Geospatial Technology

TEXT BOOK

Class XII

CENTRAL BOARD OF SECONDARY EDUCATION
2, Community Centre, Preet Vihar, Delhi-110092

नया आगाज़

आज समय की माँग पर
आगाज़ नया इक होगा
निरंतर योग्यता के निर्णय से
परिणाम आकलन होगा।

परिवर्तन नियम जीवन का
नियम अब नया बनेगा
अब परिणामों के भय से
नहीं बालक कोई डरेगा

निरंतर योग्यता के निर्णय से
परिणाम आकलन होगा।

बदले शिक्षा का स्वरूप
नई खिले आशा की धूप
अब किसी कोमल-से मन पर
कोई बोझ न होगा

निरंतर योग्यता के निर्णय से
परिणाम आकलन होगा।
नई राह पर चलकर मंज़िल को हमें पाना है
इस नए प्रयास को हमने सफल बनाना है
बेहतर शिक्षा से बदले देश, ऐसे इसे अपनाए
शिक्षक, शिक्षा और शिक्षित
बस आगे बढते जाएँ
बस आगे बढते जाएँ
बस आगे बढते जाएँ.........

Geospatial Technology

Class XII

CBSE, Delhi - 110092

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Preface

Indian Geospatial Market is on the verge of a remarkable growth. We are witnessing huge growth spurts; companies are bagging of unprecedented scale. In the early 1990s, most Indian GIS companies relied on outsourced business from overseas market with US accounting for bulk of business followed by UK/Europe. Indian business used to account for a marginal percentage of the global business. However, trends are changing and so is the equation. Business in the Indian market is increasing and what is noticeable is a fine geographic mix of business. It is a welcome change, albeit a bit slow.

Now the momentum is picking up and all the rhetoric is transforming into reality. This is largely due to government focus on use of Geospatial technology and large initiatives for its implementation. Such initiatives will give effective results only when an effective enterprise GIS system is deployed by the organization at National, State and Local levels.

Geospatial Technology is relying increasingly on digital spatial data acquired from remotely sensed images, Photogrammetry techniques, and analysis by geographical information systems (GIS) and visualized on the computer screen or on paper through Geo-engineering. This focuses on the application of (3D) Geospatial Information Technology (GIT) in a Geological, Engineering and Geo-environmental context.

To optimize the use of technology, additional capabilities must be available, such as a thorough understanding of Remote Sensing & Digital Image Processing, Photogrammetry and GIS. The extraction and analysis of Geospatial information from the GIS-based integrated systems are used in various industries such as Petroleum, Telecom, Civil, Constructions, Economics & Finance, Marketing, Agriculture, Geology, Geography, Health, Utilities, Environmental modeling for planning and execution to a variety of end users for decision making purposes. Therefore, Geospatial Technology is no longer a tool for the specialist, but is a decision making tool for the management.

Demand for Geospatial Technology has skyrocketed over the past few years. By linking geographic data with demographic information and business intelligence, organizations are finding new applications for Geospatial technology. In order to meet the huge trained manpower requirements for the Industries, it is recommended to introduce the technology at senior secondary level of education in the country. GIS applications are now regularly used by both private and public organizations of all sizes, which have generated more demand for GIS professionals.

Increased demand for GIS services has made solution providers like ROLTA to evolve a fresh approach to how people find, analyze and use GIS information and structure a vocational education and training course aiming to educate students in the field of Geospatial applications using Remote Sensing, Digital Photogrammetry and Geographic Information System (GIS).

This vocational course offers professional education dealing with mapping and Geospatial production to ensure that students obtain insight into Geospatial database concepts, creating and implementing databases, spatial analysis, developing GIS applications, through both theoretical concepts and supported by extensive practical exercises with hands-on training using Rolta Geomatica industry standard software.

It is hoped that this curriculum would help a large number of young students to acquire employable skills and to enter professional world for them to earn decent livelihoods and to aide economic growth of the country. Any suggestion(s) to improve the text book is welcomed from students, teachers and others concerned.

The Board acknowledges the contribution made by the team of experienced authors in completing the manuscript. The text book on Geospatial Technology is an outcome of a series of meetings organised by the Board. The process initiated under the direction of Sh. Shashi Bhushan, former Director (Academic) was completed by the present members of vocational cell. The Board duly acknowledges the role of Rolta Private Limited for technical guidance to promote the Geospatial Technology education at school level in India. I am sure this book would serve the purpose of a useful resource material for students and the teachers.

