damodar River
REFERENCES
Arable land
Scrub land
Scrub Forest
Reserver / Protected Forest
Dry River
Major Road
Minor Road
Railway
Air strip
Canal
Waterbody
Town / Village
LANDUSE / LAND COVER MAP
OF
PANAGARH AND ITS SURROUNDINGS
Scale
1
0
1
2
kms
kms

Fig. 1.25

The data was acquired on 8 November, 1991, whereas the image was generated by NRSA on 4 May, 1992. By applying different rules of image characteristics, various features within the area under investigation could be identified. Here it may be noted that SOI toposheet No. 73 M/7 has been used as reference data for extraction of information related to annotation, etc. Ultimately the Land use/Land cover Map (Figure 1.25) has been prepared by interpreting the geo-coded hard copy out put. Here land use refers to man made features like road, railway, arable land, settlement, etc., whereas land cover denotes natural features like forest cover, scrub areas, river system, wet land, etc.

Due to good amount of chlorophyll content, healthy vegetation absorbs energy strongly and appears as deep red in FCC. Bilaspur protected forest, situated at the north eastern corner of the image is a typical examples in this regard. At places, forest areas have been degraded and they appear in terms of lighter tone. These are typical examples of fairly dense scrub (scrub forest) areas. Other wise small patches of scrub lands are scattered, particularly to the western part of the area under investigation.

Water bodies appear either as deep blue/blackish or powder blue in colour depending upon depth/clearness of water. In case of deep/clear water, absorption of light is more, hence the apparent colour is blue/blackish blue. On the other hand in case of turbid/ shallow water, the reflection of light is more and the appearance of the object is powder blue. To the south-western corner, *Damodar River* can easily be identified. The channel of the river is characterized by braided nature with numerous bars and spits. The water is mostly sediment laden and the apparent colour is powder blue. Sand deposits within the course of the river reflect more light, hence they appear in terms of light tone/white colour. Due to sediment deposit, even an island has been formed inside the river, where crops are grown. However, in the present image, the *DVC Left Bank Main Canal* enters the region from the west and passes through the central part and curves towards the south. At the extreme western part of the image, *Damodar Branch. Canal* originates from *DVC Left Bank Main Canal* and moves northward. *Panagarh Branch Canal* branches off from *Damodar Branch Canal* and runs in between the railway line and the *Grand Trunk Road.* Actually several linear features, viz. *DVC Left Bank Main Canal, Eastern Railway Main Line* and *Grand Trunk Road* run parallel to each other from north-west to south-east. The canal, if contains water, can be recognized with the help of dark blue colour, fine texture and also the typical geometric shape. Generally speaking, the tonal expressions of railway lines and road ways are darker and lighter respectively. Moreover, unlike road, railway takes typical curvature at the turning point and tries to avoid rural settlements. On the other hand roads link up different settlements and can take any type of turning. Both sides of highways are generally associated with trees. All these factors provide clues to recognize different types of linear features.

However, these are the general rules, and exceptions are there, depending upon the real world situation and also quality of the hard copy out put.

Good or moderately good agricultural lands are wide spread within the area under investigation, which appear as light pink colour with fine or medium texture. In case of poor agricultural land the appearance is in terms of whitish gray with coarse texture. Rural settlements are associated with water bodies and vegetation cover and they are represented in terms of dark blue with fine to medium texture. *Sonal* and *Gopalpur* are two examples of rural settlements, which are easily identifiable to the east-central and north-western parts of the image. On the other hand, in case of urban areas, due to *Rayleigh* scattering blue or gray cast appear on the image. *Panagarh,* located at the center of the map is an example of urban settlement, although gray/blue casting is not that prominent for this urban area.

1.7 Summary

Topographical maps, aerial photographs and satellite images provide with different types of resource condition available on earth surface. In topographical maps, in addition to portraying geographical information, different types of annotations are also available. Thus we may know the name of a particular settlement, river or even administrative block. Geographical coordinates in terms of latitude/ longitude are also marked in topographical maps. In case of aerial photograph, the camera 'sees' the surface condition and records according. Thus the collection of precise information depends on lens of camera and other parameters of the sensor and platform. The orbiting satellites go on collecting resource information of the earth surface, with temporal information at specific location. The visual interpretation of all these products help us to prepare maps for graphical presentation of the available resource condition.

Exercises

1. What type of information are available in a topographical map?
2. Define Remote Sensing.
3. What are the different types of aerial photograph?
4. Distinguish between high oblique and low oblique photograph.

Selected Readings

Kraak, Menno-Jan & Ormeling Ferjan, *Cartography, Visualization of Geospatial Data,* First Indian Reprint, Pearson Education, Delhi, 2004

Kumar, Meenakshi, *Remote Sensing,* National Council of Educational Research and Training, New Delhi, 2001

Lillesand, T.M., et al., *Remote Sensing and Image Interpretation,* Fifth Edition, Wiley, New-York, 2004

UNIT : 2 □ DIGITAL IMAGE PROCESSING

Structure:

2.1 Introduction

Visual interpretation techniques have certain disadvantages, because the users may require extensive training and are labour intensive. In addition, spectral characteristics are not always fully evaluated in visual interpretation efforts. This is partly because of the limited ability of the eye to discern tonal values on an image and the difficulty for an interpreter to simultaneously analyze numerous spectral images. In applications where spectral patterns are highly informative, it is therefore preferable to analyze digital, rather than analog or pictorial image data.

A particular digital image is actually composed of a two dimensional array of discrete *picture elements or pixels.* The intensity of each pixel corresponds to the average brightness, or radiance, measured electronically over the ground area corresponding to each pixel. The representation of the energy measured at a point is usually expressed as a *Digital Number* or *DN* value.

At this stage, it is better to discuss in brief about resolution of satellite images. In broad sense, resolution means the resolving power of the sensor. Actually, resolution is a system which refers to the ability to record and display fine details by the sensor. In remote sensing we deal with four types of resolutions viz. spatial, spectral, radiometric and temporal resolution.

Spatial Resolution: The details visible in an image is dependent on the spatial resolution of the sensor and refers to the size of the smallest possible feature that can be detected. In other words the spatial resolution is a measure of sensors ability to image (record) closely spaced objects so that they are distinguishable as separate objects. A sensor with a 1m resolution can reproduce finer details compared to a sensor with a 10m resolution. It is the ground area sensed at any instant time. It is dependent on the Instantaneous Field of View (IFOV) of the sensor (Figure 2.1). The IFOV may be described as the angular cone of the sensor (A), which determines the area on the surface of the earth as viewed from a given altitude (B). The size of the field recorded is determined by multiplying the IFOV by the distance from the ground to the sensor (C). Images where only large features are visible are said to have low resolution, where as in high resolution images, small objects can be detected.

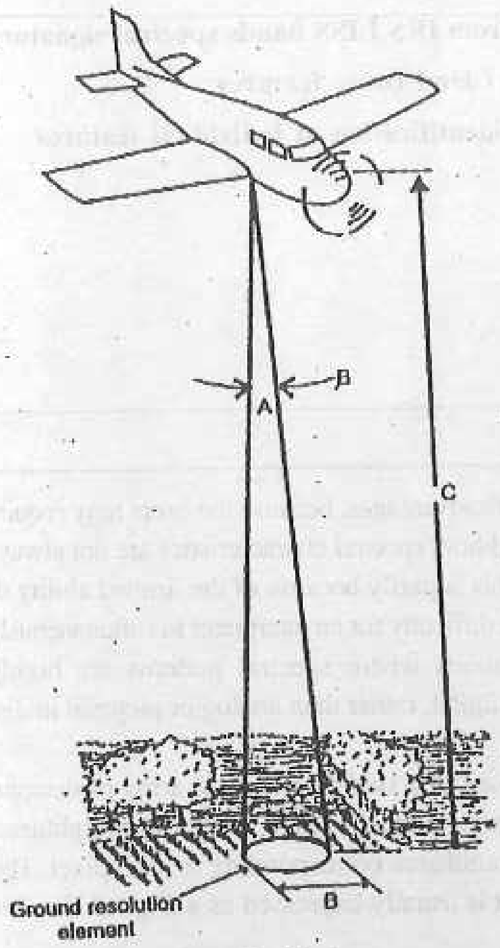


Fig. 2.1

Images where only large features are visible are said to have low resolution. Where as in case of high resolution images, small objects can be detected. Military sensors for example, are designed to view as much detail as possible, and therefore have very fine resolution. Commercial satellites provide imagery with resolution varying from a few metres to several kilometers. Generally the finer the resolution, the less total ground area can be seen.

Spectral Resolution:

Spectral resolution describes the ability of a sensor to define fine wavelength intervals. The finer the spectral resolution, the narrower the wavelength ranges for a particular channel or band. The spectral ranges of Landsat MSS and TM are shown in the following table:

Table: 2.1 Spectral range of different bands of Landsat MSS and TM

Landsat -1 (MSS)			*Landsat - 4(TM)*		
Band Code	*Spectral range (µm)*		*Band Code*	*Spectral range (µm)*	
4	*0.5-0.6*	*Blue*	*1*	*0.45-0.52*	*Blue*
5	*0.6-0.7*	*Green*	*2*	*0.52-0.60*	*Green*
6	*0.7-0.8*	*Red*	*3*	*0.63-0.69*	*Red*
7	*0.8-1.1*	*Infra Red*	*4*	*0.76-0.90*	*Near Infra Red*
			5	*1.55-1.75*	*Mid Infra Red*
			6	*10.4-12.50*	*Thermal Infra Red*
			7	*2.08-2.35*	*Mid Infra Red*

Radiometric Resolution:

While the arrangement of pixels describes the spatial structure of an image, the radiometric characteristics describe the actual information content in an image. Every time an image is acquired on film or by a sensor, its sensitivity to the magnitude of the electromagnetic energy determines the radiometric resolution. The radiometric resolution of an imaging system describes its ability to discriminate very slight differences in energy. The finer the radiometric resolution of a sensor, the more sensitive it is to detecting small differences in reflected or emitted energy.

Imagery data are represented by positive digital numbers which vary from 0 to (one less than) a selected power of 2. This range corresponds to the number of bits used for coding numbers in binary format. Each bit records an exponent of power 2 (e.g. 1 bit=2^1 =2). The maximum number of brightness levels available depends on the number of bits used in representing the energy recorded. Thus, if a sensor used 8 bits to record the data, there would be 2^8 =256 digital values available, ranging from 0 to 255. However, if only 4 bits were used, then only 2^4 =16 values ranging from 0 to 15 would be available. Thus, the radiometric resolution would be much less. Image data are generally displayed in a range of grey tones, with black representing a digital number of 0 and white representing the maximum value (for example, quantization range of 256 digital numbers in 8 bit data / DN value). (IKONOS 11 bit / 2048 gray level data).

Temporal Resolution

Temporal resolution refers to the frequency of obtaining data over a given area. It is related to revisit period, which refers to the length of time it takes for a satellite to complete one entire orbit cycle. The revisit period of a satellite sensor is usually several days. Therefore the absolute temporal resolution of a remote sensing system to image the exact same area at the same viewing angle a second time is equal to this period.

The actual temporal resolution of a sensor depends on a variety of factors, including the satellite/sensor capabilities, the swath overlap, and latitude, etc.

Now a days remote sensing data are mostly available in digital format in multiple band. Thus, an image consisting of four spectral channels can be visualized as four superimposed images with corresponding pixels in one band registering exactly to those in the other bands. These are digitally processed with the help of appropriate image processing software along with compatible hardware system. The common image processing functions are: (1) Pre-processing, performed prior to Digital Image Processing to make the necessary radiometric and geometric corrections. (2) Image enhancement, to improve the appearance of the image. (3) Image transformation: involves the combined processing of data from multiple spectral bands and (4) Image classification and analysis: uses mathematical algorithms to assign individual pixels to specific classes; accuracy of the classification is then assessed by ground truthing.

2.2 Objectives

This unit will help you to understand:

- Rectification process of satellite images.
- Enhancement techniques of satellite images.
- Preparation of False Colour Composites .
- Use of different LISS spectral bands of IRS images to identify surface features. Georeferencing of satellite images

2.3.1 Image Rectification:

The raw image recorded in terms of MSS (i.e. Multi Spectral scanner) usually contains some radiometric and geometric distortions. These distortions are caused by platform effects, sensor effects, scene effects and atmospheric effects. Corrective measures are therefore needed to reduce the distortions. The required operations aim to correct distorted or degraded image data and create a more faithful representation of the original scene. The radiometric correction is required to obtain the accurate radiance value for each picture element, while the geometric correction is required to obtain accurate geometric representation of the earth. The introduction of such corrective measures is known as image restoration. It may be mentioned here that image rectification and restoration procedures are also known as preprocessing operations, because they normally precede further manipulation and analysis of the image data to extract specific information.

2.3.2 Image Enhancement:

Image enhancement is the digital technique to improve the appearance of an image. In remote sensing, reflected or emitted energy from different features on earth surface is recorded. Under ideal conditions one object may reflect large amount of energy at a certain wavelength while the other may reflect very less energy in the same wavelength. This results in the objects getting high and low values and correspondingly bright and dark areas. It happens that different features reflect different wavelengths regions resulting in similar tones or colours, which is known as *low contrast image.* To improve contrast of the image, the entire brightness range of display device is utilized. These procedures are applied to image data in order to more effectively display or record the data for subsequent visual interpretation. Normally image enhancement involves techniques for increasing the visual distinctions between features in a scene. The objective is to create "new" images from the original image data in order to increase the amount of information that can be visually interpreted from the data.

Commonly applied digital enhancement techniques are categorized as contrast manipulation, spatial feature manipulation, or multi-image manipulation.

Contrast manipulation include *gray-level thresholding, level slicing,* and *contrast stretching.*

Grey level Thresholding is used to segment an input image into two classes, one for those pixels having values below an analyst defined grey level and one for those above these values.

Level slicing is an enhancement technique whereby the DNs distributed along x axis of an image histogram are divided into a series of analyst specific intervals or slices. Density slicing is used mainly to display thermal infrared images to show discrete temperature ranges.

