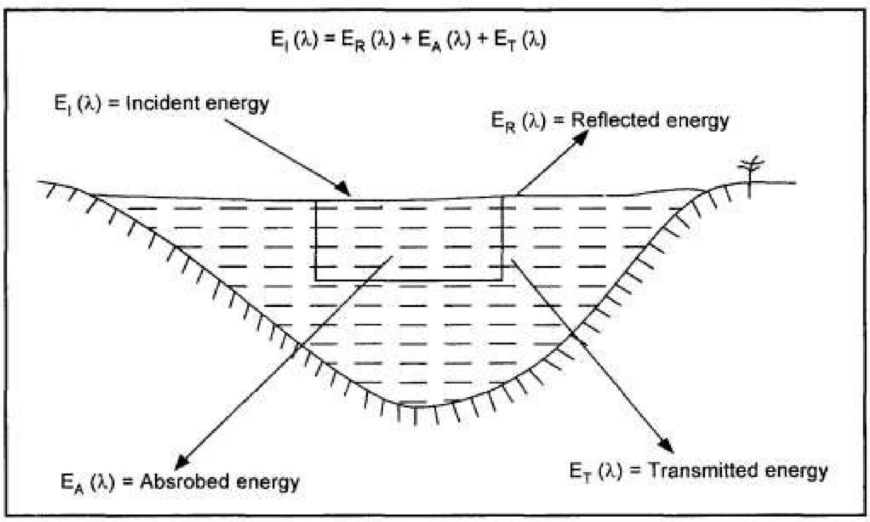
Atmospheric windows

- While passing through the atmosphere, electromagnetic radiation is scattered and absorbed by gasses and particulates. Besides the major gaseous components like molecular nitrogen and oxygen, other constituents like water vapour, methane, hydrogen, helium and nitrogen compounds play an important role in modifying the incident radiation and reflected radiation.
- This causes a reduction in the image contrast and introduces radiometric errors.
- Regions of the electromagnetic spectrum in which the atmosphere is transparent are called *atmospheric windows.*
- The atmosphere is practically transparent in the visible region of the electromagnetic spectrum and therefore many of the satellite based remote sensing sensors are designed to collect data in this region
- Some of the commonly used atmospheric windows are 0.38 - 0.72 µm (visible), 0.72 -3.00 µm (near infrared and middle infrared) and 8.00 -14.00 µm (thermal infrared).

Energy Interactions with Earth’s Surface Materials

When electromagnetic energy is incident on any feature of the earth’s surface such as a water body, various fractions of energy get reflected, absorbed and transmitted.



$$E_I(\lambda) = E_R(\lambda) + E_A(\lambda) + E_T(\lambda)$$

Where, E_I = Incident energy

E_R = Reflected energy

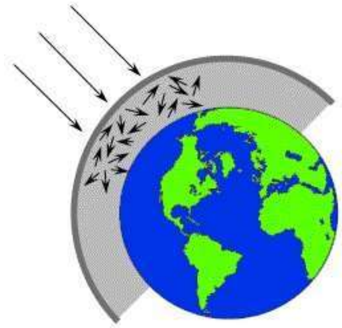
E_A = Absorbed energy

and, E_T = Transmitted energy

Energy Interactions with Earth Surface Features

There are three forms of interaction that can take place when energy strikes, or is incident upon the surface.

These are:



1. Absorption (A)
2. Transmission (T)
3. Reflection (R)

The total incident energy will interact with the surface in one or more of these three ways.

The proportions of each will depend on the wavelength of the energy and the material and condition of the feature.

• Absorption (A) occurs when radiation (energy) is absorbed into the target

• Transmission (T) occurs when radiation passes through a target.

• Reflection (R) occurs when radiation "bounces" off the target and is redirected.

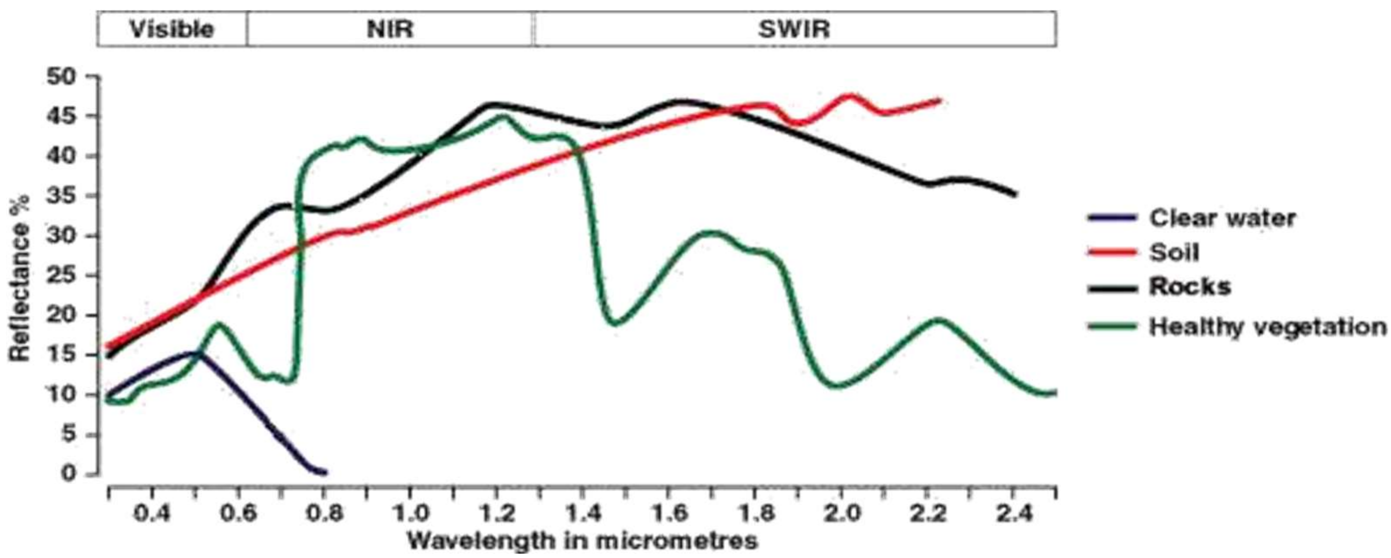
According to principles of physics, it is known that are called reflectance, absorbance, and transmittance.

$$\frac{E_R(\lambda)}{E_I(\lambda)}; \frac{E_A(\lambda)}{E_I(\lambda)} \text{ and } \frac{E_T(\lambda)}{E_I(\lambda)}$$

A measure of 1.0 means that 100% of the incident radiation is reflected off the surface, And a measure of '0' means that 0% is reflected.

Spectral Reflectance Curves: A basic assumptions made in that specific target has an Individual and characteristic manner of interaction is described by the spectral response of a target in a particular wavelength region of electromagnetic spectrum

SPECTRAL SIGNATURE



Vigorous Vegetation: Spectral reflectance curves for vigorous vegetation manifests the peak and valley configuration. The valleys in the visible portion of the spectrum are indicative of pigments in plant leaves.

Dip in reflectance that can be seen at wavelengths of 0.65 **µm, 1.4 and 1.9µm** are attributes to absorption of water by leaves.

Soil: The soil curve shows a more regular variation of reflectance. Factors that evidently affect soil reflectance are moisture content, soil texture, surface roughness, and presence of organic matter. The term spectral signatures can also b used for spectral reflectance curves.

Water: The characteristic spectral reflectance curve for water shows that about 0.5**µm,** a reduction in reflectance with increasing wavelength, so that in the near infrared range, the reflectance of water significantly affected by the presence of dissolved suspended Organic and inorganic material and depth of water body shows the spectral reflectance Curves for visible and near infrared wavelengths at the surface and at 20m depth

SATELLITE CHARACTERISTICS: ORBITS AND SWATHS

- The path followed by a satellite is referred to as its **orbit.**
- Satellite orbits are matched to the capability and objective of the sensor(s) they carry.
- Orbit selection can vary in terms of altitude (their height above the Earth's surface) and their orientation and rotation relative to the Earth.

A satellite is launched (lifted) from the Earth's surface by a rocket. Once the satellite reaches its orbit, it continues to move in its orbit and does not require the push from the rocket any more. Satellite orbits can be at different distances from the Earth.

The path followed by a satellite is referred to as its orbit.

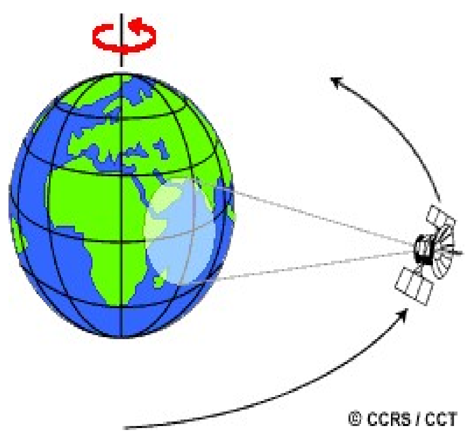
Two important types of orbits are:

•*Geostationary orbits*
are in the same plane as the equator and are about 36000 km away from the Earth.(Ex weather and communication satellites, INSAT,GOES, METEOSAT)

•*Polar orbits*
pass very close to the north and south poles (also known as near-polar orbits). They are about 700 to 800 km away from the Earth.

Geostationary orbits

- Satellites at very high altitudes, which view the same portion of the Earth's surface at all times have **geostationary orbits**.
- These geostationary satellites, at altitudes of approximately **36,000 kilometres**, revolve at speeds which match the rotation of the Earth so they seem stationary, relative to the Earth's surface.
- This allows the satellites to observe and collect information continuously over specific areas.
- Weather and communications satellites commonly have these types of orbits.
- Due to their high altitude, some geostationary weather satellites can monitor weather and cloud patterns covering an entire hemisphere of the Earth.



Geostationary orbits (Geosynchronous Equatorial Orbit)

(**from *geo* = Earth + *synchronous* = moving at the same rate).**

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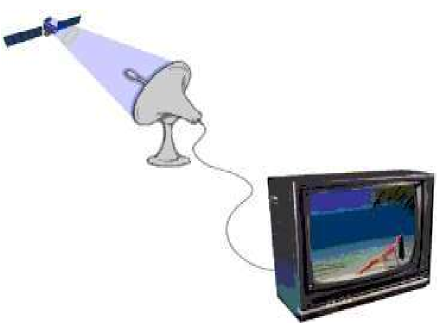
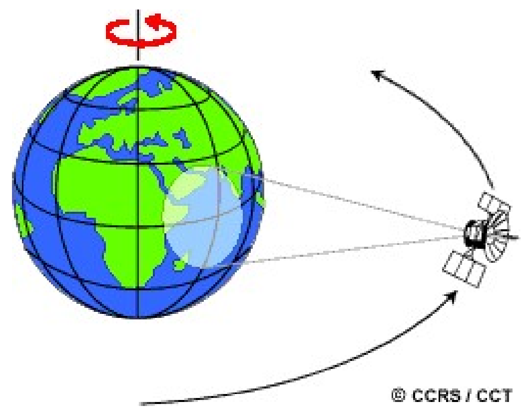




Near-polar orbits (or) sun-synchronous

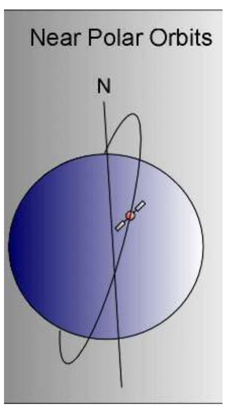
• These are **near-polar orbits**, so named for the inclination of the orbit relative to a line running between **the North and South poles.**

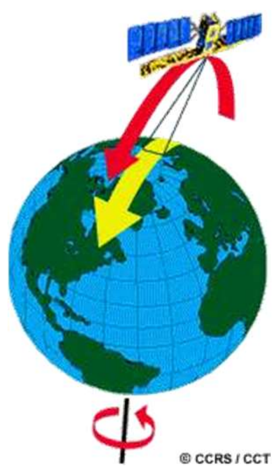
• Many of these satellite orbits are also **sun-synchronous** such that they cover each area of the world at a constant local time of day called **local sun time**.

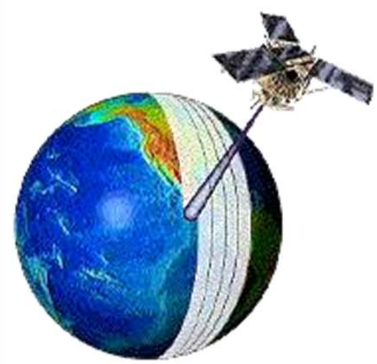
• At any given latitude, the position of the sun in the sky as the satellite passes overhead will be the same within the same season. This ensures consistent illumination conditions when acquiring images in a specific season over successive years, or over a particular area over a series of days.

• This is an important factor for monitoring changes between images or for mosaicking adjacent images together, as they do not have to be corrected for different illumination conditions. Eg: **LANDSAT, IRS and SPOT**

These orbits have an inclination near 90 degrees. This allows the satellite to see virtually every part of the Earth as the Earth rotates underneath it. It takes approximately 90 minutes for the satellite to complete one orbit.





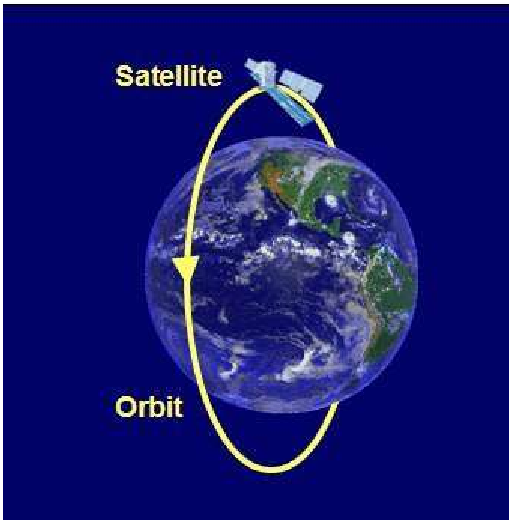


Satellites

A satellite is something that moves around something else. Satellites follow a fixed path, **known as an orbit.**

Scientists have sent many satellites into outer space that revolve around the Earth. These satellites continuously take pictures of the Earth. We can use these satellite images to study the Earth.

The science of acquiring and studying these images is called satellite remote sensing.



Depending on their use there are different kinds of satellites.

- ***Communication satellites***

help to provide radio, television and phone coverage. These satellites always look at the same point on the Earth as they revolve around the Earth (geostationary).

- ***weather satellites***

are geostationary. Others are in polar orbit. They all provide information that is used for weather forecast.

- ***Navigational satellites***

are special satellites that help us to find our exact location on the Earth. GPS (Global Positioning Systems) receivers that you can now buy at many stores use these satellites to show us our location.

• ***Satellites for planetary/astronomical studies***

point away from the Earth and are used to study outer space and other planets.

• ***Earth observing satellites***

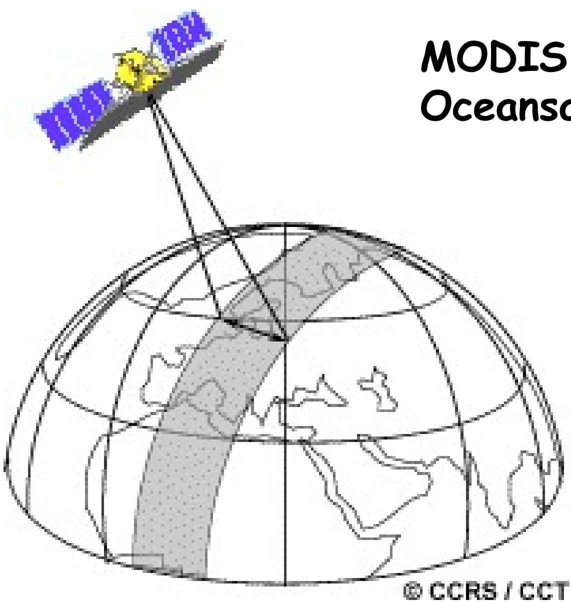
are specially designed to study the processes on Earth. Many of these satellites occupy near-polar orbits. Some also operate in other orbit types.

swath

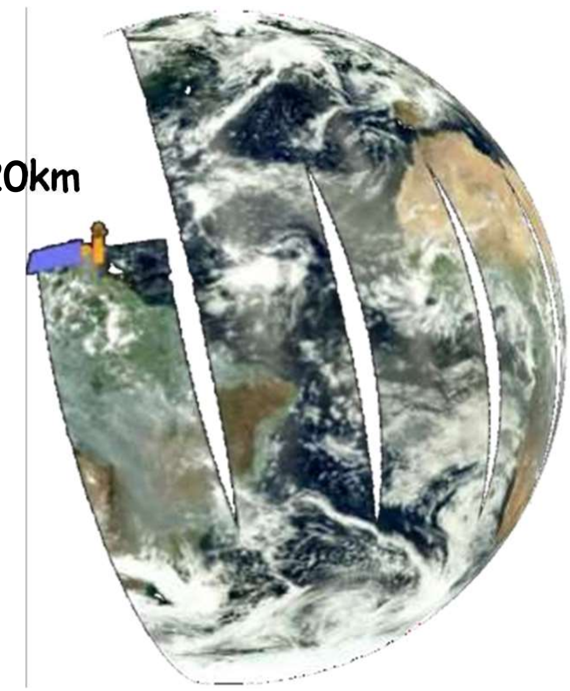
•As a satellite revolves around the Earth, the sensor "sees" a certain portion of the Earth's surface. The area imaged on the surface, is referred to as the swath.

•Imaging swaths for spaceborne sensors generally vary between tens and hundreds of kilometres wide.

•The satellite's orbit and the rotation of the Earth work together to allow complete coverage of the Earth's surface, after it has completed one complete cycle of orbits.



MODIS=2300km
Oceansat-2=1420km



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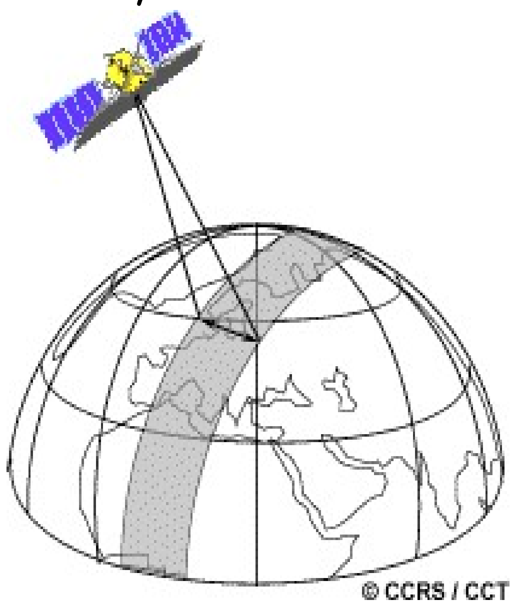
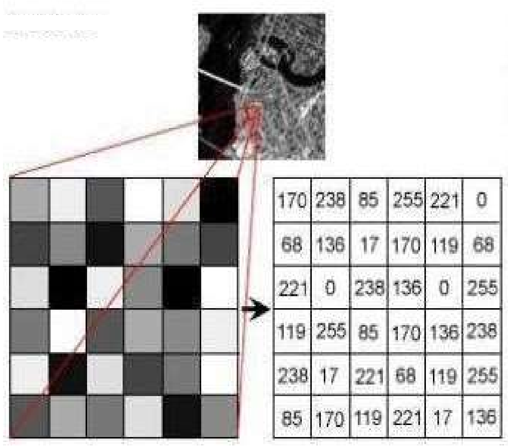


SENSOR RESOLUTION

Resolution **refers to the smallest size an object or detail can be represented in an image**. Higher resolution means that pixel sizes are smaller, providing more detail. For example, 30cm resolution satellite imagery can capture details on the ground that are greater than or equal to 30cm by 30cm



TYPES OF RESOLUTION

- **SPATIAL**
- **SPECTRAL**
- **RADIOMETRIC**
- **TEMPORAL**

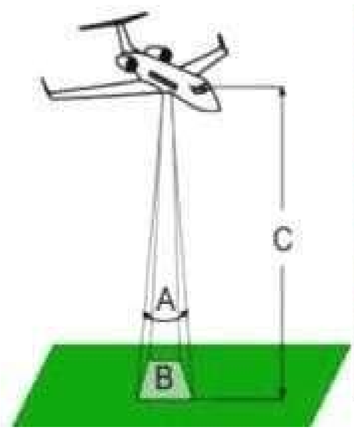
Spatial Resolution

✓spatial resolution of the sensor and refers to the size of the smallest possible
feature that can be detected.

✓Spatial resolution of passive sensors depends primarily on their Instantaneous Field of View (IFOV).

✓The IFOV is the angular cone of visibility of the sensor (A) and determines the area on the Earth's surface which is "seen" from a given altitude at one particular moment in time (B).

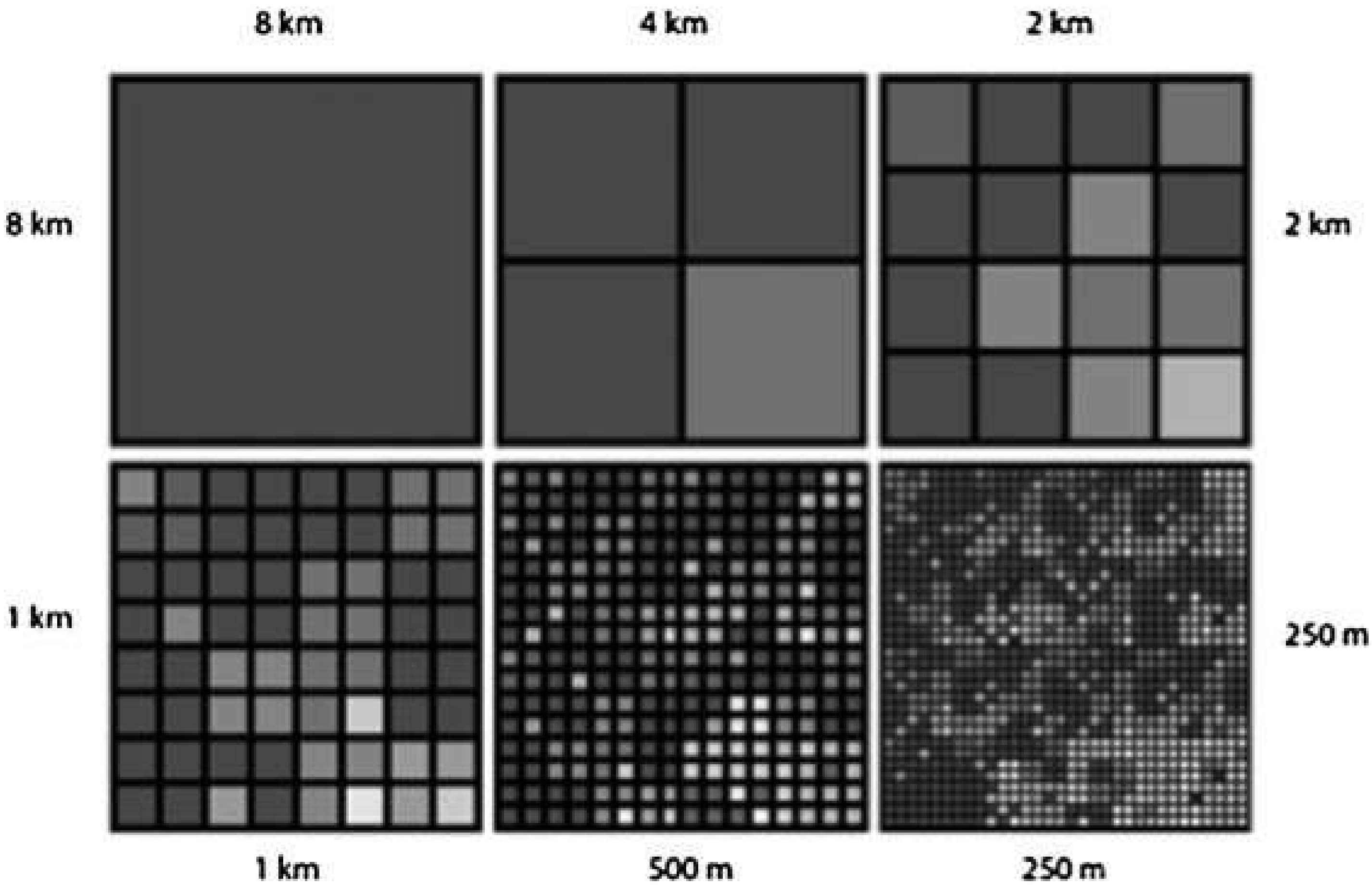
✓The size of the area viewed is determined by multiplying the IFOV by the distance from the ground to the sensor (C). This area on the ground is called the resolution cell and determines a sensor's maximum spatial resolution.




80 meter

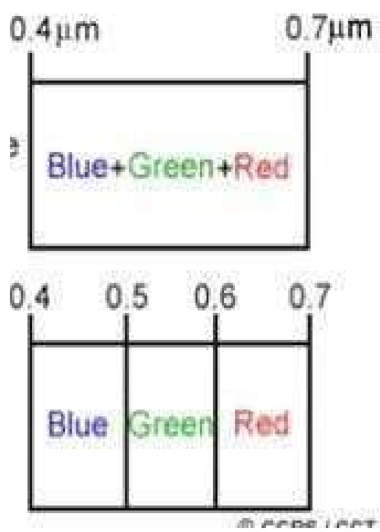

15 meter

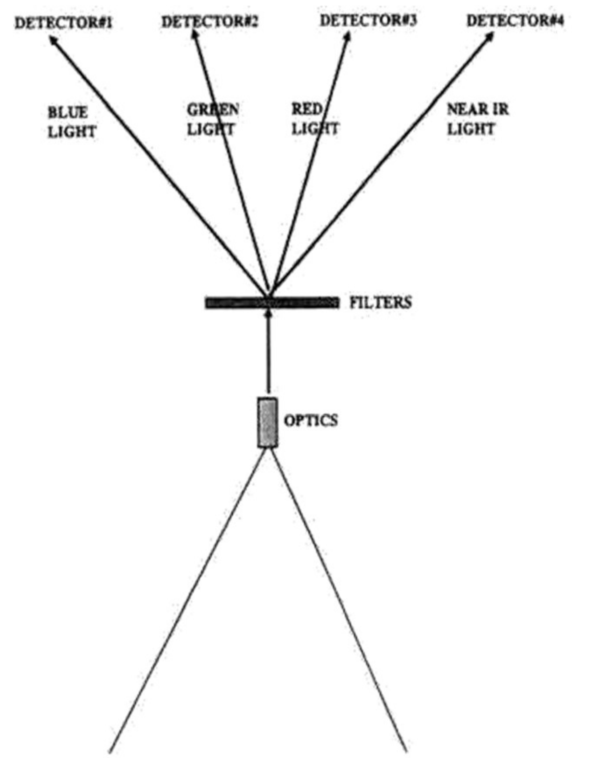

1 meter
Resolution


8 km
4 km
2 km
8 km
2 km
1 km
250 m
1 km
500 m
250 m

Spectral Resolution

Spectral resolution describes the ability of a sensor to define fine wavelength intervals. The finer the spectral resolution, the narrower the wavelength range for a particular channel or band.

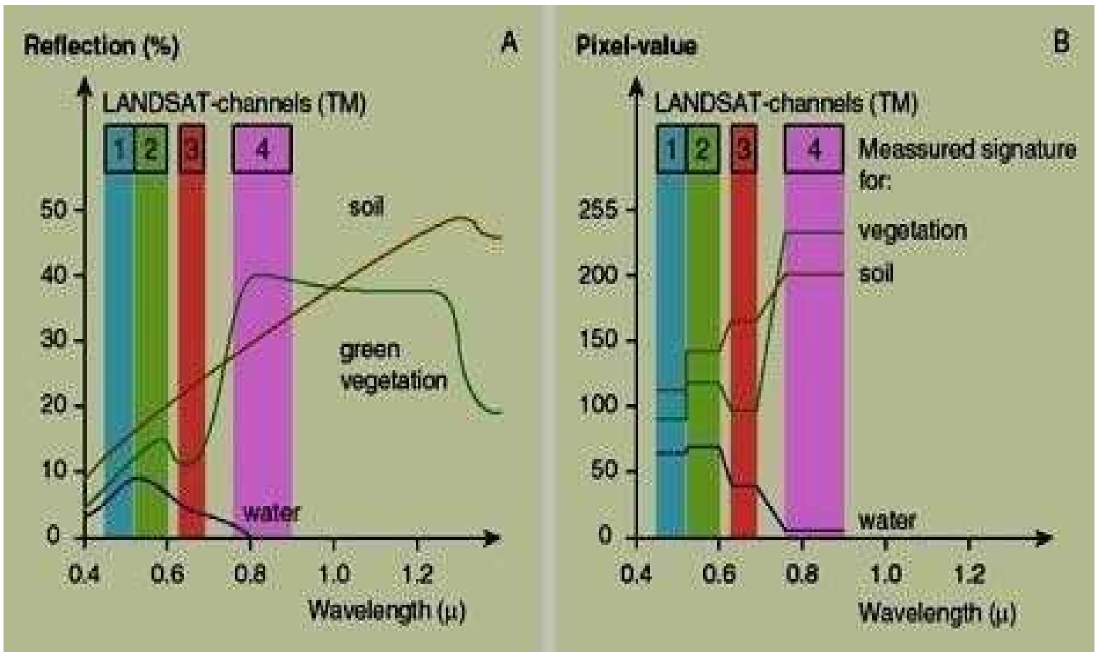




Simplified example of a multispectral digital remote sensing system.

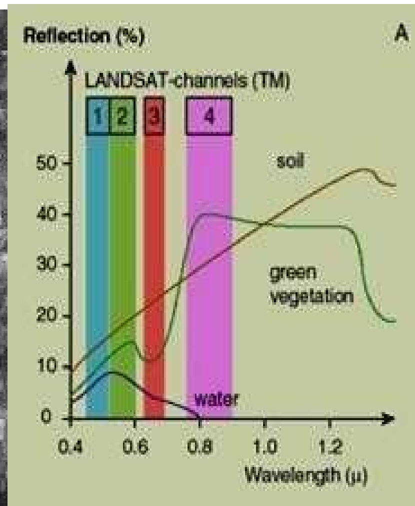
Spectral Signatures

Different surface types such as water, bare ground or vegetation reflects radiation differently in various channels. The radiation reflected as a function of the wavelength is called the spectral signature of the surface.



Band 1	0.45 - 0.52	30
Band 2	0.52 - 0.60	30
Band 3	0.63 - 0.69	30
Band 4	0.76 - 0.90	30

LANDSAT-



Band 1	0.45 - 0.52	30
Band 2	0.52 - 0.60	30
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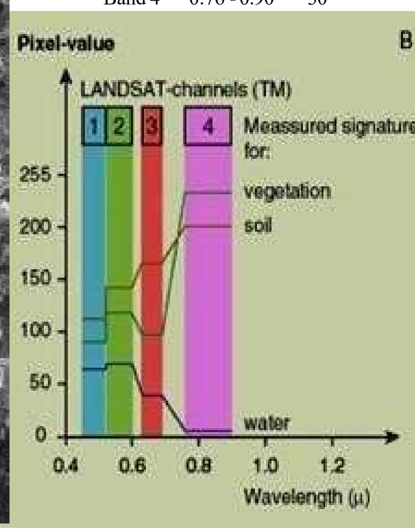
LANDSAT-

LANDSAT-



LANDSAT-

Radiometric Resolution

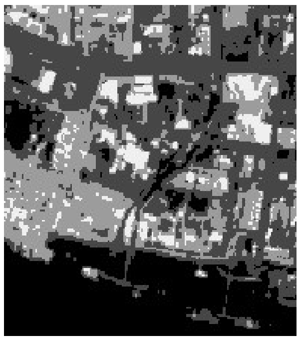
✓The radiometric resolution of an imaging system describes its ability to discriminate very slight differences in energy.

✓The finer the radiometric resolution of a sensor, the more sensitive it is to detecting small differences in reflected or emitted energy.

2-bit

$2^2=4$

0-3



4-bit

$2^4=16$

0-15

8-bit

$2^8=256$

0-255

16-bit

$2^{16}=65536$

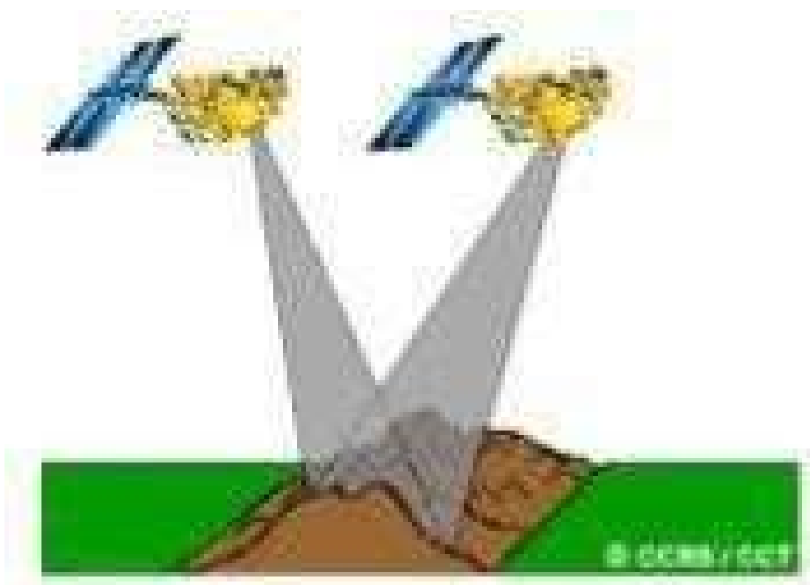
0-65535


8-bit
4-bit

Temporal Resolution

✓The ability to collect imagery of the same area of the Earth's surface at different periods of time is one of the most important elements for applying remote sensing data.

✓Spectral characteristics of features may change over time and these changes can be detected by collecting and comparing multi-temporal imagery.



REMOTE SENSING PLATFORMS AND SENSORS

Sensor is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument.

Remote sensor to collect and record energy reflected or emitted from a target or surface.

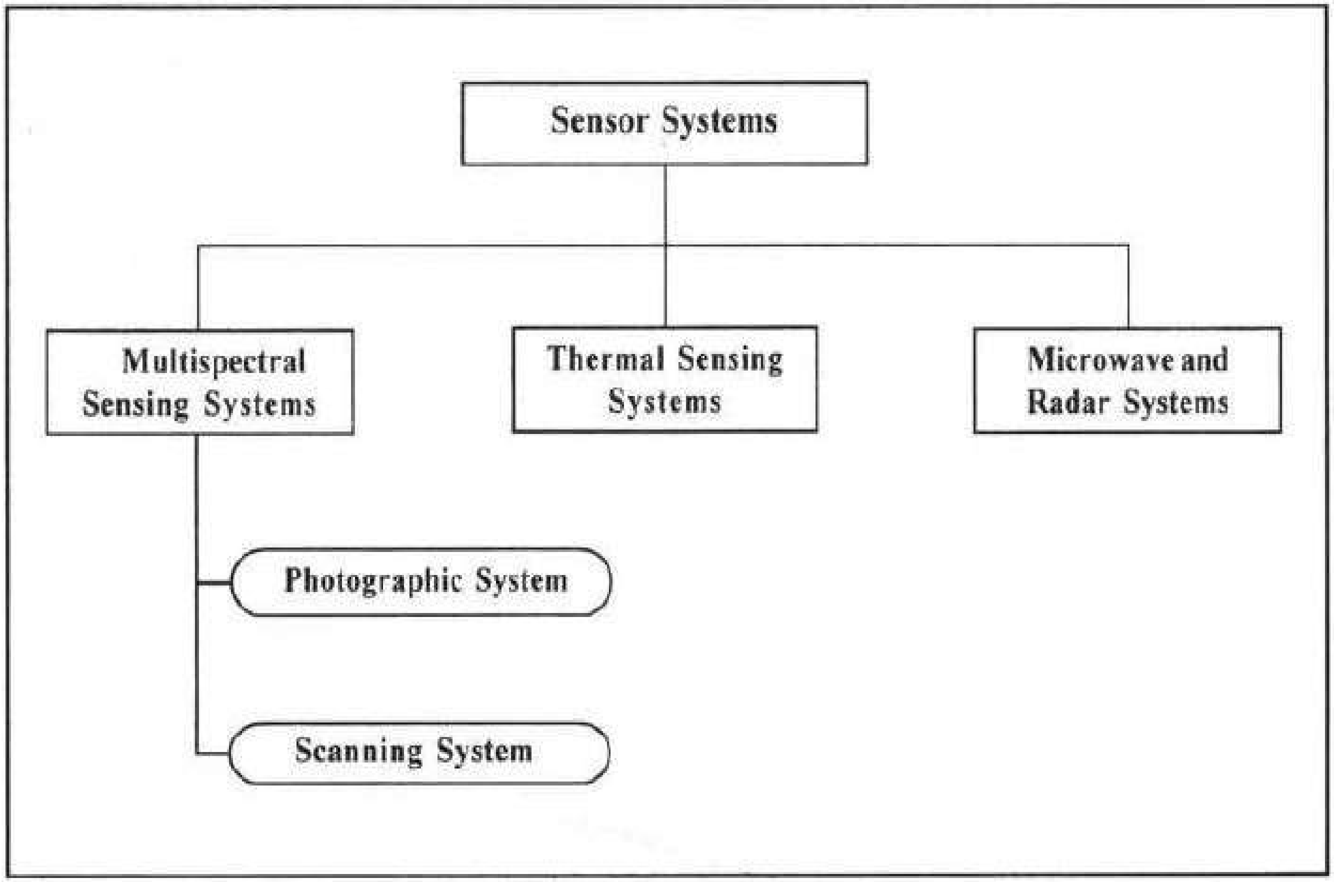
Sensor must reside on a stable platform

Platforms for remote sensors may be situated on the ground, on an aircraft or balloon (or some other platform within the Earth's atmosphere), or on a spacecraft or satellite outside of the Earth's atmosphere.