VINEET JOSHI,
Chairman, CBSE

Acknowledgement

CBSE Advisors

Sh. Vineet Joshi, Chairman, CBSE, Delhi

Sh. Shashi Bhushan, Former Director (Acadmic) CBSE

Authors

Smt. Alpana Bohra (Dr.), Assistant Vice President, Rolta India Ltd, Mumbai

Sh. R.S. Rathi, Executive Director, Rolta India Ltd, Mumbai

Review Committee Experts

Sh. (Dr.) M L Manchanda

Former Head Regional Remote Sensing Center, Dehradun.

(Dr.) Bhoop Singh

Director, National Resources Data Management Systems. Department of Science and Technology. New Delhi

Smt. (Dr.) Sucharita Sen

Associate Professor, Center for the study of Regional Development, JNU, New Delhi

Technical Contribution

Miss. Sunitha Gatty, Rolta India Ltd, Mumbai

Sh. Manoj Kukreja (Dr.), Rolta India Ltd, Mumbai

Sh. Rakesh Dubey (Dr.), Rolta India Ltd.

भारत का संविधान

उद्देशिका

हम, भारत के लोग, भारत को एक [1]**[संपूर्ण प्रभुत्व-संपन्न, समाजवादी, पंथ-निरपेक्ष, लोकतंत्रात्मक गणराज्य]** बनाने के लिए तथा उसके समस्त नागरिकों कोः

सामाजिक, आर्थिक और राजनैतिक **न्याय,**

विचार, अभिव्यक्ति, विश्वास, धर्म और उपासना की **स्वतंत्रता,**

प्रतिष्ठा और अवसर की **समता** प्राप्त कराने के लिए,

तथा उन **सबमें** व्यक्ति की गरिमा और [2]**[राष्ट्र की एकता और अखंडता सुनिश्चित]** करने वाली बंधुता बढ़ाने के लिए

दृढ़संकल्प होकर **अपनी इस संविधान सभा में** आज तारीख 26 नवंबर, 1949 ई. (मिति मार्गशीर्ष शुक्ला सप्तमी, संवत् दो हज़ार छह विक्रमी) को **एतद्‌द्वारा इस संविधान को अंगीकृत, अधिनियमित और आत्मार्पित करते हैं।**

भारत का संविधान

भाग 4क

नागरिकों के मूल कर्तव्य

अनुच्छेद 51क

मूल कर्तव्य- भारत के प्रत्येक नागरिक का यह कर्तव्य होगा कि वह -

(क) संविधान का पालन करे और उसके आदर्शों, संस्थाओं, राष्ट्रध्वजों और राष्ट्रगान का आदर करे;

(ख) स्वतंत्रता के लिए हमारे राष्ट्रीय आंदोलन को प्रेरित करने वाले उच्च आदर्शों को हृदय में संजोए रखे और उनका पालन करे;

(ग) भारत की संप्रभुता, एकता और अखंडता की रक्षा करे और उसे अक्षुण्ण बनाए रखे;

(घ) देश की रक्षा करे और आह्वान किए जाने पर राष्ट्र की सेवा करे;

(ङ) भारत के सभी लोगों में समरसता और समान भ्रातृत्व की भावना का निर्माण करे जो धर्म, भाषा और प्रदेश या वर्ग पर आधारित सभी भेदभाव से परे हो, ऐसी प्रथाओं का त्याग करे जो महिलाओं के सम्मान के विरुद्ध हों;

(च) हमारी सामासिक संस्कृति की गौरवशाली परंपरा का महत्व समझे और उसका परिरक्षण करे;

(छ) प्राकृतिक पर्यावरण की, जिसके अंतर्गत वन, झील, नदी और वन्य जीव हैं, रक्षा करे और उसका संवर्धन करे तथा प्राणिमात्र के प्रति दयाभाव रखे;

(ज) वैज्ञानिक दृष्टिकोण, मानववाद और ज्ञानार्जन तथा सुधार की भावना का विकास करे;

(झ) सार्वजनिक संपत्ति को सुरक्षित रखे और हिंसा से दूर रहे;

(ञ) व्यक्तिगत और सामूहिक गतिविधियों के सभी क्षेत्रों में उत्कर्ष की ओर बढ़ने का सतत प्रयास करे, जिससे राष्ट्र निरंतर बढ़ते हुए प्रयत्न और उपलब्धि की नई ऊँचाइयों को छू सके; और

(ट) यदि माता-पिता या संरक्षक है, छह वर्ष से चौदह वर्ष तक की आयु वाले अपने, यथास्थिति, बालक या प्रतिपाल्य को शिक्षा के अवसर प्रदान करे।

THE CONSTITUTION OF INDIA

PREAMBLE

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a [1] **[SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC]** and to secure to all its citizens :

JUSTICE, social, economic and political;

LIBERTY of thought, expression, belief, faith and worship;