It is observed that the dynamic range of a sensor is never fully utilized. As a result

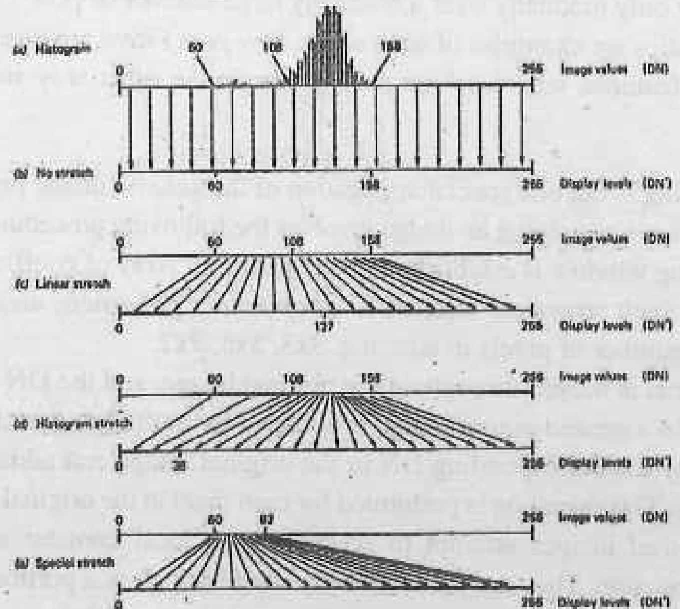


Fig. 2.2

a dull image is commonly produced. The *contrast stretching* technique allows to expand the narrow range of brightness values to a wider range of grey value. For example, in case of 8 bit data, image output levels can vary from 0 to 255. If in a particular case histogram shows scene brightness values occurring only in the limited range of 60 to 158, display levels 0 to 29 and 159 to 255 would not be utilized. A more expressive display would result if one expand the range of image levels present in the scene (60 to 158) to the full range of display value (0 to 255).

Contrast stretching may be classified into three classes: linear, histogram equalization and Gaussian. In case of linear stretch the image data is mapped to the fullest range of the display device (Figure 2.2). In case of histogram equalization, the range of pixel values in the input image is spread over the fullest range of the display device so that each level in the displayed image contains an approximately equal number of pixel values and the histogram becomes almost uniform. Gaussian stretch involves the fitting of the observed histogram to a normal Gaussian histogram.

Spatial feature manipulation includes *spatial filtering, edge enhancement,* and *fourier analysis.*

Spatial filtering process emphasizes or deemphasizes image data of various spectral ranges. Spatial frequency means the *roughness* of the tonal variations occurring in an image. Image areas of high spatial frequency are tonally rough, which means that the grey levels in these areas change abruptly over a relatively small number of pixels. Examples are across roads or field border areas. *Smooth image* areas refer to low spatial frequency areas, where gray levels vary only gradually over a relatively large number of pixels. Large agricultural fields, water bodies are examples of such areas. *Low pass filters* are designed to emphasise low frequency features, whereas *high pass filters* do the other way round.

Convolution

Spatial filtering is but one special application of the generic image processing operation called convolution. Convolving an image involves the following procedures:

1. A moving window is established that contains an array of coefficients or weighting factors. Such arrays are referred to as *operators* or *kernels,* and they are normally an odd number of pixels in size, e.g. 3x3, 5x5, 7x7.
2. The kernel is moved throughout the original image, and the DN at the centre of the kernerl in a second output image is obtained by multiplying each coefficient in the kernel by the corresponding DN in the original image and adding all the resulting products. This operation is performed for each pixel in the original image (Figure 2.3).

Edge Enhanced images attempt to preserve both local contrast and low frequency brightness information. They are produced by adding back all or a portion of the gray values in an original image to a high frequency component image of the same scene.

In case of *Fourier Analysis,* an image is separated into its various spatial frequency

1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

(*a*) Kamel

67	67	72
70	68	71
72	71	72

(*b*) Original Image DNs

	70	

(*c*) Convolved Image DN

Convolution : 1/9(67) + 1/9(67) + 1/9(72) + 1/9(70) + 1/9(68) + 1/9(71)+
1/9(72) + 1/9(71) + 1/9(72) = 630/9 = 70

Fig. 2.3

components through application of a mathematical operation known as the *Fourier transform.* Actually after an image is separated into its component spatial frequencies, it is possible to display these values in a two-dimensional scatter plot known as a *Fourier spectrum.* ***Multi-image manipulation*** include *multispectral band ratioing and differencing, principal components, canonical components, vegetation components, intensity-hue-saluration (HIS) colour space transformations, and decorrelation stretching.*

In case *of Spectral Ratioing,* ratio images are enhanced resulting from the division of DN values in one spectral band by corresponding values in another band.

Canonical Component analysis is also known as *multiple discriminant analysis.* Canonical component axes are transformed to maximize the separability of different user defined feature types.

Spectrally adjustment bands in a multispectral remote sensing image are often highly correlated. PCA is used to remove this redundancy and enhance the image, reduce the dimensionality and fix coefficients that specify the axis pointing to the directions of greatest variability. Principal components are simply the statistical abbreviation of the variability inherent in the original band set and are more interpretable.

Vegetation components: AVHRR data have been used extensively for large area vegetation monitoring. Typically the spectral bands used for this purpose have been the channel 1 visible band (0.58 to 0.68 μm) and the channel 2 near -IR band (0.73 to 1.10 μm). Various mathematical combinations of the AVHRR channel 1 and 2 data have been found to be sensitive indicators of the presence and condition of green vegetation. These mathematical quantities are thus referred to as vegetation indices. Two such indices have been routinely calculated from AVHRR data, a simple vegetation index (VI) and a normalized difference vegetation index (NDVI). These indices are computed from the equations:

$$VI = Ch_2 - Ch_1$$

and

$$NDVI = \frac{Ch_2 - Ch_1}{Ch_2 + Ch_1}$$

where Ch_1 and Ch_2 represent data from AVHRR channels 1 and 2.

Digital images are typically displayed as additive colour composites using the three primary colours: red, green and blue. Figure 2.4 represents the RGB colour cube, which is defined by the brightness levels of each of the three primary colours. For a display with 8-bit-per-pixel data encoding, the range of possible DNs for each colour component is 0 to 255. Hence there are 256^3 or 16,777,216 possible combinations of red, green blue DNs that can be displayed by such a device.

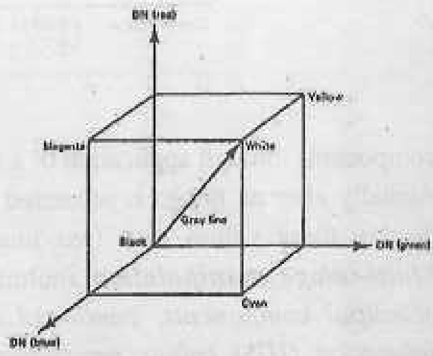


Fig. 2.4

An alternative to describing colours by their RGB components is the use of the *intensity-hue-saturation (HIS)system. Intensity* relates to the total brightness of a colour. *Hue* refers to the dominant or average wavelength of light contributing to a colour. *Saturation* specifies the purity of colour relative to gray.

Decorrelation stretching is a form of multi-image manipulation that is particularly useful when displaying multispectral data that are highly correlated. Data from the NASA Thermal Infrared Multispectral Scanner (TIMS) and other hyperspectral data collected in the same region of the spectrum often fall into this category.

As with HIS transformations, decorrelation stretching is is applied in a transformed image space, and the results are then transformed back to the RGB system for final display.

2.4 Identification of Individual features from IRS LISS bands spectral signatures

There is a tendency of steady improvement of different sensors of Indian Resource satellites. In the following tables, information related to band width, nominal spectral location and also principal applications of different bands of various IRS sensors are described in brief.

Table: 2.2 Spectral band of LISS III image and relative applications

Band	*Wavelength (Micrometer)*	*Nominal Spectral location*	*Principal Applications*
1	0.45-0.52	Blue	Designed for water body penetration, making it useful for coastal water mapping. Also useful for soil/vegetation discrimination, forest type mapping, and cultural feature identification.
2	0.52-0.60	Green	Designed to measure green reflectance peak of vegetation for vegetation discrimination and vigor assessment. Also useful for cultural feature identification
3	0.63-0.69	Red	Designed to sense in a chlorophyll absorption region aiding in plant species differentiation. Also useful for cultural feature identification.
4	0.76-0.90	Short wave Infrared (SWIR)	Useful for determining vegetation types, biomass content, for delineating water bodies and for soil moisture discrimination.

2.5 Identification of Individual land use / land cover features

With the help of IRS data, it is possible to identify different land cover features, and in the following table typical examples in this regard are presented for ready reference.

Table: 2.3 Land cover classes as identifiable in LISS-III images

Land Cover Classes	*Description*	*Characteristics on LISS-III data*
Dense Forest	Tall dense trees	Dark red with rough texture
Sparse Vegetation	Low vegetation density with exposed ground surface	Dull red to pinkish
Agriculture	Crops on hill terraces as step cultivation	Dull red and smooth appearance

Fallow Land	Agriculture fields without crops	Bluish/greenish gray with smooth texture
Barren Land	Exposed rocks without vegetation	Yellowish
Settlements	Town and villages; block like appearance	Bluish
Fresh sediments	Fresh landslides debris and river sediments on the blank	Cyan
Water bodies the	Rivers and lakes	Cyan blue to blue according to depth of water
Snow	Snow covered areas on high altitude mountains	Very bright white

2.6 Preparation of Standard FCC

Three band satellite data are used to generate colour composites. The channel selection is restricted to three additive primary light beams i.e. blue, green and red. True colour representation for visual display of an image can be made by using three band satellite data representing blue, green and red channels. In such a case blue band is projected in blue, green band is projected in green and red band is projected in red for preparation of the output image. But such true colour composites are having some constrains in terms of inadequate contrast, clarity problem, interpretability problem, etc. Hence images are generated in terms of *False Colour Composite* or FCC (Figure: 2.5). Any combination of bands not representing the true colour of the objects in the output

Fig. 2.5

image is termed as *FCC.* They are generated with the purpose of better interpretation of the multi-band satellite data.

In case of standard false colour composite, the combination of bands and the respective colour assignments are well defined. Hence they are known as *standard FCC.* The most commonly seen standard false colour images display the very near infrared as red, red as green and green as blue.

Satellite images are available to the user either in terms of digital format or hard copy out put. The user may make various experiments by using digital data with the help of available image processing software. On the other hand, by means of visual interpretation of the hard copy out put, the interpreter can identify different types of features available in the image.

To create FCC of image in Geomatica, following commands are to be given:

Layer → RGB Mapper

Red column → check the row for 'Near *Infra Red*' channel

Green column → check the row for *'Red'* channel

Blue column → check the row for *'Green'* channel

Click → *close*

From the *Enhancement button* of Focus → choose *'Linear'* enhancement.

2.7 Georeferencing of satellite images

When an image is created, it is stored in row and column geometry in raster format. There is no relationship between the rows and columns and the real world coordinates. In a process called geo-referencing the relation between row and column numbers and real world coordinates are established (Figure 2.6).

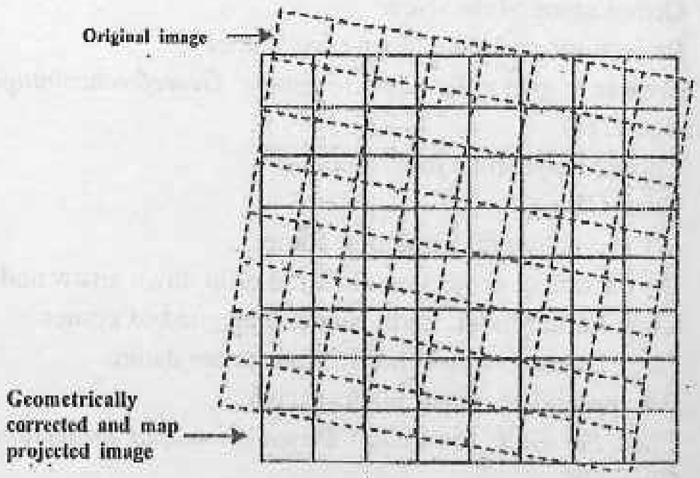


Fig. 2.6

The simplest way to link an image to a map projection system is to use a *geometric transformation.* A transformation is a function that relates the coordinates of two systems. A transformation, relating (x,y) to (i,j) is typically defined by linear equations, such as: $x=3+5i$, and $y=-2+2.5j$ (Figure 2.7).

Using the above transformation, for example, image position ($i=5$, $j=8$) relates to map

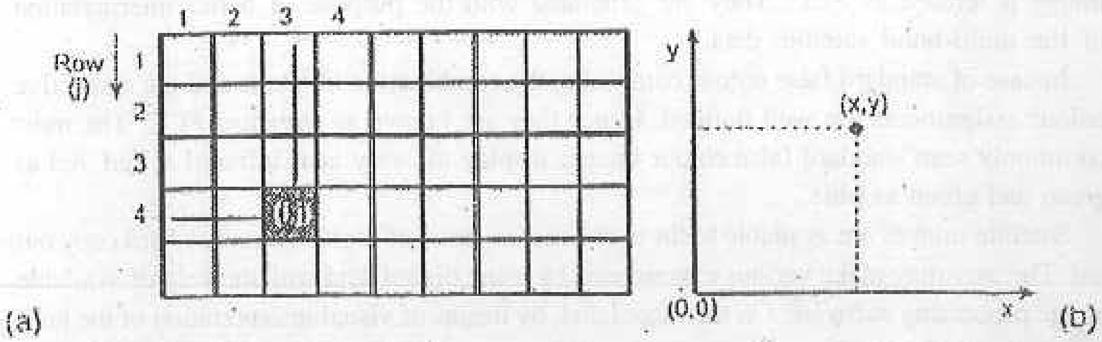


Fig. 2.7

coordinates (x=28,y=18). Once such a transformation has been determined, the map coordinates for each image pixel can be calculated. The resulting image is called *georeferenced image.* The process of georeferencing includes two steps : selection of the appropriate type of transformation (e.g. polynomial) and determination of the parameters. The transformation parameters can be determined by means of *ground control points* (GCPs). GCPs are points that can be clearly identified in the image and in a source, which is in the required map projection system.