Classification of Imaging Sensor Systems



Imaging Sensor Systems

- Various components of sensor systems operating in the visible, infrared, thermal and microwave regions of the electromagnetic spectrum.
- Useful wavebands are mostly in the visible and the infrared for passive remote sensing detectors and in the radar and microwave region for active type of sensors.
- All the imaging sensor systems are classified based on technical components of the system and the capability of the detection by which the energy reflected by the terrain features is recorded. The classification scheme is

  (a) Multispectral imaging sensor systems

  (b) Thermal remote sensing systems, and

  (c) Microwave radar sensing systems.

Multispectral Imaging Sensor Systems

- In the case of multiband photographic system, different parts of the spectrum are sensed with different film-filter combinations.
- Multiband digital camera images and video images are also typically exposed on to the camera's sensor (s) through different filters.
- Electro-optical sensors, such as, the thematic mapper of Land sat, typically sense in at least several bands of electromagnetic spectrum.

Two Types of Multispectral Imaging Sensor System

The Photographic System - Suffers from one major defect of considerable distortion at the edges. This is due to large lens opening. From lens theory, we know that distortion can be minimized and resolution considerably improved by using a narrow beam light. This can be achieved by a system called scanning system.

A Multispectral Scanner - Operate on the same Principle of a sensing in multiple spectral bands, but such instruments can sense in many more bands and over a greater range of electromagnetic spectrum.

Multi-spectral images are acquired by means of two basic process across-track and along track scanning. Multispectral scanner systems built up two dimensional images Of terrain for swath beneath the platform.

Second type of multispectral scanning system is along track scanning system.

Thermal Sensing Systems

Thermal scanner is one of the most important thermal sensing systems, a particular kind of across track multispectral scanner which senses in the thermal portion of Electromagnetic spectrum by means of inbuilt detectors. These systems are restricted to Operating in either **3 to 5 µm or 8 to 14** µm range of wavelength.

Microwave Imaging System

The fundamental principle of microwave sensing and conceptual design of radar.
It is stated that microwave region of the electromagnetic spectrum includes radiation with wavelength longer than 1mm, imaging.

Microwave instruments do not, however, rely on the detection of solar or terrestrial emissions. The properties of the operational synthetic aperture radar (SAR) systems and Radarsat systems
are presented along with other sensing systems

LATEST TRENDS IN REMOTE SENSING PLATFORMS OR SENSORS

Since the launching of high resolution IKONOS satellites series, number of high resolution Satellite have been launched. The important among them are

1) Quick Bird
2) Cartosat-1
3) Resourcesat-1

Quick Bird

Quick bird- Quick bird was launched on 18th October 2001. This is currently the highest Resolution commercial satellite data available

Quick bird acquires 61 cm(2 foot) resolution Panchromatic (Black & white) and 2.44 mt (8 foot) multispectral imagery.

At 61 cm resolution, buildings, roads, bridges and other detailed infrastructure became Visible.

Quick Bird

Cartosat-1

Cartosat-1 was successfully launched by the ninth flight of ISRO polar satellite launch Vehicle. The CARTOSAT carries two panchromatic cameras that take black and white Stereoscopic pictures in the visible region of electromagnetic spectrum. The imageries have a Spatial resolution of 2.5 mt and cover a swath of 30 km

Resourcesat-1

Resourcesat-1 is conceptualized and designed to provide continuity in operational remote sensing with its superior capabilities and Its objectives is to provide continued remote sensing data for integrated land and water

Management and agricultural and its related applications.

IRS SATELLITES

Table 1. Major specifications of present IRS series of satellites

Satellites (year)	Sensor	Spectral bands (μm)	Spatial res. (m)	Swath (km)	Radiometric res. (bits)	Repeat cycle (days)
IRS-1A/1B (1988, 1991)	LISS I	0.45–0.52 (B) 0.52–0.59 (G) 0.62–0.68 (R) 0.77–0.86 (NIR)	72.5	148	7	22
	LISS-II	Same as LISS-I	36.25	74	7	22
IRS-P2 (1994)	LISS-II	Same as LISS-I	36.25	74	7	24
IRS-1C/1D (1995, 1997)	LISS-III	0.52–0.59 (G), 0.62–0.68 (R) 0.77–0.86 (NIR) 1.55–1.70 (SWIR)	23.5 70.5 (SWIR)	141 148	7	24
	WiFS	0.62–0.68 (R) 0.77–0.86 (NIR)	188	810	7	24 (5)
	PAN	0.50–0.75	5.8	70	6	24 (5)
IRS-P3 (1996)	MOS-A	0.755–0.768(4 bands)	1570 × 1400	195	16	24
	MOS-B	0.408–1.010(13 bands)	520 × 520	200	16	24
	MOS-C	1.6 (1 band)	520 × 640	192	16	24
	WiFS	0.62–0.68 (R) 0.77–0.86 (NIR) 1.55–1.70 (SWIR)	188	810	7	5
IRS-P4 (1999)	OCM	0.402–0.885 (8 bands)	360 × 236	1420	12	2
	MSMR	6.6, 10.65, 18, 21 GHz (V & H)	150, 75, 50 and 50 km respectively	1360	–	2
IRS-P6 (2003)	LISS-IV	0.52–0.59 (G) 0.62–0.68 (R) 0.77–0.86 (NIR)	5.8	70	10 (7)	24 (5)
	LISS-III	0.52–0.59 (G), 0.62–0.68 (R) 0.77–0.86 (NIR) 1.55–1.70 (SWIR)	23.5	141	7	24
	AWiFS	0.52–0.59 (G), 0.62–0.68 (R) 0.77–0.86 (NIR) 1.55–1.70 (SWIR)	56	737	10	24(5)
IRS-P5 (Cartosat-1) 2005	PAN (Fore (+26°) & Aft (−5°)	0.50–0.85	2.5	30	10	5
Cartosat-2 (2007)	PAN	0.50–0.85	0.8	9.6	10	5

DATA INTERPRETATION AND VISUAL INTERPRETATION TECHNIQUES

Remote sensing is the process of Remote and measuring objects
from a distance without directly coming physically into contact with them.

Visual image interpretation is process of identifying what we see on the images and communicate the information obtained from these images to others for evaluating this significance.

It is not restricted to making decision concerning what objects appear in images, but it also usually includes a determination of their relative locations and extents.

Levels of Interpretation Key

The image interpretation process can involve various levels of complexity from a simple Direct recognition of objects in the scene to the inference of site conditions.

An example of this can be a national highway or a major river on the national highway or a Major river on the satellite imagery, most particularly on a false color composite

If the interpreter has some experience , the interpretation of their linear feature, road And river may be straight forward.

For example interpretation of a IRS LISS III false color composite imagery for the Identification of 18 km pipeline from patanchruvu to Amberpet of Hyderabad city which carries the industrial effluents is an indirect approach.

In this case the actual pipelines can not be seen, but there are often changes at the ground surface caused by the buried pipeline which are visible on FCC.

The process of interpretation should also consider the dates to identify the ground Cover types.

Keys that provide useful references of refresher materials and valuable training aids for Interpreters are called image interpretation keys

There are two types of keys: **selective key** and **elimination key.**

The **selective is also called reference key** which contains numerous example images With supporting text.

The elimination key is arranged so that the interpretation process step by step from General to the specific, and leads to the elimination of all the features.

Basic Elements of Image Interpretation

A systematic study of aerial photographs and satellite imageries usually involves several characteristics of features shown on an image.

(i) Tone
(ii) Texture
(iii) Association
(iv) Shape
(v) Size
(vi) Shadow
(vii) Site Factor or topographic Location
(viii) Pattern

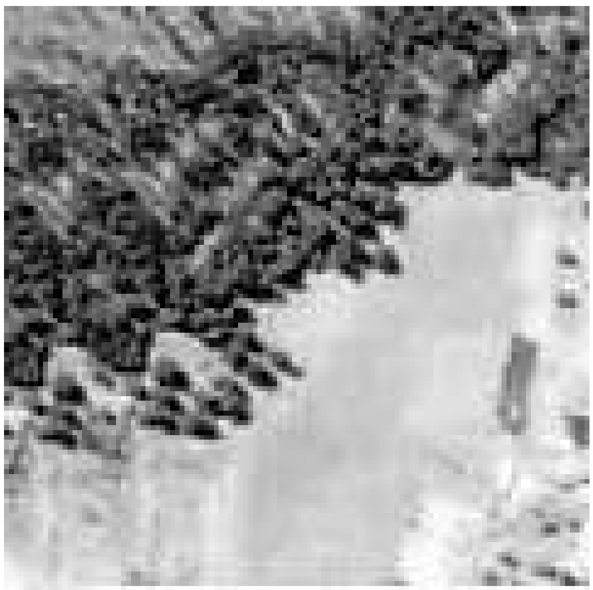
1. **Tone** refers to the relative brightness or colour of objects in an image. Generally, tone is the fundamental element for distinguishing between different targets or features.

2. **Shape** refers to the general form, structure, or outline of individual objects. Shape can be a very distinctive clue for interpretation. Straight edge shapes typically represent urban or agricultural (field) targets, while natural features, such as forest edges, are generally more irregular in shape, except where man has created a road or clear cuts. Farm or crop land irrigated by rotating sprinkler systems would appear as circular shapes.

3. **Size** of objects in an image is a function of scale. It is important to assess the size of a target relative to other objects in a scene, as well as the absolute size, to aid in the interpretation of that target. A quick approximation of target size can direct interpretation to an appropriate result more quickly.

4. **Pattern** refers to the spatial arrangement of visibly discernible objects. Typically an orderly repetition of similar tones and textures will produce a distinctive and ultimately recognizable pattern.

5. **Texture** refers to the arrangement and frequency of tonal variation in particular areas of an image. Rough textures would consist of a mottled tone where the grey levels change abruptly in a small area, whereas smooth textures would have very little tonal variation. Smooth textures are most often the result of uniform, even surfaces, such as fields, asphalt, or grasslands. A target with a rough surface and irregular structure, such as a forest canopy, results in a rough textured appearance. Texture is one of the most important elements for distinguishing features in radar imagery.

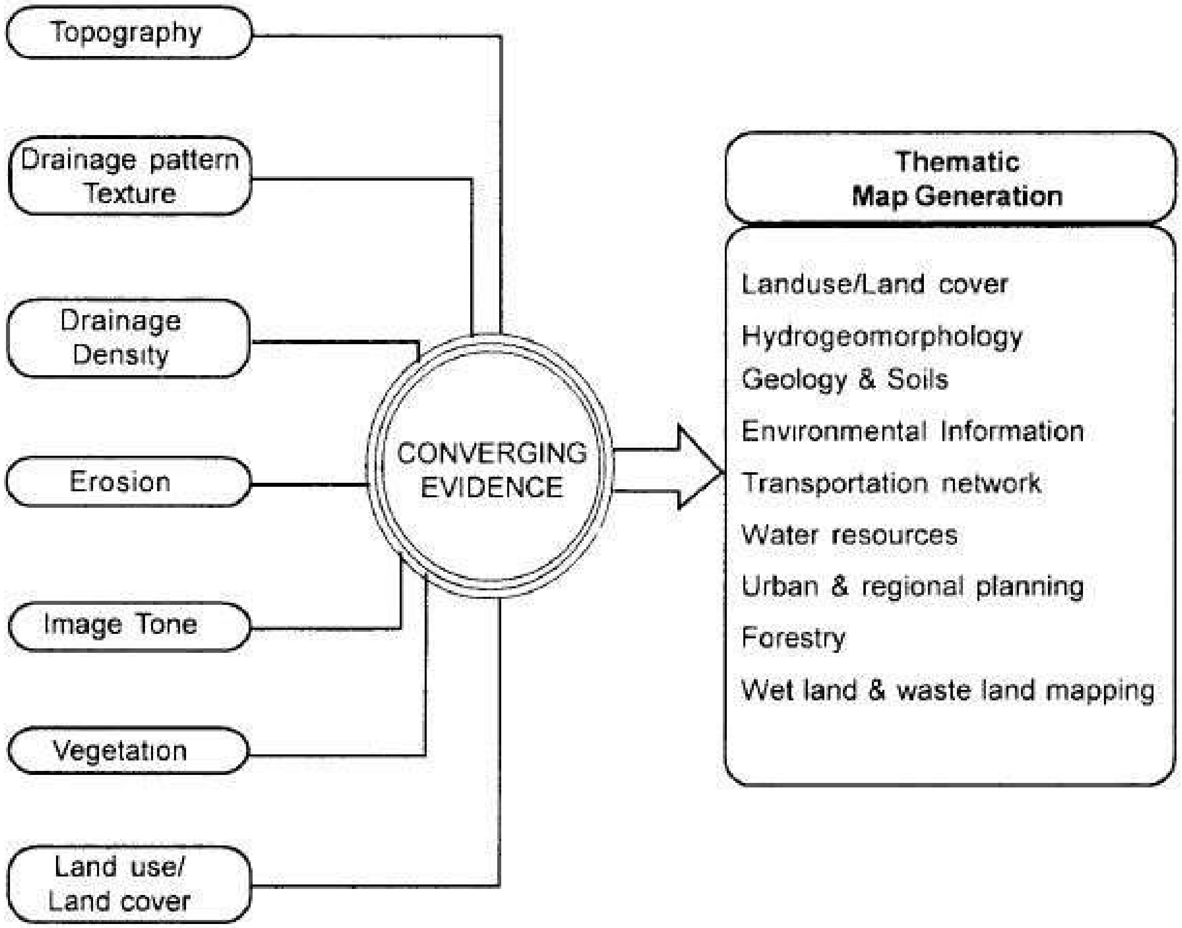


6. **Shadow** is also helpful in interpretation as it may provide an idea of the profile and relative height of a target or targets which may make identification easier. However, shadows can also reduce or eliminate interpretation in their area of influence, since targets within shadows are much less (or not at all) discernible from their surroundings. Shadow is also useful for enhancing or identifying topography and landforms, particularly in radar imagery.

7. **Association** takes into account the relationship between other recognizable objects or features in proximity to the target of interest. The identification of features that one would expect to associate with other features may provide information to facilitate identification.

CONCEPT OF CONVERGING EVIDENCE

- Terrain information can be derived from the visual image interpretation of aerial or space Image through the identification, evaluation and analysis of all the key elements.
- This image interpretation process is like the work of a detective trying to put all the pieces of evidence together to solve a mystery.
- Information derived through the analysis of the above key terrain elements can be converged and by combining all the evidences of image element identification, the inferences can be drawn.
- The inferences will be useful for GIS data input, manipulation and analysis. The process of converging the description of all the interpreted results or information's of these key elements is called "convergence evidence"


Topography
Drainage pattern Texture
Drainage Density
Erosion
Image Tone
Vegetation
Land use/ Land cover
CONVERGING EVIDENCE
Thematic Map Generation
Landuse/Land cover
Hydrogeomorphology
Geology & Soils
Environmental Information
Transportation network
Water resources
Urban & regional planning
Forestry
Wet land & waste land mapping

INTERPRETATION OF TERRAIN EVALUATION

The study of terrain is essential and a prerequisite for proper planning and utilization
of land resources .

The purpose could be short term military requirement for certain localized zones. The aim of terrain study is to gather maximum and systematic information on various aspects of the ground so that proper evaluation of this information can be done to meet the requirements of different users.

The detailed method of terrain study s as follows.

Area of Study

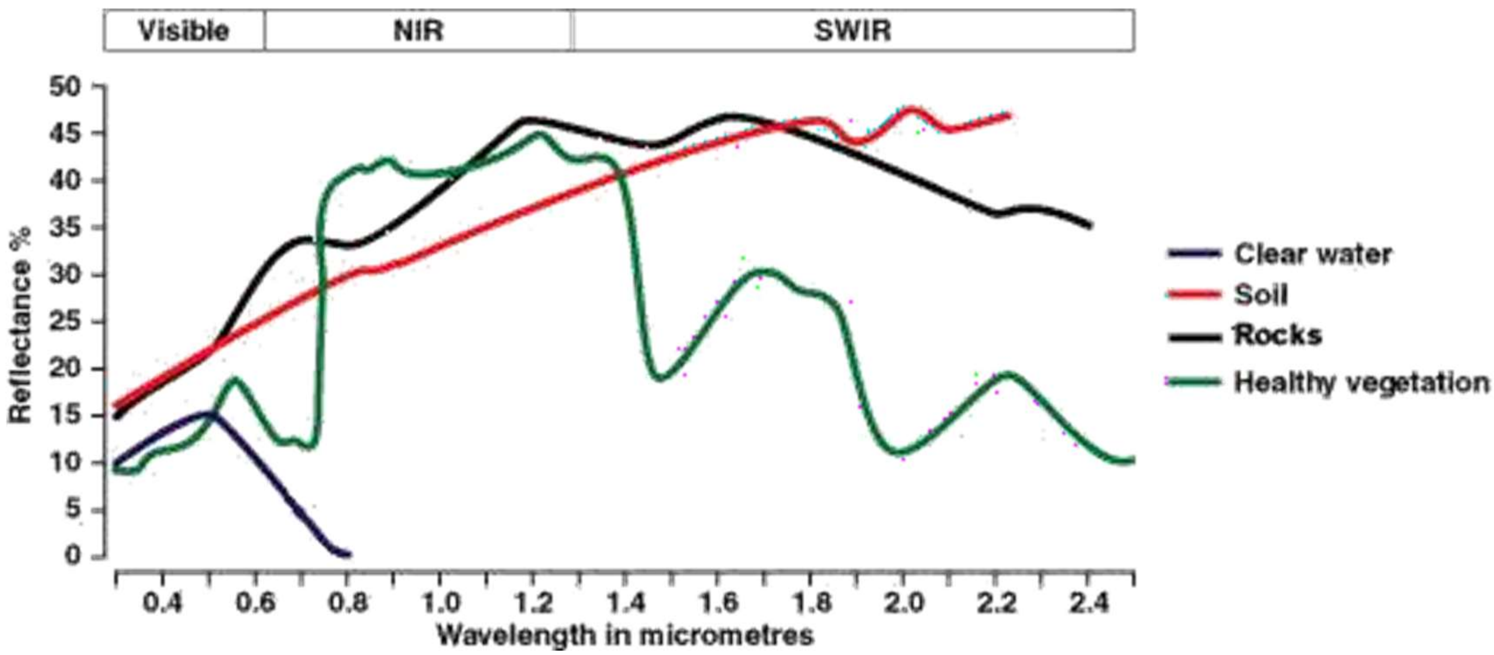
1) **Library work**: collection of basic material and background information
2) **Laboratory Exercise**: Scanning of Air photos, checking of quality , scale etc..
3) **Ground Reconnaissance** : Initial Field Traverses
4) **Study of Aerial Photos**: Delineation of facets and planning of field work
5) **Detailed field work:** checking of photo characteristics, recording terrain data, collecting soils samples field tests for moisture content and soil strengths

6) Laboratory Test : Soil test, rock identification
7) Completion of Reports: confirmatory reconnaissance if required finalization of report, Typing of cards and preparation of maps.

The recognition elements uses for photo interpretation aids to describe different terrain Units are:

(1) Position in landscape and association with other terrain units.
(2) Morphology, surface configuration and micro relief.
(3) Drainage pattern, texture and density, internal and external drainage.
(4) Erosion features and gully sections
(5) Land use and cultural features.
(6) Vegetation
(7) Total variation and special photo texture

SPECTRAL PROPERTIES OF SOIL, WATER AND VEGETATION



Vigorous Vegetation: Spectral reflectance curves for vigorous vegetation manifests the peak and valley configuration. The valleys in the visible portion of the spectrum are indicative of pigments in plant leaves.

Dip in reflectance that can be seen at wavelengths of 0.65 **µm, 1.4 and 1.9µm** are attributes to absorption of water by leaves.

Soil: The soil curve shows a more regular variation of reflectance. Factors that evidently affect soil reflectance are moisture content, soil texture, surface roughness, and presence of organic matter. The term spectral signatures can also b used for spectral reflectance curves.

Water: The characteristic spectral reflectance curve for water shows that about 0.5**µm,** a reduction in reflectance with increasing wavelength, so that in the near infrared range, the reflectance of water significantly affected by the presence of dissolved suspended Organic and inorganic material and depth of water body shows the spectral reflectance Curves for visible and near infrared wavelengths at the surface and at 20m depth

CONCEPTS OF DIGITAL IMAGE PROCESSING

The basic character of digital image data through the image appears to be continuous tone photograph. It is composed of the 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.

A digital image is defined as the matrix of digital numbers (DNs). Each digital number is the output of the process of analog to digital conversion.

Each parcel of land can be represented as a pixel on the image and each pixel is occupied by a digital number and is called pixel value or digital number shows the radiometric resolution of remote sensing data.

Image qualitative and quantitative Analysis

- Preprocessing
- Image Registration
- Image Enhancement
- Image Classification and Analysis

Pre-processing

• Remotely sensed raw data, received from imaging sensor mounted on satellite platforms generally contain flaws and deficiencies.

• The correction of deficiencies and removal of flaws present in the data through some methods are termed as pre-processing methods

• All pre-processing methods are considered under three heads, namely,

(i) Geometric correction

(ii) Radiometric correction and

(iii) Atmospheric correction

Geometric correction

The transformation of a remotely sensed image into a map with a scale and projection properties is called geometric correction.

S.No.	Effect	Source of error
1.	Platform	altitude, attitude, scan-skew mirror, scan velocity
2.	Scene effect	earth rotation, map projection
3.	Sensor effect	Mirror sweep
4.	Scene and sensor effect	panorama, perspective

Radiometric correction

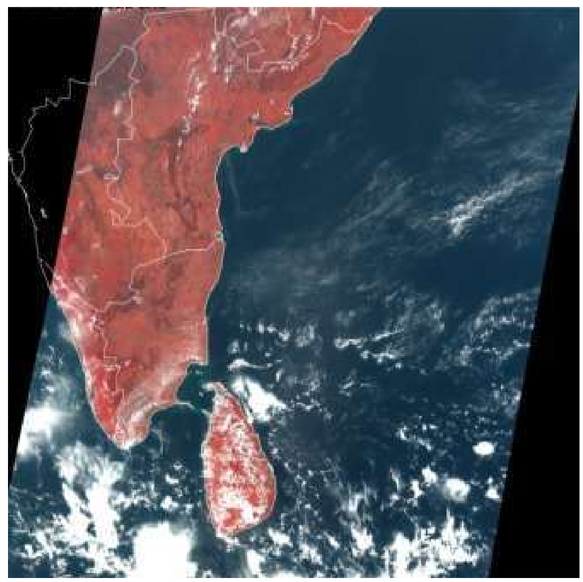
The radiance measured by any given system over a given object is influenced by factors, such as, changes in scene illumination, atmospheric conditions, viewing geometry and instrument response characteristics

Atmospheric correction

Because of the presence of haze, fog, or atmospheric scattering, there always exists some kind of unwanted signal value. These errors are called atmospheric corrections

Pre-processing operations, sometimes referred to as image restoration and rectification, are intended to correct for sensor- and platform-specific radiometric and geometric distortions of data. Radiometric corrections may be necessary due to variations in scene illumination and viewing geometry, atmospheric conditions, and sensor noise and response. Each of these will vary depending on the specific sensor and platform used to acquire the data and the conditions during data acquisition. Also, it may be desirable to convert and/or calibrate the data to known (absolute) radiation or reflectance units to facilitate comparison between data.

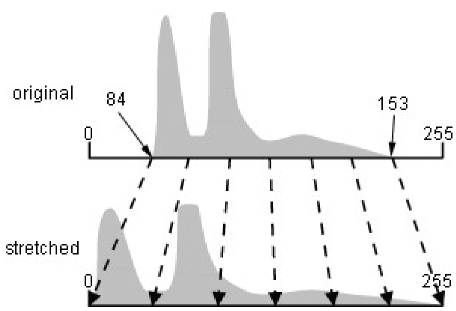
Before

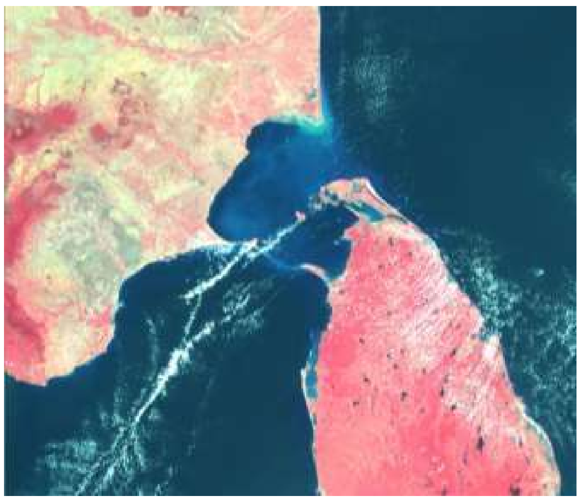


After

Image Enhancement

In raw imagery, the useful data often populates only a small portion of the available range of digital values (commonly 8 bits or 256 levels). Contrast enhancement involves changing the original values so that more of the available range is used, thereby increasing the contrast between targets and their backgrounds. The key to understanding contrast enhancements is to understand the concept of an **image histogram**. A histogram is a graphical representation of the brightness values that comprise an image. The brightness values (i.e. 0-255) are displayed along the x-axis of the graph. The frequency of occurrence of each of these values in the image is shown on the y-axis.



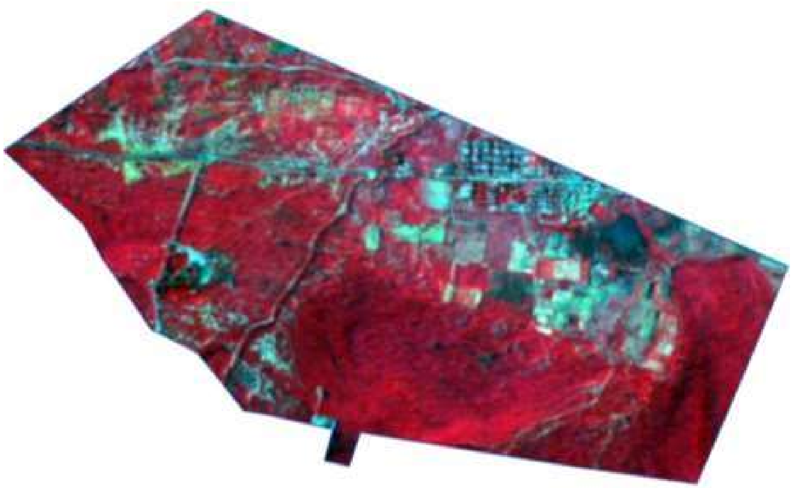


Before

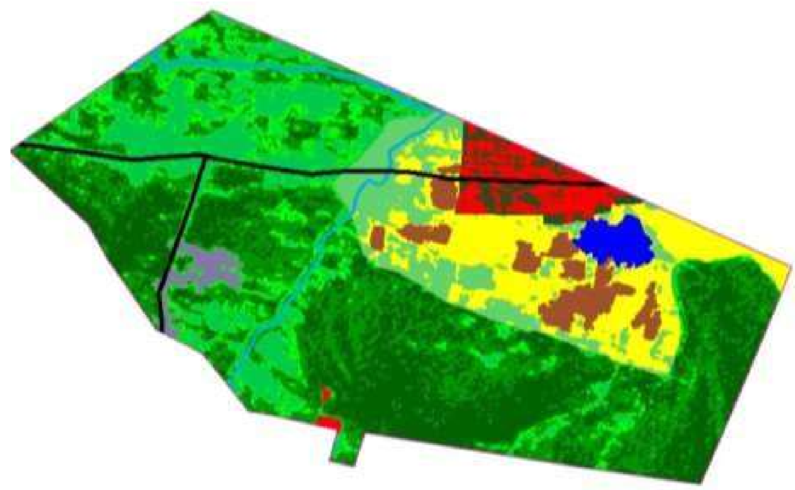
After

/.Image Classification and Analysis

Digital image classification uses the spectral information represented by the digital numbers in one or more spectral bands, and attempts to classify each individual pixel based on this spectral information. This type of classification is termed **spectral pattern recognition**.



FCC



Classified

CLASSIFICATION TECHNIQUES AND ACCURACY ESTIMATION

Image classification is a procedure to automatically categorize all pixels in an image of terrain into land cover classes.
Normally, multispectral data are used to perform the classification of spectral pattern present within the data of each pixel is used as the numerical bases for categorization.

The concept is dealt under the broad subject namely, pattern recognition.

Spectral pattern recognition involves the categorization of image pixel on the basis of the spatial relationship with pixels surrounding them.

Image classification techniques are grouped into two types, namely Supervised and Unsupervised.

The classification process may also include features, such as land surface elevation and soil types that are not derived from the image.

1) Supervised Classification: A supervised classification algorithm requires a training Sample for each class, that is collection of data point known to have come from the class of interest.

The three basic steps involved in a typical supervised classification procedure are follows

1) **Training Stage**: The analyst identifies representative training areas and develops numerical description of the spectral signatures of each land cover types

ii) Classification Stage: Each pixel in the image data set is categorized into the land cover classes if the pixel is insufficiently similar to any training data set usually labeled unknown.

iii) The Output stage: results may be used in number of different ways.

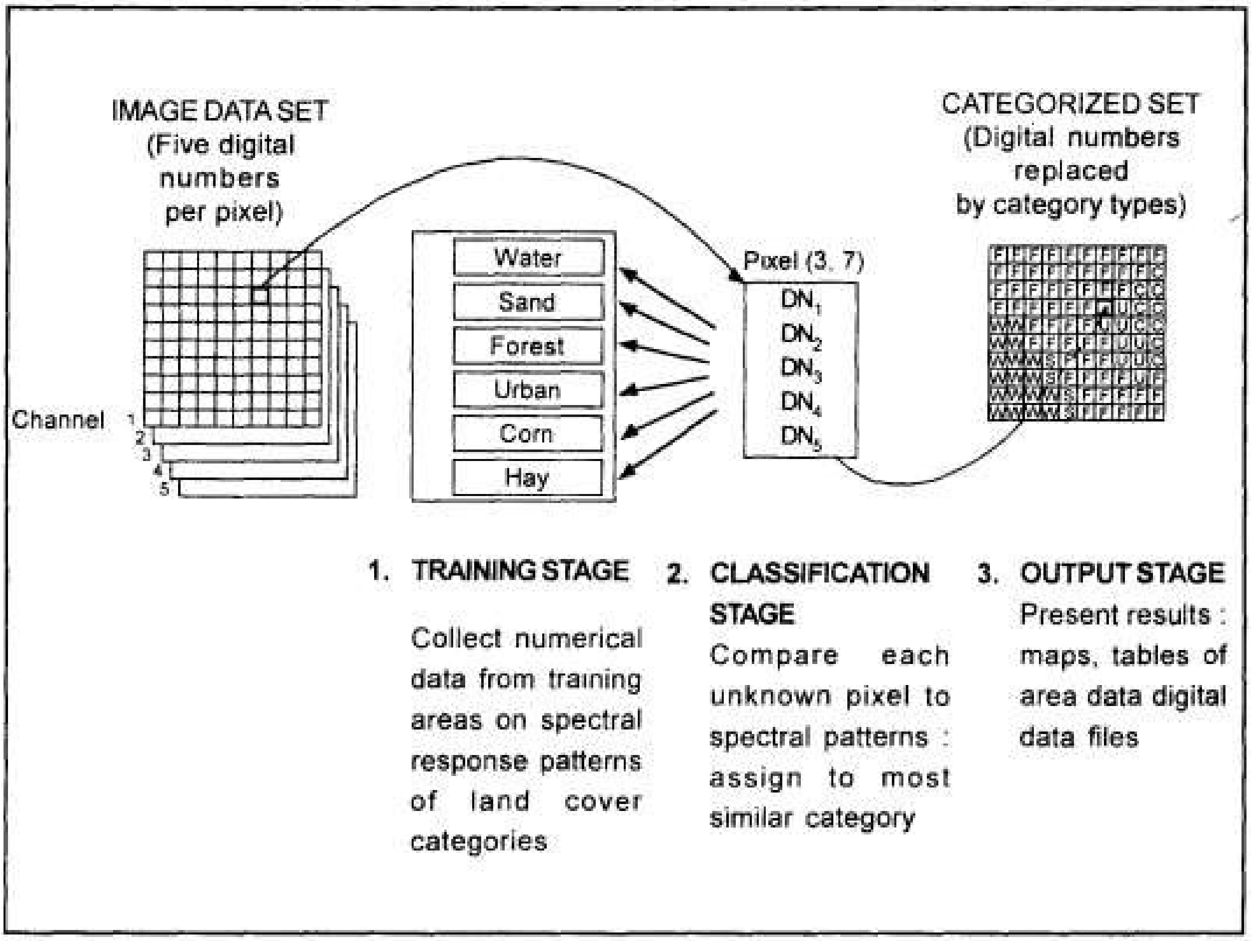


Fig. 6.23 Basic steps supervised classification.

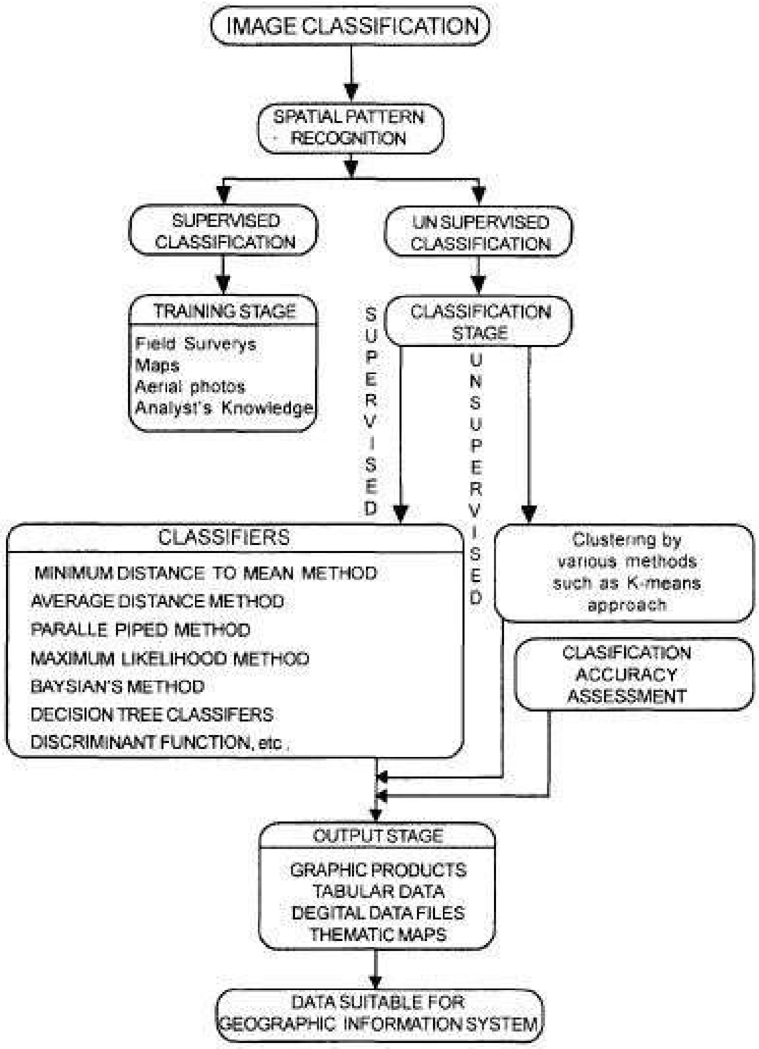


IMAGE CLASSIFICATION
SPATIAL PATTERN RECOGNITION
SUPERVISED CLASSIFICATION
UN SUPERVISED CLASSIFICATION
TRAINING STAGE
Field Surverys
Maps
Aerial photos
Analyst's Knowledge
CLASSIFICATION STAGE
SUPERVISED
UNSUPERVISED
CLASSIFIERS
MINIMUM DISTANCE TO MEAN METHOD
AVERAGE DISTANCE METHOD
PARALLE PIPED METHOD
MAXIMUM LIKELIHOOD METHOD
BAYSIAN'S METHOD
DECISION TREE CLASSIFERS
DISCRIMINANT FUNCTION, etc ,
Clustering by various methods such as K-means approach
CLASIFICATION ACCURACY ASSESSMENT
OUTPUT STAGE
GRAPHIC PRODUCTS
TABULAR DATA
DEGITAL DATA FILES
THEMATIC MAPS
DATA SUITABLE FOR GEOGRAPHIC INFORMATION SYSTEM

2) Unsupervised Classification: Unsupervised classification algorithms do not compare point To be classified with training data. Rather, unsupervised algorithms examine a large number of unknown data vectors and divide the into classes based on properties inherent to the data themselves.

UNIT-2

INTRODUCTION TO GIS

DEFINITION OF GIS

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

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

GIS definition

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

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

Why Study GIS?