EQUALITY of status and of opportunity; and to promote among them all

FRATERNITY assuring the dignity of the individual and the [2] [unity and integrity of the Nation];

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949, do **HEREBY ADOPT, ENACT AND GIVE TO OURSELVES THIS CONSTITUTION.**

1. Subs, by the Constitution (Forty-Second Amendment) Act. 1976, sec. 2, for "Sovereign Democratic Republic (w.e.f. 3.1.1977)
2. Subs, by the Constitution (Forty-Second Amendment) Act. 1976, sec. 2, for "unity of the Nation (w.e.f. 3.1.1977)

THE CONSTITUTION OF INDIA

Chapter IV A

Fundamental Duties

ARTICLE 51A

Fundamental Duties - It shall be the duty of every citizen of India-

(a) to abide the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;

(b) to cherish and follow the noble ideals which inspired our national struggle for freedom;

(c) to uphold and protect the sovereignty, unity and integrity of India;

(d) to defend the country and render national service when called upon to do so;

(e) To promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities; to renounce practices derogatory to the dignity of women;

(f) to value and preserve the rich heritage of our composite culture;

(g) to protect and improve the natural environment including forests, lakes, rivers, wild life and to have compassion for living creatures;

(h) to develop the scientific temper, humanism and the spirit of inquiry and reform;

(i) to safeguard public property and to abjure violence;

(j) to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievement.

Contents

CHAPTER - 1

Remote Sensing (RS)

Learning Objectives

By the end of this chapter students would be able to:

1.1 Understand Introduction to Remote Sensing

1.2 Understand Spectral Reflectance Signature of various earth features

1.3 Learn about Digital Image Processing

1.4 Understand the Visual Interpretation of Satellite data

1.5 Know Aerial Photo and Its Interpretation

1.6 Learn about Advanced Remote Sensing Technologies

1.7 Understand the Advantages and Benefits of RS

1.1 Introduction

We have learnt in class XI, that Remote sensing (RS) is the observation of an object, surface or phenomenon through the use of a variety of recording devices that are wireless, or not in physical or intimate contact with the object. An aircraft, spacecraft, satellite or ship may be used for this purpose and equipped with recording devices such as camera, laser, radar, sonar etc.

> Remote sensing deals with inventory, monitoring and assessment of natural resources through analysis of data obtained from remote sensing platform.

Remote Sensing measures energy such as ultra-violet, infrared, microwave,which that cannot be reached by human vision. Remote sensing data has a unique advantage of multidisciplinary application.

- Sun is the principal source of EM energy
- Earth receives only 1/50 millionth of total solar energy
- 46% of solar energy reaching the earth falls in the visible region of EM spectrum

The same RS data can be used by researchers / workers in different disciplines such as geology, forestry, land use, agriculture, hydrology etc. It offers wide regional coverage and good spectral resolution.

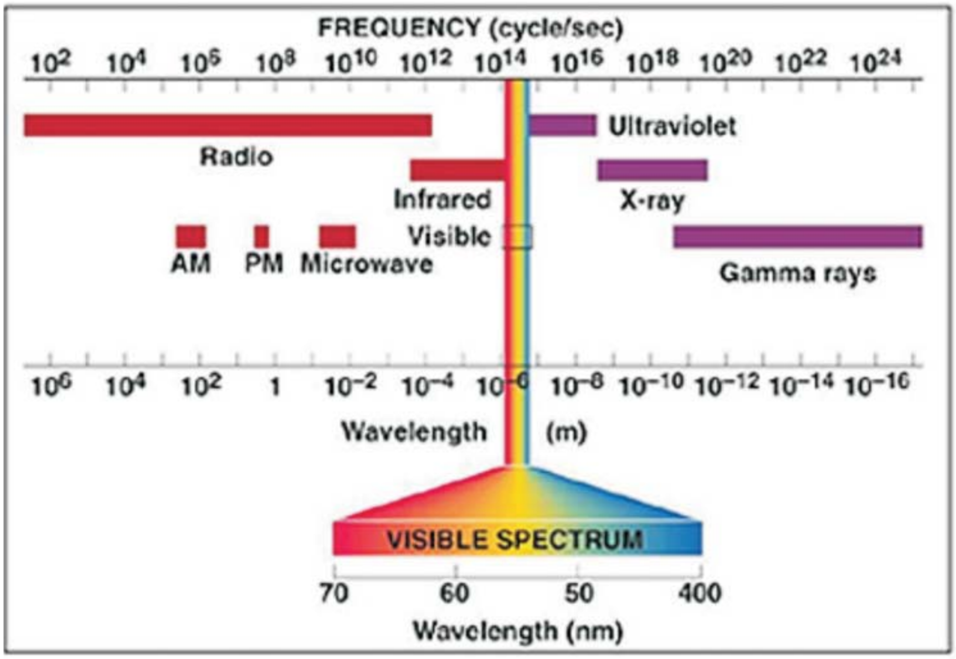


Fig. 1

Electro Magnetic Spectrum

The basic principle involved in remote sensing is that different objects reflect or emit radiations in different wavelengths and intensities depending upon properties of the objects serves as