By using the following commands in Geomatica, georeferencing of an image can be done:

Open *OrthoEngine*

OrthoEngine >File >New

Project information dialogue box comes

Browse to give a file name (example: *Georeferencejmagel.prj)* for OrthoEngine project -image 1. pr)

Choose Polynomial math model

Click *OK*

Set *Projection* dialogue box comes

On the output projection click the drop down arrow and choose *Lat/Long* projection

Click Earth Model. Earth Model dialogue box comes

Click Datum tab and choose appropriate datum

Put appropriate output pixel spacing

Click *Set GCP Projection Based on output projection*

Click *OK*

Set Projection dialogue box closed and OrthoEngine main panel comes

OrthoEngine > File > Save

From the drop down list in the *Processing Step,* choose *GCP Collection*

Click the first tool *(i.e. open a new or existing image).* Open image dialogue box will come

Click *New Image* and browse to choose *image 1* file

Click open in the file selection window
The *image* 1 file will come on the Open image dialogue box
Select the *image 1* file. Now the open tool is active. Click *Quick Open & Close*
Image viewer opened with *imagel* file. Enhance the file if the file is not properly visible
In the OrthoEngine main panel, click 2nd tool (i.e. *collect GCP manually)*
GCP collection panel will come
In the image viewer *locate the point* with appropriate Longitude and Latitude values
Click *Use Point*
First GCP id *(G0001)* will appear on the image viewer
Come to the GCP Collection panel and put the longitude and latitude in the appropriate place
Accept
You have collected the first GCP
In the same way you have to collect at least 4 GCPs
Save the project in the OrthoEngine main panel
Close the image viewer and GCP collection panel
In the *processing step* from the drop down menu choose *Geometric Correction*
Click *3rd tool* to open *Geometric Correction* dialogue box
On the available image click over the file *(imagel: No Ortho)*
Click on the *arrow* to take the file to *image to process* box.
In the uncorrected image keep everything *default*
In the Corrected image *browse* to give an output file name *(Corrected imagel.pix)*
Set *Sampling Interval* as *1*
Keep all others default
Click *Correct Images*
Geometric correction progress window will come with task bar
On completion of the Geometric correction the Geometric correction dialogue box will come again
Geometric Correction has been completed
Save the project in the OrthoEngine main panel and close OrthoEngine
Open the Corrected_imagel .pix file on the focus viewer to check the georeference.

2.8 Image Classification

As soon as a satellite image is georeferenced, it is possible to do various exercises like image classification, change detection with periodic data, etc. It may be mentioned here that in the real world the human being is used to categorize all the objects on the earth's surface cover by describing them for example forest, agriculture field, river, residential building, etc. We do not label areas by numbers as is the case in digital images.

Digital image classification is the process of assigning pixels to classes. Each pixel in a digital image is treated as an individual unit having different wavelength region or spectral band. By comparing pixels to one another and to those of known identity, it is possible to group pixels of similar classes of interest to user. These classes are represented by suitable colours assigned by the user.

Actually, digital image classification, also known as spectral pattern recognition, uses the spectral information for each pixel in an image file to group pixels into common spectral themes. Classified images are, in effect, thematic maps containing a mosaic of pixels belonging to different classes.

The objective of the classification process is to assign all pixels in an image to a finite number of categories, or classes of data, based on their data file values. If a pixel satisfies a certain set of criteria, then it is assigned to the class that corresponds to that criteria.

There are two different image classification methods: unsupervised and supervised.

Unsupervised Classification:

This is a highly computer-automated procedure. It allows the user to specify parameters that the computer uses as guidelines to uncover statistical patterns in the data. In an unsupervised classification the software automatically divides the range of spectral values, contained in an image file, into classes or clusters (Figure 2.8). These natural clusters are then related to actual land use/ land cover categories after a very careful ground truthing. With Focus of Geomatica, the user can choose the number of classes the data is divided into. The classified results report the proportions of spectral values in the image and can therefore indicate the prevalence of specific ground covers.

In *Geometica,* the following steps are involved to get the result through unsupervised classification:

File → Open → Desktop → (e.g.) image 1 .pix → Open

Right click Sundarban.pix 1,2,3 → Image classification → Unsupervised

New session

Description box → Type → (any name) unsuper

Input channel → check 1,2,3

Add Layer → Add 2 number of 8 bit channel → Add

Output Channel → Check Empty channel → OK → OK

Supervised Classification:

Supervised classification is more closely controlled by the supervisor than unsupervised classification. In this process, the user, i.e. the supervisor select recognizable regions within an image, with the help of other sources, to create sample area called training sites. These training sites are then used to train the computer system to identify pixels with similar characteristics.

Knowledge of the data, the class desired, and the algorithm to be used, is required before the user begin selecting the training sites. By setting priorities to the classes, the user supervise the classification of pixels as they are assigned to a class value. If classification is accurate, each resulting class corresponds to a pattern that the user originally identified (Figure 2.8).

SUPERVISED CLASSIFICATION

SUNDARBAN AREA (PART) 2005

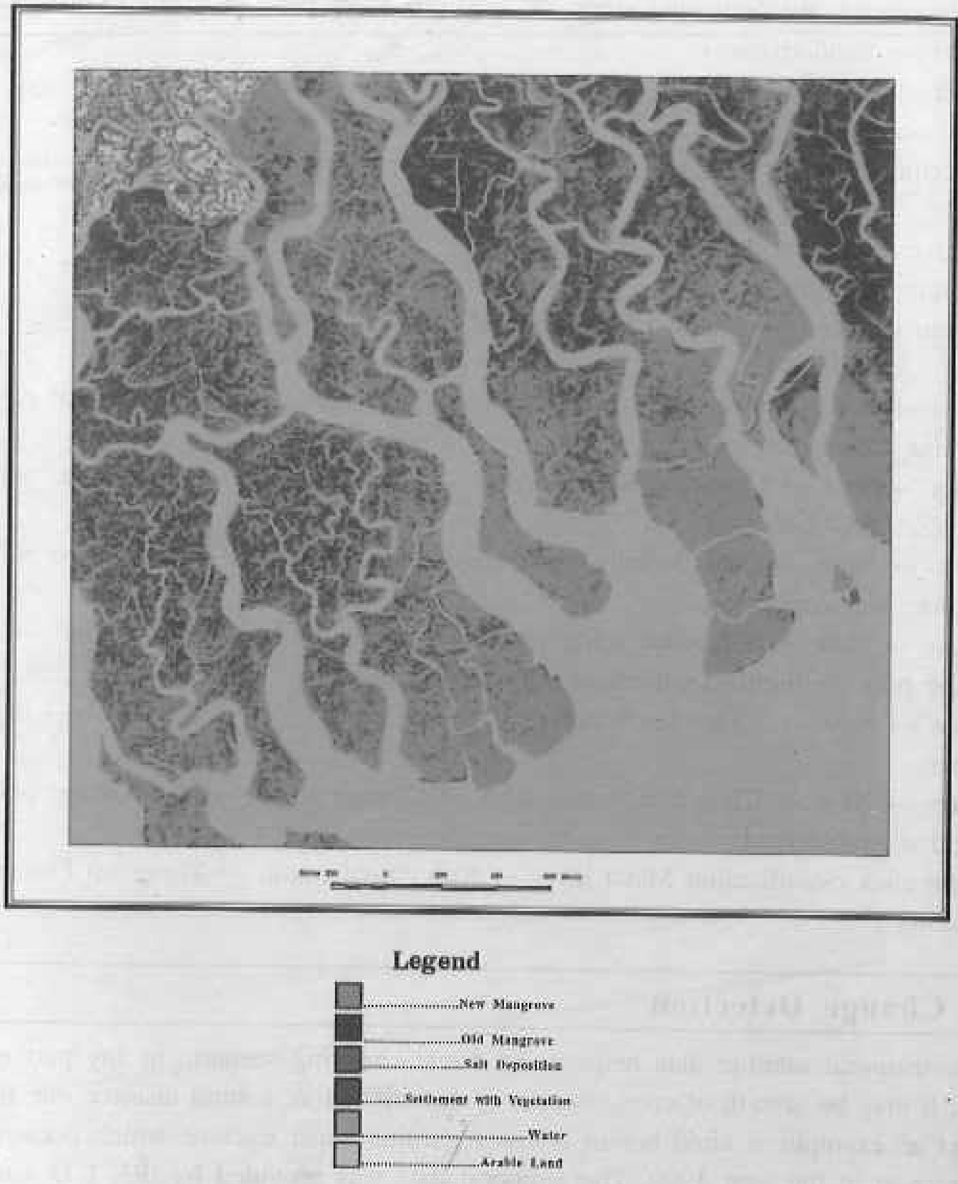


Fig. 2.8

Typical supervised classification involves three stages:

- The training stage, wherein the multi-spectral parameters are extracted for various classes from training sites identified in the image
- The classification stage, wherein each pixel is assigned to a class to which it probably belongs
- The output stage, where the presentation of the data is in the form of maps, tables, graphs, etc.

In geomatica, the following steps are involved to prepare supervised classification

Open → Sundarban.pix

Right click Sundarban.pix → Image classification → Supervised

New session

Description → Type → super → Add Layer → Add 3 number of 8 bit channel

Add

Input channel → check 1,2,3

Training channel → Check (✓) Empty channel

Output channel → Check Empty channel

Ok

Class → New → Class-1= New Mangrove → Change colour → New shape poly → digitize New Mangrove

Class → New → Class-2= Old Mangrow → Change colour → New shape poly → digitize Old Mangrove

Class → New → Class-3=Salt deposition→ Change colour → New shape poly → digitize Salt deposition

Class → New → Class-4= settlement with vegetation→ Change colour → New shape poly → digitize settlement with vegetation

Class → New → Class-5 = Water → Change Colour → New shape poly→ digitize water

Class → New → Class-6 = Arable land → Change colour → New shape poly → digitize Arable land

Right click classification Metal layer → Run classification → Minimum Distance→ Classify

2.9 Change Detection

The temporal satellite data helps us to detect changing scenario in any part of the world. It may be growth of crop, process of desertification, natural disaster, etc. In this context an example is cited herein below regarding super cyclone which occurred in odisha coast in the year 1999. The temporal data was provided by IRS 1 D satellite. (Figure 2.9 & 2.10).

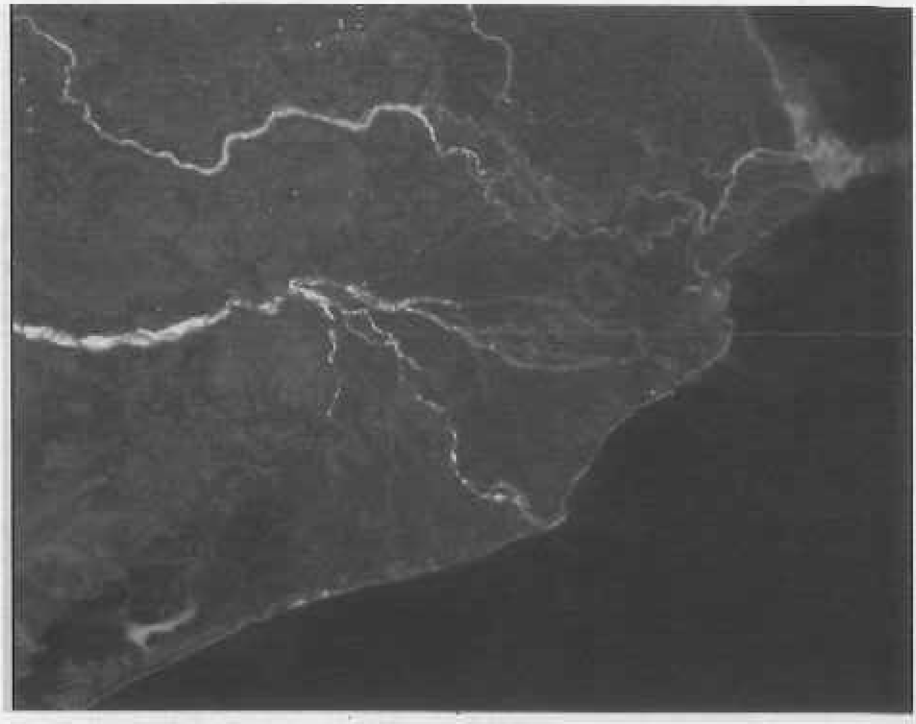


Fig. 2.9

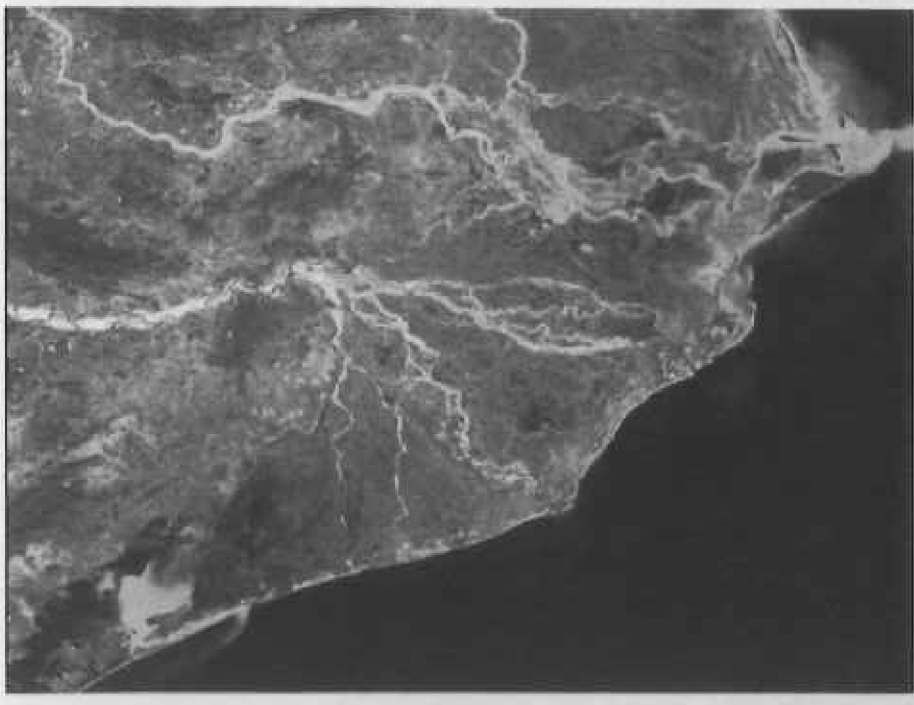


Fig. 2.10

2.10 Summary

Visual image interpretation has some inherent shortcoming, which may be overcome with the help of digital image processing systems. But to undertake such exercises, there are some preconditions like image rectification, image enhancement etc. After passing through these processes, it is possible to play with digital data with the help of appropriate image processing software. It is possible to generate False Colour Composites by selecting appropriate band combinations. To perform such exercises, Geometica software has been uses.