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

What GIS Applications Do:
manage, analyze, communicate

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

HISTORY OF GIS

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

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

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

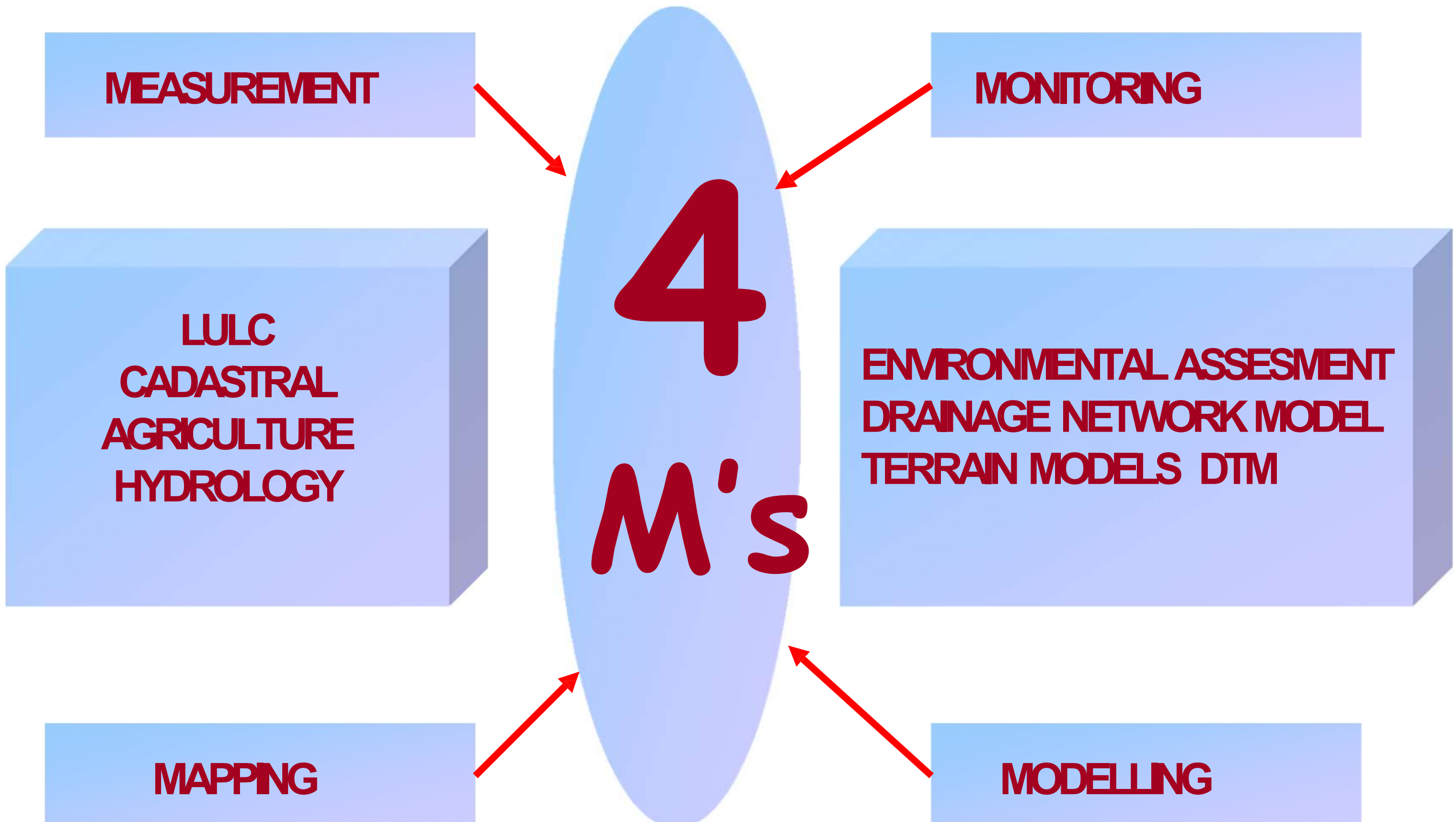
GIS has many roots of evolution like map production process, **one root lies in landscape, architecture and environmentally sensitive planning** another **root in urban and demographic data analysis.**

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

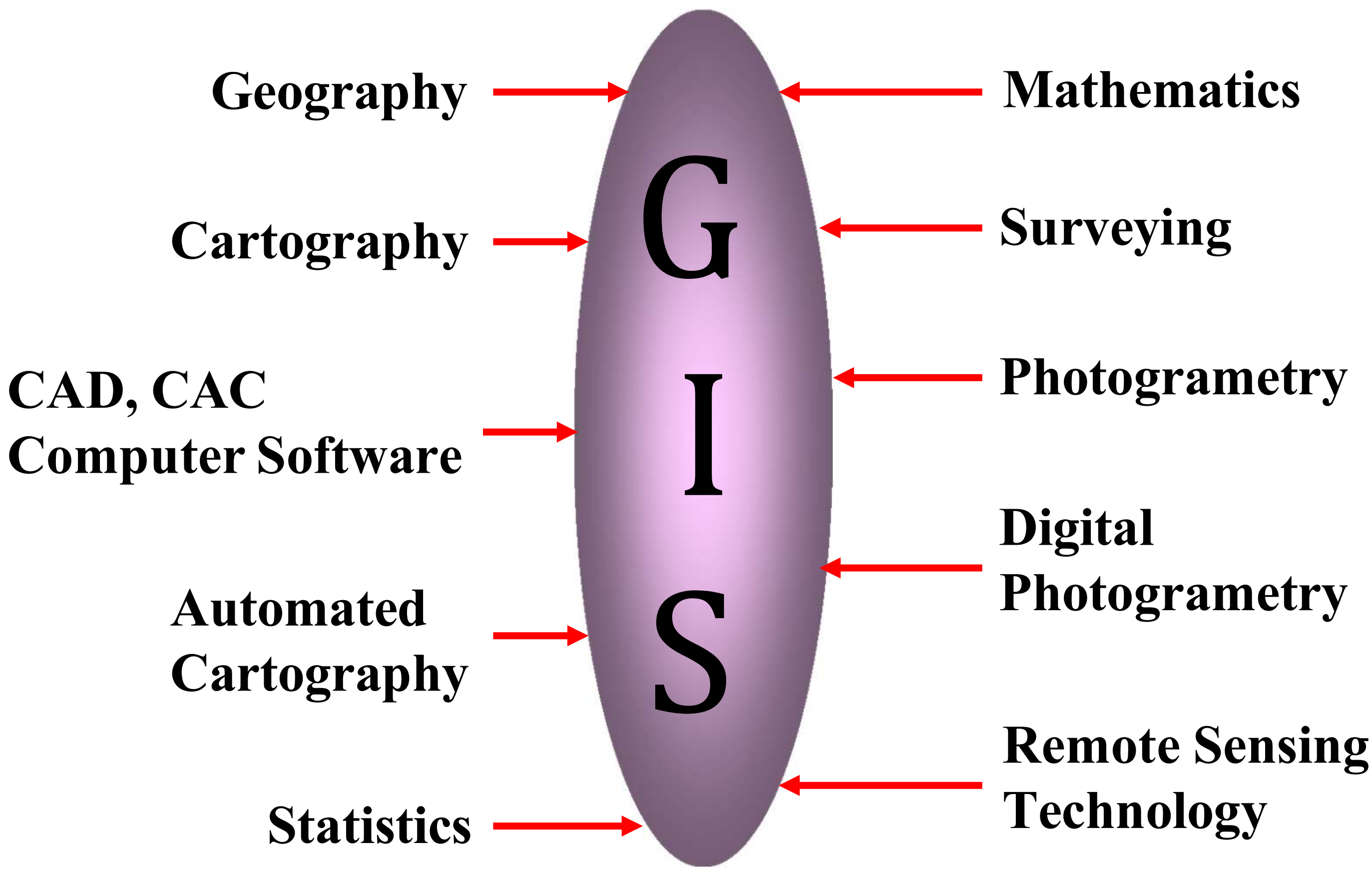
GIS gives people the ability to create their own digital map layers to help solve real-world problems. GIS has also evolved into a means for data sharing and collaboration, inspiring a vision that is now rapidly becoming a **reality—a continuous, overlapping, and interoperable GIS database of the world,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

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

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

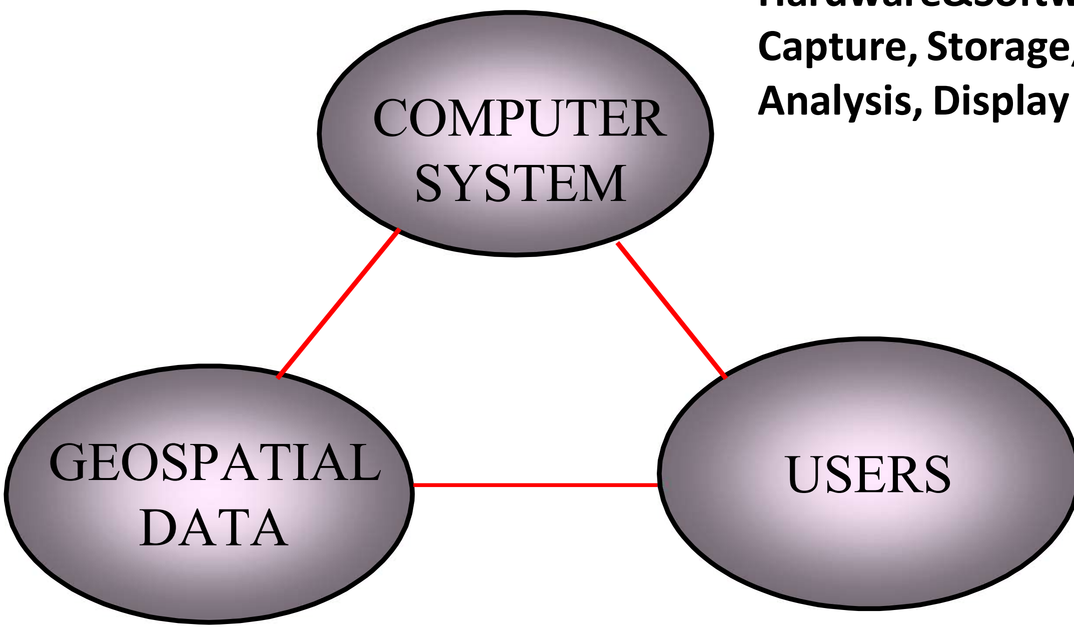

MEASUREMENT
MONITORING
4
M's
LULC
CADASTRAL
AGRICULTURE
HYDROLOGY
ENVIRONMENTAL ASSESMENT
DRAINAGE NETWORK MODEL
TERRAIN MODELS DTM
MAPPING
MODELLING

Contribution Disciplines



KEY COMPONENTS OF GIS

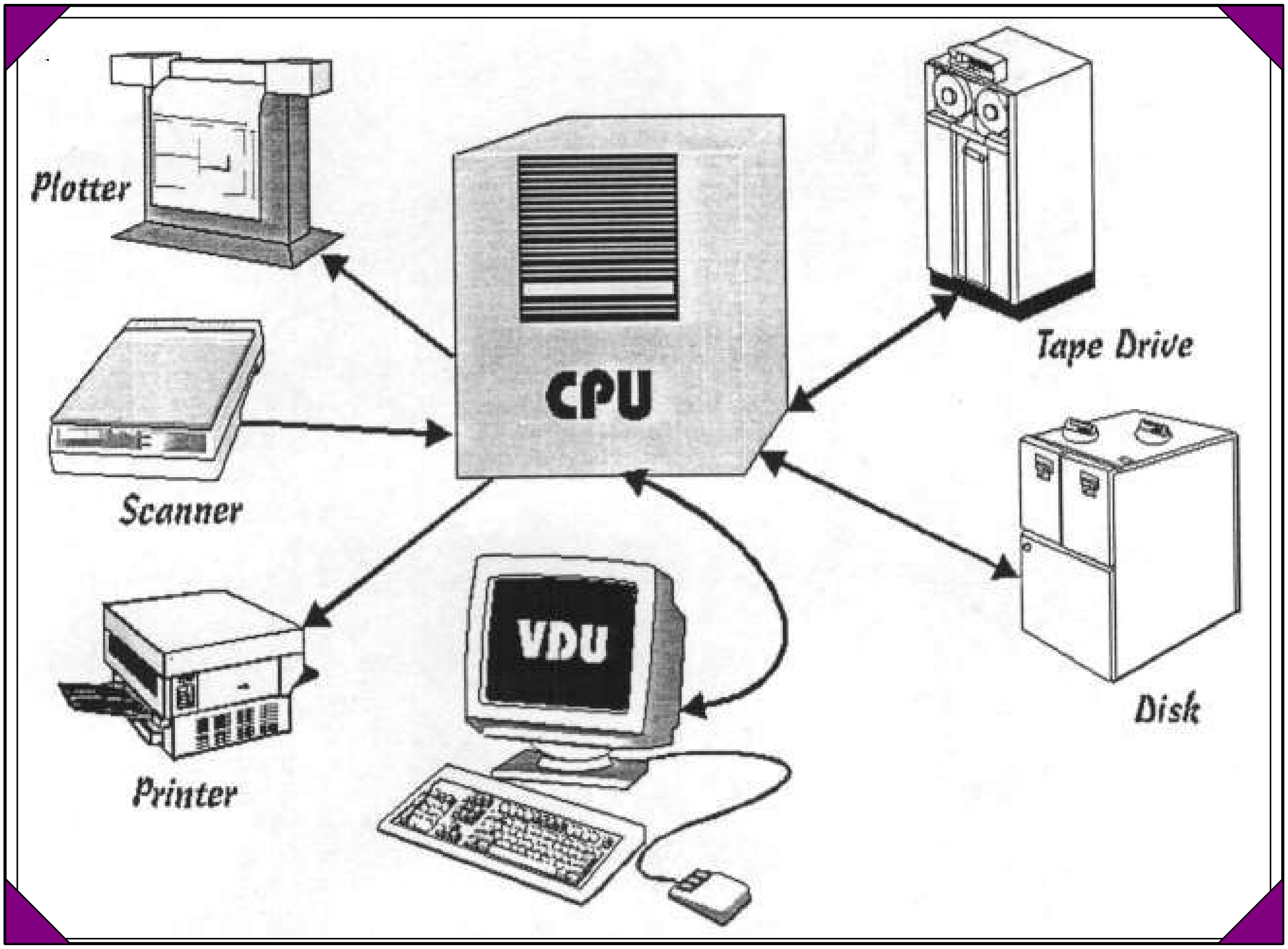
Hardware&Software
Capture, Storage, processing
Analysis, Display etc.,



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

Design of Standards, Updating, Analysis and Implementations

HARDWARE COMPONENTS



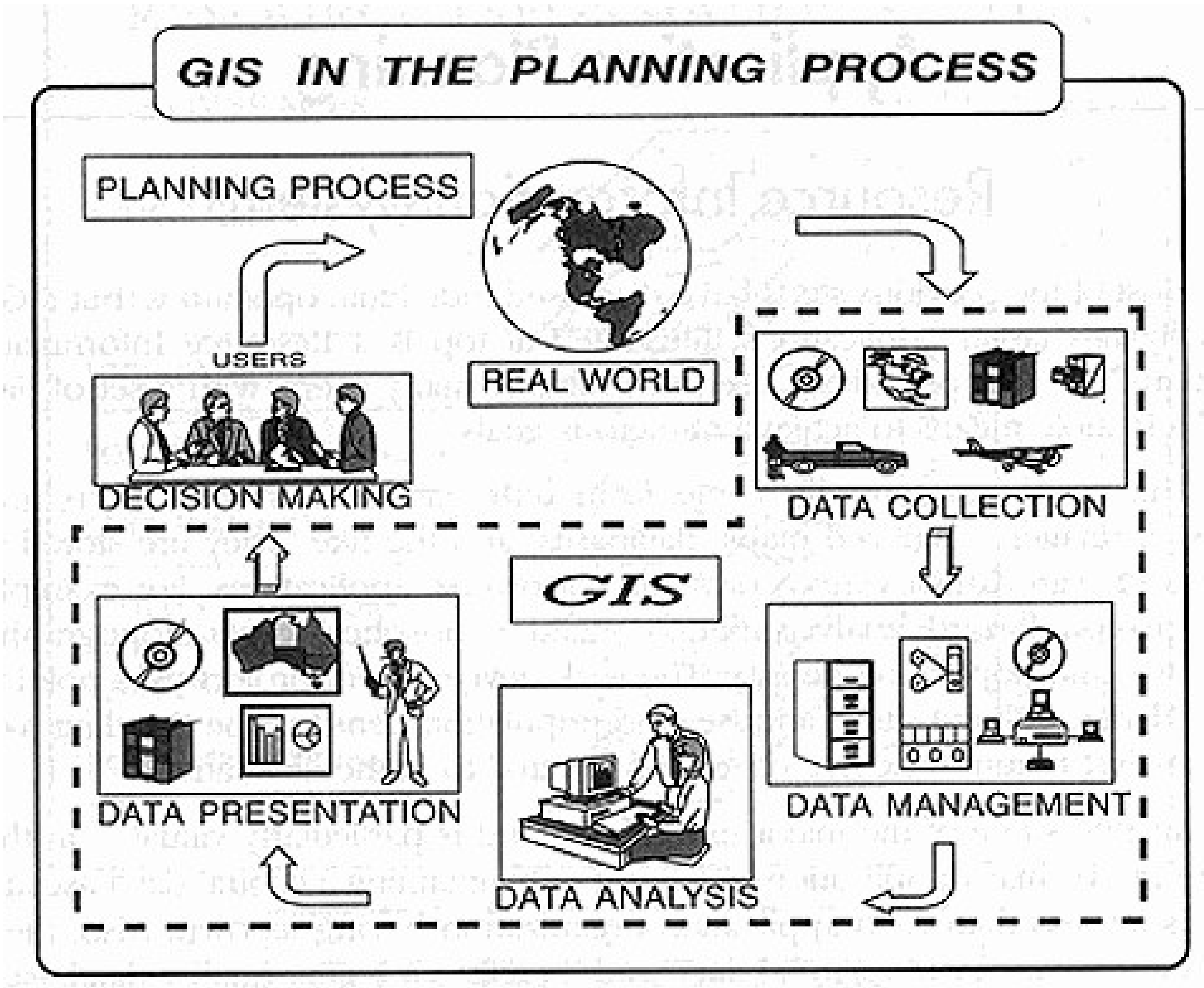
Geographic Information systems have three components, namely computer hardware, sets of application software modules, and proper Organizational setup.

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

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

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

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


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

GIS APPLICATIONS IN REAL LIFE

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

1. Agricultural Applications:

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

2. Forestry Applications:

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

3. Rangeland Applications:

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

4. Water Resource Applications:

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

Uses of GIS in water resources:

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

5. Urban and Regional planning Applications

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

6. Wetland Mapping:

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

7. Land use / Landover Applications:

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

8. Geologic and Soil mapping

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

THE NATURE OF GEOGRAPHIC DATA

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

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

DATA

1. **SPATIAL DATA**

2. **ATTRIBUTE DATA**

GIS Data and Structures

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

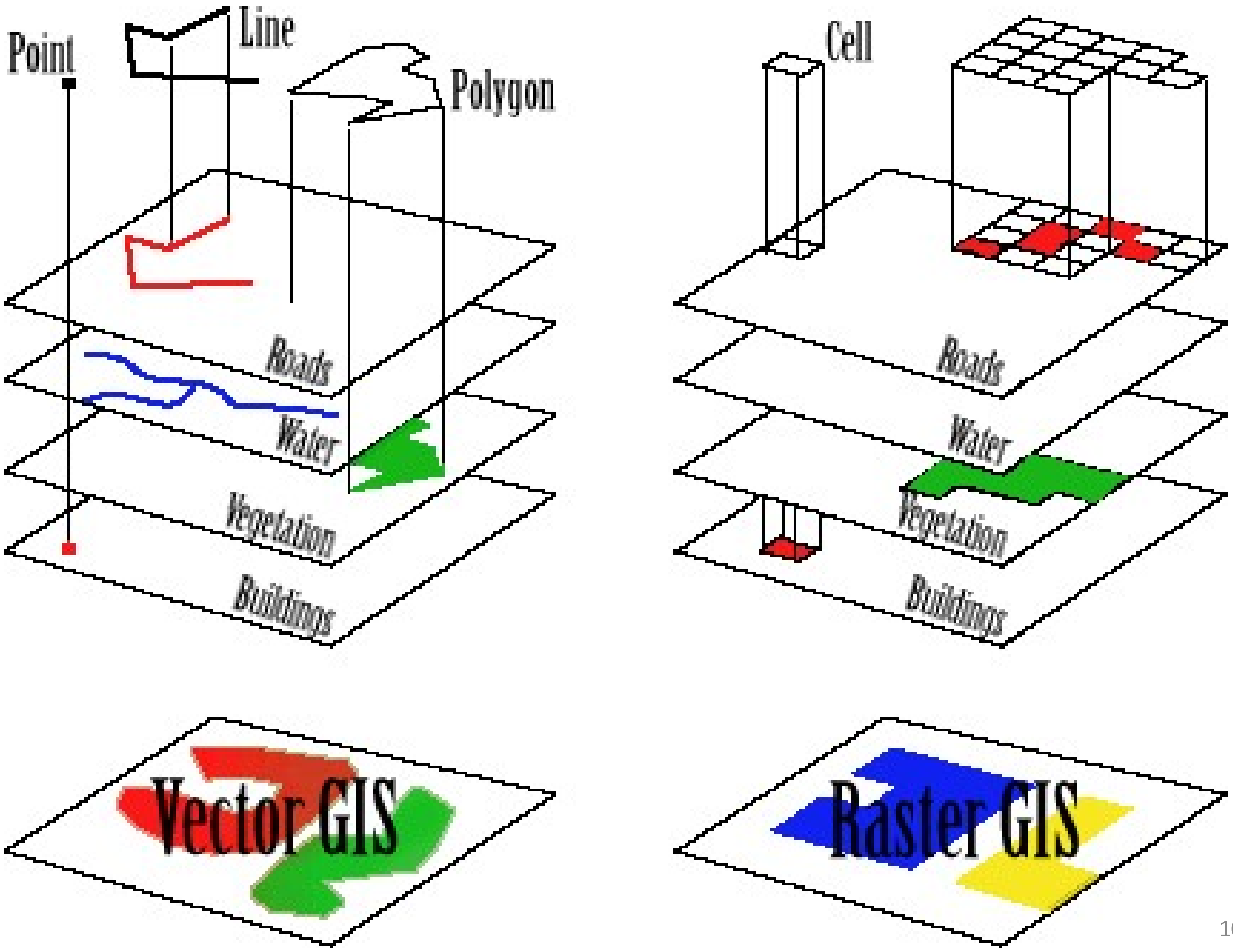
Examples of Spatial Data

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

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

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

Vector and Raster

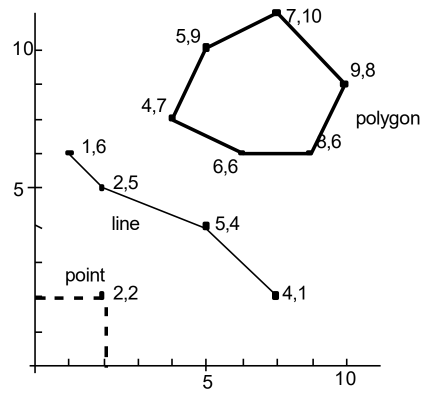



Software
Hardware
GIS
Data
People
Methods

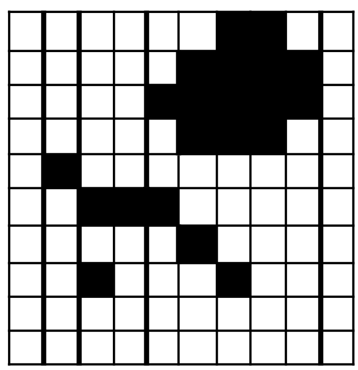

Land Use
Streets
Districts
Parcels
Parks
River
Discharge Point
Sand and Gravel
Sandstone Aquifer
Water Table
Shale

Spatial data storage

- Vector model



as geometric objects:
points, lines, polygons



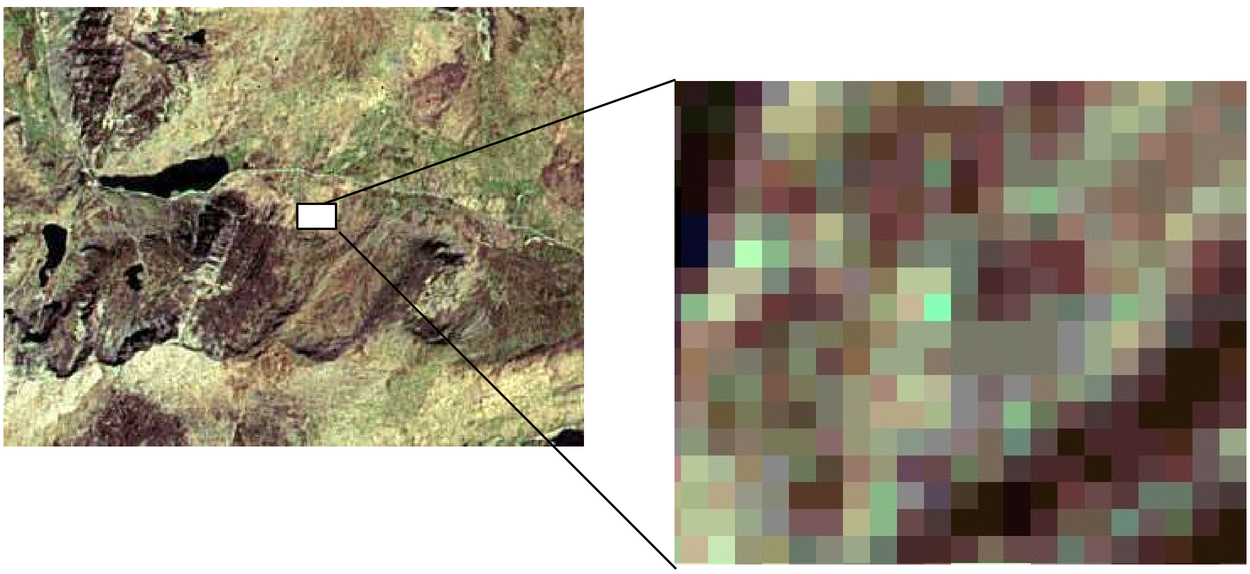
as image files
composed of grid-cells
(pixels)

- Raster model

Vector data

Land use parcels

Raster data



TYPES OF SCALES

The four commonly referred levels of measurement are,

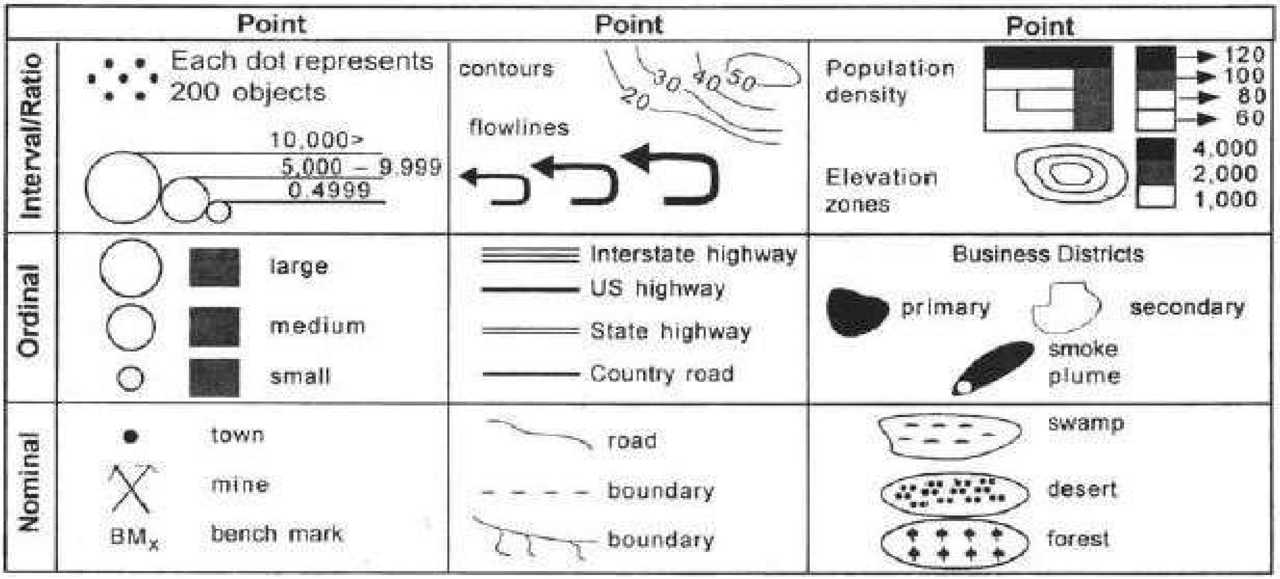
Nominal Scale, Ordinal scale, Interval Scale, Ratio Scale

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

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

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

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



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

MAP SCALE

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

The scale may be represented in three ways

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

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

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

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

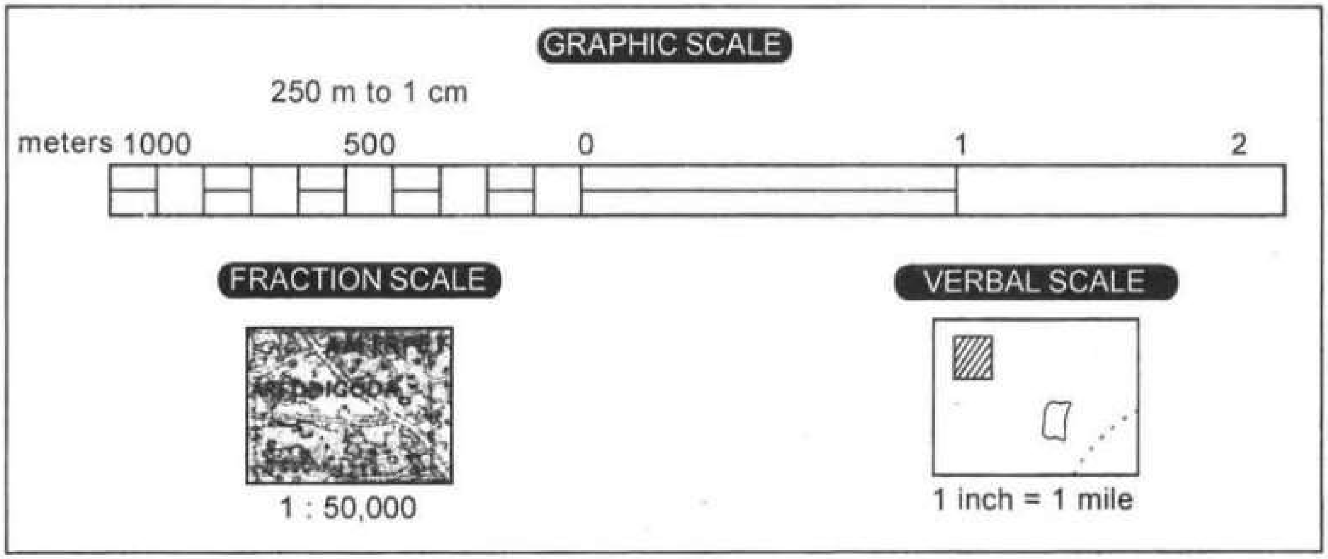


Fig. 1.4 Three different types of scale representation.

MAP AND GLOBE

What is a Map?

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

Types of Maps

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

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

Components of Maps

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

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Globe Versus A Map

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

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

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

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

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

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

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

COORDINATE SYSTEM

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

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

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

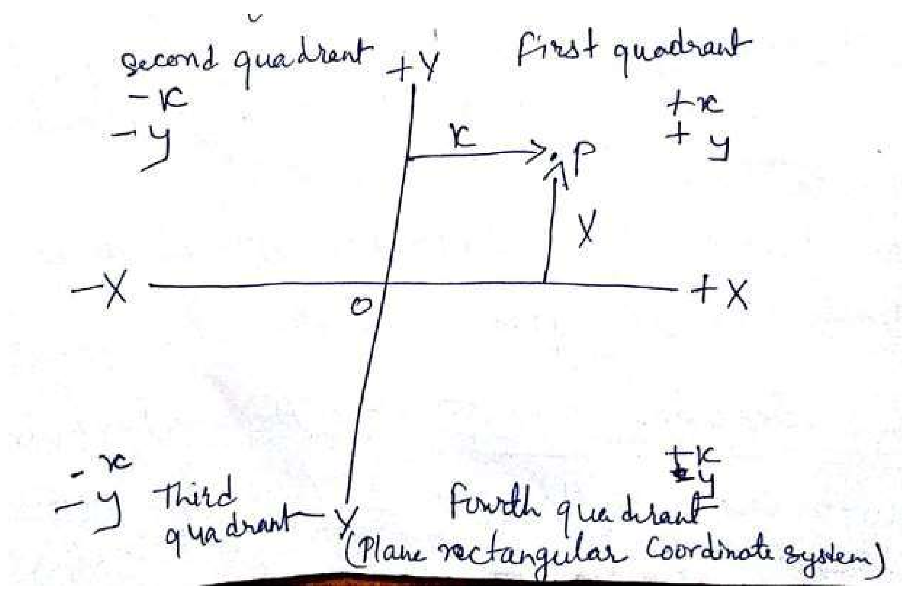
A digital elevation model (DEM) is a three dimensional space, in which the location of a point is fixed by a set of three numerical values(x,y,z)

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

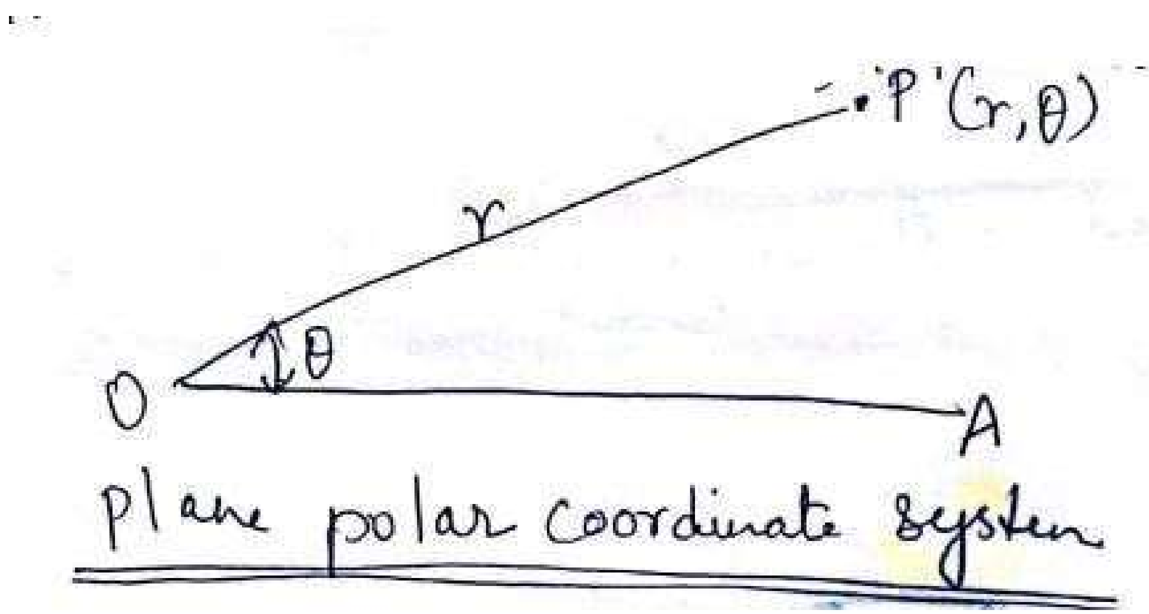
1) **Plane Rectangular coordinates**
2) **Plane polar coordinates**
3) **Geographic coordinates**

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

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

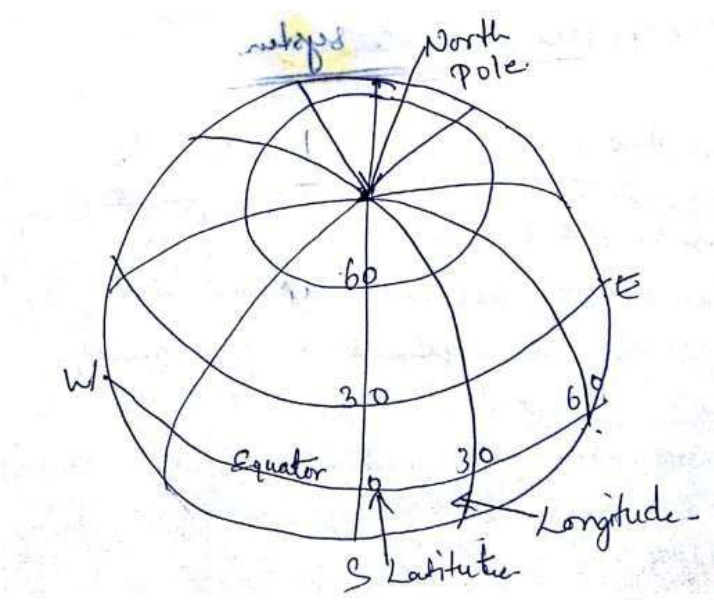


Plane Polar Coordinate System: The polar coordinates system is a **two dimensional Coordinates systems** in which each point on a plane is determined by a distance from reference point and an angle from the reference directions.



Geographic Coordinate System of Earth

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



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

MAP PROJECTIONS

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

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

Onto two dimensional space of map sheet.