Stages in Remote Sensing

- A source of electromagnetic energy
- Transmission of Energy from the source to the surface of earth
- Interaction with the intervening atmospheres
- Interaction of EMR with the earth's surface
- Transmission of Energy from the surface to the remote sensor
- Sensor Data output
- Data transmission , Processing and Analysis

the main communication link between the sensor and the objects. All object matter that have temperature higher than absolute zero 0° emit EMR continuously.

The intensity of the emitted radiation depend upon the composition and temperature of the body. A blackbody is an ideal body that absorbs all radiation incidents on it without any reflection. It represents a continuous spectral emission curve, in contrast to natural bodies that emit only at separate spectral bands. Temperature plays great role on the intensity of blackbody emitted radiation. This relationship is called Wien's displacement Law. Law represent as: ? max = A / T where ? max is the wavelength (cm) where highest radiation occurs. A is constant (= 0.29 cm K) and T is the temperature (K) of the object. Using this law it can estimate the temperature of objects by measuring the wavelength of peak radiation.

The above figure shows spectral distribution of energy radiated from black bodies of various temperatures such as sun, incandescent lamp, fire and Earth. For the Sun max occurs at 0.48 µm, which measures the temperature of the Sun approx. as 6000 K similarly for the earth, the ambient temperature is 3000 K and max occurs at 9.7µm. The ambient temperature of fire is 5000 K and for incandescent lamp it is 4000 K.

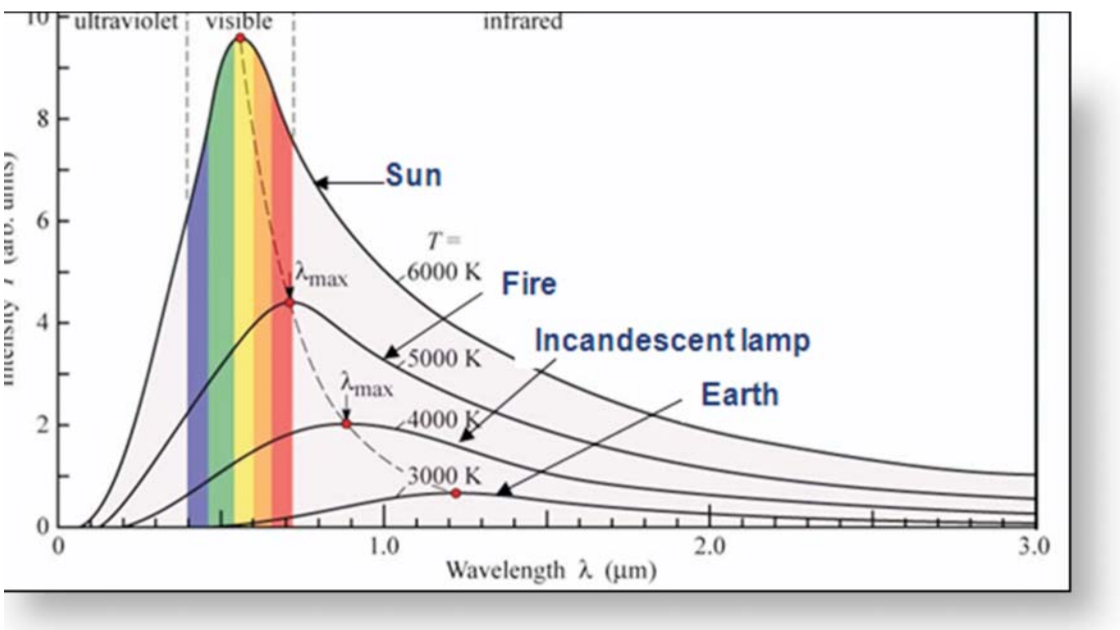


Fig. 2

Spectral distribution of energy by a black body

> Black body is an ideal body which absorbs all radiation without any reflectance. Whereas white body completely reflects incident radiation and absorbs nothing

Most useful regions of the EMR are visible, Infra red and thermal and microwave for carrying out RS activities. The human eye can detect energy in the visible portion of the electromagnetic spectrum. Photographic cameras are sensitive to broader range of wavelength ranges from 0.3 μm – 0.9 μm, the near ultraviolet to the near infrared. Thermal scanners operate in the thermal infrared portion of the spectrum. Multispectral scanners operate over a broad range of wavelengths from ultraviolet to thermal infrared. Passive microwave and active radar systems operate in microwave portion of the electromagnetic spectrum.