Exercises

1. What are the different types of distortions available in a raw image? How to rectify them?
2. What do you mean by image enhancement? What are the different types of contrast manipulation techniques?
3. What is FCC? Prepare a FCC with the help of available satellite image by choosing appropriate bands using Red, Green and Blue light beams.
4. Georeference the available satellite image by using appropriate inputs.
5. Why image rectification is necessary? What are the steps to be followed in Geometica for rectifying a satellite image?
6. What is the spectral range of Band 1 of IRS LISS -III sensor? What are the principal applications of the same band?

Selected Readings

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UNIT : 3 ❑ GEOGRAPHIC INFORMATION SYSTEM

Structure:

3.1 Introduction

A Geographic Information System (GIS) is a system which is designed to capture, store, manipulate, analyse and present geographical data in different graphical and tabular forms. Actually it describes such an information system that interacts, stores, edits, analyses and displays different types of geographical information. The data may be spatial or aspatial, i.e. attribute in type. It is possible to make analysis with GIS data in terms of overlay or proximity (buffer), allows to make query, and also can display the information in the form of thematic maps and diagrams.

3.2 Objectives

This unit will help you to understand:

- Basic concept of GIS.
- Raster and Vector data format.
- Generation of Vector layers
- Attachment if attribute data.
- Editing of spatial/data
- Preparation of Thematic Maps

3.3 The Basic Concept of GIS

Geographic Information System (GIS) is an organised collection of computer hardware, software, geographic data and personnel designed to efficiently capture, store, update, manipulate, analyze and display all forms of geographically referenced information.

It is also said that GIS is computer system that records, stores, and analyses information about the features that make up the earth's surface. A GIS can generate two or three dimensional images of an area, showing such natural features as hills and rivers with artificial features such as road and power lines. Scientists use GIS images as models, making precise measurements, gathering data, and testing ideas with the help of the computer. It may be mentioned here that a working GIS integretes five key components: **hardware, software, data, people** and **methodology.**

3.3.1 Raster and Vector Data Format

Geographic information systems work with two fundamentally different types of geographic models - the *vector* model and the *raster* model (Figure: 3.1). In the vector model,

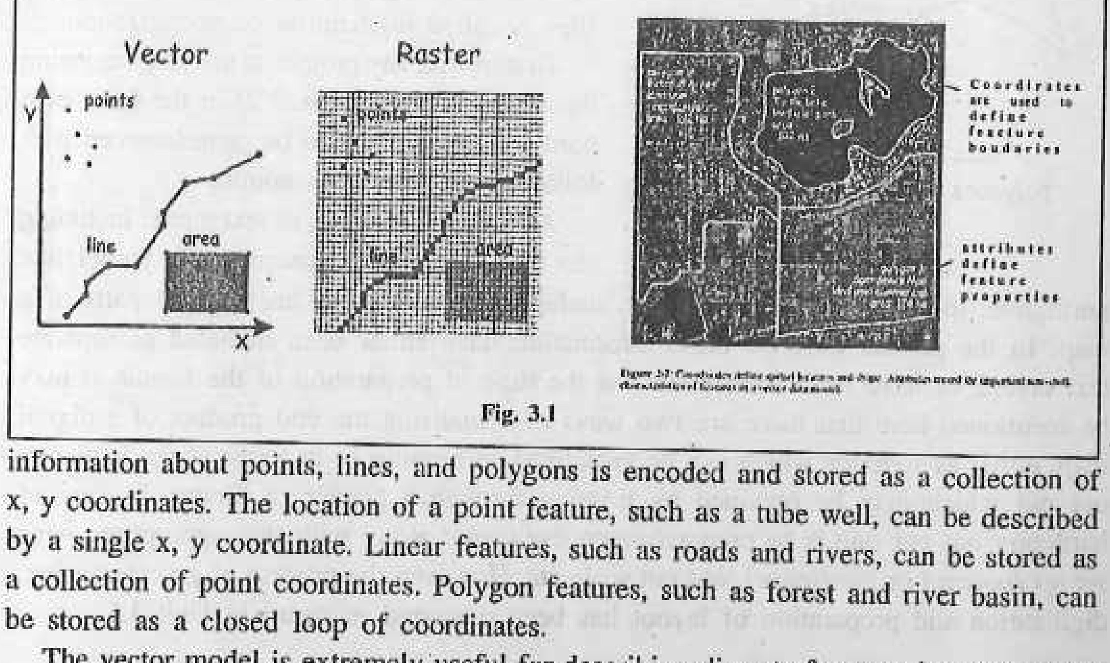

Fig. 3.1

information about points, lines, and polygons is encoded and stored as a collection of x, y coordinates. The location of a point feature, such as a tube well, can be described by a single x, y coordinate. Linear features, such as roads and rivers, can be stored as a collection of point coordinates. Polygon features, such as forest and river basin, can be stored as a closed loop of coordinates.

The vector model is extremely useful for describing discrete features, but less useful for describing continuously varying features such as soil type or accessibility costs for hospitals. The raster model has evolved to model such continuous features. A raster image comprises a collection of grid cells rather like a scanned map or picture. Both the vector and raster models for storing geographic data have unique advantages and disadvantages. Modern GIS is able to handle both models.

3.3.2 Generation of Vector layers:

Many GIS database consists of sets of information called layers. Each layer represents a particular type of geographic data. For example, one layer may include information on communication network. Another layer may contain information about land use pattern, while another records drainage system. The GIS can combine these layers into one image, showing how the communication network, drainage system and land use pattern relate to one another. A GIS database can include hundreds of such layers. Thus with the help of registered image, one can create as many thematic layers as one desires. In digital cartography, different types of geographical information are represented in terms of line, point and area (polygon) symbols. Generally each layer contains a particular thematic information. Sometimes separate text layers are also generated.

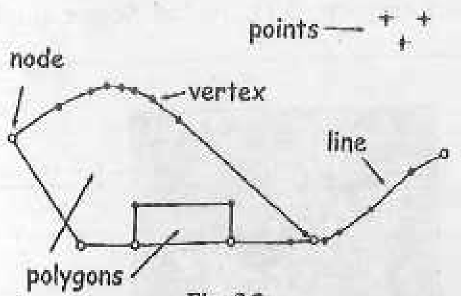

Fig. 3.2

Before geographic data can be used in a GIS mode, the data must be converted into a suitable digital format. The process of converting data from paper map into computer files is called digitization or vectorization.

To start with any project, at the very beginning the raster image (Figure 3.2) in the form of a hard copy map needs to be georeferenced with following commands in mapinfo:

Annotations in terms of text matter including the title of the map, insertion of symbol like north line, incorporation of auto scale, inclusion of index, etc. are integral parts of a map. In the present exercise these information have either been included as separate text layers, or have been incorporated at the time of preparation of the *layout*. It may be mentioned here that there are two ways of visualising the end product of a digital map, either as *softcopy* which can be visualized on monitor or in terms of the hardcopy out put which may be obtained by printing through a printer or plotter. In case of hardcopy out put one is to prepare/assign the *layout* along with that appropriate *page set up (portrait* or *landscape)*, out put scale etc. However, the process of georeferencing, digilization and preparation of layout has been discurred in detail in Unit 3.5.

3.3.3 Attachment of Attribute Data

Geographic Information Systems are computer based systems that can deal with virtually any type of information about features that can be referenced by geographical location. These systems are capable of handling both *locational* or *spatial* data and *attribute* or *non-spatial* data about such features. Spatial data refers to geographic areas or features which occupies a location, whereas non-spatial data has no specific location in space. It can however, have a geographic component and be linked to a geographic location. Tabular and attribute data are non-spatial but can be linked to location. Actually a GIS not only contains a "map" of the locations of say railway line, but also a database of descriptors about each railway line. These attributes might include information such as gauge width, electrified or not, single line or double line, jurisdiction of the route (i.e. it falls within which zone), date of construction, etc. The following table is the other examples of attributes that might be associated with a given point, line or area feature:

Table 3.1: Attachment of attribute data

Point feature	Pond (depth, area, use)
Line feature	Railway line (gauge width, electrified or not, single line or double line, jurisdiction of the route)
Area feature	Forest (name, status, species)

A map may contain spatial as well as non spatial or attribute data. In Geographical Information System, variety of attribute data may be attached to spatial data. For example in case of an agricultural plot, attribute information like owner of the plot, tax imposed there on, crops grown, whether the plot is irrigated or not, etc. may be attached in tabular form. For that purpose appropriate number of fields are to be opened and necessary data are to be attached there in. In Mapinfo software, the following steps are to be followed for attachment of attribute information for creation of data base.

File
New Table
Create
New Table Structure
Field information → Block
Type → Integer
Create
File name → Block
Save
Right click the mouse → Layer Control
Make the Block layer editable (by checking ✓)
Select *polyline* from tool box
Select appropriate line style, colour and width from style box
Snap by pressing' S' from key board

Digitize Goghat II Block
Right click block_bnd → Attribute Manager
Right click Area → Table Definitions-Display Unit → Sq km → Apply → Ok
Field → Add New → Name → Text + Population → Integer
Attach Name and population data for each block from the follwing table.

Table 3.2 : Hooghly District : Density of Population

Block	*Shape ID*	*Area (Sq km)*	*Population (2001)*	*Population Density (pop/sq km)*
Dhaniakhali	1	275.68	293,345	1064
Pandua	2	276.43	284,231	1028
Balagarh	3	202.15	214,784	1062
Chinsurah-Mogra	4	81.86	211,049	2578
Polba-Dadpur	5	285.69	239,493	838
Tarekeswar	6	119.93	162,371	1354
Haripal	7	184.42	235,494	1277
Singur	8	164.85	260,827	1582
Jangipara	9	164.23	201,001	1224
Chanditala-I	10	93.45	165,837	1775
Chanditala-II	11	70.34	213,485	3035
Seramur-Uttarpara	12	44.80	126,380	1821
Goghat-I	13	186.32	125,280	672
Goghat-II	14	190.03	143,359	754
Arambag	15	269.31	253,579	942
Khanakul-I	16	171.92	221,871	1291
Khanakur-II	17	121.83	160,888	1321
Pursurah	18	100.42	156,332	1557

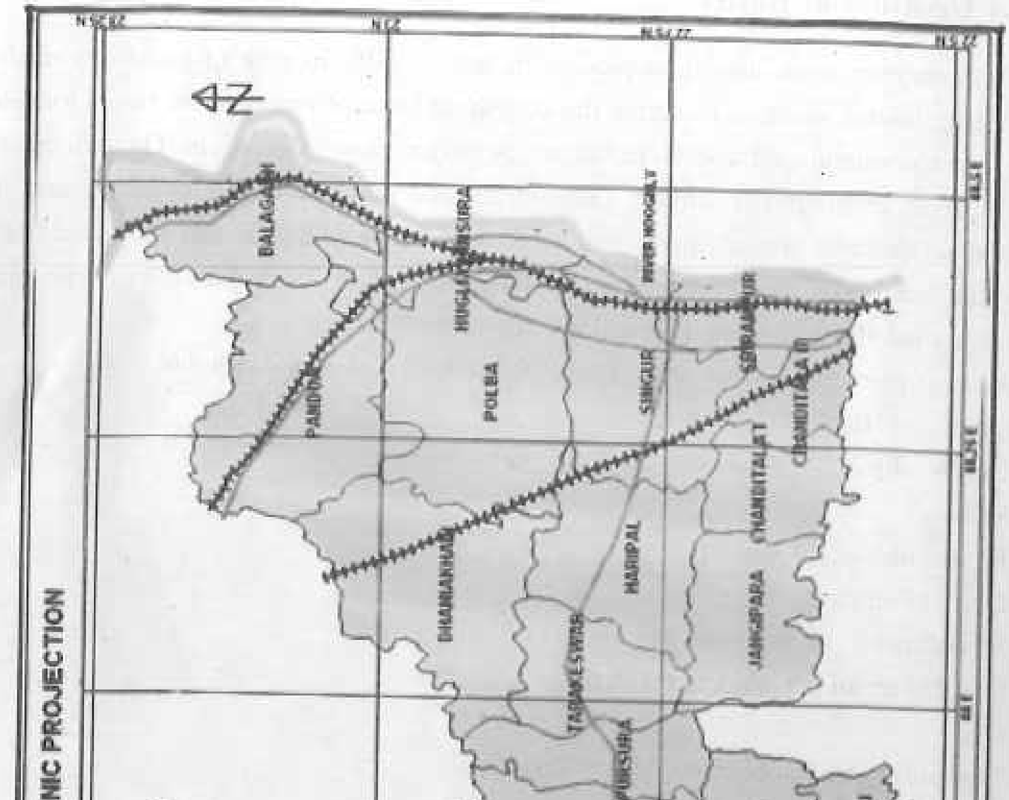

Fig 3.6 (Raster Image)

3.3.4 Creation of Buffer

Data analysis is an important process or task in GIS. In case of proximity analysis we use geometric distance to define the neighbour hood of one or more target locations. The most common and useful technique is buffer zone generation. The principle of buffer zone generation is simple. One selects one or more target locations, and then determine the area around them, with a certain distance. Buffer can be created along any line feature or around any point or polygon feature. In *Mapinfo*, to create buffer along a road the following instructions are to be folowed:

Keep a particular table (e.g. Major Road/Rail) selectable/editable

Object → Buffer

Buffer object

Value: 1

From column: id (select)

Unit: kilometers

Smoothness: 12 segment per circle

One buffer of all objects (select)

OK

The buffer will appear on Major Road/Rail

3.4 Editing attribute tables using demographic and/ or Land use data

3.4.1 Introduction

The data can be two major types (a) Spatial (i) Non-geographic (ii) Geographic

b) Non-Spatial (It can be used in Data Management System)

These data can be processed by editing the data table. Nature wise the data can be demographic or land use or dispaly other character. The editing method of copying and pasting records is valid for attribute tables of layers by using editor toolbar.