BASIC CONCEPTS AND PROPERTIES OF MAP PROJECTIONS

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

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

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

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

These properties include the following:

1) Area 2) Shape 3) Distance and Direction

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

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

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

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

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

CLASSIFICATION OF MAP PROJECTIONS

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

There are three types of developable surface

1) Cylindrical
2) Conical
3) Planner

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

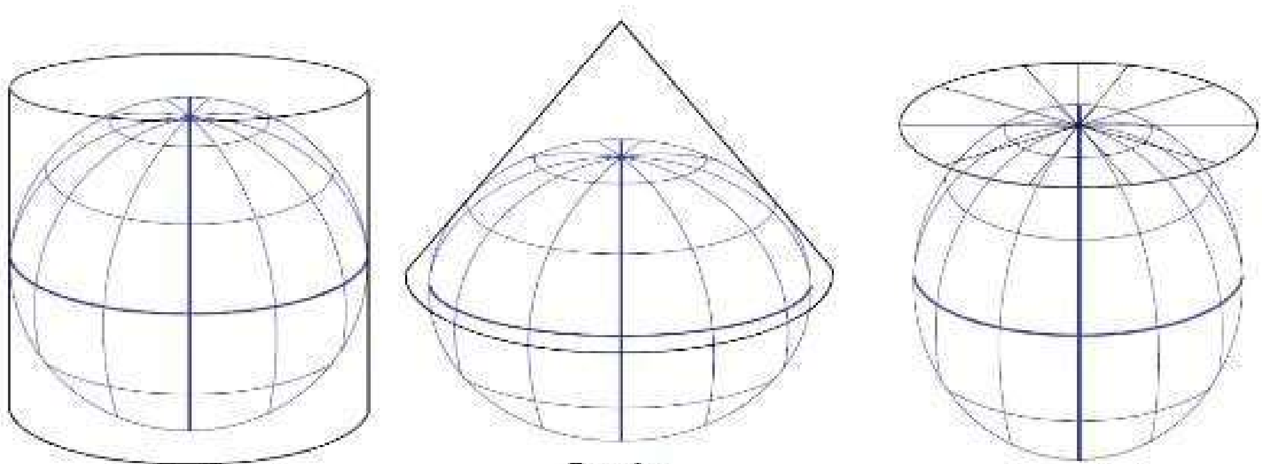
So that the cylinder touches the equator throughout its circumference. Assume that a

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

On to the cylinder

Three main types of map projection are:

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

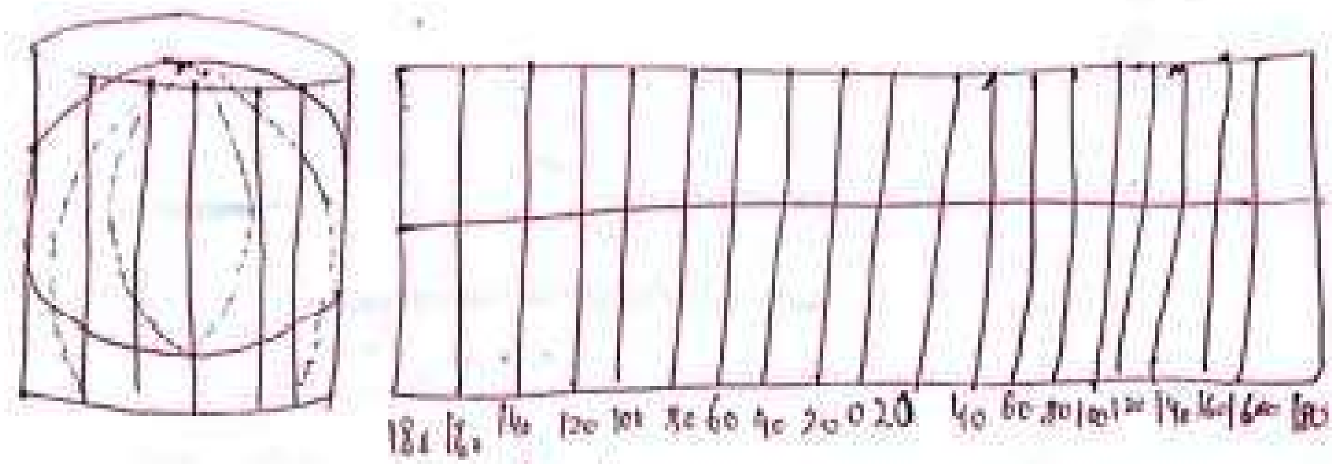


Cylindrical Projection

Conic Projection

Azimuthal Projection

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

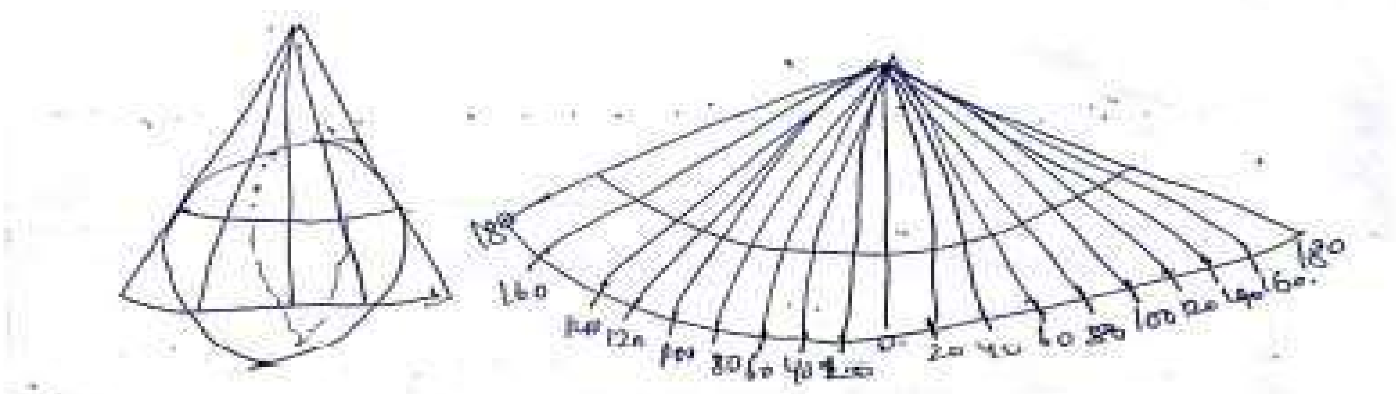


a Cylindrical

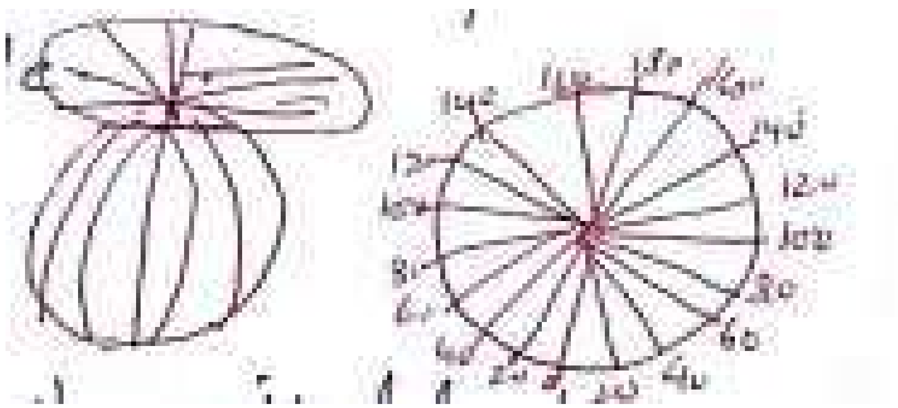
Conical Projection: A cone is placed over the globe in such a way that the apex of the Cone exactly over the polar axis. A cone must touch the globe along a parallel o latitude, kwon as standard Parallel, which can be selected by the cartographer.

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

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



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



MAP TRANSFORMATIONS

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

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

Control Points

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

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

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

GEOREFRENCING

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

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

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

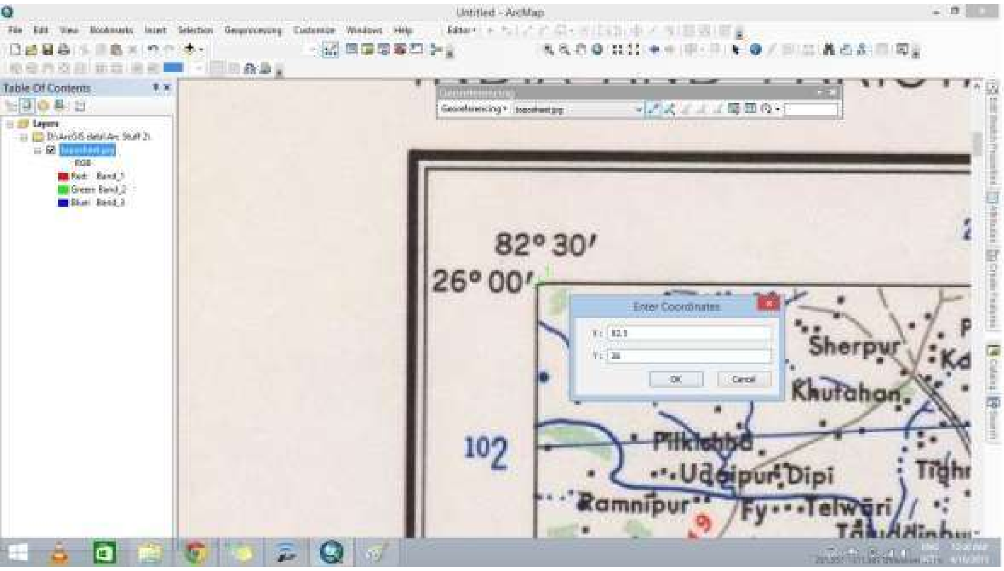
Latitude: Latitude is angular distance measured north and south of the equator.
The equator is 0 degrees, As you go north of the equator the latitude increases all the way up to 90 degrees at the south pole.

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

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

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

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


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

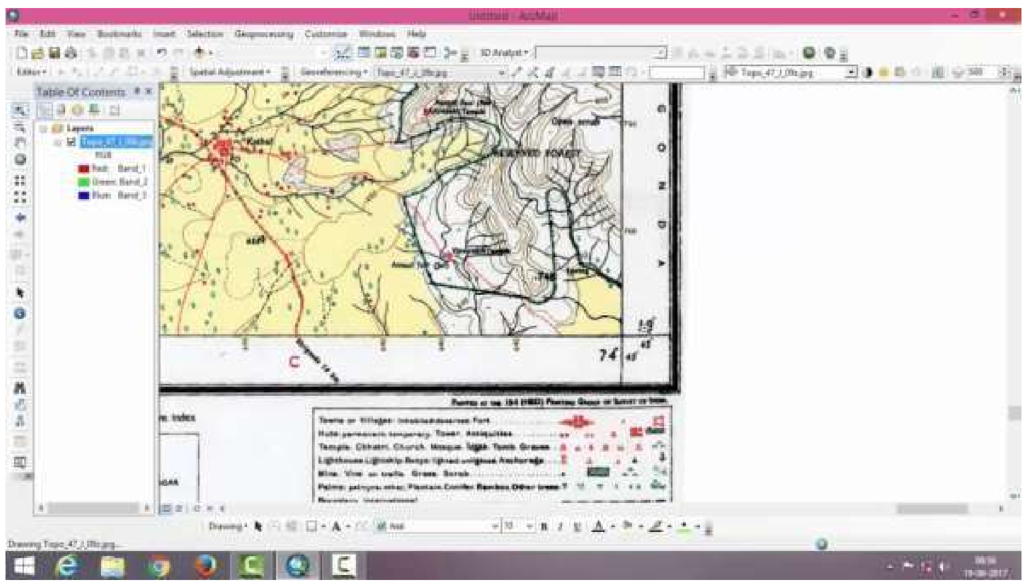
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Table Of Contents
RESERVED FOREST
74° 45′

UNIT-III
SPATIAL DATA BASE MANAGEMENT SYSTEM

SPATIAL DATA INPUT AND EDITING

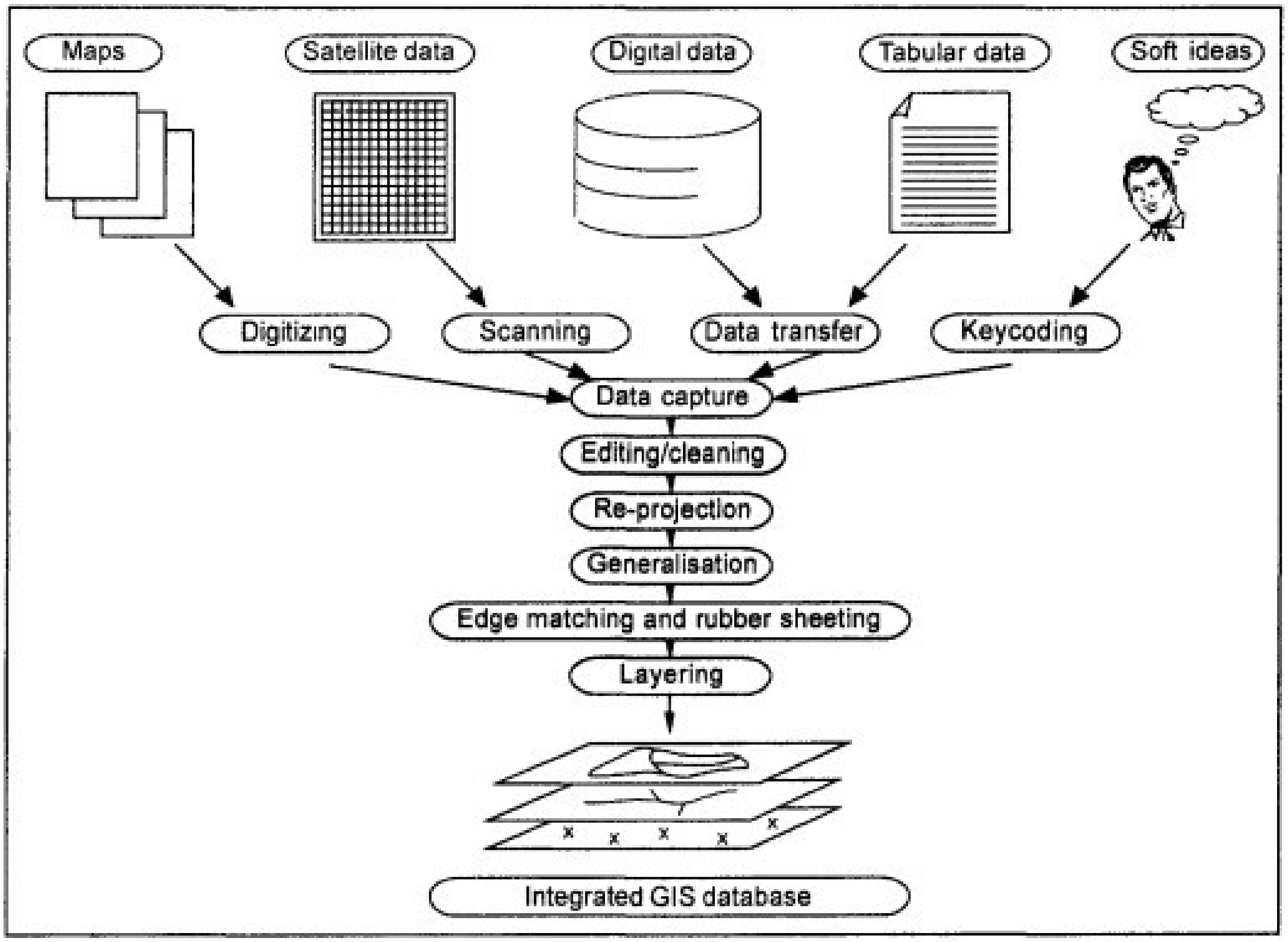


Fig. 10.1 The conceptual view of data stream in GIS.

Table 10.1 Data types and their source in India

Data Type	Data Source
Topography	GSI, NATMO, SOI
Digital Elevation Model	
Digital Terrain Data	
Land Use and Land Cover	
Ownership and Political Boundaries	SOI, Land Records
Transportation	R & D, A.P.S.R.T.C.
Hydrography	Ministry of Water Resources State & Central Ground Water Board
Socioeconomic and Demographic data	
Census Tract Boundaries	Department of Census
Demographic Data	Bureau of Economics & Statistics
Soils	NATMO
Wetlands	NATMO
Remotely Sensed Data	National Remote Sensing Agency

GSI - Geological Survey of India

NATMO - National Atlas Thematic Mapping Organisation

SOI - Survey of India

APSRTC - Andhra Pradesh State Road Transportation Corporation

DATA INPUTS METHODS

There is distinction between analogue (non-digital) and digital sources of spatial data. Analogue data are normally in paper form and include paper maps, tables of statistics and hardcopy aerial photographs.
All these forms of data need to be converted to digital form before use in a GIS.

Digital data like remote sensing data are already in compute-readable formats and are supplied on diskette, magnetic tape or CD-ROM or across a computer network.

All data in analogue form need to be converted to digital form before they can be input into GIS.

There are four methods of data input which are widely used:

Keyboard entry, manual digitizing, automatic digitization, and scanning.

Digital data must be downloaded from their source media and may require reformatting to convert them to an appropriate format for the GIS being used. **Reformatting or conversion may also be required after analogue data have been converted to digital form.**

For example, after scanning a paper map, the file produced by the scanning equipment may not be compatible with the GIS, so it needs reformatting. For both the analogue and digital data, keyboard entry method, manual digitizing and automatic digitizing and scanning methods are very important as detailed below.

1. KEYBOARD ENTRY

Keyboard entry, often referred to as key coding, is the entry data into a file at a computer terminal. **This technique is used for attribute data that are available only on paper**. This technique can be mixed with digitizing process for the creation of GIS database

The **coordinates of spatial entities like point, line and area features can be encoded by keyboard entry. This method is used when the coordinates of these spatial entities are known and there are not too many of them.** If the coordinates are more in number, this data can be encoded using digitizing. The **procedure of keyboard entry can be used to enter land record information.** This method leads to obtain very high level of precision data by entering the actual surveying measurements. This method is used for the development of cadastral information system.

2.Manual Digitizing

Manual digitizing is the most common method of encoding spatial features from paper maps. It is a process of converting the spatial features on a map into a digital format. Point, line, and area features that form a map, are converted into (x, y) coordinates.

A point is represented by a single coordinate, a line by a string of coordinates, and, when one or more lines are combined with a label point inside an outline, then an area (polygon) is identified. **Thus digitizing is the process of capturing a series of points and lines.** Points are used for two different purposes: to represent point features or to identify the presence of a polygon.

Manual digitizing requires a table digitizer that is linked to a computer work station. To achieve good results, the following steps are necessary.

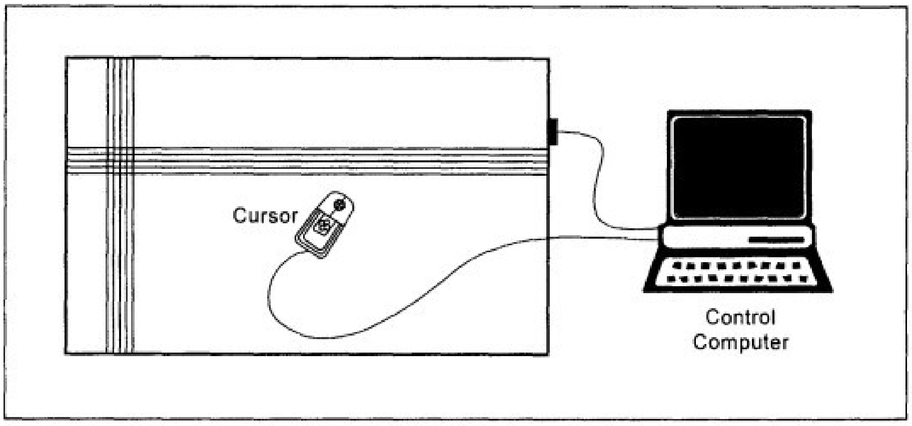


Fig. 10.2 Contemporary tablets using a grid of wires embedded in the tablet to generate a magnetic field which is detected by the cursor.

The Digitizing Operation

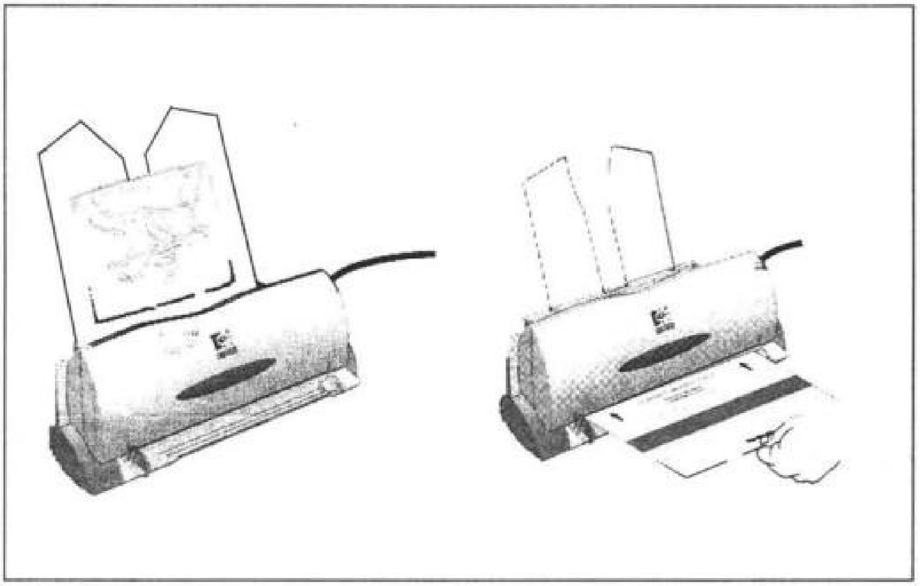
The map is affixed to a digitizing table. Three or more control points are to be identified and digitized for each map sheet. These points should be those that can be easily identified like intersections of major streets and prominent landmarks. The points are called reference points or tics or control points. The coordinates of these control points will be known in the coordinate system to be used in the final data, such as, latitude and longitude. The control points are used by the system to calculate the necessary mathematical transformations to convert all coordinates to the final system. The more the control points, the better the accuracy of digitization. Digitizing the map contents can be done in two different modes: point mode and stream mode. Point mode is the mode in which the operator identifies the points to be captured explicitly by pressing a button, and stream mode is the mode in which points are captured at set time intervals, typically 10 per second, or on movement of the cursor by filed distance. Most digitizing is currently done in point mode.

3. Scanning and Automatic Digitizing

Scanning is the most commonly used method of automatic digitizing. Scanning is an appropriate method of data encoding when raster data are required, since this is the automatic output format from most scanning software. Thus scanning may be used as a background raster dataset for the over-plotting of vector infrastructure data, such as, pipelines and cables. A scanner is a piece of hardware for converting an analogue source document to a digital raster format (Jackson Woodford, 1997).

There are two types of scanners,

(i) Flatbed scanner and
(ii) Rotating drum scanners. The cheapest scanners are small flatbed scanners, and high quality and large format scanners are rotating drum scanners in which the sensor moves along the axis of rotation.



A digital image of the map is produced by moving an electronic detector across the map surface. The size of the map area viewed by the detector and scanning should be processed or edited to improve the quality and convert the raster to vector after online digitization. The accuracy of the scanned output data depends on the quality of the scanner, the quality of the software used to process the scanned data, and the quality of the source document. A very important feature that a GIS user should observe after scanning the paper map is the occurrence of splines, which is black appearance on the scanned output. This can be removed by using a process called thinning. The resolution of the scanner used affects the quality and quantity of output data. The cheaper flat-bed scanners have resolutions of 200-500 mm whereas the more expensive drum scanners use resolutions of 10-50 mm. The higher the resolution, the larger the volume of the data produced. Fig. 10.7 shows scanned output of paper map and the output of automatic digitisation.

DATA EDITING

The storage and editing subsystem of GIS provides a variety of tools for storing and maintaining the digital representation of study area. It also provides tools for examining each coverage for mistakes that may have crept into our preparations. **The input data that is encoding may consist of a number of errors derived from the original data source as well as errors that have been introduced during the encoding process**. There may be errors in coordinate data as well as in accuracies and uncertainty in attribute data. **Before successfully using the methods of data analysis for any specific application, it is better to intercept errors before they contaminate the GIS database.** **The process of detecting and removing errors through editing is called cleaning.**

All the errors into 3 groups: (i) entity errors, (ii) attribute errors, and (iii) entity-attribute errors. They occur during the execution of the project using vector based GIS and attribute and entity attribute agreement errors occur in the use of both raster and vector based GIS.

Data editing and cleaning of GIS database are covered under three subheads:

(a)Detecting and correcting errors

(b) Data reduction and generalization\and

(c)edge matching and rubber sheeting.

(A) Detecting and correcting errors

In any information system, **facilities must be provided to detect and correct errors in the database.** Different kinds of errors are common in different data sources. To illustrate some of the common varieties, will discuss **some of the errors that must be detected when generating a vector dataset, whether developed from a manual digitization or an automated digitization.**

Polygonal areas, by definition, have closed boundaries. **If a graphic object has been encoded as a polygon (rather than a vector or point), the boundary must be continuous.** **Software should be able to detect that polygon which is not closed.** The causes for this kind of error include encoding error (the object is a vector, rather than a polygon) and digitizing error (either points along the boundary of the polygon, or connections between the points, are missing).

Table 10.2 Common errors in GIS database

Error	Description
Missing entities	missing points, lines or boundary segments
Duplicate entities	points, lines or boundary segments that have been digitised twice
Mislocated entities	points, lines or boundary segments digitised in wrong place.
Mislocated labels	unidentified polygons
Duplicate labels	two or more identification labels for the same polygon.
Artifacts of digitising	undershoots, overshoots, wrongly placed nodes, loops and spikes
Noise	Irrelevant data entered during digitising, scanning or data transfer.

Pseudo nodes occur where a single line connects itself (an island) or where only two arcs intersect. Pseudo nodes do not indicate an error. **There can be pseudo nodes representing an island or an intermediate point having an attribute data attached to it.** A dangling node refers to the unconnected node of a dangling segment. **Every segment begins and ends at a node point.** **So if a segment does not close properly (undershoot), or was digitized past an intersection (overshoot), it will register a dangling node.** There can be instances where dangling nodes are representing some real-world feature. It is always better to have overshoots. It is much easier than editing an undershoot. Fig 10.8 shows some of the examples of spatial error in vector data.

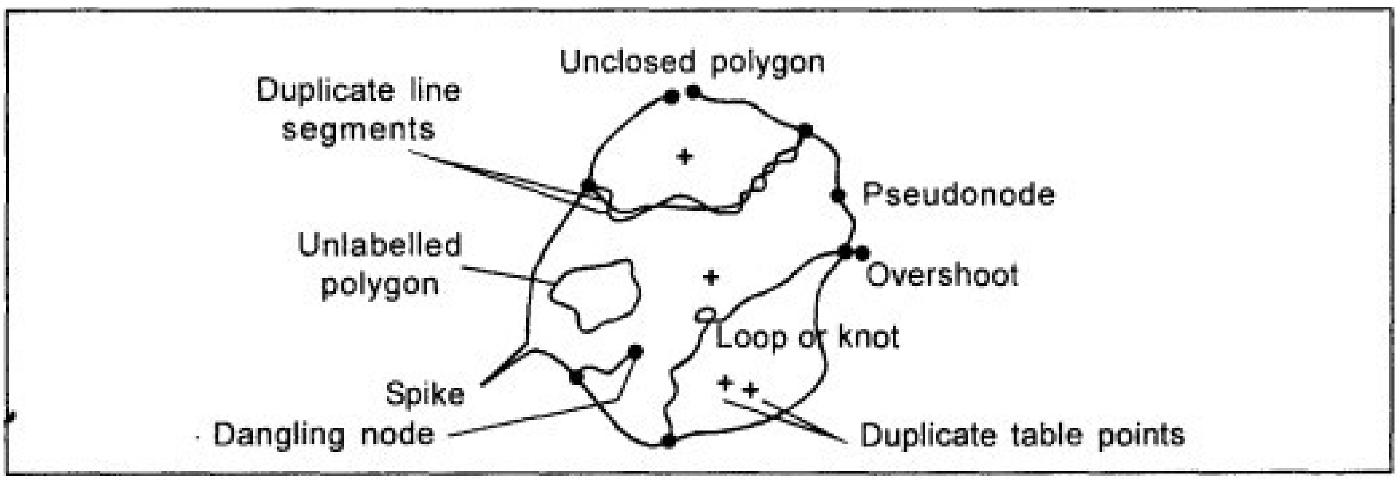
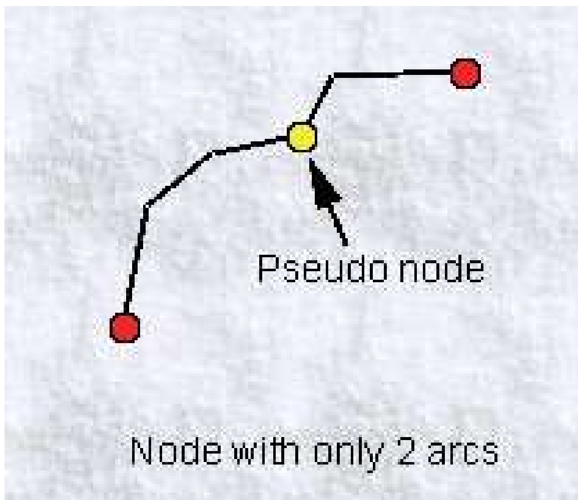


Fig. 10.8 Examples of commonly committed errors in vector data.

Pseudo nodes occur: Where a single line connects itself or when only two arcs intersects

For example a long road segment may have been divided into two features

Dangling Node: A dangling node refers to the unconnected node of dangling segment



(B) Data Reduction and Generalisation

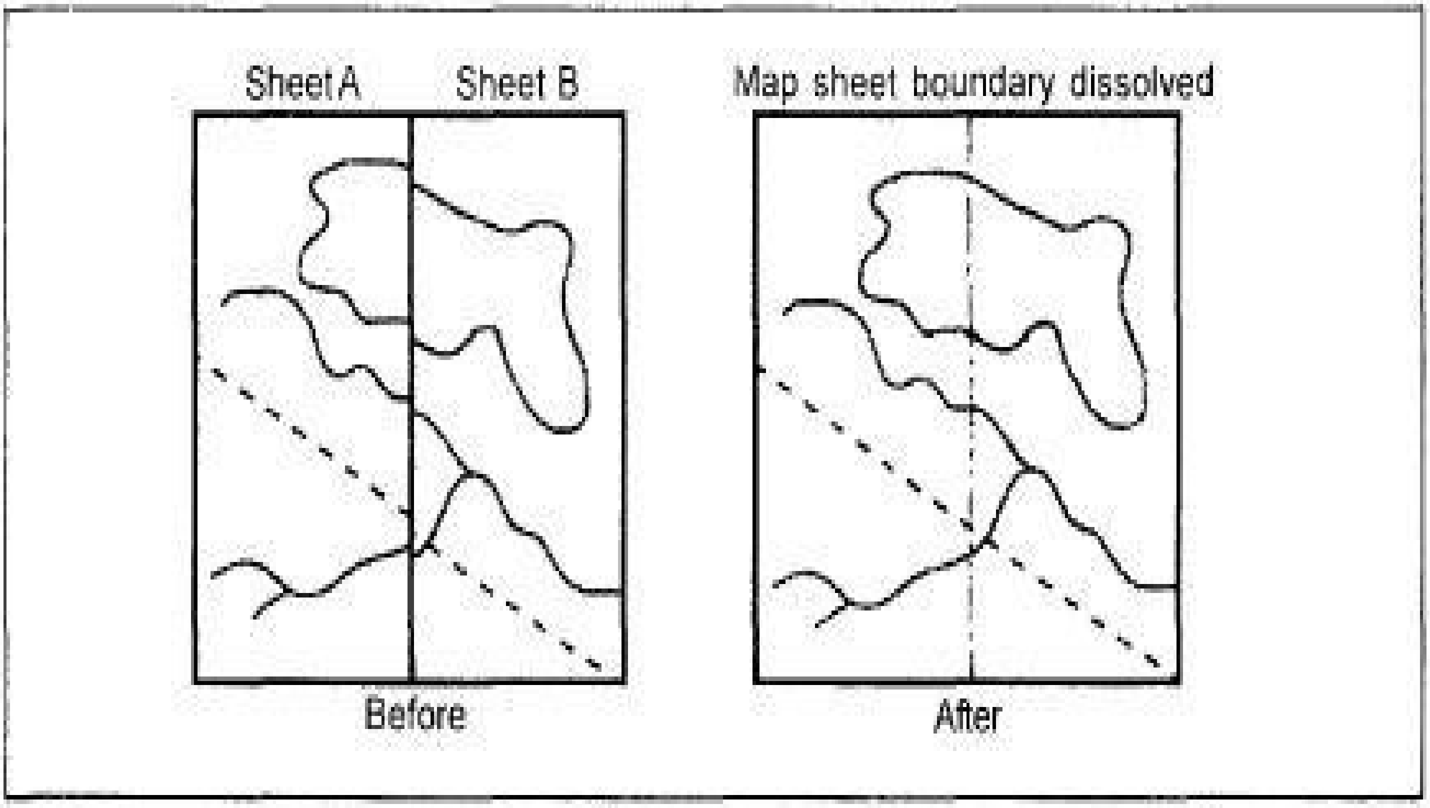
•In a given application, we may need to average the measurements of a single tree, and enter the average into our database. This is ***Data Reduction***

•We may need to assemble property ownership records in an area, and the **original surveyor's records may be more detailed than we require**. There are two obvious options: either accept the level of detail (and thus, incorporate a greater volume of data than necessary, with the attendant increased processing and storage costs), or develop a less precise representation from the original source data. The latter is called ***Generalisation***.

(C)Edge Matching and Rubber Sheeting

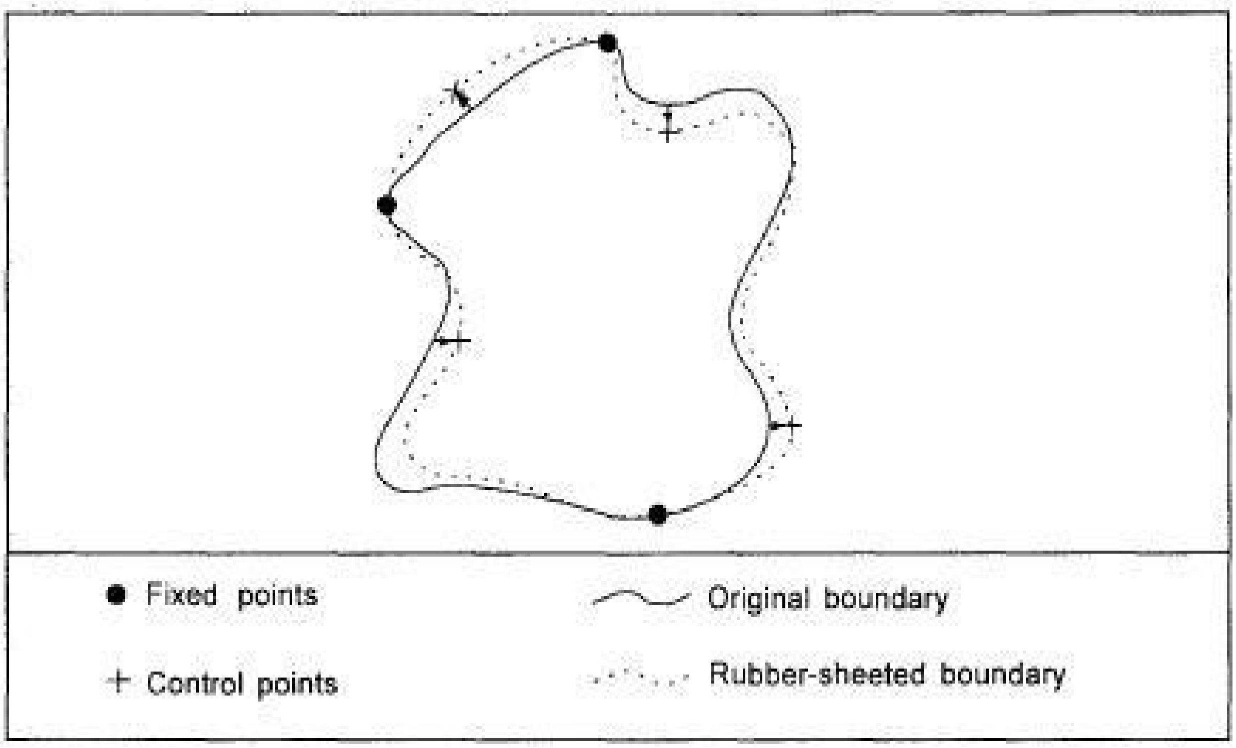
Sometimes, any given project area under study, extends across two or more map sheets. small differences or mismatches between adjacent map sheets may need to be resolved. Normally, each map sheet would be digitised separately and then adjacent **sheets joined after editing, projection, transformation, generalisation, and scaling. The process of joining is known as edge matching.**

Many vector GIS systems also allow you to separately stores potions of database as large, predefined subsections for archival purposes. This process is called tiling. This tiling process is commonly used to reduce the volume of the data needed for the analysis of extremely large database. Edge matching is a process of operating on more than one tile at a time to ensure that there is a correct match between the two tiles for entities for entries that extend across the tile boundaries.


Sheet A
Sheet B
Map sheet boundary dissolved
Before
After

Rubber Sheeting

- **Certain data sources may give rise to internal distortion within individual map sheets. This is especially true of data derived from aerial photographs as the movement of the aircraft and the distortion caused by the camera lens can cause internal inaccuracies in the location of features within the image.**
- **These inaccuracies remain even after transformation and re projection.** These problems can be rectified through a process known as rubber sheeting or conflation. **Rubber sheeting involves stretching the map in various directions as if it were drawn on a rubber sheet.**
- Objects on the map that are accurately placed are tacked down and kept still while others that are in the wrong location or have wrong shape are stretched to fit with the control points, which are known points identified on the ground and on the image. The coordinates of these control points may be determined from field observation using GPS.


Fixed points
Control points
Original boundary
Rubber-sheeted boundary

DATA ACCURACY

A useful starting point for discussing accuracy is the **0**, **which serves as the conceptual basis for most database implementations of real world phenomena**. **According to this model, 'entities' represent real-world phenomena,**

such as, streets, districts, and hazardous waste sites, and 'attributes' specify the relevant properties of these objects, such as, width and number of lanes, while 'values' give the specific qualitative and quantitative measurements pertaining to a particular attribute

In this model error is defined as the discrepancy between the encoded and actual value of a particular attribute for a given entity. **Accuracy is the inverse of error**. **This model can be used to define spatial, temporal, and thematic error for a particular entity as, the discrepancies in the encoded spatial, temporal, and thematic attribute values**

Accuracy is a **relative measure** rather than an absolute one, since it depends upon the intended form and content of the database. Different specifications can exist for the same general types of geospatial data. To judge the fitness-for-use of the data for some applications, one must not only judge the data relative to the specification, but also consider the limitations of the specification itself.