> In case of dust, cloud, fog all wavelengths are equally scattered so they all look white. Natural uneven (rough) surface scattered in multiple directions.
>
> Shorter wavelengths are scattered more than longer wave lengths. This type of scattering is seen more in ultraviolet and blue. That is why the sky would appear blue otherwise it would appear as dark space.

The Sun is primary source of energy. When these solar rays arrive at the Earth, the atmosphere absorbs or backscatters a part of them and transmits the rest. When rays striking the land, ocean surface and atmosphere target, such as air, moisture, and clouds the incoming radiation go through various modes of energy-interaction response for example transmission, absorption, reflection and scattering as shown in both the figures given below (fig. 3 & 4).

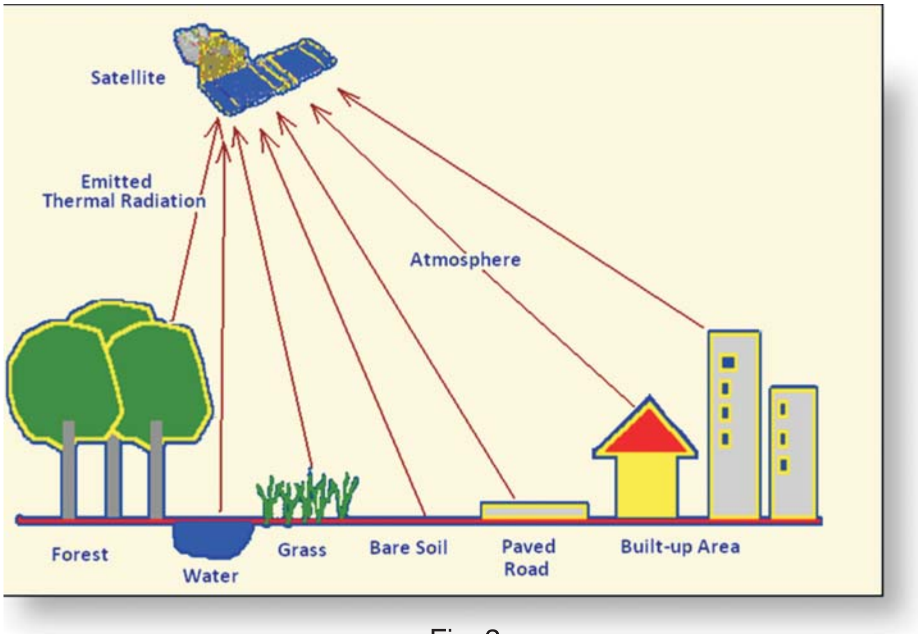


Fig. 3

Remote Sensing System Source: CRISP

Various Interaction Responses of Sun rays.

Transmittance - The radiation penetrates into certain surface materials such as water and if the material is transparent, it transmits 100% of energy.

Absorption – It occurs when EMR passes through an opaque medium;

Reflectance– Reflection occurs when incident EMR bounces off from a smooth surface

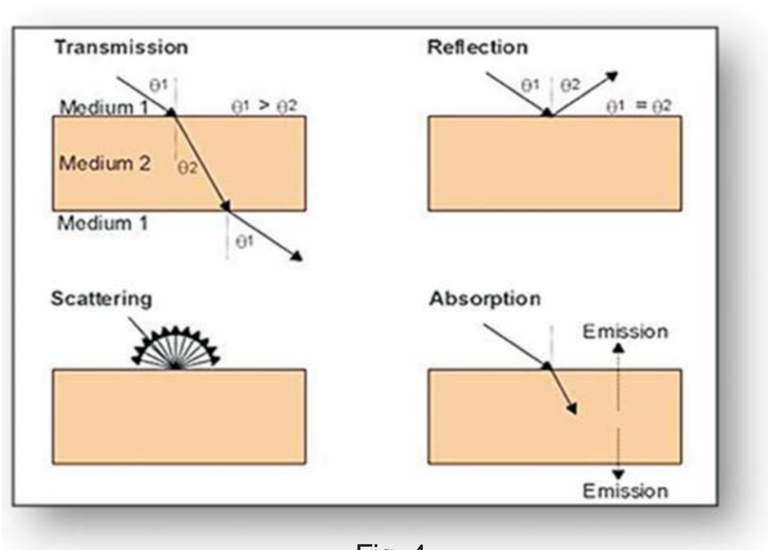


Fig. 4

Various modes of energy Interaction response of incoming radiation

Scattering – It occurs when EMR disbursed in all the direction from a rough surface. In this picture the energy interaction with red roof, glass window & black soil are shown. When incident energy strikes on red roof it reflects in red band, so roof appears red. Similarly the black soil absorbs all the energy therefore it appears in black color. When the energy passes through glass window it transmits all energy that is why it appears transparent in color.