3.4.2 Procedure

Let us know how to do the data attachment in the map info software. The steps are given below:

(After digitization of block the data input or attachment can be done)

a) Data field creation

Table → Maintenance → Table structure → Add fields Name → male → type →[Integer] → Add field → Female → Type → [Integer] → OK (here male/ female are examples)

b) **Data Input:**

- Window → New browser window → Thematic map → OK → Input data (Male & Female)

- Select info tool → Click on digitized block map → Put data (male & female by using keyboard)

(The other demographic data like—Literate, illiterate, workers, non-workers and various land use data like—cultivation, forest, settlement, waterbody, waste land or other area data can also be put in the same procedure)

- After attaching/ putting the data different thematic maps can be prepared in the map info software.

GIS is a computer based system that can deal with virtually any type of information about features that can be referenced by geographical location. It is capable of handling both locational (spatial data) and attribute (non-spatial) data.

- Spatial data refers to geographic areas of features which occupies a location.

- Non-spatial data has no specific location in space.Tabular and attribute data are non-spatial but can be linked to location.

3.5 Preparation of Annotated maps

3.5.1 Introduction

The preparation of annotated maps can be done after attaching or putting the data related to demography or land use and land cover. Spatial data or attribute data has to be incorporated in the digitized map and different sort of thematic maps can be prepared in the GIS software.

All kind of data (demographic/ socio-economic/ land use or land cover data) can be used to prepare the thematic map. As the Map Info (12.5 version) is a GIS software, all the GIS related maps/ thematic maps can be prepared. (But using remote sensing data from the satellete images can not be prepared by using this version of Map Info software).

After attaching the data, preparation of different thematic maps like Bar Graph, Pie Graph, Choropleth Map can be done by using the attached data. The preparation of these maps in the Map Info software is almost the same procedure to be followed.

How to do in map info software :

3.5.2.1 About Mapinfo Software

Mapinfo professional is a powerful Microsoft Windows-based mapping application. It allows GIS professional to easily visualize the relationships between data and geography. MapInfo Professional is an industry leader in usability and is part of a comprehensive integrated locational platform.

3.5.2.2 Tools/ Icons used for the operation under Mapinfo

Standard Toolbar

2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

1. Open dialog **New Table (Ctrl + N)** and allow to create new data.
2. Open dialog **Open (Ctrl + O)** and allow to load data.
3. Open dialog **Open Workspace** and allow to load workspace data.
4. Open Microsoft Bring Arial Satellite Imagery.
5. Open Microsoft Bring Hybrid Satellite Imagery.
6. Bring roads tool.
7. OSM roads tool.

8. Move map to tool.
9. Open dialog **Save Table (Ctrl + S)** and allow to save data.
10. Open dialog **Save Workspace (Ctrl + K)** and allow to save workspace data
11. Allow to close all open data.
12. Open dialog **Save Window to File** and allow to save window as raster file
13. Open dialog **Print (Ctrl + P)** and allow to print data.
14. Open dialog **Print** and allow to convert data to PDF.
15. Cut out the selected objects and put into the clipboard.
16. Paste the object from the clipboard to the current editable layers.
17. Copy the selected objects into the clipboard.
18. Undo the last editing action.
19. Open dialog **New Browser Window (F2)** and allow to view attribute data
20. Open dialog **Map Window** and allow to view map data.
21. Open dialog **Create Graph** and allow to create graph.
22. Open dialog **New Layout Window** and allow to create map layout.
23. Open dialog **New Redistrict Window.**

Main Toolbar

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27

1. Select vector object.
2. Vector object select by marquee selection.
3. Vector object select by radius selection.
4. Vector object select by polygon selection.
5. Vector object select by boundary selection.
6. Unselect all vector objects.
7. Vector object select by invert selection.
8. Graph selection.
9. Select zoom in tool.
10. Select zoom out tool.
11. Open dialog **Change View** and allow to specify the input zoom scale
12. Activates working window navigation mode.
13. Open dialog **Info Tools,** which allows preview and editing of vector attribute.
14. Hot links tool.
15. Labeling vector object.
16. Drag map windows tool.
17. Open dialog **Layer Control** and allow loading and creation of vector data.

18. Select distance measuring tool.
19. Show and hide legend window.
20. Show and hide statistics window.
21. Set target district tool.
22. Assign selected object tool.
23. Clip region on / off tool.
24. Set clip region tool.
25. Open dialog **Create Adornment** and allows to create a scale bar.
26. Display table list tool.
27. Add table to Mapinfo manager library tool.

Drawing Toolbar

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

1. Adds the **<<Symbol>>** object to the vector layer being edited.
2. Adds the **<<line>>** object to the vector layer being edited.
3. Adds the **<<Polyline>>**object to the vector layer being edited.
4. Adds the **<<Arc>>** object to the vector layer being edited.
5. Adds the **<<Polygon>** object to the vector layer being edited.
6. Adds the **<<Ellipse>>** object to the vector layer being edited.
7. Adds the **<<Rectangle>>** object to the vector layer being edited.
8. Adds the **<<Rounded Rectangle>>** object to the vector layer being edited.
9. Adds the **<<Text>>** object to the vector layer being edited.
10. Adds the **<<Frame>>** object to active layout window.
11. Reshapes vector object being edited and selected.
12. Adds vertex to the vector object being edited and selected.
13. Open dialog **Symbol Style** and allows to change style, color & scale of symbol
14. Open dialog **Line Style** and allows to change style, color & width of line.
15. Open dialog **Region Style** and allows to change style of region.
16. Open dialog **Text Style** and allows to change style of text.

3.5.2.3 Supported Mapinfo File Format: Raster & Vector

The native file format of Mapinfo is TAB. The Mapinfo TAB format is a popular geospatial vector data format for GIS software. The basis file components for a Mapinfo Professional data set relate to the two basic environment for working in Mapinfo; "Browser View" and "Mapper View". The basic file set for viewing data and it's graphic representation in vector form within Mapinfo Professional requires a minimum of five files as below.

- **.TAB** (The ASCII file that is the link- between all other files and nolds information about the type of data set file).
- **.DAT** (The file that stores the attribute data. This is a dBase 111 DBF file)
- **.IND** (Optional index file for tabular data. This is present if any columns are indexed).
- **.MAP** (Stores the graphic and geographic information needed to display each vector feature on a map).
- **.ID** (stores information linking graphic data to the database information. This contains a 4-byte integer index into the MAP file for each feature

Supported File Format

Map Info Professional 11.5 Supports the following file format for raster & vector.

TAB: MapInfo .TAB files (*.tab)

WOR: MapInfo workspace files (*.wor)

MDB: Microsoft Access files (*.mdb)

ACCDB: Microsoft Access 2007 files (*.accdb)

DBF; dBASE DBF files (*.dbf)

TXT: Delimited ASCII files (*.txt)

WKS: Lotus 1-2-3 files (*.wkl, *.wks, *,.wk3, *.wk4)

XLS: Microsoft Excel files (*.xls)

XLSX: Microsoft Excel 2007 files (*.xisx)

SHP: ESR1 Shapefiles (*.shp)

Raster image files (*.bil, *.sid, *.gen, *.adf, *.img, *.ntf, *.ecw, *.url, *.tif, *.grc, *.bmp, *.gi *.tga, *.jpg, *.pcx, * jp2, *.j2k, *.png, *.psd, *.wmf, *.emf, *.map)

Grid images (*.adf, *.flt, *.txt, *.asc, *.img, *.dem, *.dtO, *.dtl, *.dt2, *.mig, *.grd)

CSV: Comma Delimited files (*.csv)

DWG/DXF: AutoCAD

MID/MIF: MapInfo file formats

DGN: Microstation Design files

CATD.DDF: Spatial Data Transfer Standard (SDTS)

FT: Vector Product Format (VPF)

MB1: MapInfo Professional Boundary Interchange format. An ASCII file for MapInfo DOS boundary files.

MMI: MapInfo DOS MMI

GML/XML: Geographic Markup Language 2.1 (*.gml, *.xml)

MrSID: The MrSID raster handler allows you to open and display raster images compressed in the MrSID format.

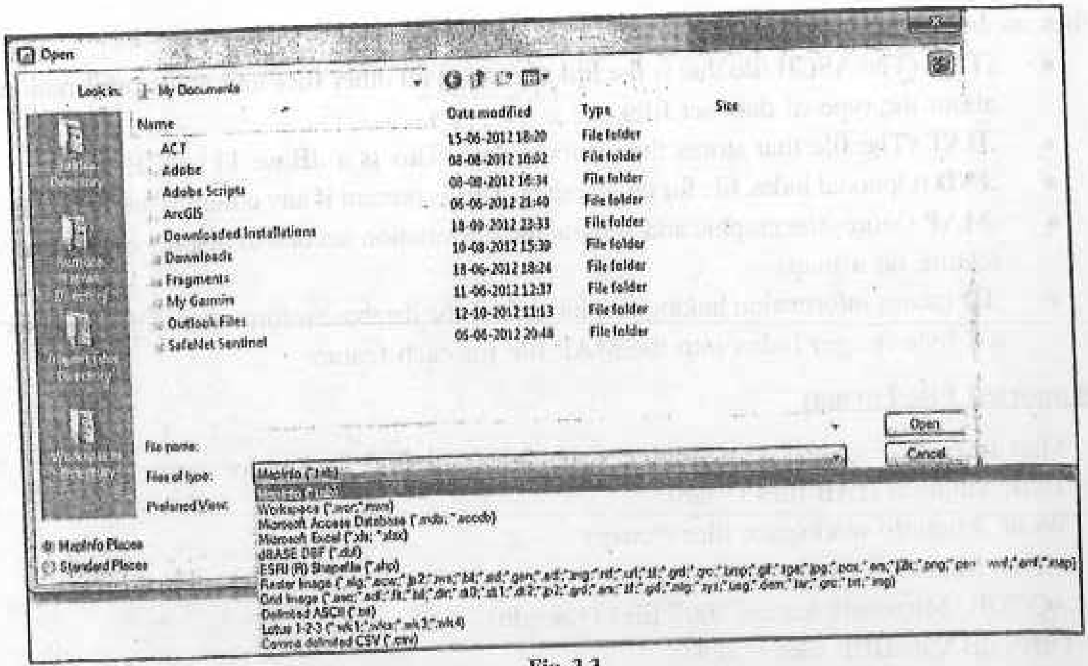

Fig 3.3

3.5.2.4 Geo-rectification (Registering Raster Image)

Image Registration/ Rectification: Projection: Indian Geodetic System/ Polyconic/ UTM-WGS 84

1. On the **file** menu, Click **Open**.
2. Open Window will appear.
3. Select **Raster Image** as **File of type**.
4. Browse to the desire location (MapInfo Training Data)
5. Select **Hooghly.jpg** and chose **Open.**
6. A question message will appear.
7. Click on **Register** button.
8. **Image Registration** dialog box will appear.
9. Click on **Projection** button to specify the projection system.
10. **Chose Projection** dialog box will appear.
11. Chose **India-polyconic systems** from **Category** drop down box.
12. From **Category Members** drop down box chose **India (WGS 84).**
13. Click OK button from **chose Projection** dialog box.
14. Click **Add** button and select a point on raster image, **Edit Control Point** dialog box will open.
15. Type X value in **Map X** and Y value in **Map Y.**
16. Click on **OK** button.

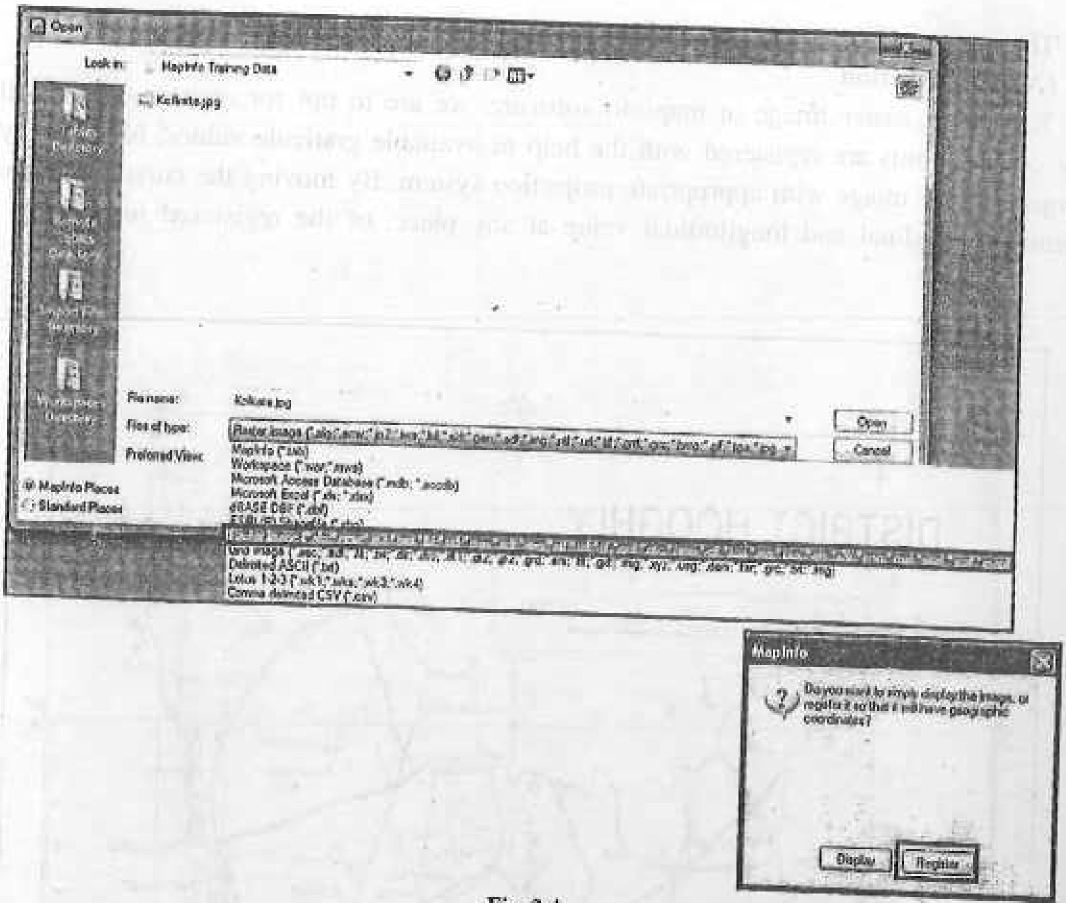

Fig 3.4

17. Click **Add** button again and select another point and type the XY value
18. Repeat the process and try to take several points throughout the image
19. Use + and – button to Zoom In and Zoom Out.
20. Click **Edit** button to edit a point.
21. Click **Remove** button to remove a point.
22. Click **Ok**.