Error and Corresponding action to remove that error

Error	Action
Missing Segment	Draw it
A gap between two Segments	Indicate which arc to extend or which node to move
An overshoot	Delete node if needed
An Undershoot	Merge nodes or extend segment

Accuracy of the GIS data can be discussed in terms of

1. **spatial accuracy,**
2. **temporal accuracy,**
3. **thematic attribute data accuracy, and**
4. **conceptual accuracy.**

1. Spatial Accuracy

Spatial accuracy also called 'positional accuracy' refers to the accuracy of the spatial component of a database. Measurements of spatial accuracy depends upon the dimensionality. This applies to both horizontal and vertical positions. Accuracy and precision are the functions of the scale. This means that when we see a point on a map we have its **"probable" location within a certain area**. This is a very great danger in computer systems that allow users to pan and zoom to an infinite number of scales. **Accuracy and precision are tied to the original map scale and do not change even if the user zooms in and out.**

For points, error is usually defined as the discrepancy between the encoded location and the location as defined in specification. Error can be measured in anyone of, or in combinations of, the three dimensions of space. The most common measures are horizontal error and vertical error

Clearly this is not the case since a database can achieve a high level of temporal accuracy without being current and is dependant upon the availability of historical data.

2. Temporal Accuracy

Temporal accuracy and correctness are two distinct concepts . Temporal accuracy refers to the agreement between 'encoded' and 'actual' temporal coordinates.

Correctness is an application-specific measure of temporal accuracy.

A value is current if it is correct in spite of any possible time-related changes in value. Thus correctness refers to the degree to which a database is up-to-date (Redman 1992). To equate temporal accuracy with correctness is to state, in effect, that to be temporally accurate a database must be up-to-date.

3. Attribute Accuracy

Attribute accuracy indicates the attribute attached to the points, lines and polygons features of the spatial database, which are how reliable and reasonably correct or free from bias.

- For categorical data, most of the research into quality has come from the field of classification accuracy assessment in remote sensing.

- Accuracy assessment is based on the selection of a sample of point locations and a comparison of the land cover classes assigned to these locations by the classification procedure with the classes observed at these locations on a reference source usually called '**ground truth**'

•The non-spatial data linked to location may also be inaccurate or imprecise.

• Non-spatial data can also vary greatly in precision. Precise attribute information describes phenomena in great detail.

For example, a precise description of a person living at a particular address might include gender, age, income, occupation, level of education, and many other characteristics.

• An imprecise description might include just income, or just gender

4.Conceptual Accuracy

- **GIS depends upon the abstraction and classification of real-world phenomena.**
- **The users determine what amount of information is used and how it is classified into appropriate categories. Sometimes users may use inappropriate categories or misclassify information.**

For example, classifying cities by population size would probably be an ineffective way to study land patterns

•Even if the correct categories are employed, data may be misclassified

•**A study of drainage systems may involve classifying streams and rivers by "order," that is where a particular drainage channel fits within the overall tributary network. Individual channels may be misclassified if tributaries are miscounted**

SOURCES OF ERROR IN GIS

- Spatial and attribute errors can occur at any stage in a GIS project.
- **These errors may arise during the derivation of spatial entities.**
- ***Encoding these entities in the computer system, forms the use of data in analysis.***
- **Errors may also be present in source data, arising during data conversion arising** during data manipulations and can be produced

- There are many sources of error that may affect the quality of a GIS dataset.
- **Few of these will be automatically identified by the GIS itself.** It is the user's responsibility to prevent them.

Burrough divided source of error into three main categories:

(a) Obvious sources of error,
(b) Errors resulting from natural variations or from original measurements,
(c) errors arising through processing.

- during the presentation of results.

(i)	Obvious sources of error Age of data Areal coverage Map scale Density of observations Relevance Format Accessibility
(ii)	Error resulting from natural variations or from original measurements Positional accuracy Accuracy of content Qualitative and Quantitative Variation in data Natural variation Data entry/output faults
(iii)	Error arising through processing Numerical error in computer Faults due to topological analyses Misuse of Logic Problems associated with map overlay Classification and generalisation problems Interpolation

DATA ANALYSIS

Pre-processing procedures are used to convert a dataset into a form suitable for permanent storage within the GIS database for application development. Often, **a large proportion of the data entered into a GIS requires some kind of processing and manipulation** in order to make it conform to a data type, georeferencing system, and data structure that is compatible with the system

Format Conversion

Format conversion covers a number of different problems, but can be discussed in terms of two families:

conversion between different digital data structures problem of modifying one data structure into another

2. **conversion between different data media**. **Involves converting source material, such as, paper maps, photographic prints, and printed tables into a computer based digital data either by means of manual digitisation or by means of scanning with automated digitisation**

Data Medium Conversion

Most of the spatial data available for development of various applications are not in computer-compatible formats.

These include maps on different scales, printed manuscripts, and imagery.

Converting these materials into a format compatible with a digital geographical information system can be very expensive and time-consuming.

The most common methods of converting maps and other graphic data to digital format is to use a technique called digitisation

Spatial Measurement Methods

Measurements allow to produce ratios of lengths to widths and of perimeters to areas.

The GIS user need to describe not only what objects are, how many objects exist, and where they are, but also how large they are, how far apart and what the distance between them is like. Calculating length, perimeters, and areas is a common application of GIS.

For example, measuring length of tank bund, perimeter of HussainSagar lake and its area are straightforward methods using in GIS.

SPATIAL ANALYSIS

Spatial analysis is **a process in which you model problems geographically, derive results by computer processing, and then explore and examine those results**. Several fundamental spatial analysis workflows form the heart of spatial analysis: spatial data exploration, modeling with GIS tools, and spatial problem solving.

SPATIAL ANALYSIS

A distinction is made in this course between GIS and spatial analysis. In the context of mainstream GIS software, **the term *analysis* refers to data manipulation and data querying.** In the context of **spatial analysis**, the *analysis* focuses on the *statistical analysis* of patterns and underlying processes or more generally, spatial analysis addresses the question "what could have been the genesis of the observed spatial pattern?" It's an **exploratory process** whereby we attempt to quantify the observed pattern then explore the processes that may have generated the pattern.

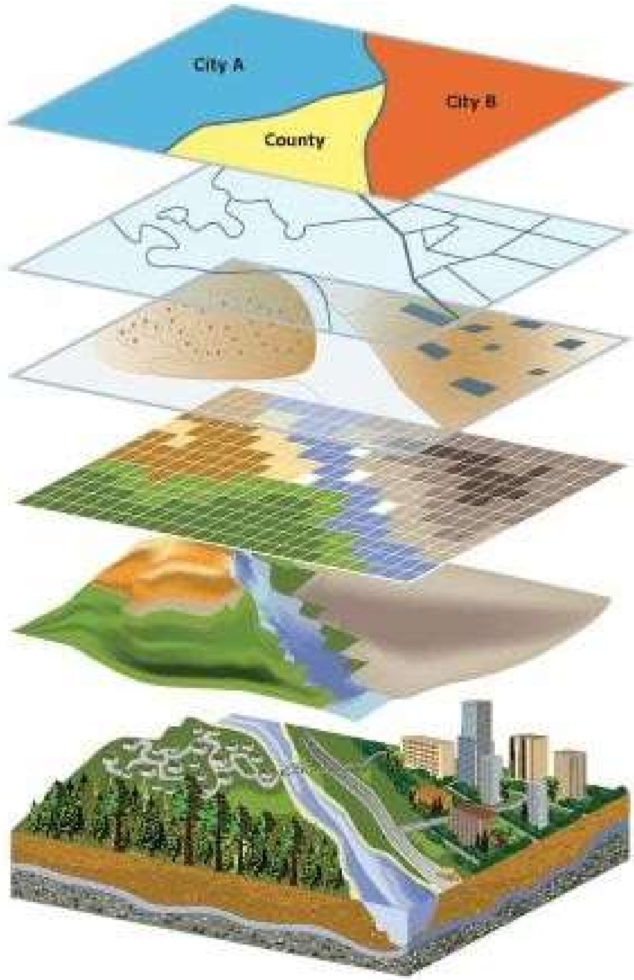
For example, you record the location of each tree in a well defined study area. You then map the location of each tree (a GIS task). At this point, you might be inclined to make inferences about the observed pattern. Are the trees clustered or dispersed? Is the tree density constant across the study area? Could soil type or slope have led to the observed pattern? Those are questions that are addressed in spatial analysis using quantitative and statistical techniques.

What is Spatial Analysis?

The most important function of GIS is to enable the analysis of the spatial data and their attributes for decision support.

Spatial analysis is categorized as follows.

1. **Query**: retrieval of attribute data without altering the existing data by means of arithmetic and logical operations.
2. **Reclassification**: reclassification of attribute data by dissolving a part of the boundaries and merging into new reclassified polygons.
3. **Coverage Rebuilding**: rebuilding of the spatial data and the topology by "update", "erase", "clip", "split", "join" or "append".
4. **Overlay**: Overlaying of more than two layers, including rebuilding topology of the merged points, lines and polygons and operations on the merged attributes for suitability study, risk management and potential evaluation.
5. **Connectivity Analysis**: analysis of connectivity between points, lines and polygon in terms of distance, area, travel time, optimum paths etc.

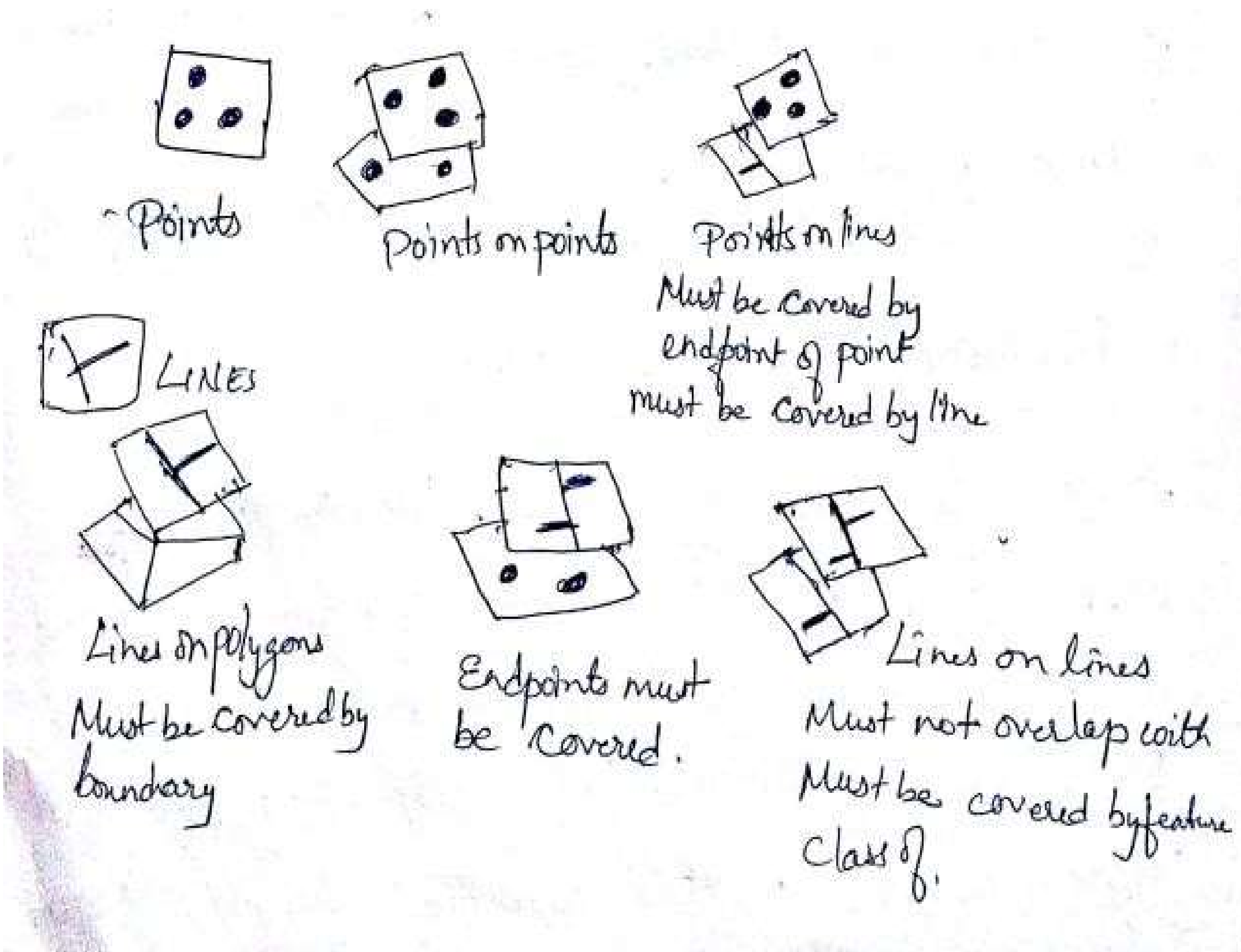

City A
City B
County

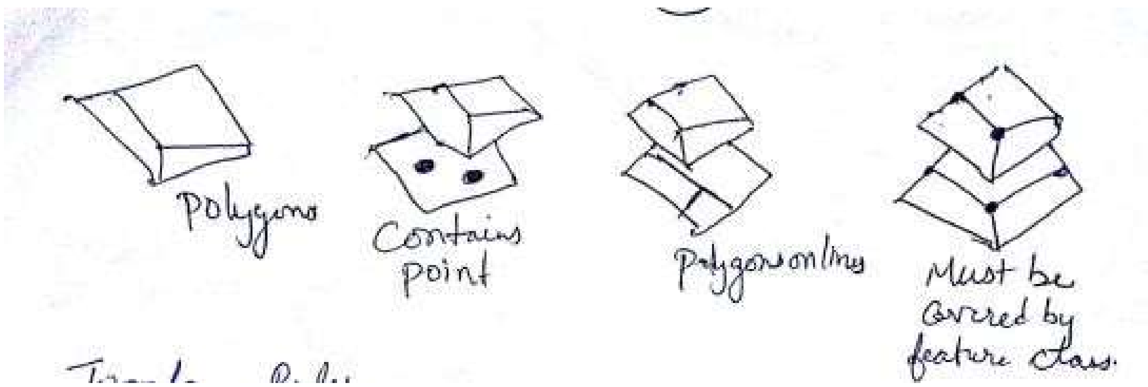
TOPOLOGY

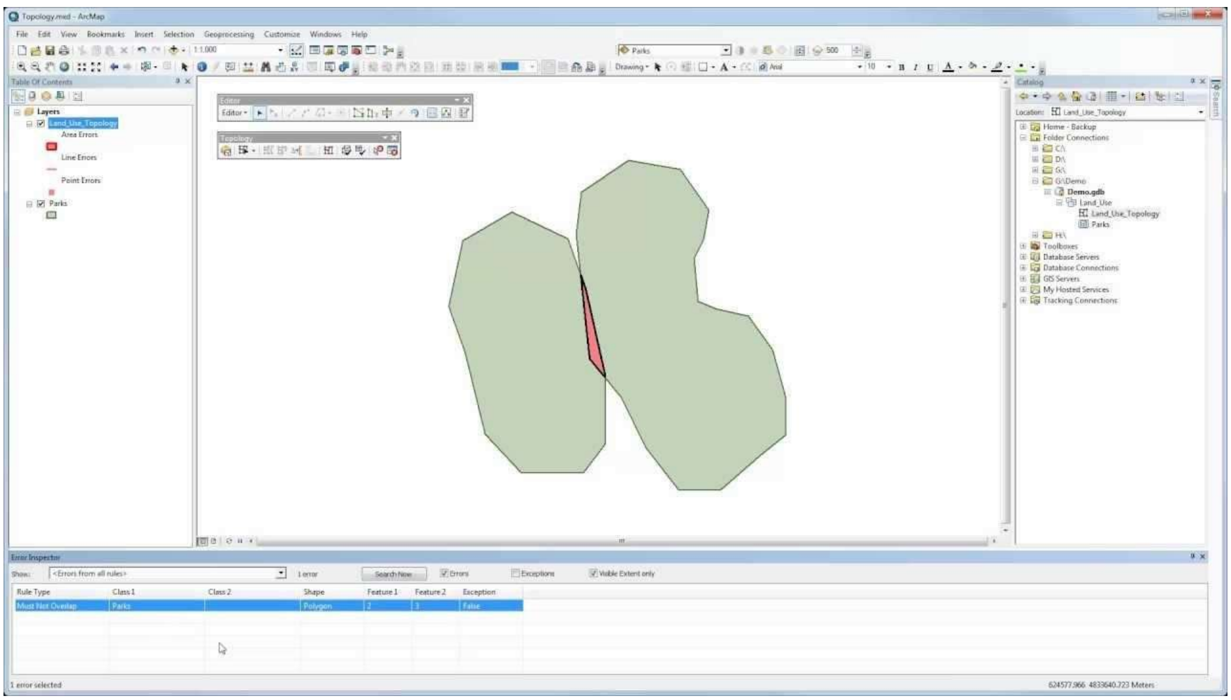
In **GIS Topology is a collection of rules that, coupled with a set of editing tools and techniques to enable the geospatial data** to more accurately mode geometric relationships topology is defined through a set of rules that **define how features may share geometry in an integrated fashion**. **A topology is commonly stored in geodatabase as one or more relationships that defined how the features in one or more feature classes share geometry.**

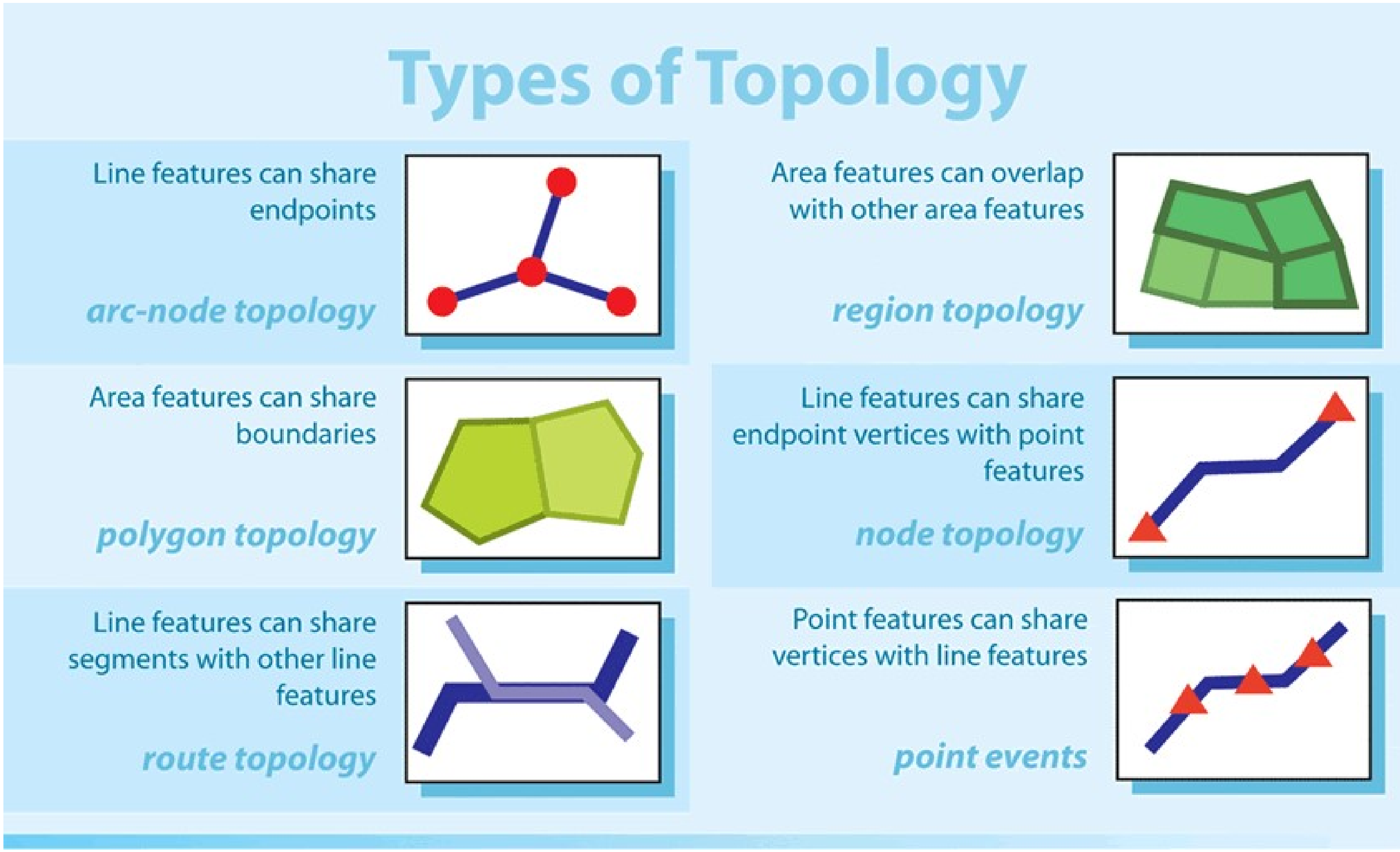
The feature participating in a topology are still simple feature class.

Rather than modifying the definition of the feature class, **a topology serves as a description of how the features can be spatially related**


Points
Points on points
Points on lines
Must be covered by
endpoint of point
must be covered by line
LINES
Lines on polygons
Must be covered by
boundary
Endpoints must
be covered.
Lines on lines
Must not overlap with
Must be covered by feature
Class of.


Polygons
Contains point
Polygons on lines
Must be covered by feature class.


Topology.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Table Of Contents
Layers
Land_Use_Topology
Area Errors
Line Errors
Point Errors
Parks
Catalog
Error Inspector
Rule Type
Class 1
Class 2
Shape
Feature 1
Feature 2
Exception
Must Not Overlap
Parks
Polygon
False


Types of Topology
Line features can share endpoints
arc-node topology
Area features can overlap with other area features
region topology
Area features can share boundaries
polygon topology
Line features can share endpoint vertices with point features
node topology
Line features can share segments with other line features
route topology
Point features can share vertices with line features
point events

Topology Rules:

Topology in “ArcGIS” allows you to model spatial relationship between feature classes in a feature dataset.

Topology rules allow you to define those relationships between two feature classes or Subtypes . Topology rules allow you to define those relationships between features class or subtype or between two feature classes or subtypes. Topology rules allow you to define the relationship between two feature classes or subtypes.

Topolology errors are violations of rules that you can easily find and manage using the editing tools found in Arc Map.

Vector Data Analysis

Vector data analysis uses the geometric objects of point, line and polygon.

The accuracy of analysis results depends on accuracy of these objects in terms of location and Shape.

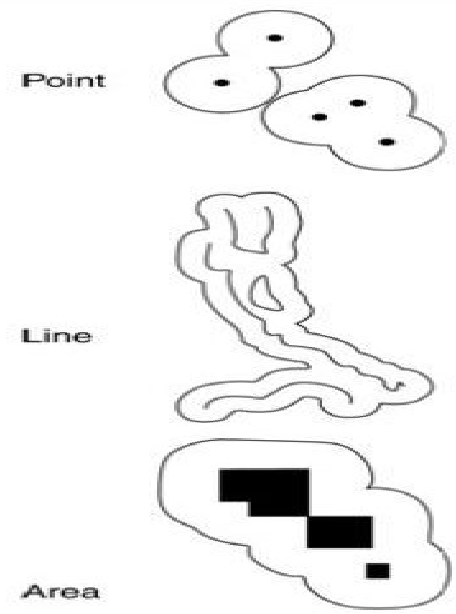
The accuracy of analysis results depends on the accuracy of these objects in terms of location and shape.
Topology can also be factor for some vector data analysis such as buffering and overlay

Buffering

Based on the concept of proximity, buffering creates two areas: one area that is within a Specified distance of select features and the other area that is beyond.

The area that is within the specified distance is called the buffer zone.

The buffer distance can vary according to values of given field. Buffering around the line feature.



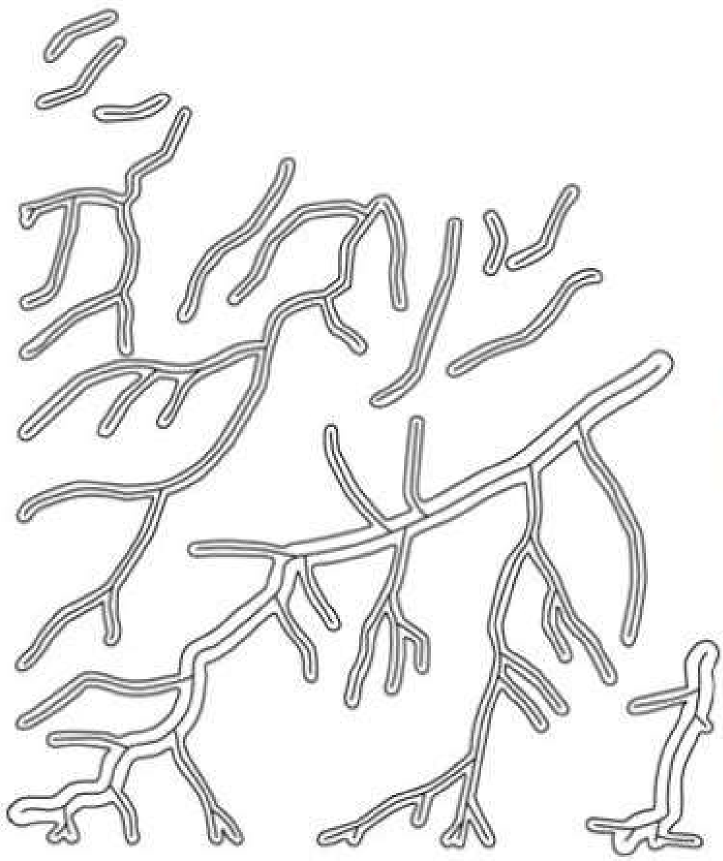


Figure 11.2
Buffering with different buffer distances.

Overlay

- An overlay operation combines the geometries and attributes of two feature layers to create the output.
- The geometry of the output represents the geometric intersection of features from the input layers.
- Each feature on the output contains a combination of attributes from the input layers, and this combination differs from its neighbors.

Feature Type and Overlay

Overlay operations can be classified by feature type into point-in-polygon, line-in-polygon, and polygon-on-polygon.

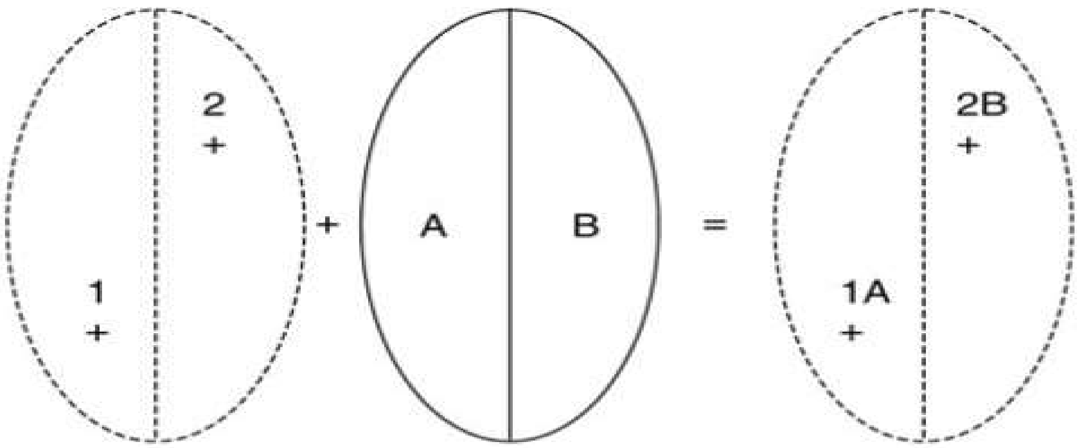


Figure 11.6
Point-in-polygon overlay. The input is a point layer (the dashed lines are for illustration only and are not part of the point layer). The output is also a point layer but has attribute data from the polygon layer.

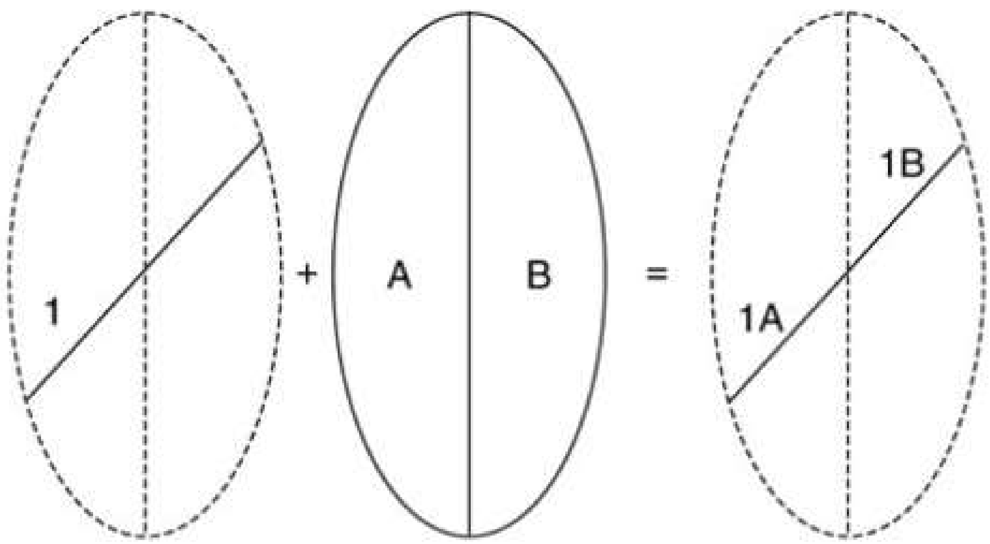


Figure 11.7
Line-in-polygon overlay. The input is a line layer (the dashed lines are for illustration only and are not part of the line layer). The output is also a line layer. But the output differs from the input in two aspects: the line is broken into two segments, and the line segments have attribute data from the polygon layer.

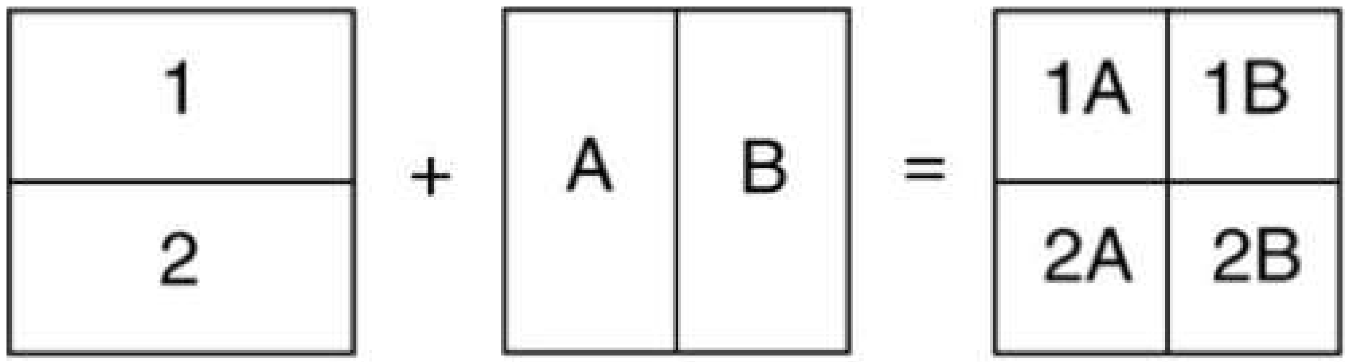


Figure 11.8
Polygon-on-polygon overlay. In the illustration, the two layers for overlay have the same area extent. The output combines the geometry and attribute data from the two layers into a single polygon layer.

Slivers

- A common error from overlaying polygon layers is slivers, very small polygons along correlated or shared boundary lines of the input layers.
- To remove slivers, ArcGIS uses the cluster tolerance, which forces points and lines to be snapped together if they fall within the specified distance.

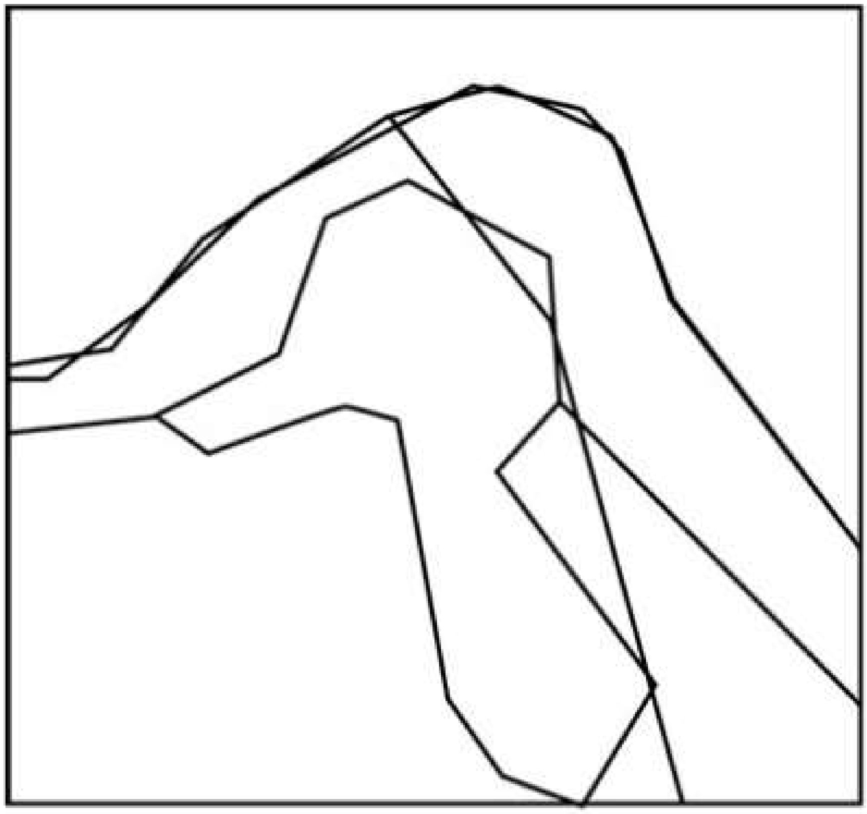


Figure 11.13
The top boundary has a series of slivers. These slivers are formed between the coastlines from the input layers in overlay.

Feature Manipulation

- Tools are available in a GIS package for manipulating and managing maps in a database.
- These tools include Dissolve, Clip, Append, Select, Eliminate, Update, Erase, and Split.

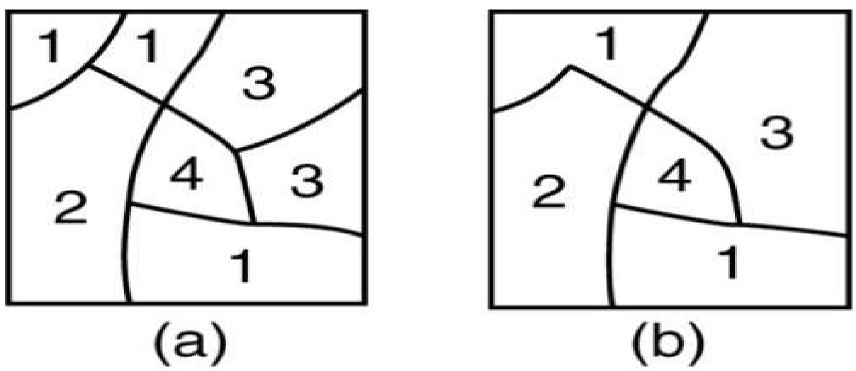


Figure 11.22
Dissolve removes boundaries of polygons that have the same attribute value in (a) and creates a simplified layer (b).

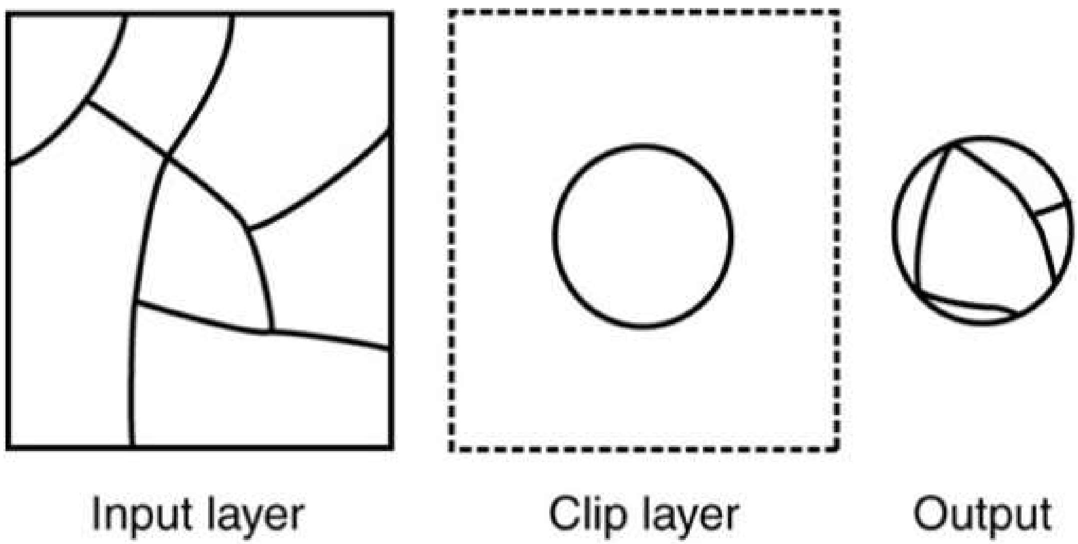


Figure 11.23
Clip creates an output that contains only those features of the input layer that fall within the area extent of the clip layer. (The dashed lines are for illustration only; they are not part of the clip layer.)