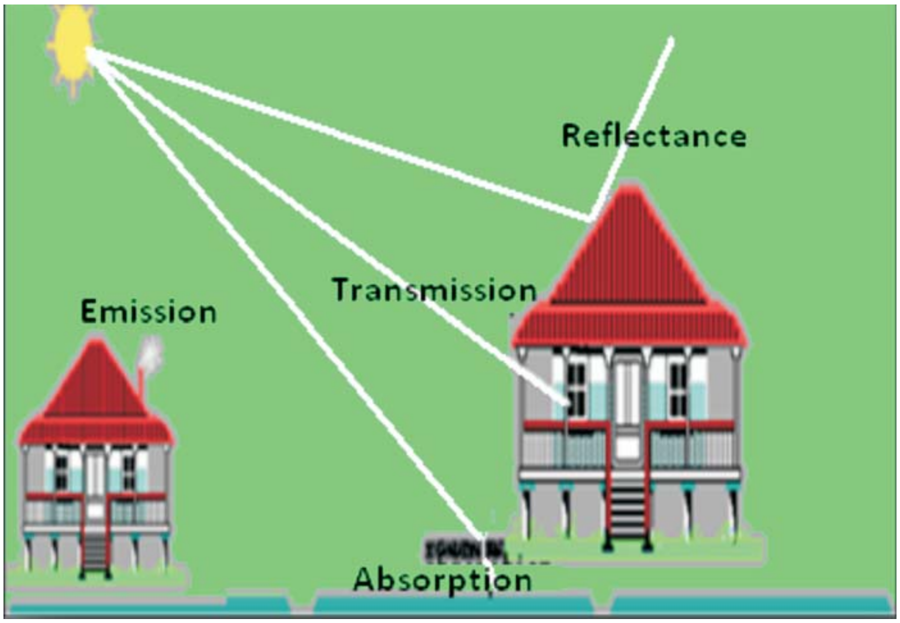


Fig. 5

Energy Interaction with Window, Roof and Soil

1.2 Spectral Reflectance Signature

The reflectance characteristics of the different features of the earth surface are measured by the incident energy that is reflected by the surface. This spectral reflectance of natural features are collected and stored by satellite sensors. Spectral reflectance of any object usually varies according to the wavelength of the EMR. A graph showing the spectral reflectance of an object for various wavelengths is known as a Spectral Reflectance Curve. It helps in selecting the wavelength bands for identifying the object.

The radiation reflected as a function of the wavelength is called the spectral signature of the surface.

Spectral reflectance characteristics are the most important aspect for feature classification in any satellite imagery. Typical spectral reflectance curve for soil, vegetation, water are shown in above graph. Details of spectral behaviors of soil, water and vegetation are discussed below separately.

- Radiation reflected or emitted from earth surface is converted to signal (Digital Numbers- DN)
- The reflectance from a feature depends on the atmospheric conditions, seasons, time of a day, physical and chemical characteristics of the feature
- Secular reflectance from smooth surfaces e.g. water, paved roads is lower than that from rough surfaces.