3.5.2.5 Starting Mapinfo [12.5 version]

To start the work in mapinfo software for GIS work, one shall need a hardcopy analog base map that should be made compatible to the computer system. Such map must be scanned with the help of a scanner. This raster image is used as an input file to initiate the digital mapping job. It may be noted that appropriate number of registration marks in terms of latitudinal and longitudinal values should be inserted in the base map, so that the scanned image may be transformed into a registered image, thus matching with the real world coordinate system.

The various GIS work in mapinfo software can be followed by the following steps:-

(A) **Registration**

To open a *raster* image in mapinfo software, we are to opt for register option. All the conrol pionts are registered with the help of available graticule values, followed by projecting the image with appropriate projection system. By moving the cursor, one can identity latitudinal and longitudinal value at any place. of the registered image.

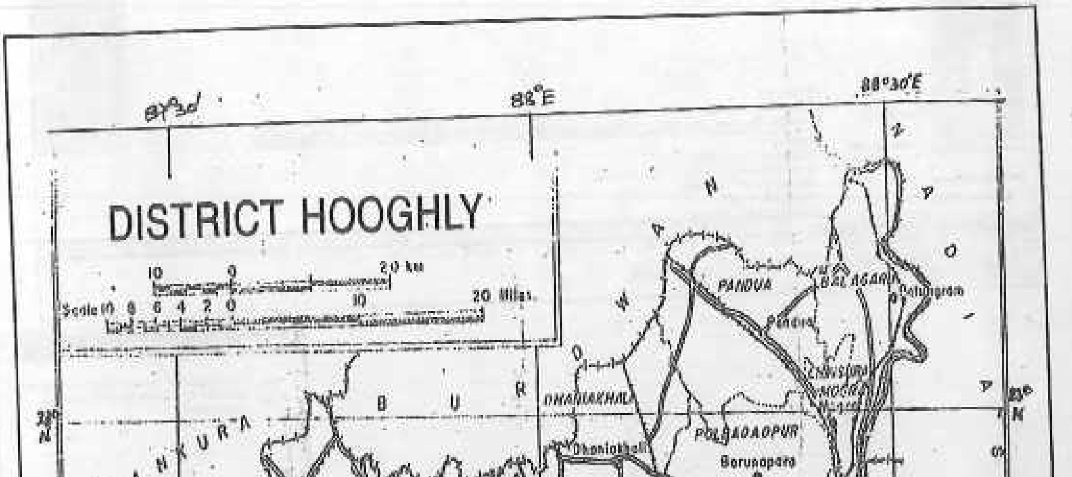

Fig 3.5

To register a map in Mapinfo software, the following instructions are to be followed:

File → Open table → File name (Select a rester file; for example: map Hooghly Fig. 3.6) → File of type : Rarter image → Open → Register

- Select (Add) Point 1 → label Pt 1 → Mapx : 88 degree
  Tab → Mapy: 22.75 degree → OK
- Add → Point 2 → lable Pt 2 → Map X: 88.25 degree
  Tab → Map Y: 22.75 degree → Ok
- Add → Point 3 → label Pt 3 → Map X: 88.50 degree
  Tab → Map Y : 22.50 degree → Ok
- Add → Point 4 → table Pt 4 → Max X : 87.50 degree
  Tab → Map Y : 22.50 degree → Ok → Ok

(It is desirable that the error in less than 5)

Following the same prosedure, anybody can register any maps with proper coordinate value. Here, map of Hooghly was registered following the same procedure. [Raster and vector images (maps) of Hooghly are attached herewith] (Fig. 3.5)

(B) **Projection :**

Projection → Longitude / latidue (WGS 84) → Ok [Fig 3.6 and 3.7]

(C) **Digitization**

The digitization must be of three heads:

(i) Line (ii) Point (iii) Area.

i) **Line :**

Railway Line :

File → New table → Add to current Mapper (✓) → ☐ Open new mapper off → creat → Name (type select) → Create → own folder → Same (give same name).

- Map → Layer control
- Layer (✓) editable on →
- Polyline → digitize railway line in map by single clicking of mouse → end with double click.

[Save : File → save table → Rail → save]

[**Save in workspace :** File → save workspace → own folder → Name (Question No.) → Save]

[**Delete:** Wrong digitization is to be deleted by using select tool on clicking the mouse on the wrong line and → delete it]

[**Colour and style change:** click on the digitized railway line ☒ → colour → style change → Ok.

[**Name Writing**: control layer editable on → (A) text → write besides the line]

[**Length Selection :** Double click on digitized railway line → Note the total length]

Road :

- File → New table → Add to current mapper [✓] → Open New mapper off ☒ → create → Name (type select) → create → own folder → give same name) → save then digitized → File → save table → save. (Fig. 3.8)

River :

- File → New table → Add to current mapper (✓) Open New mapper off ☒ → creat → Name (type select) → create → own folder → give same name) → Save.
- Then digitize → File → Save table → Save.

(ii) Point :

- File → New table → Add to current mapper [✓] → Open New mapper off ☒ → create → Name (type select) → creat → own folder → give same name) → save
- Select symbol (O) → editable on → click on map → file save table → save.

(iii) Area:

- File → New table → Add to current mapper [✓] → ☐ Open New mapper off → create → Name → own folder → give same name) → save
- Select Polygon to (☒) → editable on → click on point on map (block) → file → save table → save.

[**Snap tool :** During block digitization press the 'S' button of the keyboard (then snap will be on) → It will help to digitize the common boundary]

[**Area measurement:** Double click on the digitized block → Note the total area] (Fig 3.9)

Thematic Map preparation :

It has two part—(i) Data attachment/ input (ii) Thematic map preparation

(i) **Data attachment:**

- Table → Maintainance → Table structure → Add field → Name → [Male] → Type → [Integer] → Add field → Name → [Female] → Type → [Integer] → Ok.
- Data put → Window → New Browser window → Thematic map → Ok → data put (male & female).
- Took info tool → click on digitized block → put data (male & female)

ii) **Thematic map preparation:**

a) Bar graph b) Pie graph c) Choropleth map.

a) **Bar Graph :** • Map → create thematic wap → Bar chart → default of Next [male] select → field from tab [fimale] → Select → Add → Next → Ok.

Editing Bar Graph: Select the bar in the layer → control → click → style → change the colour → height → width → Ok. (Fig. 3.10)

ii) **Pie Graph :**

- Map → create thematic map → pie chart → default → Next → [male] → Add → [female] → Add → Next → Ok.
- **Editing Pie Graph** → select the pie group in the layer control → click → style → change the colour → height → width → Ok (Fig. 3.11)

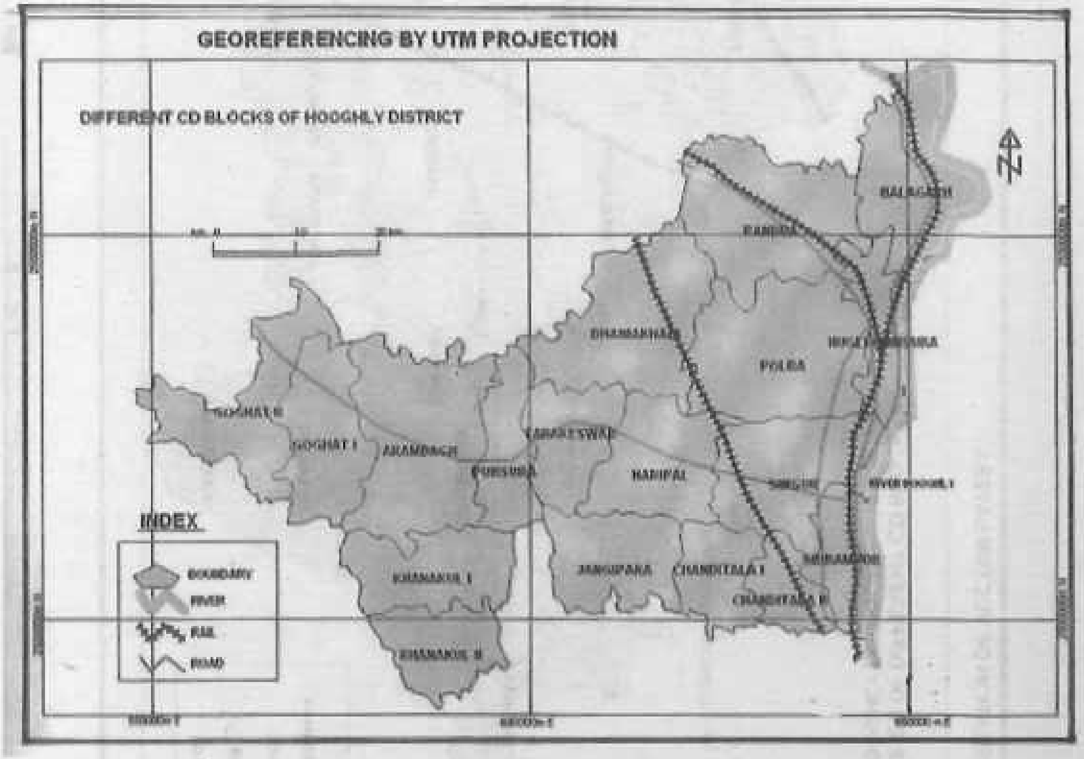

Fig 3.7

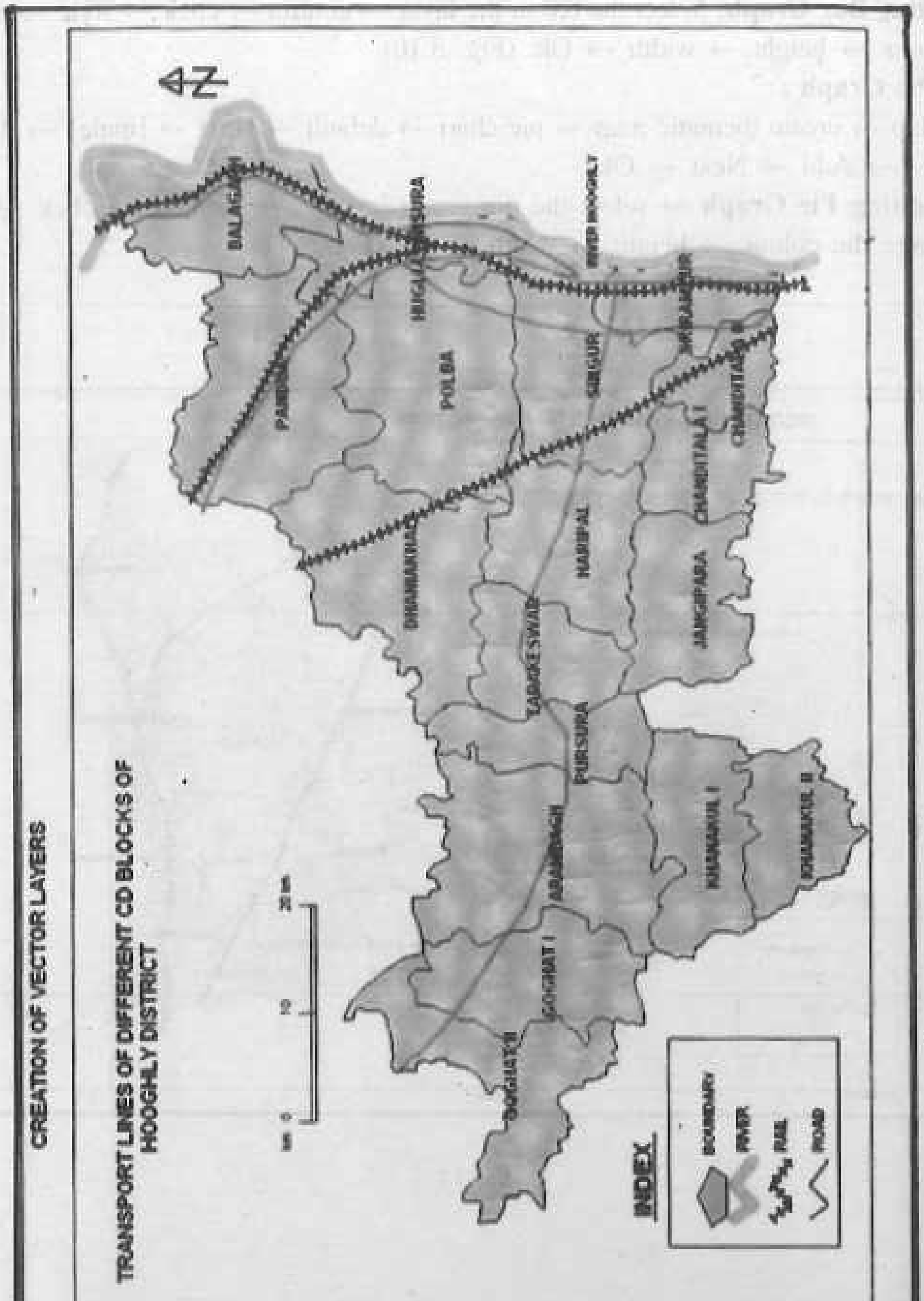
CREATION OF VECTOR LAYERS
TRANSPORT LINES OF DIFFERENT CD BLOCKS OF HOOGHLY DISTRICT
BALAGARH
PANDUA
HUGLI CHINSURA
POLBA
RIVER HOOGHLY
SINGUR
SRIRAMPUR
CHANDITALA I
CHANDITALA II
DHANIAKHALI
HARIPAL
JANGIPARA
TARAKESWAR
PURSURA
ARAMBAGH
KHANAKUL I
KHANAKUL II
GOGHAT I
GOGHAT II
INDEX
BOUNDARY
RIVER
RAIL
ROAD