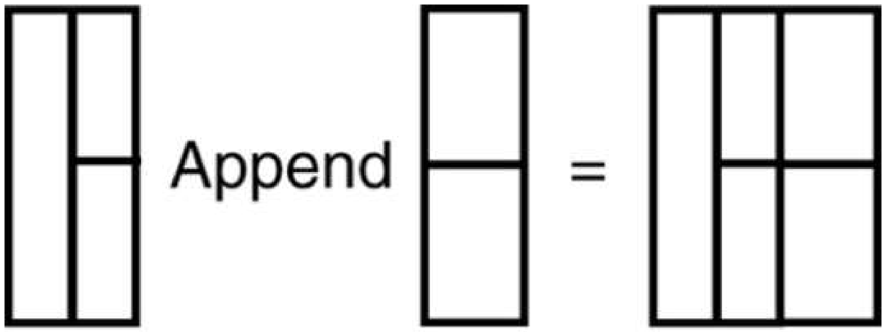


Figure 11.24
Append pieces together two adjacent layers into a single layer but does not remove the shared boundary between the layers.

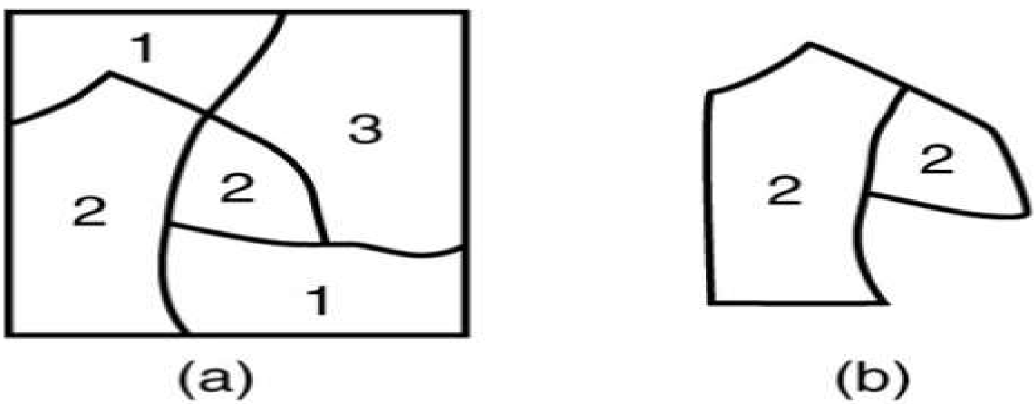


Figure 11.25
Select creates a new layer (b) with selected features from the input layer (a).

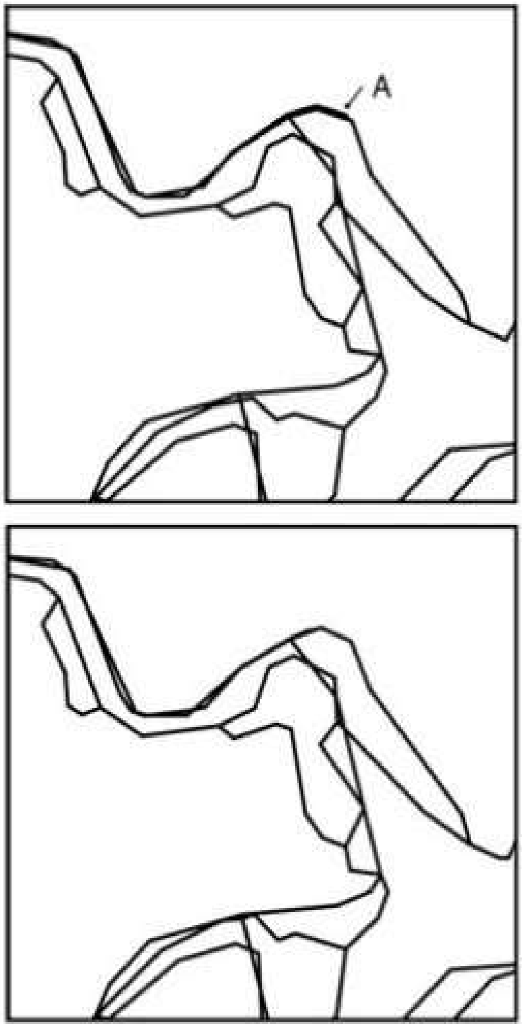


Figure 11.26
Eliminate removes some small slivers along the top boundary (A).

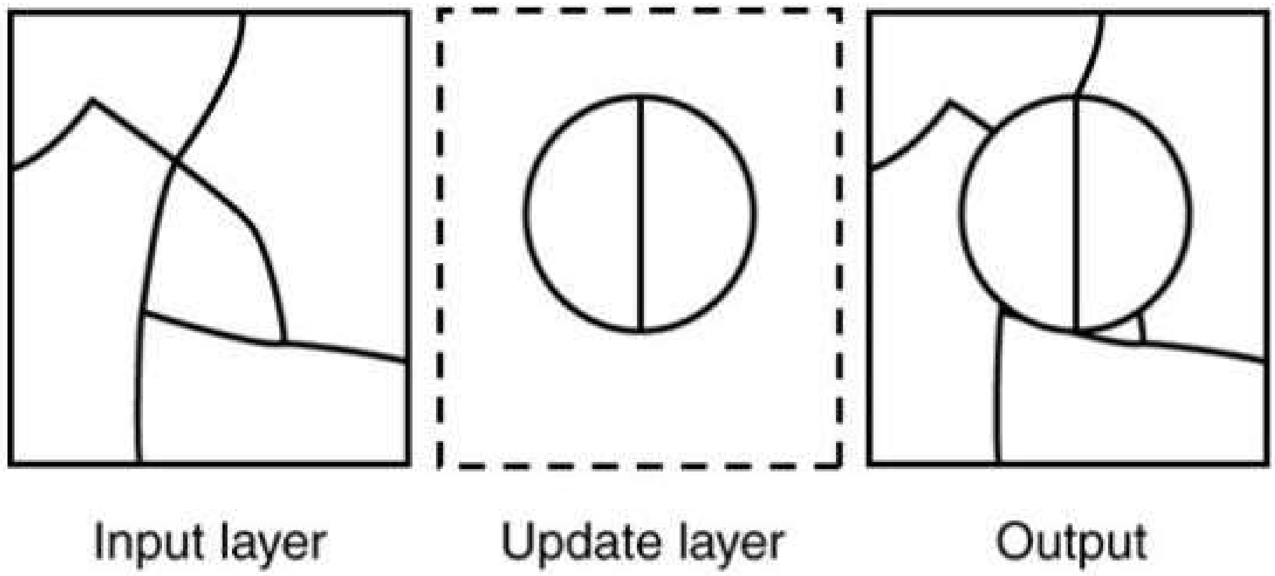


Figure 11.27
Update replaces the input layer with the update layer and its features. (The dashed lines are for illustration only; they are not part of the update layer.)

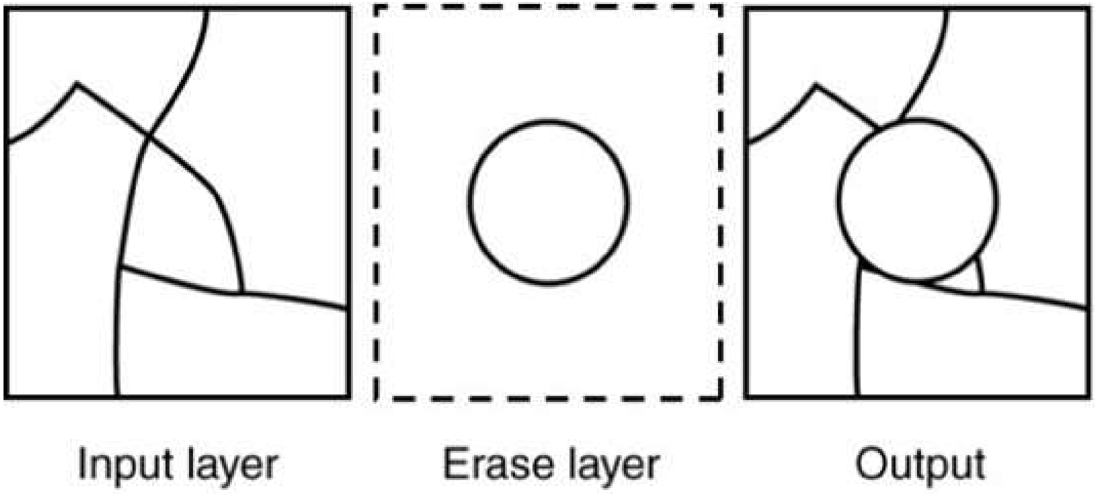


Figure 11.28
Erase removes features from the input layer that fall within the area extent of the erase layer. (The dashed lines are for illustration only; they are not part of the erase layer.)

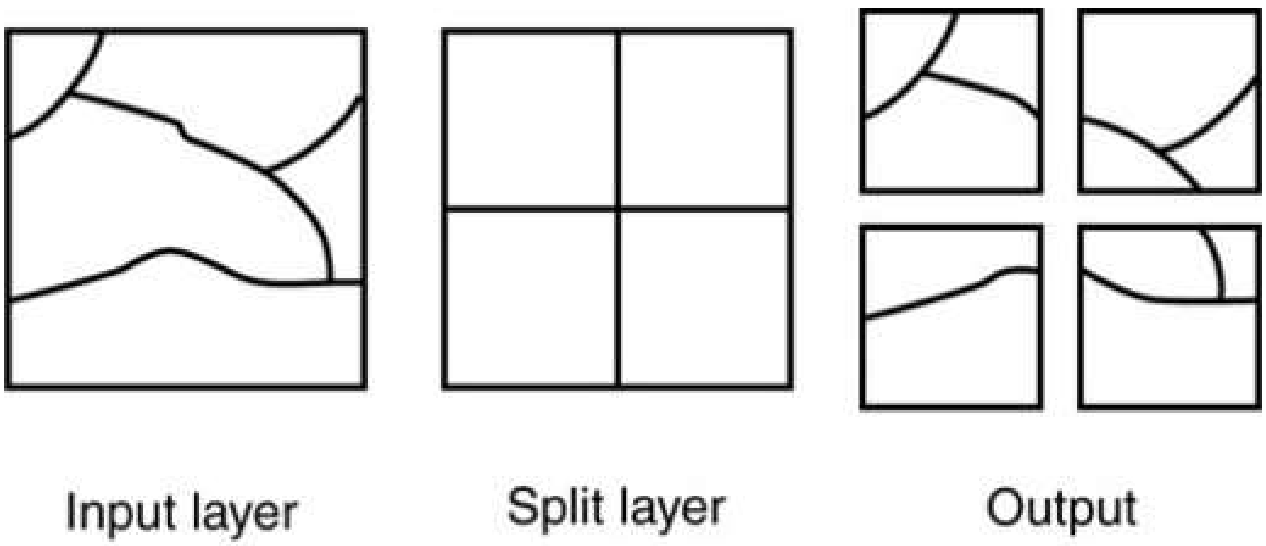


Figure 11.29
Split uses the geometry of the split layer to divide the input layer into four separate layers.

What is Network Analysis?

Almost everyone has needed a **type of network analysis** in their life. **For example:**

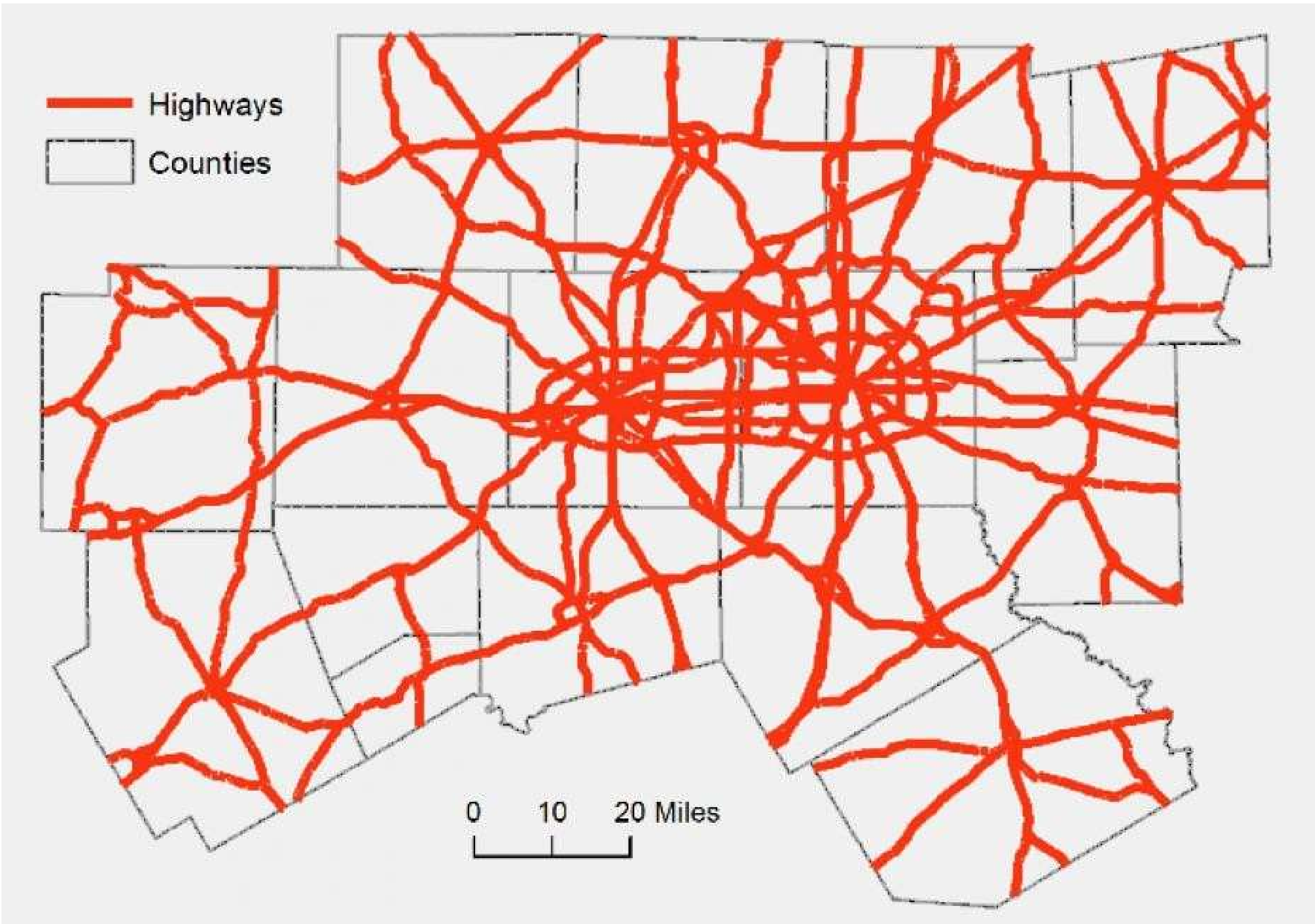
What's the shortest route to the beach?

Where should I build a hospital to best serve a community?

How can I optimize a vehicle delivery fleet?

Here are the 5 most common types of network analysis:

Network analysis is an operation in GIS which **analyses the datasets of geographic network or real world network**. Network analysis examine the properties of natural and man-made network in order to understand the behavior of flows within and around such networks and locational analysis.

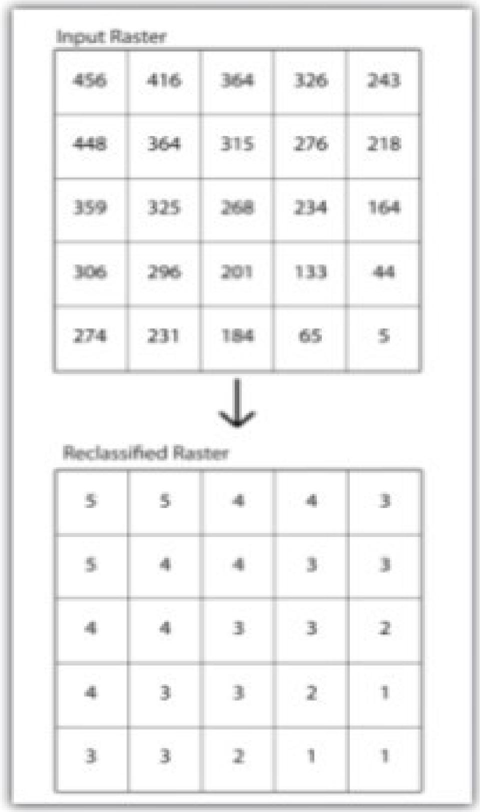

Highways
Counties
0
10
20 Miles

RASTER DATA ANALYSIS

Raster data analysis is **based on cells and rasters**. Raster data analysis can be performed at the level of individual cells, or groups of cells, or cells within an entire raster. Some raster data operations use a single raster; others use two or more rasters.

Single Layer Analysis

Reclassifying, or recoding, a dataset is commonly one of the first steps **undertaken during raster analysis.** Reclassification is basically the **single layer process of assigning a new class or range value to all pixels** in the dataset based on their original values

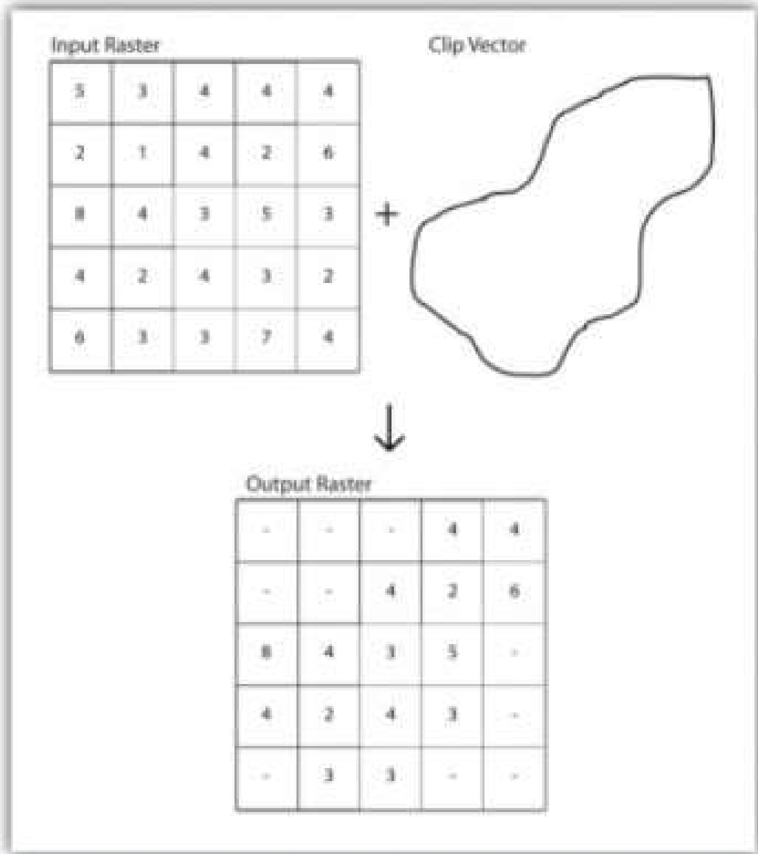


Multiple Layer Analysis

A **raster dataset can also be clipped similar to a vector Here**, the input raster is overlain by a vector polygon clip layer. The raster clip process results in a single raster that is identical to the input raster but **shares the extent of the polygon clip layer.**

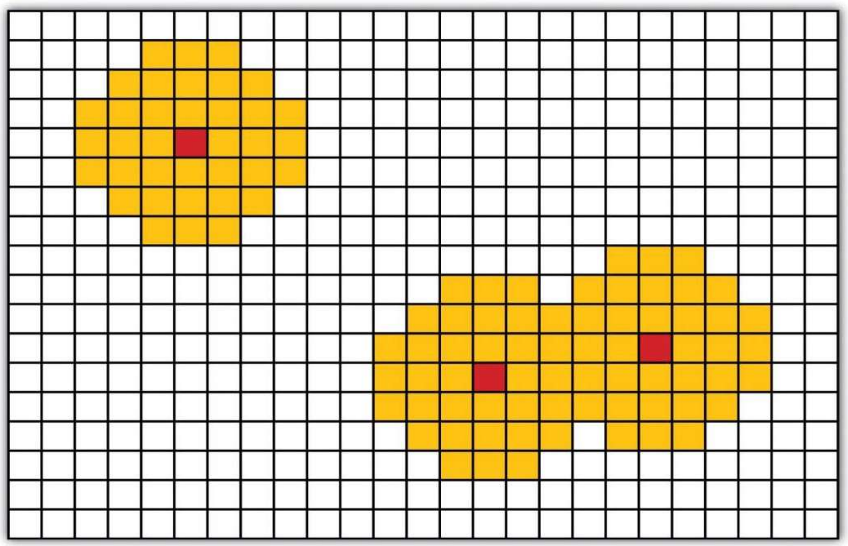
Figure 8.3 Clipping a Raster to a Vector Polygon Layer

Raster overlays are relatively simple compared to their vector counterparts and require much less computational power



Raster buffer

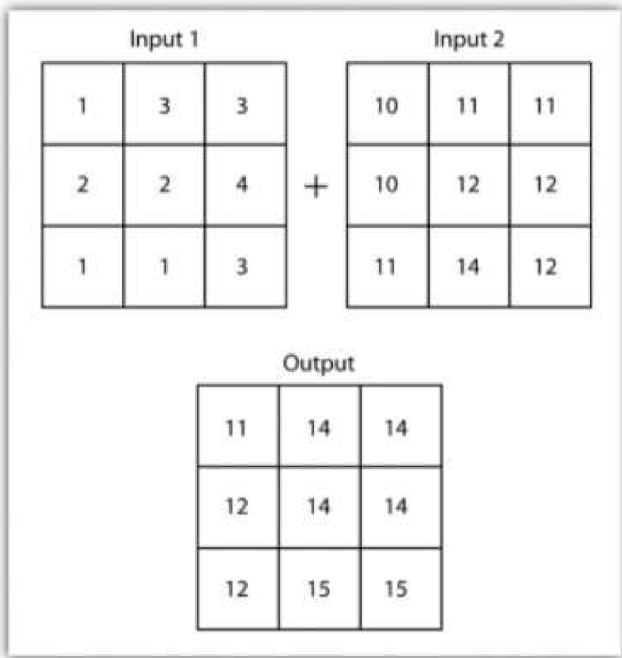
by creating a grid of **distance values from the center of the target cell(s)** to the center of the neighboring cells and then reclassifying those distances such that a **"1" represents those cells composing the original target, a "2" represents those cells within the user-defined buffer area, and a "0" represents those cells outside of the target and buffer areas.**



Raster Buffer around a Target Cell(s)

The **mathematical raster overlay** is the most common overlay method. The numbers within the aligned cells of the **input grids can undergo any user-specified mathematical transformation**. Following the calculation, an output raster is produced that contains a new value for each cell

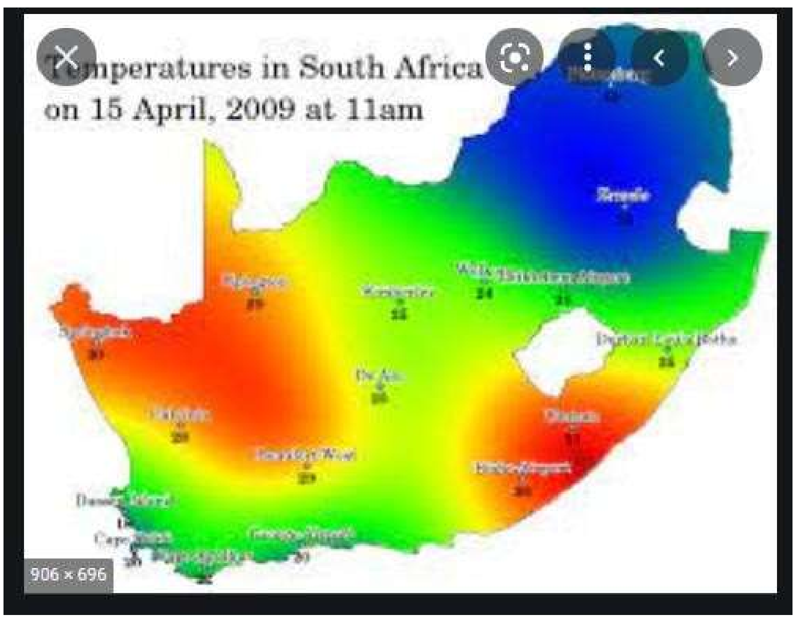
Figure 8.4 Mathematical Raster Overlay



Two input raster layers are overlain to produce an output raster with summed cell values.

SPATIAL DATA INTERPOLATION TECHNIQUES

Interpolation is the process of using points with known values or sample points to estimate values at other unknown points be used to predict unknown values for any geographic point data, such as **elevation, rainfall, chemical concentrations, noise levels, and so on.**



Spatial Interpolation

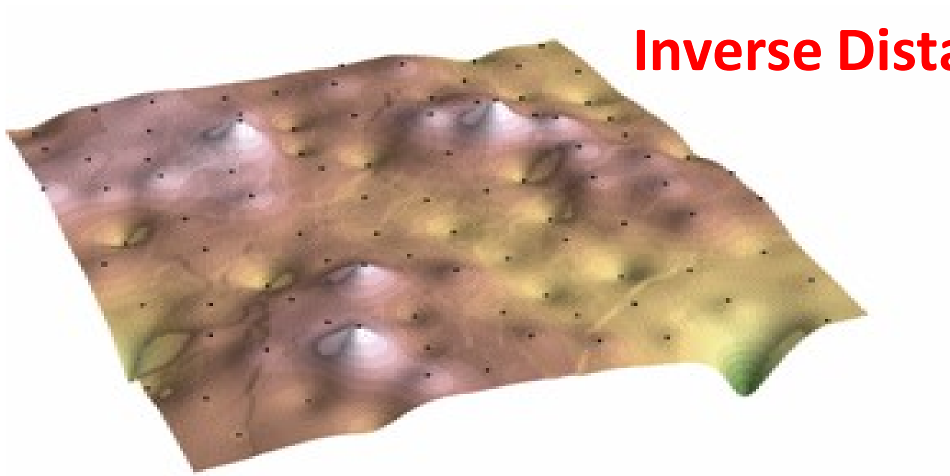
Spatial interpolation is the process of using points with known values to estimate values at other unknown points. For example, to make a precipitation (rainfall) map for your country, you will not find enough evenly spread weather stations to cover the entire region.

Spatial interpolation can estimate the temperatures at locations without recorded data by using known temperature readings at nearby weather stations.

This type of interpolated surface is often called a statistical surface. **Elevation data, precipitation, snow accumulation, water table and population density are other types of data that can be computed using interpolation.**

Interpolation uses vector points with known values to estimate values at unknown locations to create a raster surface covering an entire area. The interpolation result is typically a raster layer.

The Inverse Distance Weighting interpolator assumes that each input point has a local influence that diminishes with distance. It weights the points closer to the processing cell greater than those further away. **A specified number of points, or all points within a specified radius can be used to determine the output value of each location**. Use of this method assumes the variable being mapped **decreases in influence with distance from its sampled location.**



Inverse Distance Weighted (IDW)

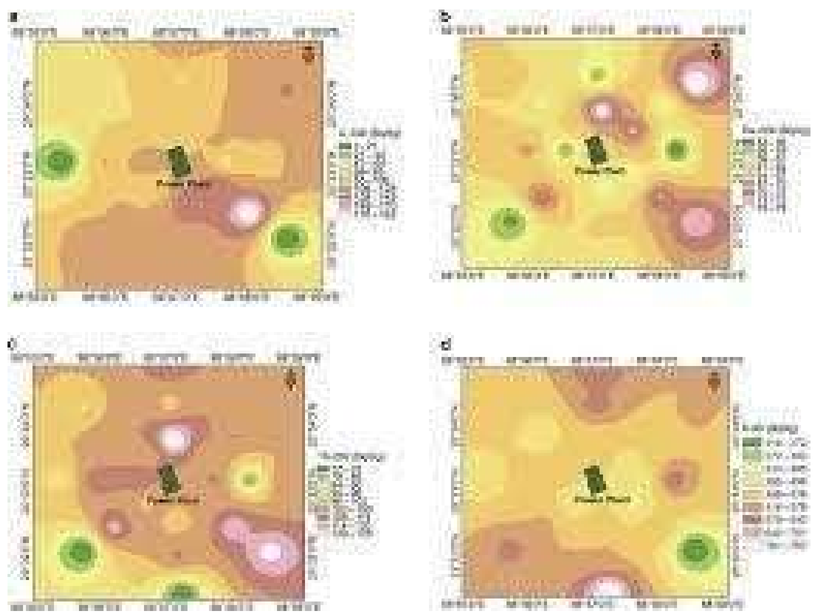
IDW Interpolated Surface; Courtesy:ESRI

IDW assumes that each measured point has a local influence that diminishes with distance. **The IDW function should be used when the set of points is dense enough to capture the extent of local surface variation needed for analysis. IDW determines cell values using a linear-weighted combination set of sample points. It weights the points closer to the prediction location greater than those farther away, hence the name inverse distance weighted.**

Natural Neighbor Inverse Distance Weighted (NNIDW)

Natural neighbor interpolation has many positive features, can be used for both **interpolation and extrapolation**, and generally **works well with clustered scatter points.** This method can efficiently handle large input point datasets. When using the Natural Neighbor method, local coordinates define the amount of influence any scatter point will have on output cells.

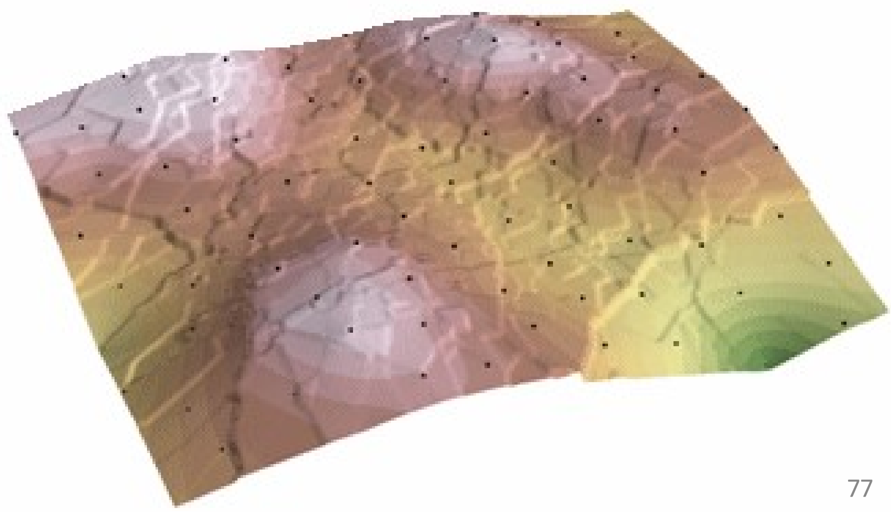
The Natural Neighbor method is a geometric estimation technique that uses natural neighborhood regions generated around each point in the data set.



Kriging

Kriging is a geostatistical interpolation technique that considers **both the distance and the degree of variation between known data points** when estimating values in unknown areas. **A kriged estimate is a weighted linear combination of the known sample values around the point to be estimated.**

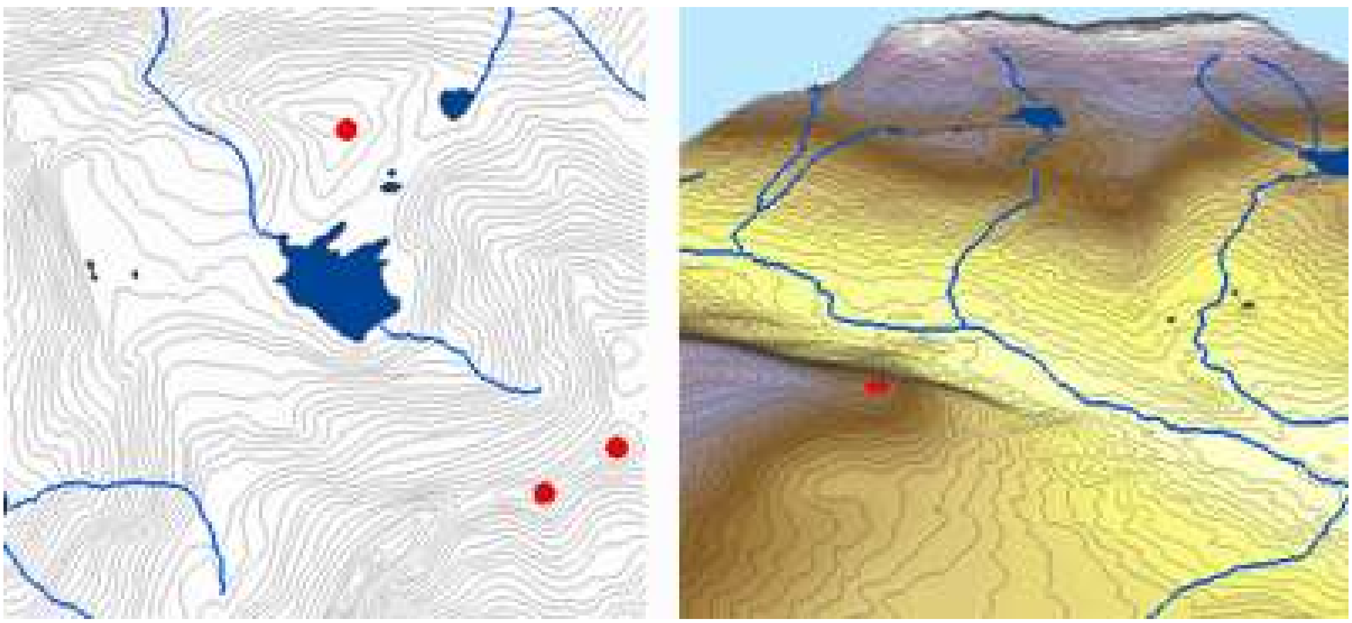
Kriging



Topo to Raster

By **interpolating elevation values for a raster, the Topo to Raster method imposes constraints that ensure a hydrological correct digital elevation model**

It was specifically designed to work intelligently with contour inputs. Below is an example of a surface interpolated from elevation points, contour lines, stream lines, and lake polygons using Topo to Raster interpolation



Topo to raster

UNIT IV
SPATIAL DATA INPUT AND EDITING

INTRODUCTION

spatial database management system (SDBMS) is an extension, of a conventional database management system (DBMS).

Basic data types such as integers and/or real numbers are extended into spatial data types **such as points, polylines and polygons** in spatial data structures. Operations constitute capabilities that manipulate the data structures, and as such when sequenced into operational workflows in **specific ways generate information from data;** one might say that new relationships constitute the information from data. Different data model designs result in different combinations of structures, operations, and rules, which combine into various SDBMS products.

Spatial database management systems, **both software and hardware sub-components**, organize data for **enumerating and querying databases**, **conducting spatial analysis, and creating map visualizations** within an integrated manner for managing large data stores

Database management is a subset of a larger category of technology called data management technology.

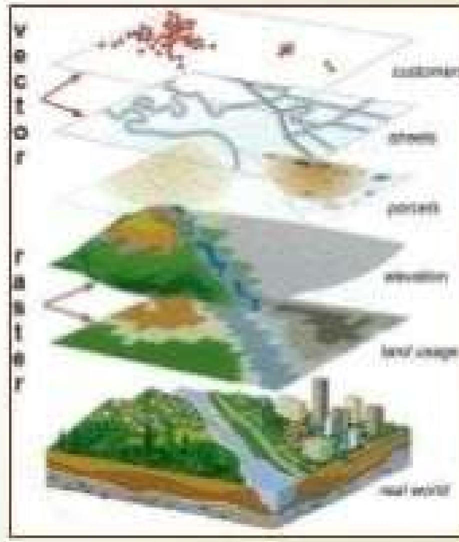
Data are managed using two types of computer-based files, **physical files and logical files.**

A physical file is a collection of records managed by the operating system software as stored on disk; a data file being different than a database file.

A **logical file is a collection of records managed by application software**, most fundamentally database management system software. **Many logical files can be combined into a physical file.**

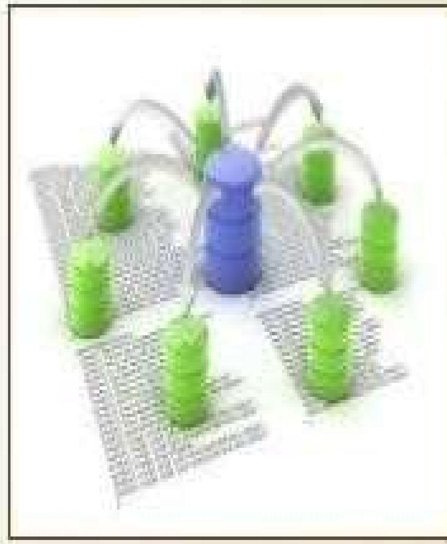
DATA

- Collection of some observations.
- In simple words, data can be facts related to any object inconsideration.
- For example your name, age, height, mobile numbers, etc.
- Data are mainly of two types:
  - Spatial data
  - Non-spatial or attribute data



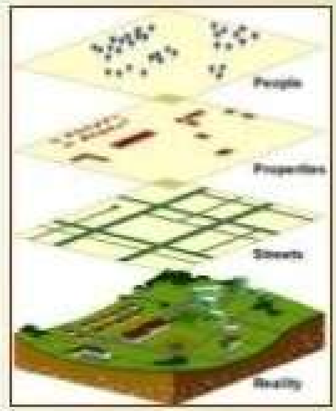
DATABASE

- A collection of related data with an implicit meaning.
- We use database in our day-to-day life.
- Consider the names, telephone numbers and addresses of the people you know.
- We may record this data in an indexed address book, using a personal computer and software such as FoxPro, Excel, and Access etc.
- A database is a repository capable of storing large amounts of data.