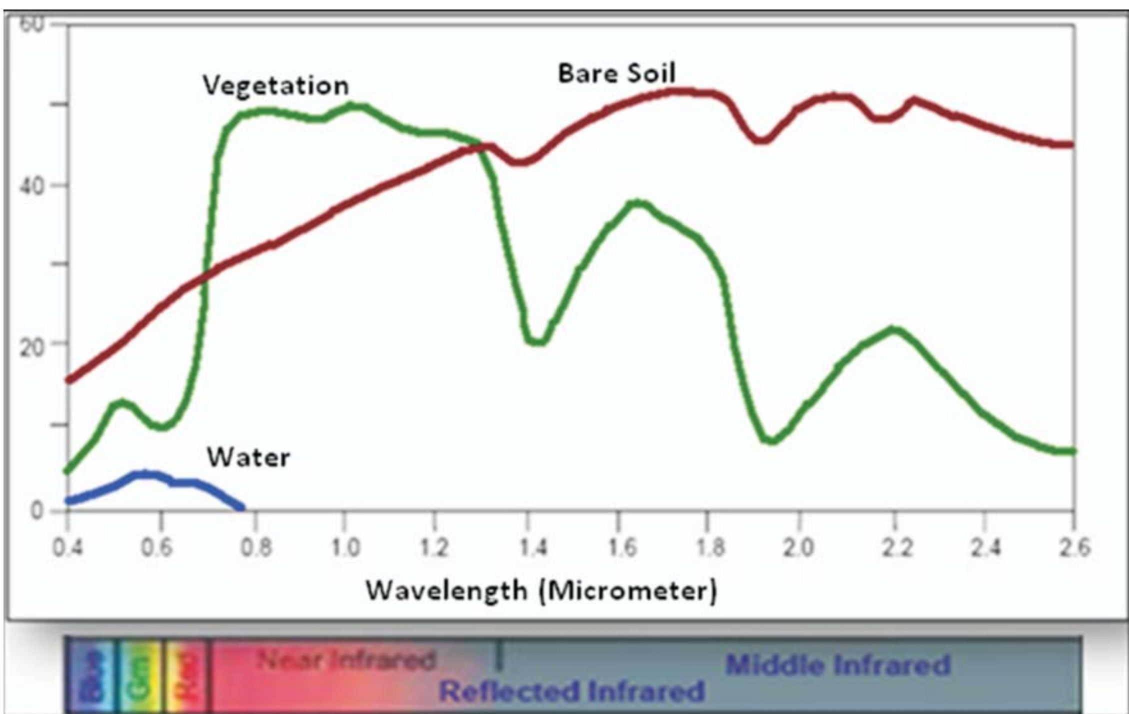


Fig. 6

Spectral Reflectance curve for Vegetation and Water Soil

The graph fig. 6 shows the reflectance of water in blue band, vegetation in green and infrared band where as bare soil shows linear reflectance in visible and infrared bands.

In the figure below (fig. 7) vegetation reflects in green band and the red roof reflects the energy in red band therefore the color appears as green and red respectively.

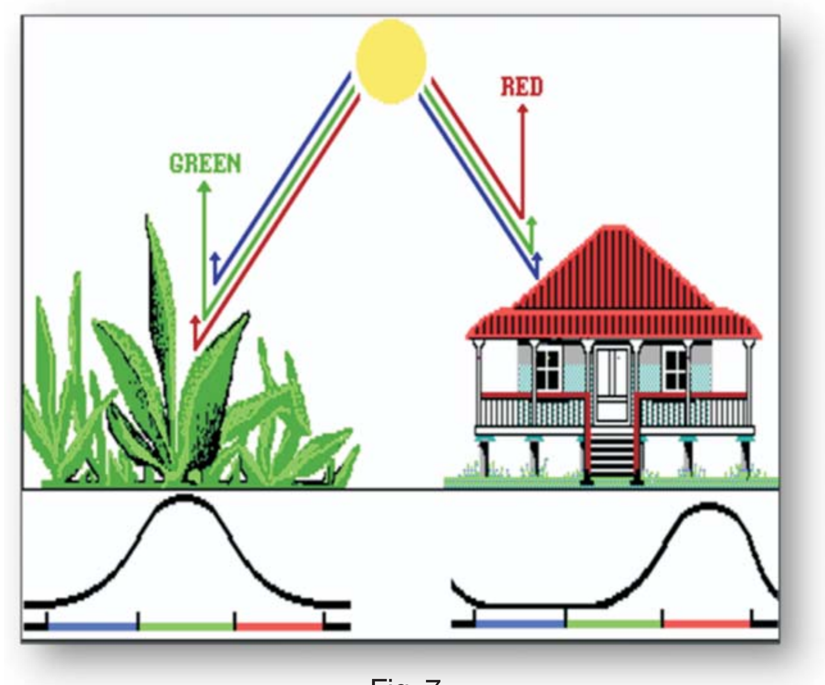


Fig. 7

Reflectance from roof and vegetation

1. Soil

Reflectance characteristics of soil are depending on the various factors:

- Soil moisture content
- Sand, silt & clay Composition
- Soil texture, color & grain size
- Surface roughness
- Mineral composition.