Fig 3.8


CREATION OF VECTOR LAYERS
DIFFERENT CD BLOCKS OF HOOGHLY DISTRICT
INDEX
BOUNDARY
BALAGARH
PANDUA
POLBA
HUGLI-CHINSURA
DHANIAKHALI
HARIPAL
SINGUR
SERAMPUR
CHANDITALA I
CHANDITALA II
JANGIPARA
TARAKESWAR
PURSURA
ARAMBAGH
GOGHAT I
GOGHAT II
KHANAKUL I
KHANAKUL II

Fig 3.9

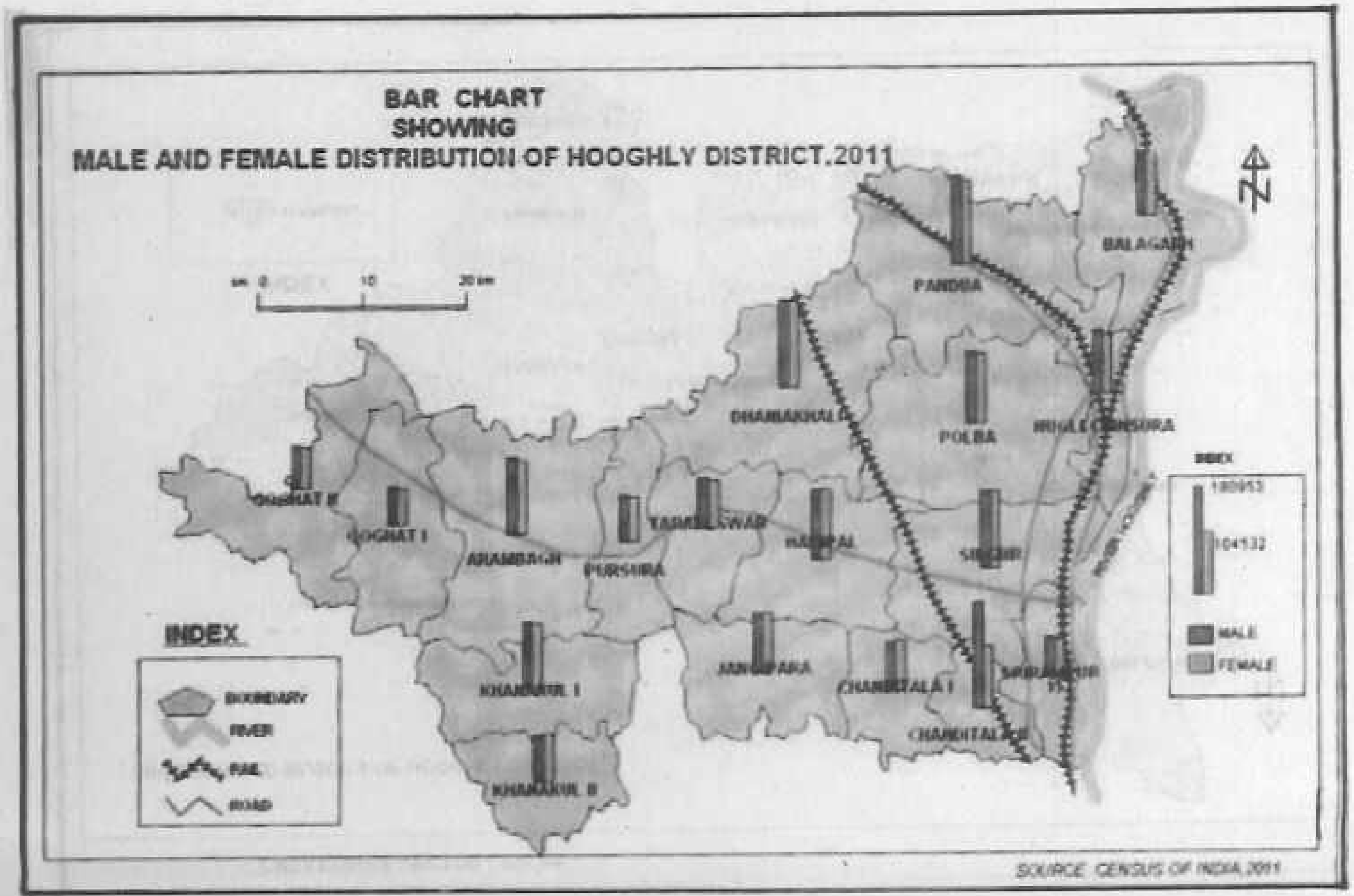
BAR CHART
SHOWING
MALE AND FEMALE DISTRIBUTION OF HOOGHLY DISTRICT.2011
N
BALAGARH
PANDUA
DHANIAKHALI
POLBA
ARAMBAGH
PURSHURA
KHANAKUL I
KHANAKUL II
JANGIPARA
SINGUR
INDEX
MALE
FEMALE
180953
104132
INDEX
BOUNDARY
RIVER
RAIL
ROAD
SOURCE CENSUS OF INDIA 2011

Fig 3.10

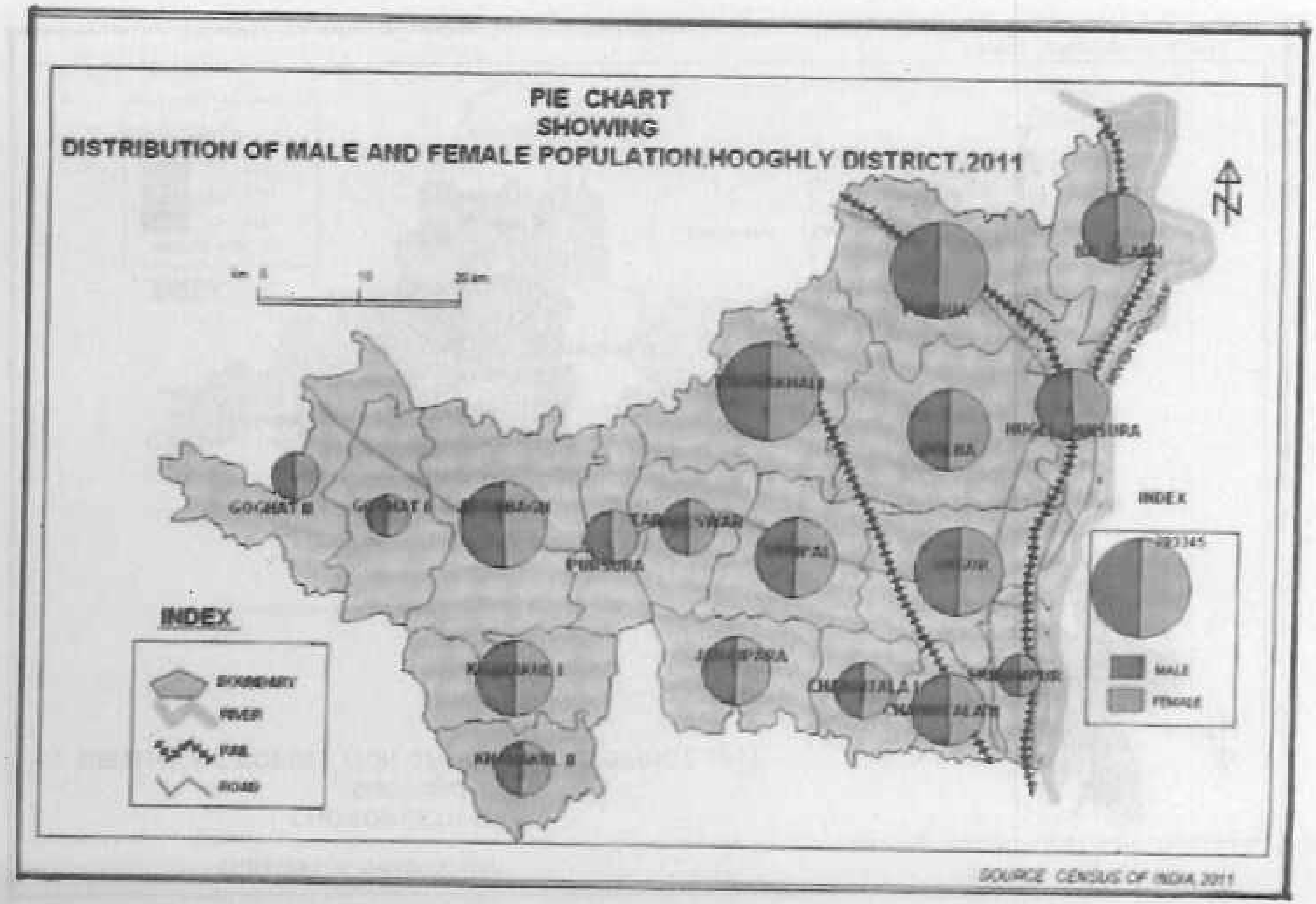
PIE CHART
SHOWING
DISTRIBUTION OF MALE AND FEMALE POPULATION.HOOGHLY DISTRICT.2011
INDEX
BOUNDARY
RIVER
RAIL
ROAD
GOGHAT II
GOGHAT I
PURSURA
INDEX
MALE
FEMALE
SOURCE CENSUS OF INDIA 2011

Fig 3.11

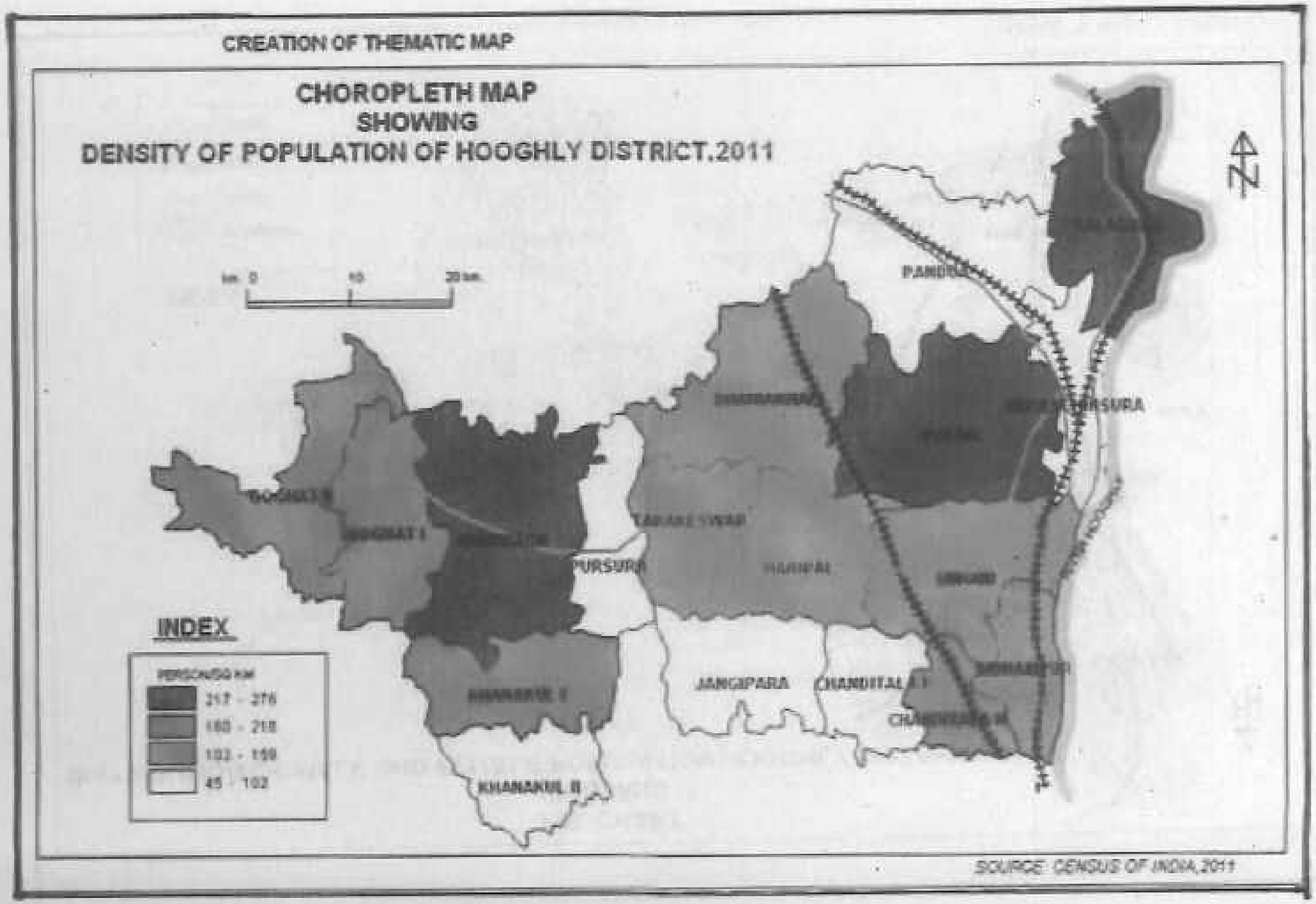
CREATION OF THEMATIC MAP
CHOROPLETH MAP
SHOWING
DENSITY OF POPULATION OF HOOGHLY DISTRICT.2011
INDEX
PERSON/SQ KM
217 - 276
160 - 216
103 - 159
45 - 102
PANDUA
TARAKESWAR
PURSURA
JANGIPARA
CHANDITALA I
KHANAKUL II
SOURCE: CENSUS OF INDIA,2011