SPATIAL DATABASE

- Spatial databases are a specific type of database.
- They store representations of geographic phenomena in the real world to be used in a GIS.
- They are special in the sense that they use other techniques than tables to store these representations. This is because it is not easy to represent geographic phenomena using tables
- A spatial database focuses on the functions we listed above for databases in general: concurrency, storage, integrity, and querying especially.



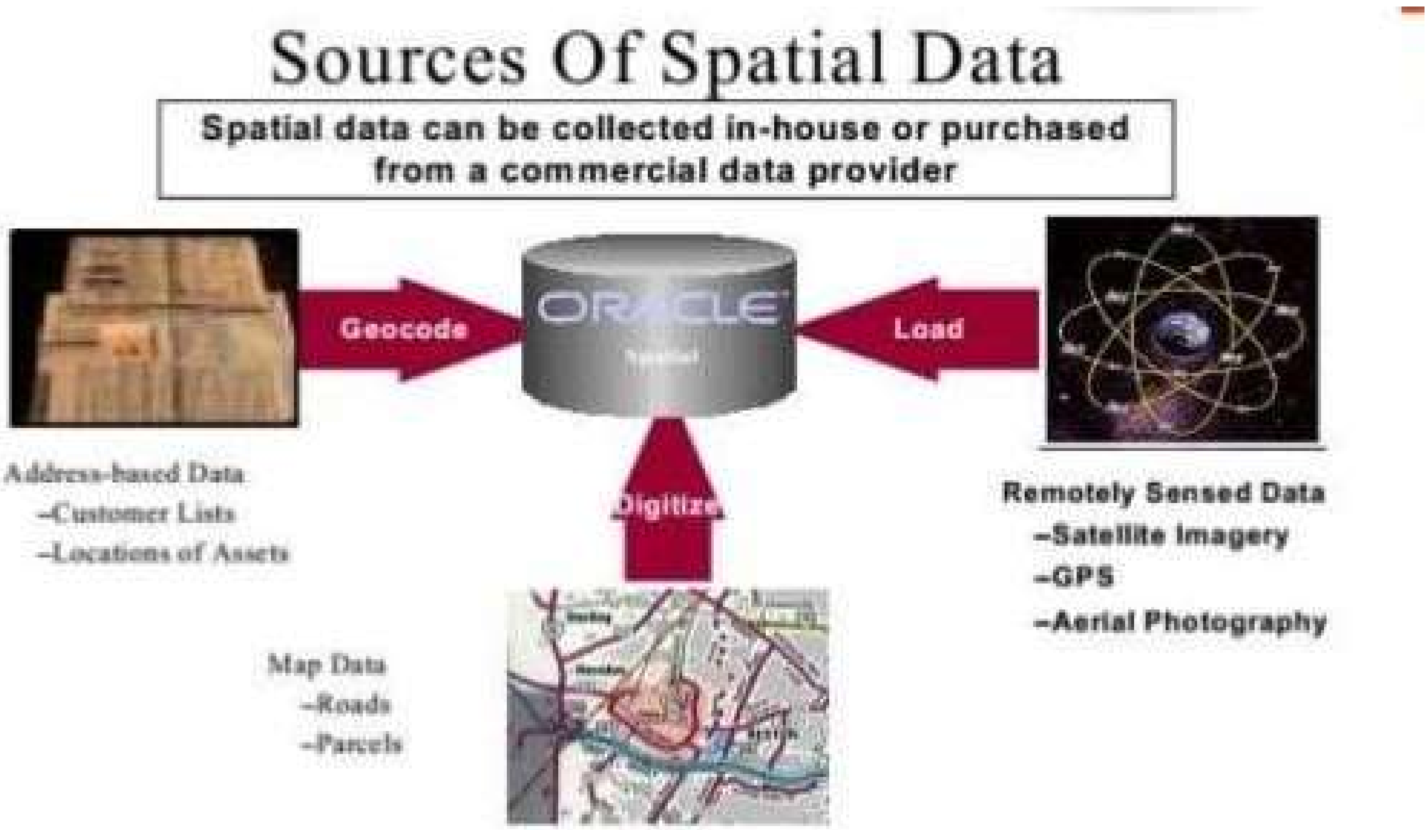


Figure Spatial Data Comes from Many Sources

DATA STORAGE IN GIS

The different types of information required for a GIS require storage which allows the information to be updated and queried for analysis by the user. There are two types of information to be stored; spatial data and attribute data. **Spatial data: Spatial data is usually stored as themes, layers, or coverage's.**

DATA STORAGE, RETRIEVAL, AND MANAGEMENT:

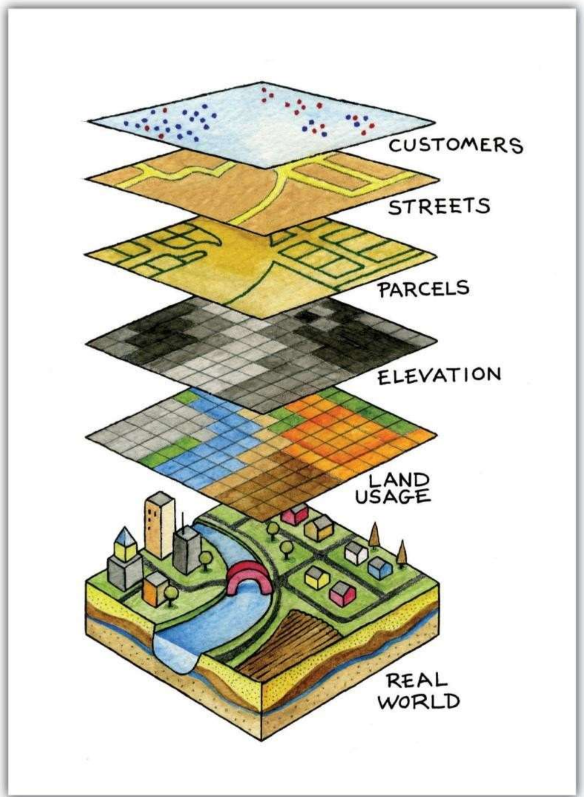
The different types of information required for a GIS require storage which allows the information to be updated and queried for analysis by the user.
There are two types of information to be stored; **spatial data and attribute data.**

Spatial data: Spatial data is usually stored as **themes, layers, or coverage**. The georeferenced spatial data is displayed in a GIS in its proper place in relation to other spatial data because of the georeference information attached to the data. An example could be the latitude and longitude in decimal degrees.

The latitude and longitude of this school is embedded in the file so it will be displayed in a GIS in its proper location in relation to other features in the city. Themes can be anything that are currently located on a traditional paper map, such as roads, rivers, cities, wells, forest boundaries, school district boundaries, etc., and they are all georeferenced.

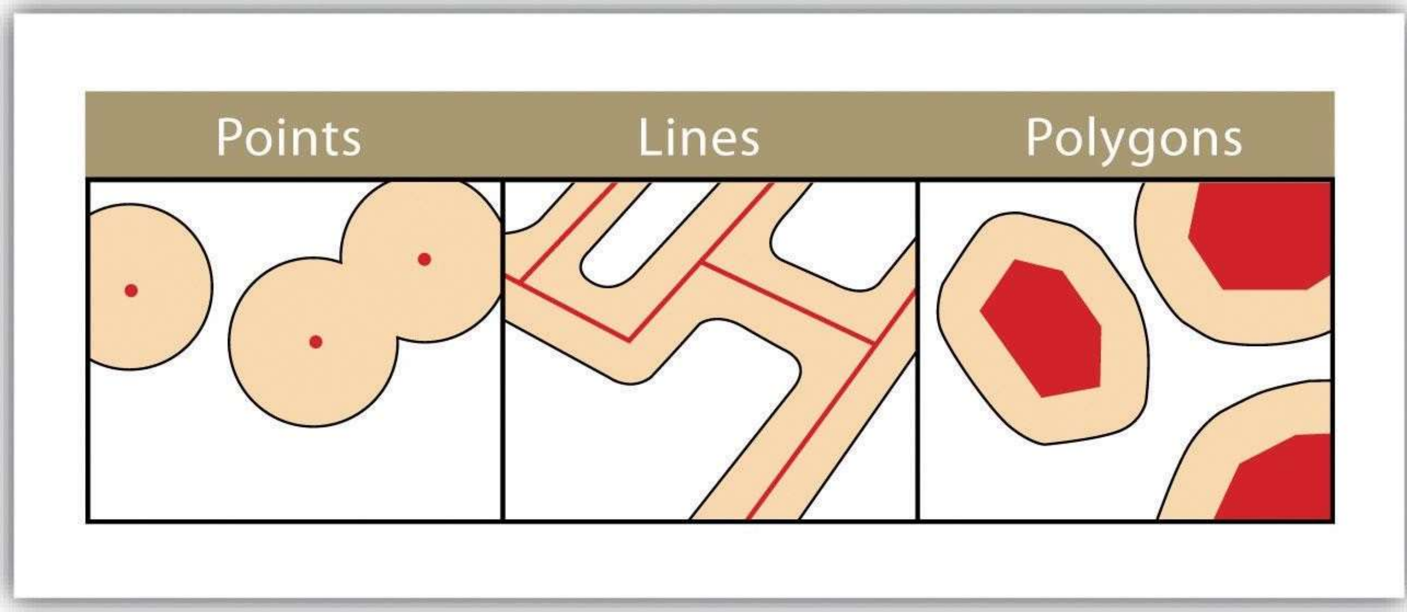
Attribute data: Attribute data is the information about an object or feature. An example could be our school. Its name, location, what district, how many children attend each year, etc.

Data manipulation and analysis: A good system and/or software package allows the user to define and execute spatial and attribute procedures. This is commonly thought of as the heart of the GIS. **Overlaying, buffering, modeling**, and analysis are some of the methods used in building a coverage or project. It also takes the users knowledge to recognize what is seen in the resulting map and data.



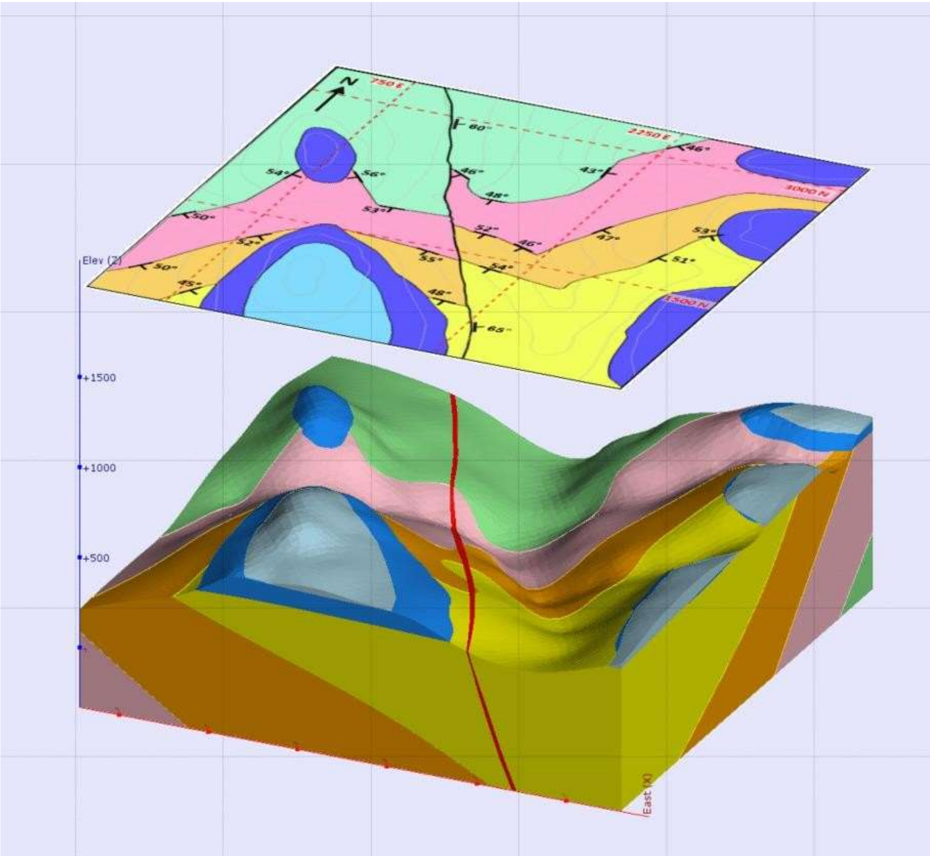
OVERLAYING

Overlay is a GIS operation that **superimposes multiple data sets** (representing different themes) together for the purpose of identifying relationships between them.. An overlay creates a composite map by combining the geometry and attributes of the input data sets.



Buffering

In GIS, a buffer is **a zone that is drawn around any point, line, or polygon that encompasses all of the area within a specified distance of the feature**. This zone is drawn by a GIS in the form of a new polygon. ... Buffers may be used for both raster and vector data model



A **digital elevation model** (DEM) is a digital representation of ground surface topography or terrain. It is also widely known as a digital terrain model (DTM). While the term can be used for any representation of terrain as GIS data, it is generally restricted to the use of a raster grid of elevation values.

Data output: Usually this is a map or graphic, which the user has generated after analyzing the data. Tabular data and reports can be generated as well to help explain the details seen in the map or graphic.

STORAGE MEDIA

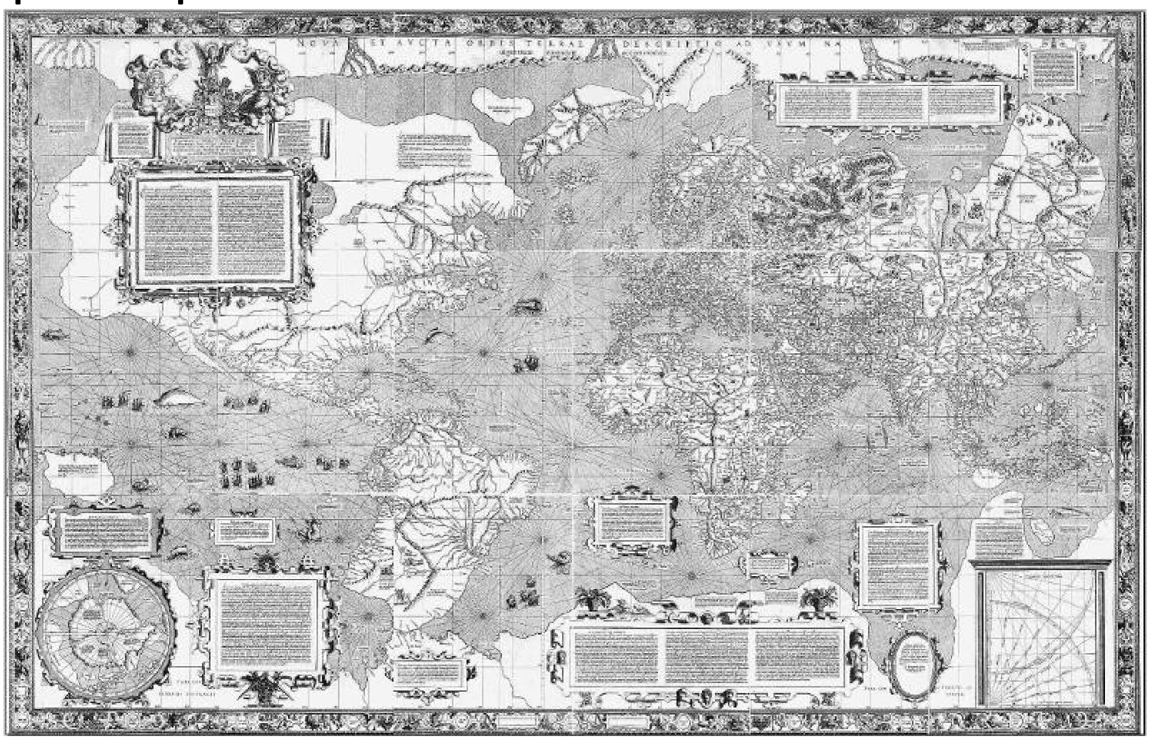
Digital data is stored on a variety of physical media, depending on how quickly the data needs to be accessed, how much data needs to be stored, and whether the data needs to continue to exist when the digital device is turned off or rebooted.

Random access memory (RAM)
Magnetic hard disks
Flash memory
Magnetic floppy disks
Magnetic tape

Storage Formats

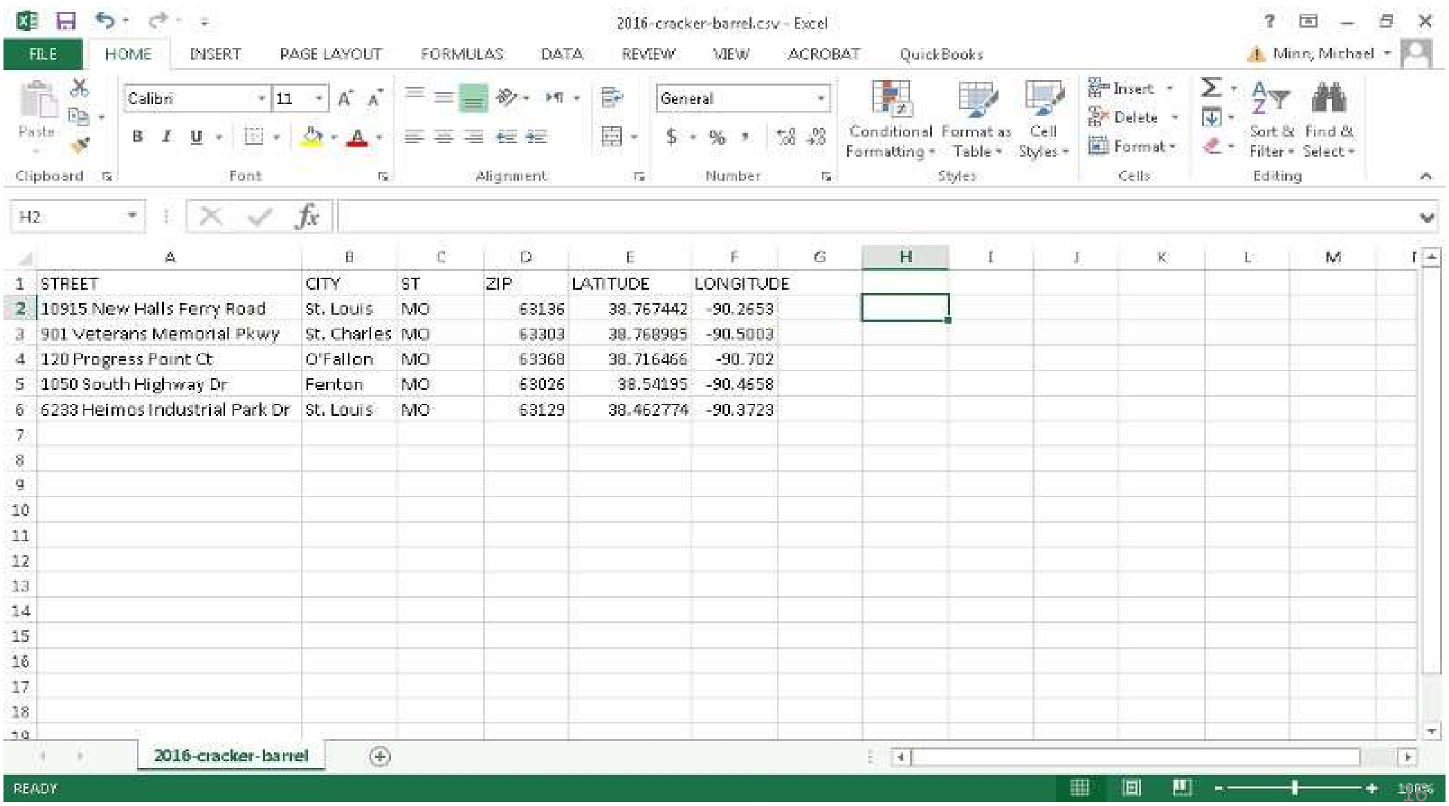
Geospatial data can be stored in a number of different types of digital files on the physical media described above. The following are file types you will commonly encounter when performing basic GIS

Graphical Maps



CSV

Geospatial data can be stored in simple table formats like **comma-separate variable (CSV)** files as columns of latitude and longitude associated on each row with specific attributes at those latitudes and longitudes. However, this is largely limited to points, rather than areas.

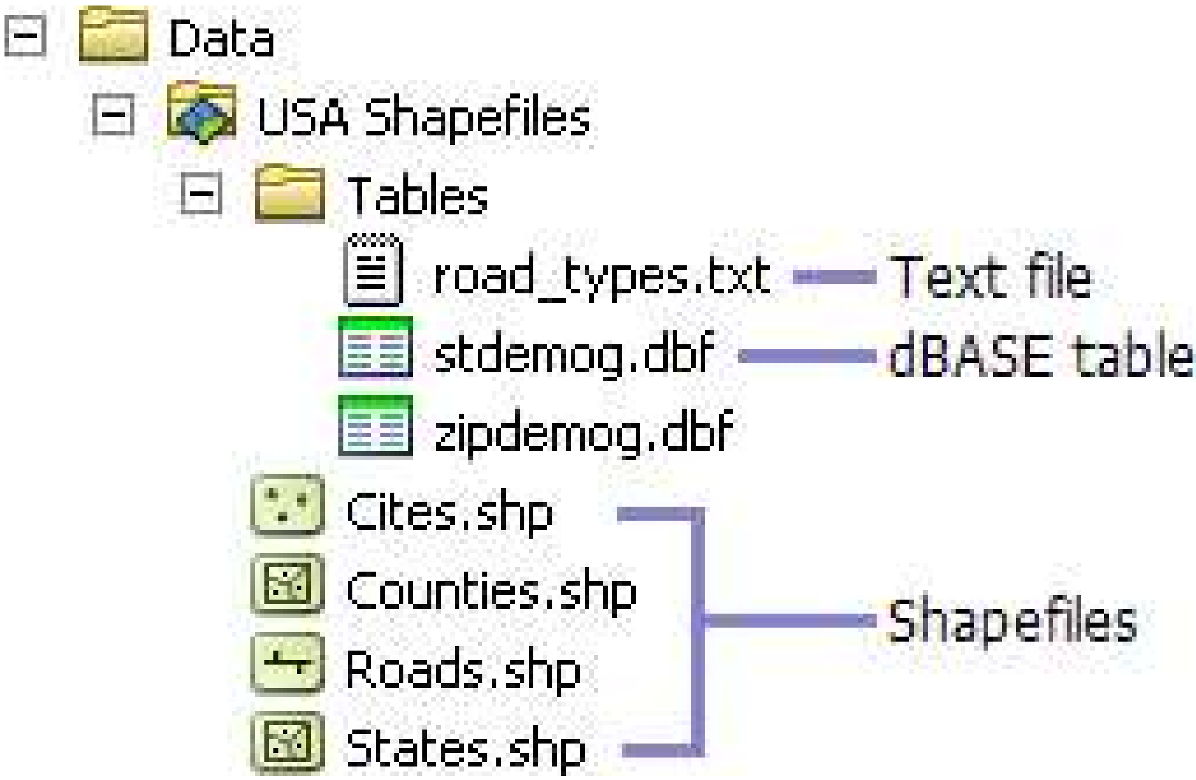


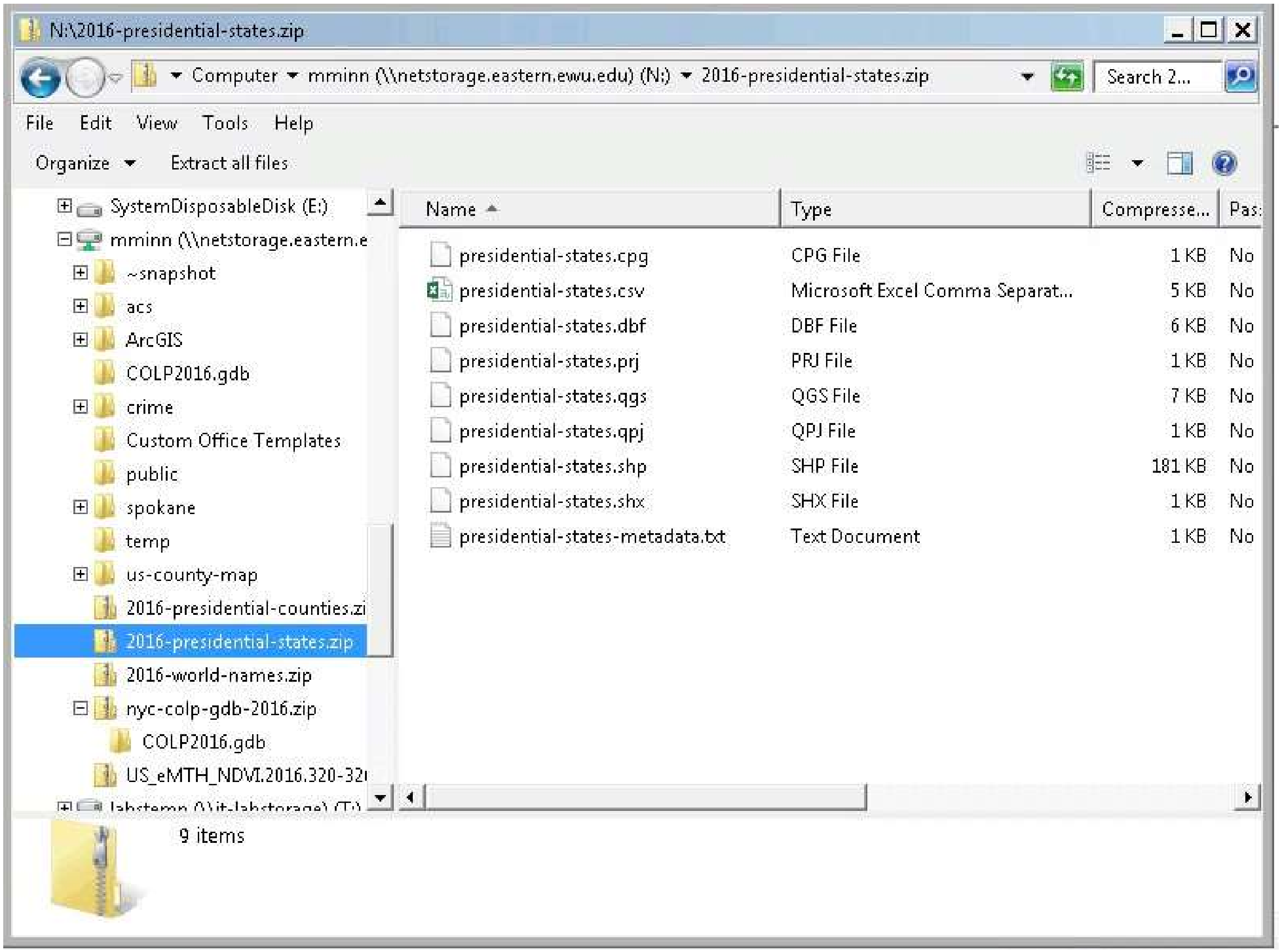
	A	B	C	D	E	F
1	STREET	CITY	ST	ZIP	LATITUDE	LONGITUDE
2	10915 New Halls Ferry Road	St. Louis	MO	63136	38.767442	-90.2653
3	901 Veterans Memorial Pkwy	St. Charles	MO	63303	38.768985	-90.5003
4	120 Progress Point Ct	O'Fallon	MO	63368	38.716466	-90.702
5	1050 South Highway Dr	Fenton	MO	63026	38.54195	-90.4658
6	6233 Heimos Industrial Park Dr	St. Louis	MO	63129	38.462774	-90.3723

Shape files

The shape file is actually a collection of at least three (and usually more) separate files that store the location data, the characteristics associated with those locations, and other information about the data. Some common files associated with a shape file include (listed by the file extension):

.shp: Contains the feature geometry (points, lines, polygons)
.shx: An index file that indicates where specific features are in the .shp file
.dbf: A dBase IV database file of attributes associated with each of the shapes in the .shp file
.prj: The coordinate system and projection used by the feature geometry (optional)
.cpg: The character encoding used by the attributes (optional)
.qpj: The coordinate system and projection in a format used by QGIS (optional)

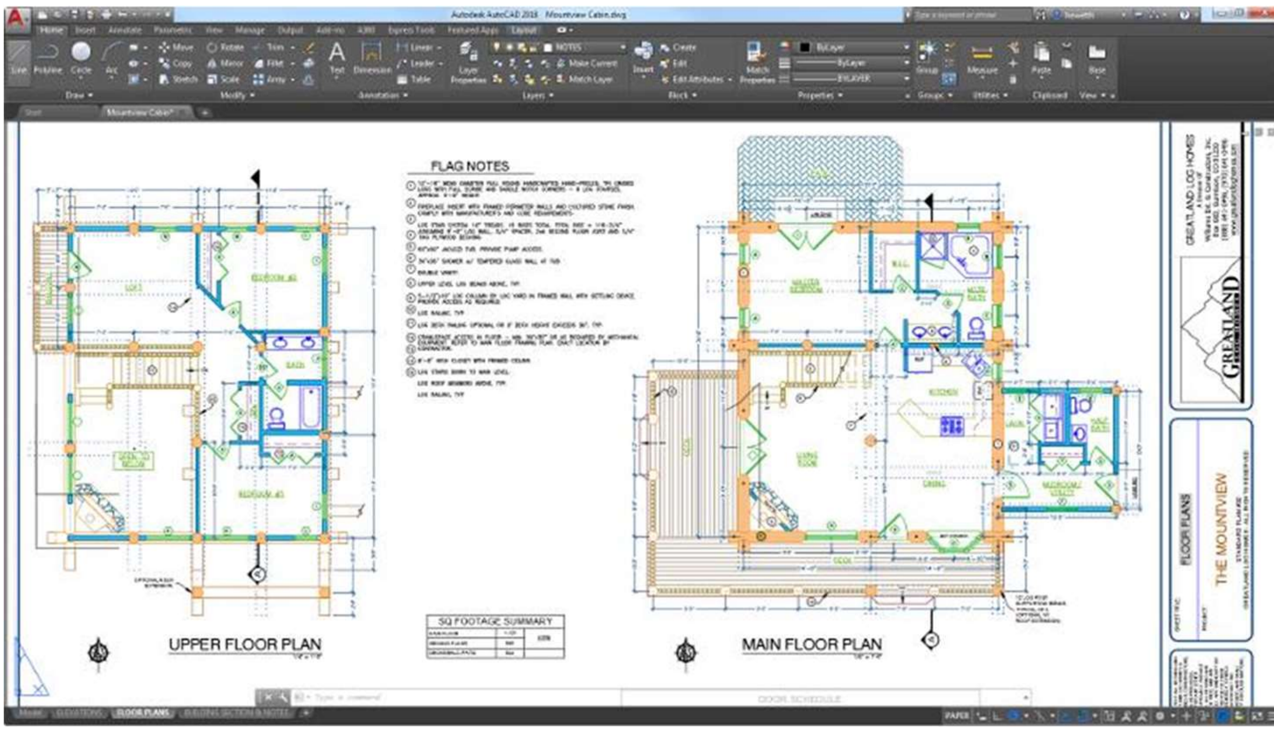

Data
USA Shapefiles
Tables
road_types.txt
Text file
stdemog.dbf
dBASE table
zipdemog.dbf
Cites.shp
Counties.shp
Roads.shp
States.shp
Shapefiles



shpefile created in GIS Software

AutoCAD

You occasionally may see geospatial data stored in the files used by the engineering drafting program **AutoCAD**. However, AutoCAD is a general use drafting program for objects of all sizes and the proprietary file format often does not contain adequate coordinate or attribute information to allow data to be transferred directly into GIS software.



A database model shows **the logical structure of a database**, including the relationships and constraints that determine how data can be stored and accessed. Individual database models are designed based on the rules and concepts of whichever broader data model the designers adopt.

DATA BASE MANAGEMENT SYSTEM

Management of GIS data consists of storing a variety of data categorized under two types, **entity (spatial data) and attribute (aspatial) data** in a way that permits us to retrieve or display any combinations of these data after analysis and manipulation.

In order to perform these operations, the computer is able to store, locate, retrieve, analyze and manipulate the raw data derived from a number of sources by using representational file structures. In other words, each graphical identity must be stored explicitly, along with its attributes, so that, we can retrieve and select the correct combinations of entities and attributes in a reasonable time. **GIS database comprise spatial or entity or graphical database**, nonspatial or attribute database, and a linkage mechanism for their topology, to show the relationship between the spatial data and attribute data for further analysis.

An entity (either a point, or a line, or an area) has both spatial and attribute data to describe it. Spatial data can be known as " where the things are" and attribute data the 'what things are'

For example, a point entity, the Charminar, a monument in Hyderabad, has the reference in terms of a latitude and longitude, and to accompany this there would be an **attribute data** about the nature of Remote Sensing and GIS the real world -feature that the point represents. More clearly, in this example, **Entity type is the point Spatial data are longitude and latitude Attribute data is the monument, Charminar.** Nonspatial (attribute) data can be stored in any conventional databases, whereas spatial data, which is the dominant data in GIS, should have the database' which is capable of handling spatial data.

Data Base Management Systems

DBMS as a computer program to control the storage, retrieval and modification of data (in a database). Stern and Stern (1993) consider that a DBMS will allow users to join, manipulate or otherwise access the data in any number of database files. A DBMS must allow the definition of data and their attributes and relationships, as well as providing security, and an interface between the end users and their applications and the data themselves.

THE FUNCTIONS OF A DBMS CAN BE

(i) File handling and file management (for creating, modifying, or deleting the database structure),

(ii) adding, updating, and deleting records,

(iii) the extraction of information from data,

(iv) maintenance of data security and integrity, and

(v) application building.

A database management system is the software that permits the users to work efficiently with the data. The essential functions of the system must provide the means to define the **contents of a database, insert new data, delete old data, ask about the database contents,** and modify the contents of the database, **updating of data, minimization of redundancy, and physical data independence, security and integrity.**

Components of DBMS

Tile interaction with database systems is to perform the following broad types of tasks :

(a) Data definition

(b) Storage definition

(c) Database administration, and

(d) Data manipulation

The first three tasks are most likely to be performed by the database professional, while the fourth will be required by a variety of user types possessing a range of skills and experience as well as variable needs or requirements in terms of frequency and flexibility of access

To retrieve the required data from the database, mapping must be made between the high-level objects in the query language statement and the physical location of the data on the storage device. These mappings are made using the system- catalogue. Access to DBMS data is handled by the stored data manager, which is called the operating system for control of physical access to storage devices. The DBMS has a query complier which may call the query optimizer to optimize the code, so that the performance on the retrieval is improved. The logical item of interaction with a database is the transaction, which broadly means to create, modify and delete.

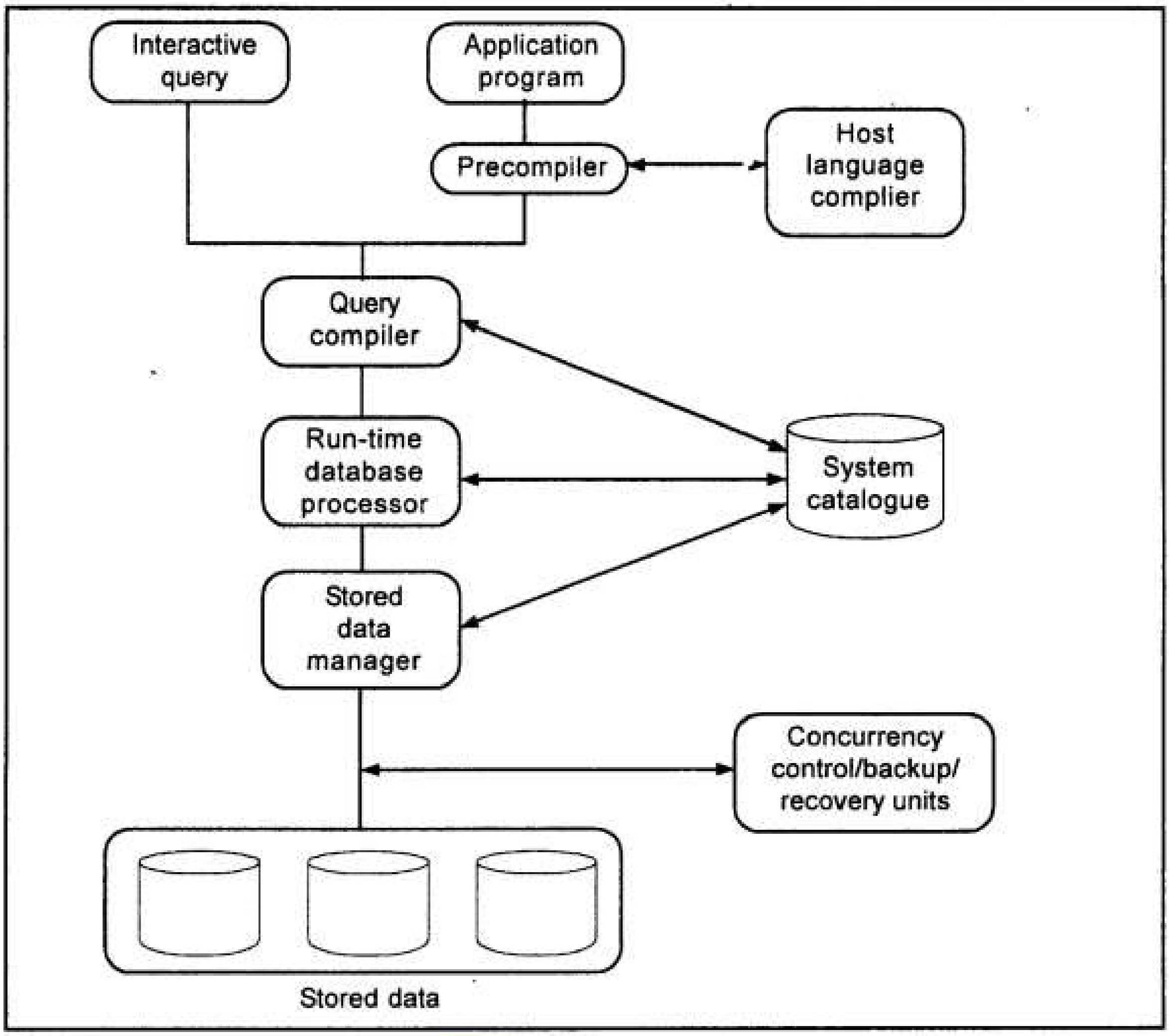


Fig. 9.1 Schematic diagram of DBMS components used to queries.

ENTITY-RELATIONSHIP-ATTRIBUTE MODEL

A entity may be any object, class, person or place.

The primary components of an object-based model are its objects or entities. The entity-relationship attribute (ERA) model and the object-oriented models are the two main object-based modeling approaches.

An entity is a semantic data modeling construct and is something that has an independent and uniquely identifiable existence in the application domain.

Entities are describable by means of their attributes (for example, the name, boundary, and population of a district). Entities have explicit relationships with other entities. Entities are grouped into **entity types, where entities of the same type have the same attribute and relationship structure.** An ERA diagram representing the structure of these data in the example database. Entity types are represented by rectangles with offshoot attributes and connecting edges showing relationships.

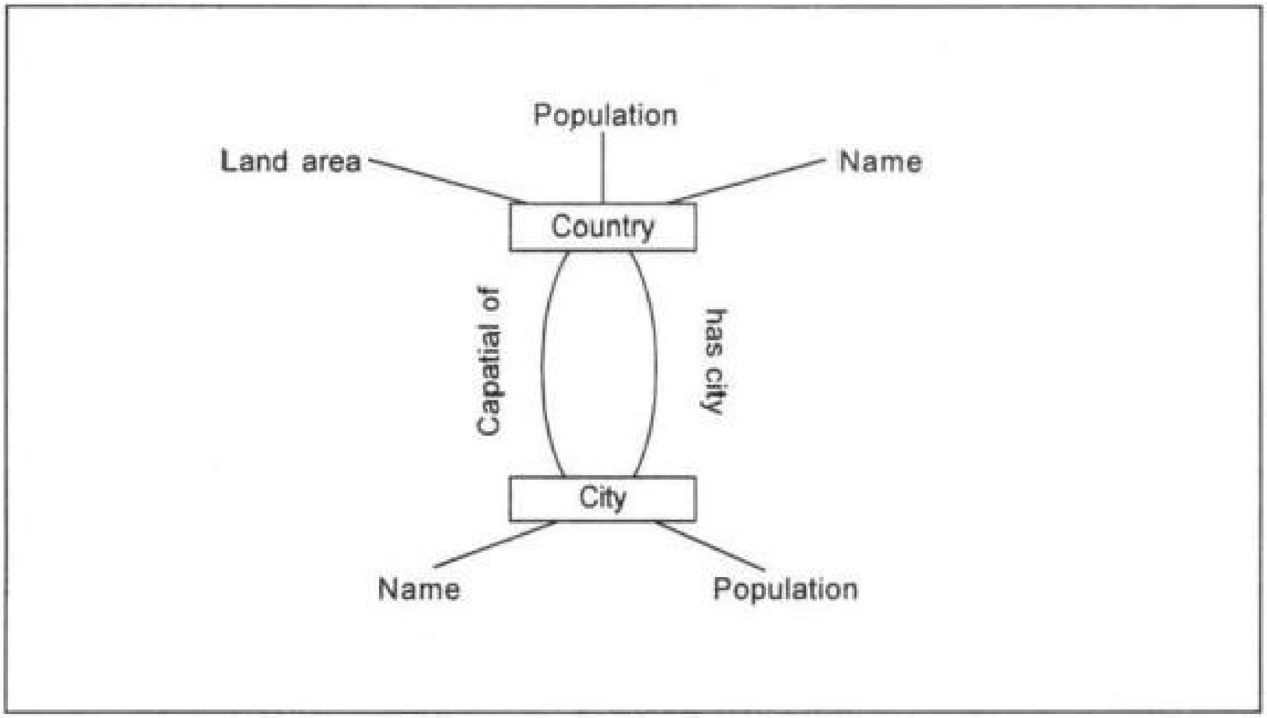


Fig. 9.9 Example of an ERA diagram.

GIS DATA MODELS

The construction of models of spatial form can be taken as a series of stages of data abstraction. By applying this abstraction process the GIS designer moves from the position of observing the geographical complexities of the real world to one of simulating them in the computer.

This process involves,

i) **Identifying the spatial features from the real world that are of interest in the context of an application**. (**ii) Representing the conceptual model by an appropriate spatial data model. This involves choosing between one of the two approaches: raster or vector. (iii) Selecting an appropriate spatial data structure to store the model within the computer**. The spatial data structure is the physical way in which entities are coded for the purpose of storage and manipulation.

i) **GIS data model at each stage in the model-building process, we move further away from the physical representation of a feature in reality and closer to its abstract representation in the computer. T**he definition of entities and graphical representation of the surface features in the computers are considered along with the different spatial data models and structures available. **The modeling of more complex features and the difficulties of including the third and fourth dimensions in a GIS model are also presented.**

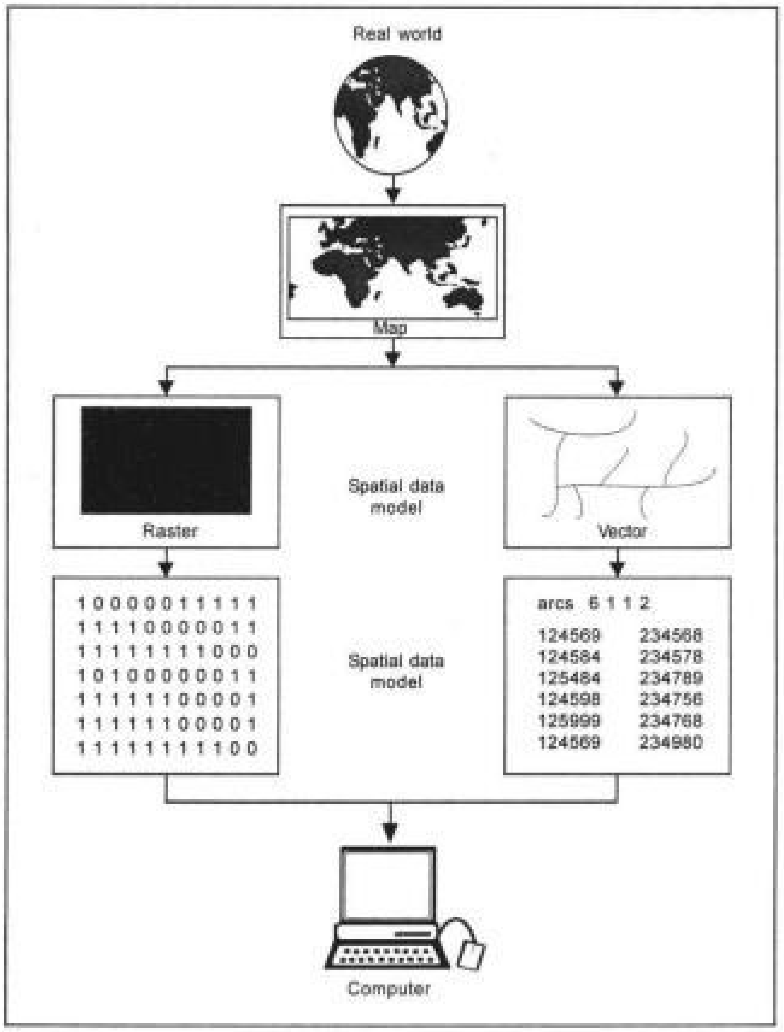


Fig. 8.1 Stages in creating a GIS model.

Raster Data Representation

In raster representation , the terrain is divided into a number of parcels or quantized the space into units. A parcel or a unit is called a grid cell. Raster data structures do not provide precise locational information because geographic space is now divided into discrete grids, as much as we divide a checkerboard into uniform squares. Instead of representing points with their absolute locations, they are represented as a single grid cell.

In grid-based or raster GIS, there are two general ways of including attribute data for each entity. The simplest is to assign a single number representing an attribute like a class of land cover, for each grid cell location. By positioning these numbers, we, ultimately, are allowing the position of the attribute value to act as the default location for the entity. **For example, if we assign a code number of 10 to represent water, then list this as the first number in the X or column direction, and the first in the Y or row direction, by default the upper left grid cell is the location of a portion of the earth representing water**

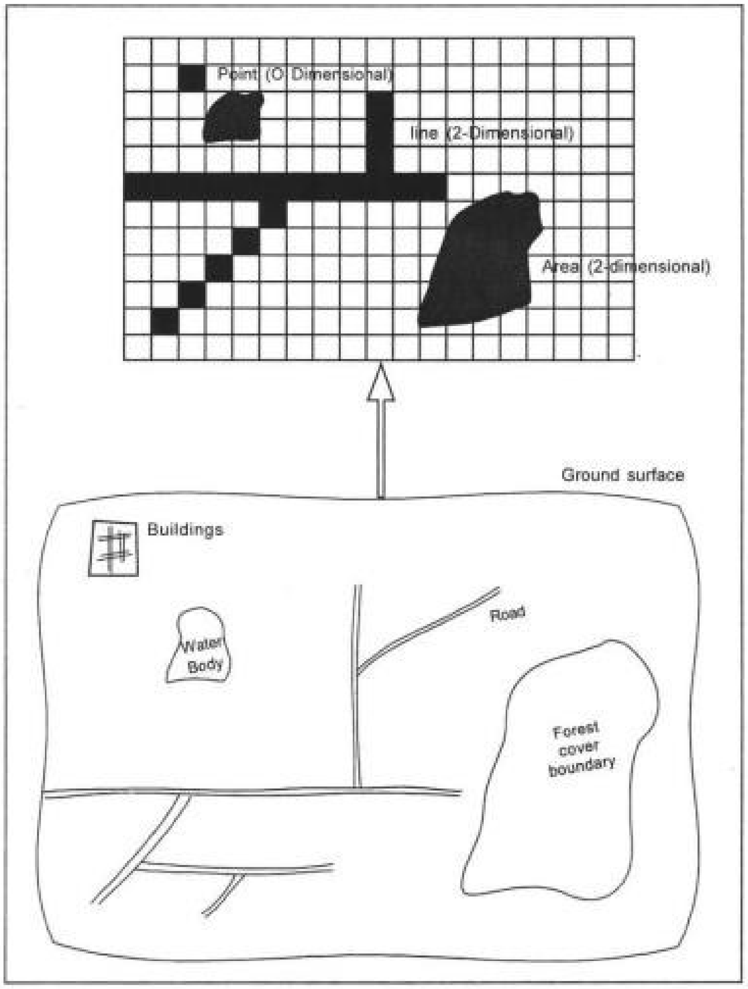


Fig. 8.3 Raster Graphic Data Representations.

Vector Data Representation

The second method of representing geographic space, called vector, allows us to give specific spatial locations explicitly. In this method it is assumed that geographic space is continuous , rather than being quantized as small discrete grids. This perspective is acquired by associating points as a single set of coordinates (X and Y) in coordinate system ,lines as connected sequences of coordinate pairs of points, and areas as sequences of interconnected lines whose first and last coordinate points are the same

Anything that has a single (X, Y) coordinate pair not physically connected to any other coordinate pair is a point (zero-dimensional) entity.

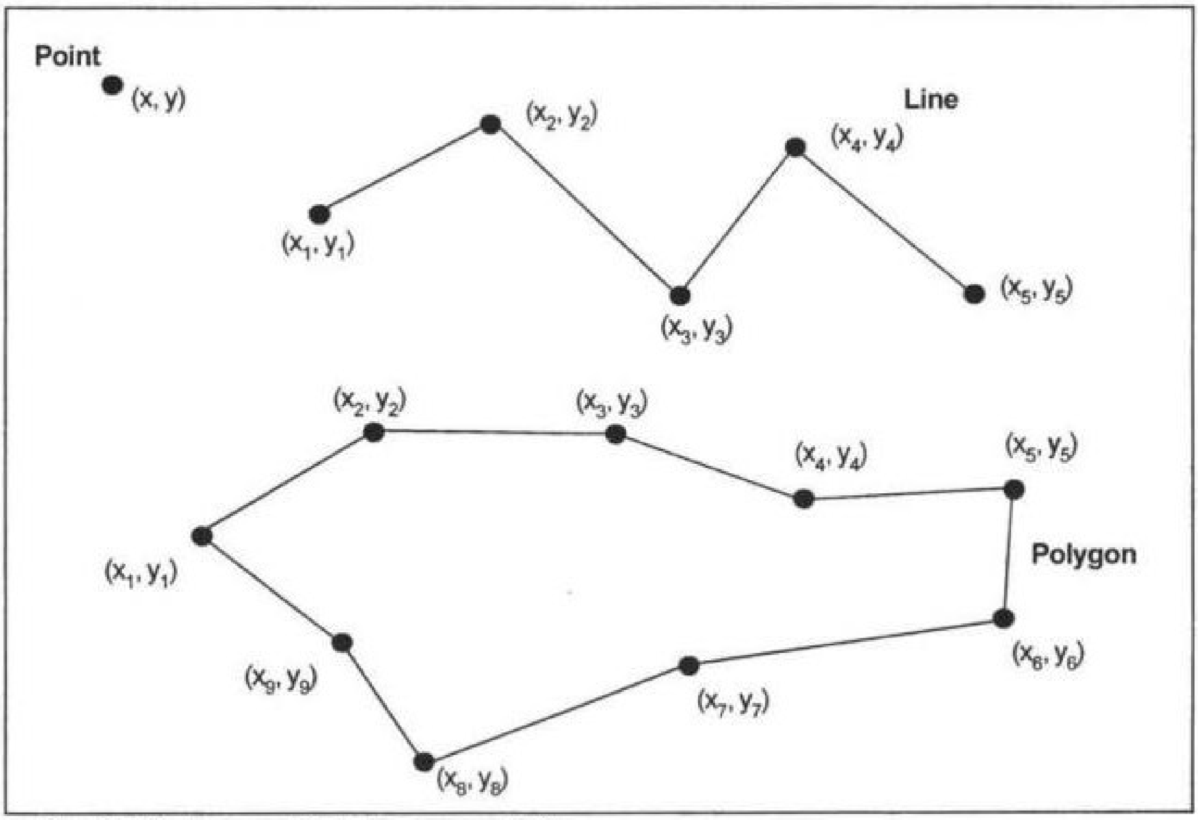


Fig. 8.5 Vector graphic data representation.

A vector spatial data model uses two-dimensional Cartesian (x, y) coordinate system to store the shape of a spatial entity. In the **vector world the point is the basic building block from which all spatial entities are constructed.** **The simplest spatial entity, the point, is represented by a single (x, y) coordinate pair. Line and area entities are constructed by connecting a series of points into chains and polygons**.

The more complex the shape of a line or area feature, the greater the number of points required to represent it. Selecting the appropriate number of points to construct an entity is one of the major problems in vector based GIS data representation.

The representation of the vector data is much more representative and generally, we combine the entity data with associated attribute data kept in a separate file through a database management system, and then link them together

In vector data structures, a line consists of two or more coordinate pairs, again storing the attributes for that line in a separate file. This is explained in the next section under vector models. For straight lines, two coordinate pairs are enough to show location and orientation in space. More complex lines will require a number of line segments, each beginning and ending with a coordinate pair.

GIS DATA MODELS AND DATA STRUCTURE

RASTER DATA MODEL

VECTOR DATA MODEL

Raster GIS Models

The simplest approach of structuring spatial data is to use grid cells to represent quantized portions of the earth which is called GRID based GIS or raster GIS. In the raster GIS, a range of different methods are used to encode a spatial entity for storage and representation in the computer.

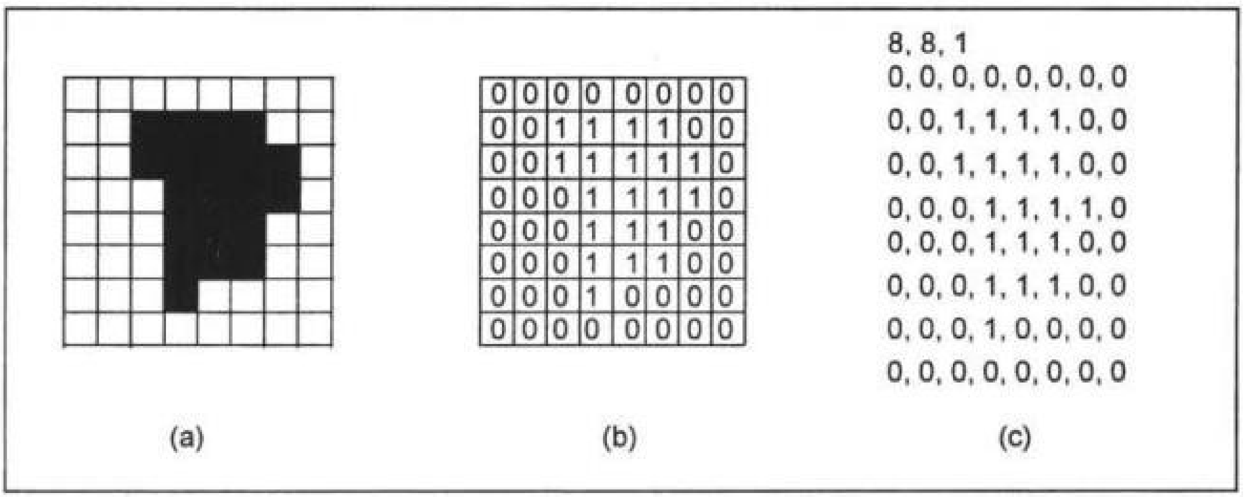


Fig. 8.6 A simple Raster Data structure (a) entity model; (b) cell values and (c) file Structure

method of coding raster data. The cells in each line of the image are mirrored by an equivalent row of numbers in the structure. The line of the file structure indicates the number of rows, the number of columns and the maximum cell value in the image.

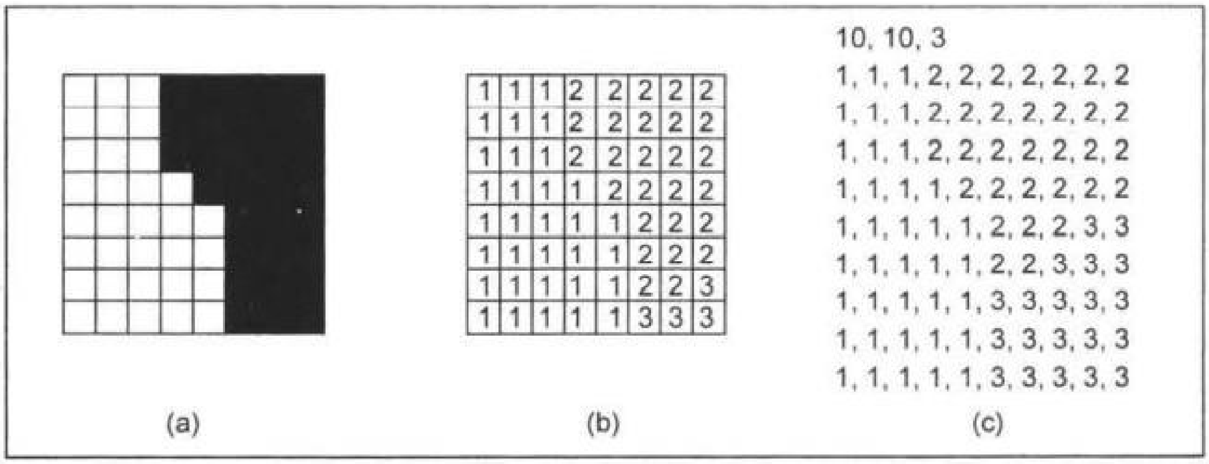


Fig. 8.7 Coding of features in Raster GIS.

Types of Raster GIS Models

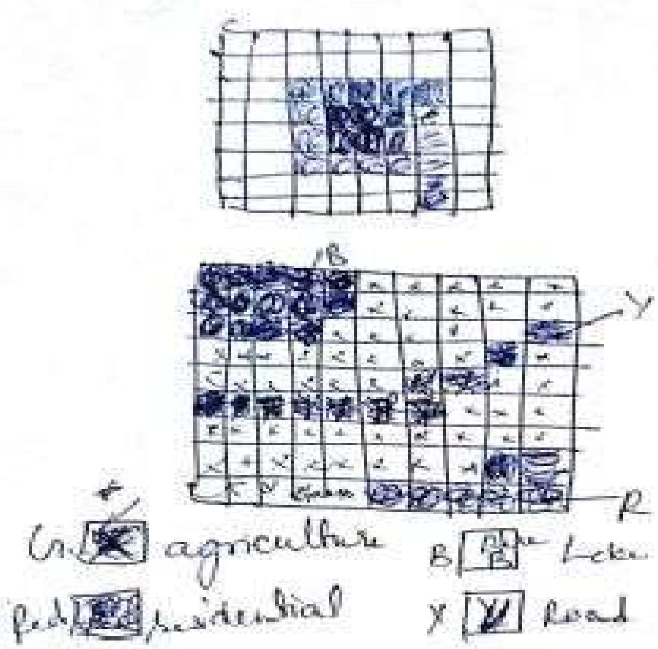
The grid based GIS spatial data can be stored, manipulated, analyzed, and referenced basically in anyone of the three methods/models. These three models (Burrough, 1983) are: **GRID/LUNAR/MAGI model, IMGRID model and MAP model.** All of these models use the grid cell values, their attributes, coverage and corresponding legends. These models are developed depending upon the requirements from time to time. **Based on the applications of interest, availability of software's and other related information, anyone of the above models can be selected for the execution of a particular GIS project.** There are a number of ways of forcing a computer to store and reference the individual grid cell values, their attributes, coverage names and legends.

GRID Model

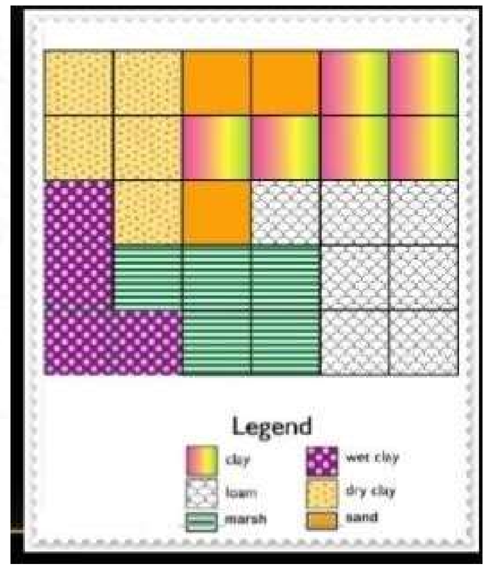
The first and foremost model for the representation of raster data is the GIRD model. The method of storing, manipulating, and analyzing the grid based data was first conceptualized by an attempt to develop GRID model.

In this method, **each grid cell is referenced and addressed individually and is associated with identically positioned grid cells in all other coverages, rather like a vertical column of grid cells, each dealing with a separate theme**. Comparisons between coverage are therefore performed on a single column at a time.

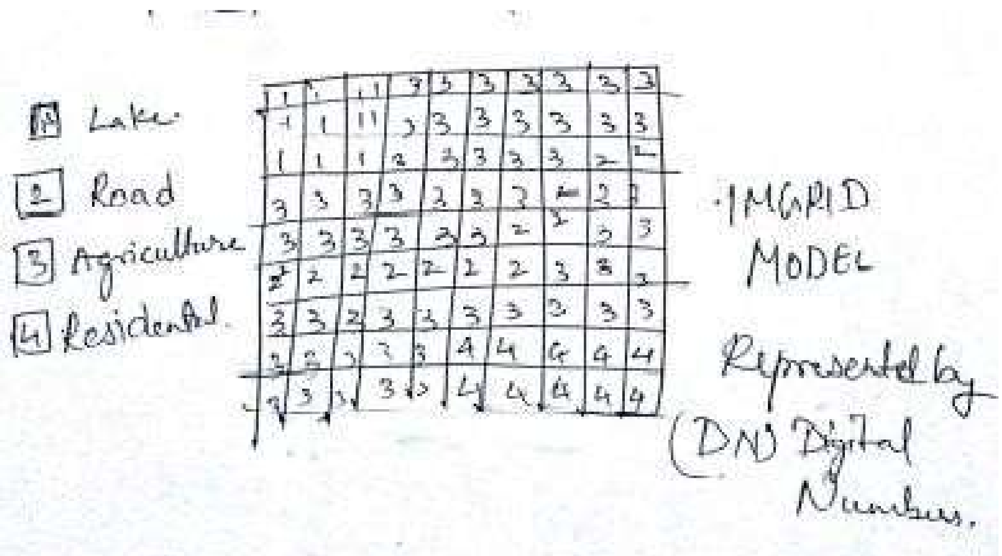
ex. For example, to compare soil attributes in one coverage with vegetation attributes in a second coverage, land use/land cover attributes in a third coverage, **each X and Y** location must be examined individually So a soil grid cell at location must be examined individually.



GRID MODEL
Represented by colors.



IMGRID Model With a slight modification of the checkerboard analog, the second basic raster data model, that is the IMGRID data model, This model is also used in the early GIS system Instead, we can use the number 1 (red squares) to represent water and 0 (black squares) to indicate the absence of water. How can we represent a thematic map of land use that contains, say four categories, namely, recreation, agriculture, industry, and residences? Each of these four attributes would have to be separated out as an individual layer. One layer would stand for agriculture only, with **1 's and O's** representing the presence or absence of this activity for each grid cell



MAP Model

The third raster GIS model Map Analysis Package (MAP) model developed by formally integrates the advantages of the above two raster data structure methods. n this data model each thematic coverage is recorded and accessed separately by map name or title. This is accomplished by recording each variable, or mapping unit, of the coverage's theme as a separate number code or label, which can be accessed individually when the coverage is retrieved.

VECTOR GIS MODELS

Vector data structures allow the representation of geographic space in an intuitive way reminiscent of the familiar analog map. The geographic space can be represented by the spatial location of items or attributes which are stored in another file for later access. shows how the **different entity, namely, points, lines, and areas can be defined by coordinate geometry.**

Like the raster spatial data model, there are many potential vector data models that can be used to store the geometric representation of entities in the computer.

A point is the simplest spatial entity that can be represented in the vector world with topology. A point requires to be topologically correct with respect to a geographical reference system which locates it with respect to other spatial entities. **To have topology a line entity must consist of an ordered set of points a locus of number points, (known as an arc, segment, or chain) with a defined start and end points (nodes).** The simplest vector data structure that can be used to reproduce a geographical image in the computer is a **file containing (x, y) coordinate pairs** that represent the location of individual point features.

Such a vector data structure for a car park near Hussain Sagar lake in Hyderabad. Now, how a closed ring of coordinate pairs defines the boundary of the polygon, is clear. The limitations of simple vector data structures start emerging when more complex spatial entities are considered.

There are two types of data model in GIS

Spaghetti Model

Topological Models

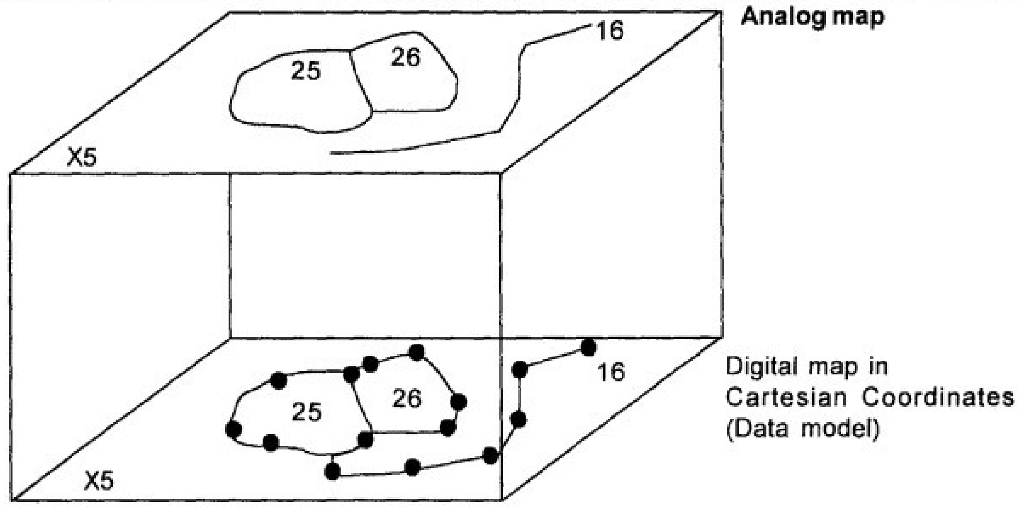
Spaghetti Model

The simplest vector data structure that can be used to reproduce a geographical image in the computer is a file containing (x, y) coordinate pairs that represent the location of individual point features.

Each graphic object can be represented with a piece of spaghetti. Each piece of spaghetti acts as a single entity. The shortest spaghetti can be represented as a point, collection of a number of point spaghettis for a line entity and collections of line segments that come together at the beginning and ending of surrounding areas form an area entity. Each entity is a single, logical record in the computer, coded as variable length strings of (x, y) coordinate pairs.

Let us assume that two polygons lie adjacent to each other in a thematic coverage. These two adjacent polygons must hake separate pieces of spaghetti for adjacent sides. That is, no two adjacent polygons share the same string of spaghetti.

Each side of polygon is uniquely defined by its own set of lines and coordinate pairs. In this model of representing vector data, all the spaghettis are recorded separately for polygons. But in the .computer they should have the same coordinates.



Data structure

Feature	Number	Location
Point	5	*x*, *y* (single pair)
Line	16	(string of *x*,*y* coordinate pairs)
Polygon	25	(closed loop of *x*, y coordinate pairs where first and last pair are the same)
	26	(closed loop sharing coordinates with adjacent polygons to form a data structure)

Fig. 8.12 Spaghetti Vector Data Model.

Topological Models

In order to use the data manipulation and analysis subsystem more efficiently and obtain the desired results, to allow advanced analytical techniques on GIS data and its systematic study in any project area, much explicit spatial information is to be created. **The topological data model incorporates solutions to some of the frequently used operations in advanced GIS analytical techniques.**

This is done by explicitly recording adjacency information into the basic logical entity in topological data structures, beginning and ending when it contacts or intersects another line, or when there is a change in the direction of the line.

Each line then has two sets of numbers: a pair of coordinates. and an associated node number. The node is the intersection of two or more lines, and its number is used to refer to any line to which it is connected. In addition, each line segment, called a link, has its own identification number that is used as a pointer to indicate the set of nodes that represent its beginning and ending polygon. These links also have identification codes that relate polygon numbers to see which two polygons are adjacent to each other along its length. In fact, the left and right polygon are also stored explicitly, so that even this tedious step is eliminated.

This design feature allows the computer to know the actual relationships among all its graphical parts to identify the spatial relationships contained in an analog map document.

The topological models available in GIS ensure (a) that no node or line segment is duplicated, (b) that line segments and nodes can be referenced to more than one polygon, and (c) that all polygons can be adequately represented.

To understand the topological vector data structure, let us consider a network with 8 nodes encoded as n1 to n8. The links

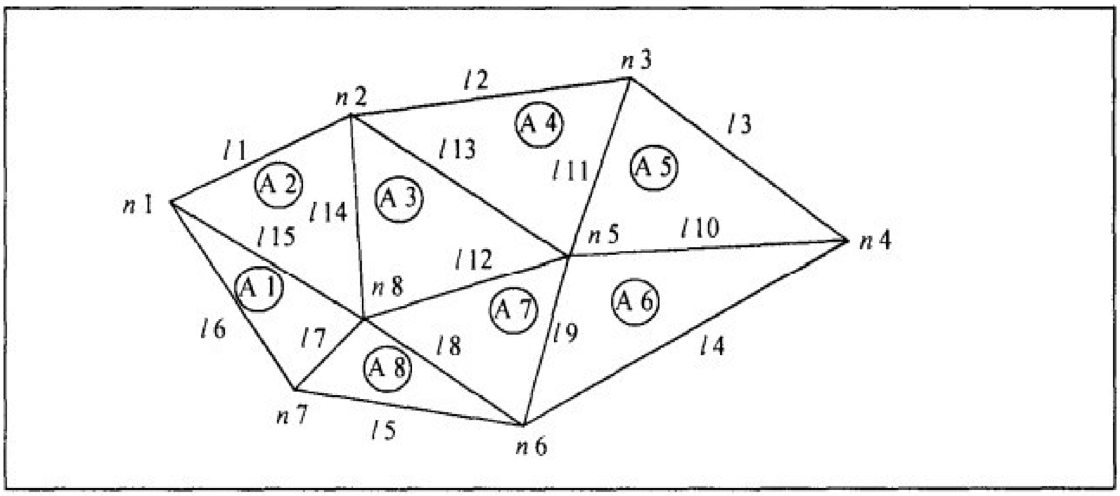


Fig. 8.13 Topological vector Data Model.

To understand the topological vector data structure, let us consider a network with 8 nodes encoded as n1 to n8. The links joining all these nodes are encoded as 11 to 114 and the polygons created by all these line segments links are coded as A 1 to A8. The creation of this structure for complex area features is carried out in a series of stages. Burrough (1986) identifies these stages as identifying a boundary network of arcs (the envelope polygon), checking polygons for closure, and linking arcs into polygons. The area of polygons can then be calculated and unique identification numbers attached. This identifier would allow nonspatial information to be linked to a specific polygon.

Table 8.2 Comparison of raster and vector Data models

Raster model	Vector model
Advantages	**Advantages**
1. It is a simple data structure. 2. Overlay operations are easily and efficiently implemented. 3. High spatial variability is efficiently represented in a raster format. 4. The raster format is more or less required for efficient manipulation and enhancement of digital images.	1. It provides a more compact data structure than the raster model. 2. It provides efficient encoding of topology, and, as a result, more efficient implementation of operations that require topological information, such as, network analysis. 3. The vector model is better suited to supporting graphics that closely approximate hand-drawn maps.
Disadvantages	**Disadvantages**
1. The raster data structure is less compact. 2. Topological relationships are more difficult to represent. 3. The output of graphics is less aesthetically pleasing because boundaries tend to have a blocky appearance rather than the smooth lines of hand-drawn maps. This can be overcome by using a very large number of cells, but it may result in unacceptably large files.	1. It is a more complex data structure than a simple raster. 2. Overlay operations are more difficult to implement. 3. The representation of high spatial variability is inefficient. 4. Manipulation and enhancement of digital images cannot be effectively done in the vector domain.

ATTRIBUTE DATA

Attribute Data in GIS

Data in GIS are stored as features AND tabular info

- Tabular information can be associated with features OR
- Tabular data may NOT be associated with any specific feature

"Tabular" means stored in a table with rows and columns

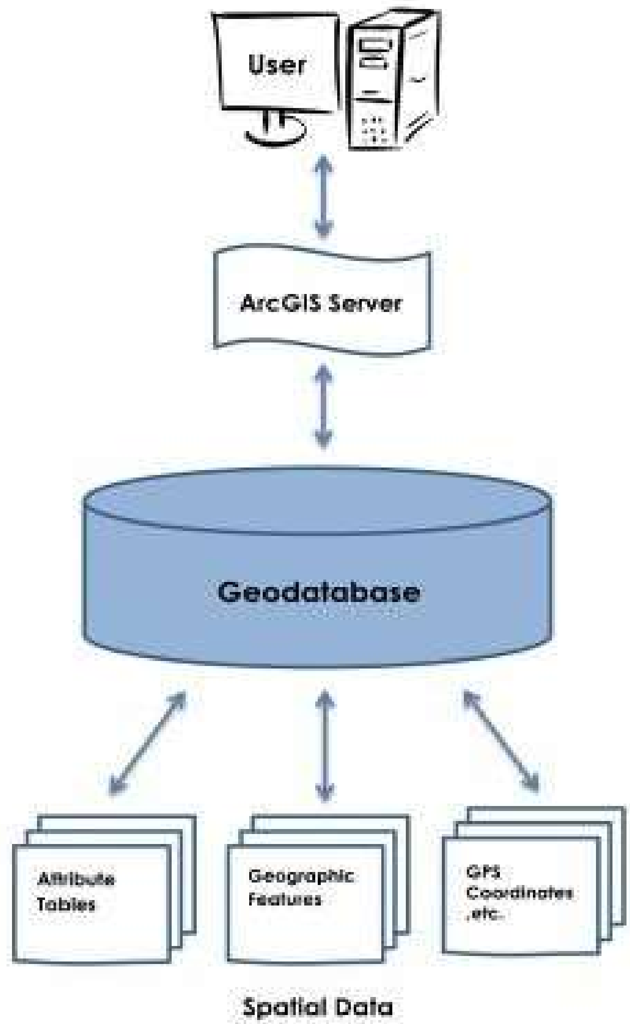
- Rows are called "RECORDS" in GIS
- Columns are called "ATTRIBUTE FIELDS" or "FIELDS"

Attributes of US Counties

FID	Shape*	NAME	STATE_NAME	STATE_FIPS	CNTY_FII
0	Polygon	Lake of the Woods	Minnesota	27	077
1	Polygon	Ferry	Washington	53	019
2	Polygon	Stevens	Washington	53	065
3	Polygon	Okanogan	Washington	53	047

GEODATABASE

A geodatabase is **a database designed to store, query, and manipulate geographic information and spatial data**. It is also known as a spatial database. ... Within a geographic information system (GIS) a spatial database is one component that can be used to store and manipulate data


User
ArcGIS Server
Geodatabase
Attribute Tables
Geographic Features
GPS Coordinates .etc.
Spatial Data

Geospatial metadata (also **geographic metadata**) is a type of metadata applicable to geographic data and information. Such objects may be stored in a geographic information system (GIS) or may simply be documents, data-sets, images or other objects, services, or related items that exist in some other native environment but whose features may be appropriate to describe in a (geographic) metadata catalog (may also be known as a data directory or data inventory).