Fig 3.12

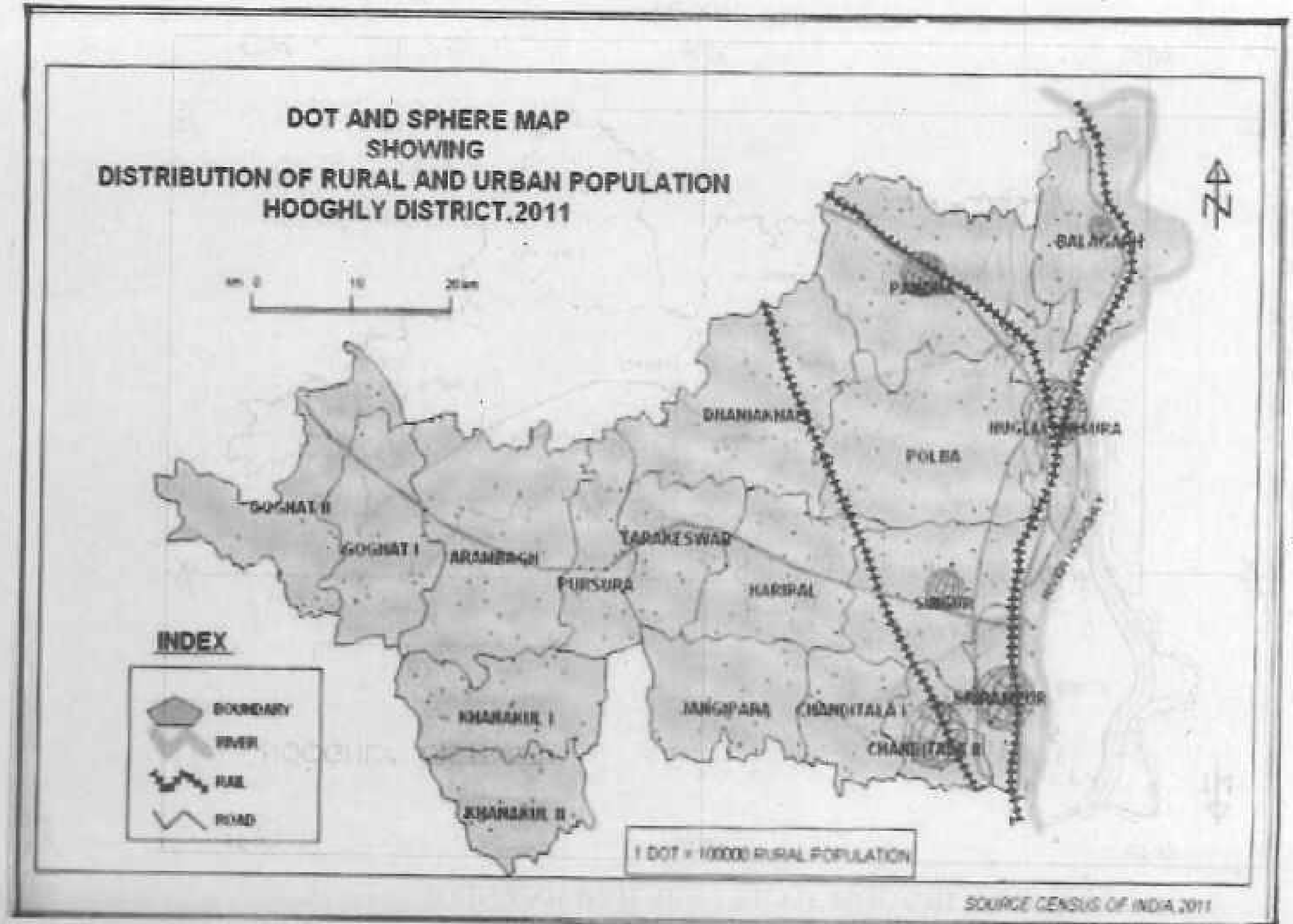
DOT AND SPHERE MAP
SHOWING
DISTRIBUTION OF RURAL AND URBAN POPULATION
HOOGHLY DISTRICT.2011
INDEX
BOUNDARY
RIVER
RAIL
ROAD
1 DOT = 100000 RURAL POPULATION
GOGHAT II
GOGHAT I
ARAMBAGH
PURSURA
TARAKESWAR
HARIPAL
DHANIAKHALI
POLBA
SINGUR
JANGIPARA
CHANDITALA I
KHANAKUL I
KHANAKUL II
SOURCE CENSUS OF INDIA 2011

Fig 3.13

RAIL AND RAIL BUFFER OF HOOGHLY DISTRICT

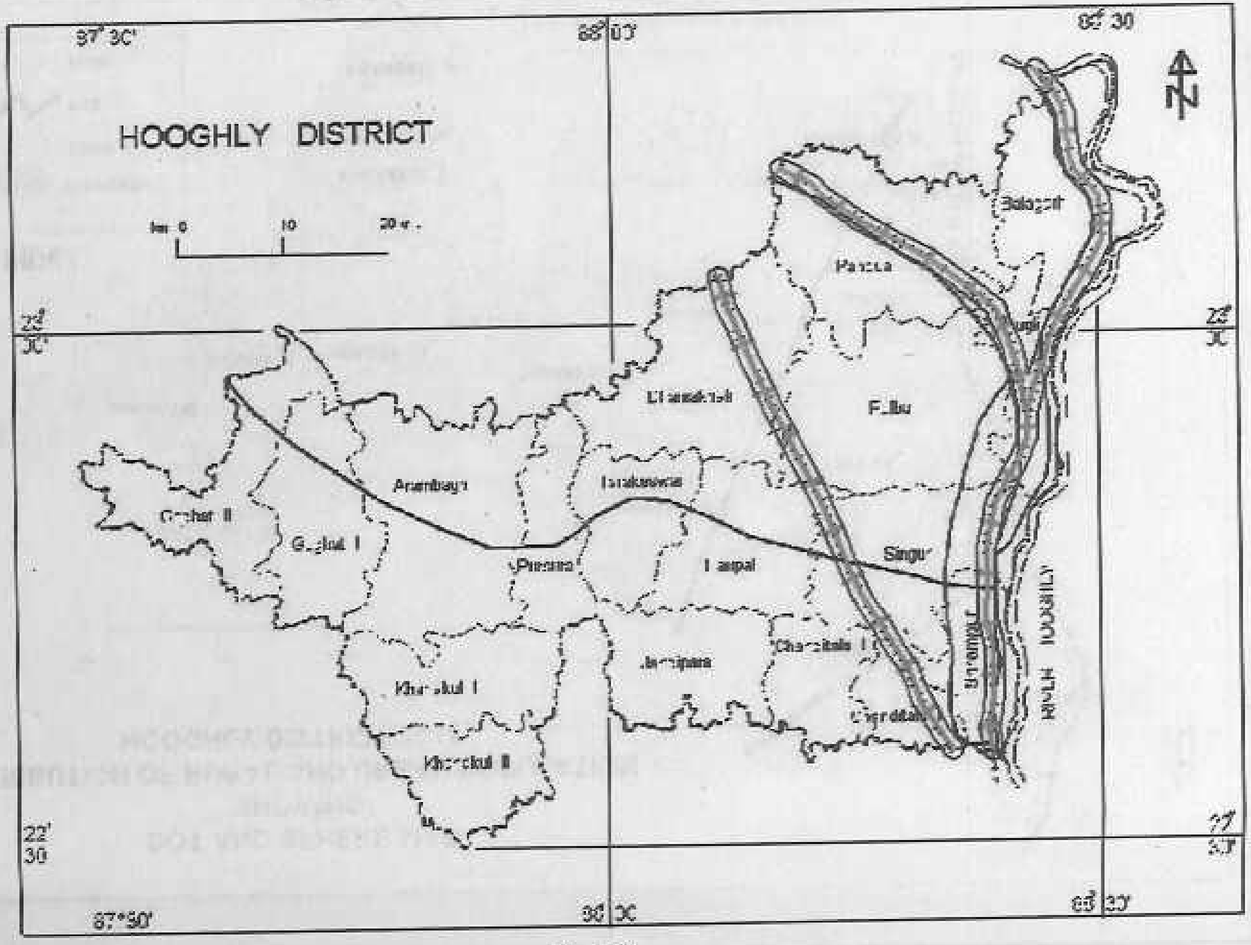

Fig 3.14

iii) **Choropleth Map :**

Choropleth map is prepared to represent the density of any demographic or socio-economic data in respect of area. Here you can prepare choropleth map to represent the population density.

• Map → create thematic map → Ranges (type) → region ranges → Next → Table → Blolck → [Field] Expression → [Column] → population → [Operation] → Divide/ → Function → Area → Ok.

Editing Choropleth Map

Select the choropleth map → select the layer control → click → style → change the colour → Range change → Ok. (Fig. 3.12)

* **Buffer creation:**

i) Rail Buffer ii) Road Buffer iii) River Buffer iv) Point Buffer

* Select table → buffer → select rail/ road/ river/ point → Next → Add to current mapper (✓) → Open New Mapper off ☒→ Create → width → [100] → Unit → Meter/ Km → create → File name: Rail Buffer / Road buffer etc. (which one you want to prepare) → Save → one buffer of all objects/or one buffer for each object → Ok.

• Editing buffer → Road buffer from layer ☒→ click → change the colour in foreground → Ok. (Fig. 3.14)

Similarly Dot and sphere maps can also be prepared (Fig. 3.13)

* **Heading:**

Cursor location → editable on → [A] text → Select → Click on map where you want to write heading.

• **Editing** :–Double click on the already written heading → change the colour → font size etc. → Ok.

* **North Line:** → Select North Arrow [N] → click on map (where you want to draw the arrow) → Ok.

* **Scale** : Map → create scale bar → Next → Unit [Cm] → [Km] → Finish.

* **Map does not display on screen (If the case arises, then follow the procedure):-**

Map → view entire layer → Haora Map → Map will display on screen.

* **Legend:**

Map → create legend → Finish → Minimize it beside the map display

* **Distance measurement:**

i) Straight line distance:- select line → Draw the straight line between two points → then double click on the drawn line → Note the total length → Ok.

ii) **Actual distance:** select polyline → Draw the polyline connection along the road between two points then double click on the drawn line → Note the total length → Ok.

* **Latitude / Longitude determination:–**

* Open digitized map → Click on zoom (At the lower left corner) → Cursor location → Plot the mouse on particular point. → Note the longitude and latidue value.

[Items Taught]

1. Raster image
2. Vector image
3. Registration
4. Projection
5. Digitization—Point (Hospital/ School/ Temple) — Line (Rail/ Road/ River) — Polygon (Area/ Block)
6. Editing the digitized items
7. Heading
8. North Arrow
9. Scale
10. Distance Measurement
11. Length Measurement
12. Latitude/ Longitude determination.
13. Name writing
14. Save table
15. Buffer creation (Line/ Point) (Rail/ Road/ River)
16. Save
17. Save workshop (Question No.)
18. Use of snap tool
19. Use of info tool
20. Data attachment
21. Thematic Map Preparation —Bar Graph —Pie Graph —Choropleth Map.
22. Editing —Editing (style/ colour) —Thematic (Height/ Width/ Colour/ Size)
23. Creation of Legend
23. Deleting wrong digitization

Major Questions of Map Info Software

1. Register the given map (Hooghly Map).
2. Digitize the railway line of the registered map.
3. Digitize the highway road of the registered map.
4. Digitize the river network of the registered map.
5. Make a rail buffer of 500 meters.
6. Digitize four/five/six/seven blocks of the registered map.
7. Attach the data in the digitized block of the given map.
8. Prepare suitable thematic map using the attached/ input data file.
9. Prepare a choropleth map to show the population density of the given map.
10. Prepare a pie chart bar graph to represent the given data.

3.6 Summary

The basic concept of Geographic Information System is to record, store, and analyse information about the features that make up the earth's surface. To start with any GIS project, Georeferencing is necessary, so that the available raster format is converted into real world coordinate system. In the next step line, point and area features are to be digitized in line, point and polygon modes. Attribute data need to be attached to the data base for overlay analysis as well as query purposes. A neatly prepared thematic map with proper layout and annotation helps the viewer to visualize the available geographical information 'concerning a particular part of the world.

Exercises

1. Distinguish between raster and vector data format with illustration.
2. Georeference the raster image of Hooghly District with Mapinfo software.
3. Prepare separate layers for road network, block head quarters and block boundries of Hooghly District using Mapinfo software.
4. Create a buffer along Damodar River (800 metre) flowing within Hooghly District.

Selected Readings

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NOTE

মানুষের জ্ঞান ও ভাবকে বইয়ের মধ্যে সঞ্চিত করিবার যে একটা প্রচুর সুবিধা আছে, সে কথা কেহই অস্বীকার করিতে পারে না। কিন্তু সেই সুবিধার দ্বারা মনের স্বাভাবিক শক্তিকে একেবারে আচ্ছন্ন করিয়া ফেলিলে বুদ্ধিকে বাবু করিয়া তোলা হয়।

—রবীন্দ্রনাথ ঠাকুর

ভারতের একটা mission আছে, একটা গৌরবময় ভবিষ্যৎ আছে, সেই ভবিষ্যৎ ভারতের উত্তরাধিকারী আমরাই। নূতন ভারতের মুক্তির ইতিহাস আমরাই রচনা করছি এবং করব। এই বিশ্বাস আছে বলেই আমরা সব দুঃখ কষ্ট সহ্য করতে পারি, অন্ধকারময় বর্তমানকে অগ্রাহ্য করতে পারি, বাস্তবের নিষ্ঠুর সত্যগুলি আদর্শের কঠিন আঘাতে ধূলিসাৎ করতে পারি।

—সুভাষচন্দ্র বসু

Any system of education which ignores Indian conditions, requirements, history and sociology is too unscientific to commend itself to any rational support.

–Subhas Chandra Bose

Price : Rs. 150.00

Published by Netaji Subhas Open University, DD-26, Sector-I, Salt Lake, Kolkata - 700064 & Printed at Gita Printers, 51A, Jhamapukur Lane, Kolkata-700 009.