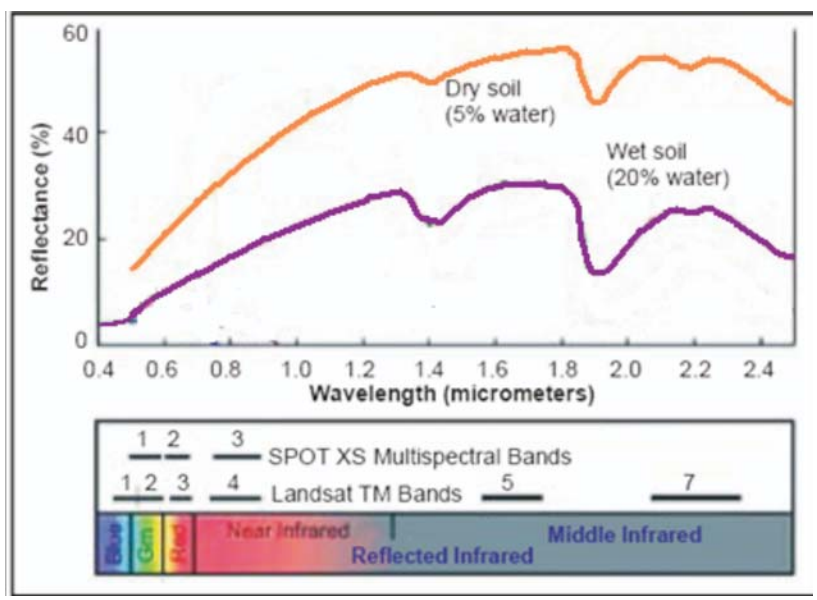


Fig. 8

Reflectance curve based on soil moisture

A typical reflectance curve for various soils is shown in two graphs. First graph shows spectral behavior of dry and wet soil. The presence of moisture in soil will decrease the reflectance in the visible and near-infrared regions. Dry soil increases reflectance in visible and near infrared wavelength as compare to wet soil due to less moisture content. Second graph shows reflectance curve for soil based on soil texture.

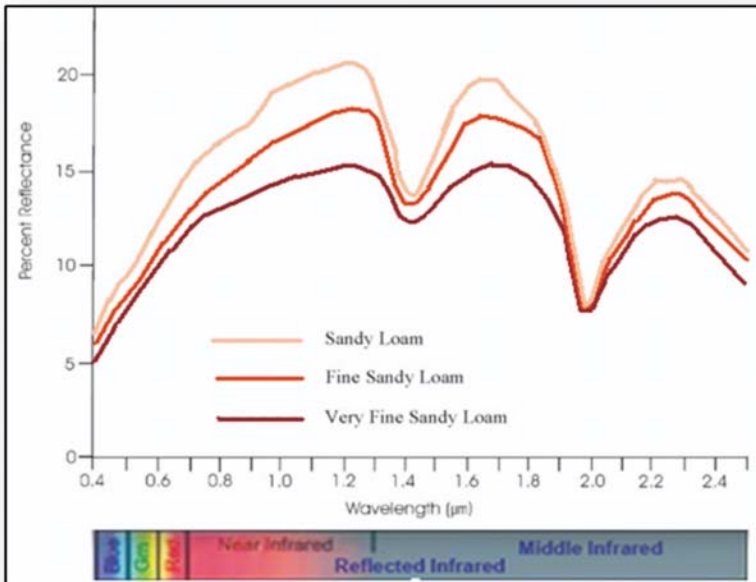


Fig. 9

Reflectance curve for soil based on soil texture

There is high reflectance in visible and infrared band, for sandy loam as compare to fine sandy loam and very fine sandy load due to its fine texture soil. The presence of iron oxide in soil will also decreases the reflectance in visible wavelength.

2. Vegetation

Healthy growing vegetation appears green because of Chlorophyll content. The reflectance from vegetation depends on various factors:

- Leaf pigmentation
- Leaf cell structure
- Leaf moisture
- Crown architecture
- Plant physiology

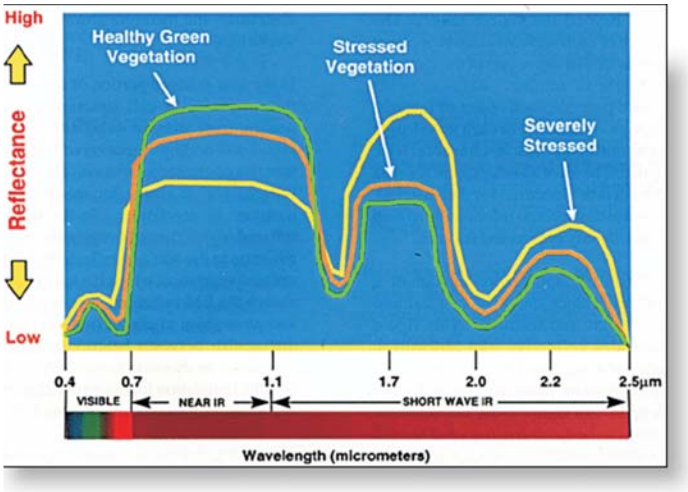


Fig. 10

Reflectance curve of vegetation based on health

Source: rst.gsfc.nasa.gov

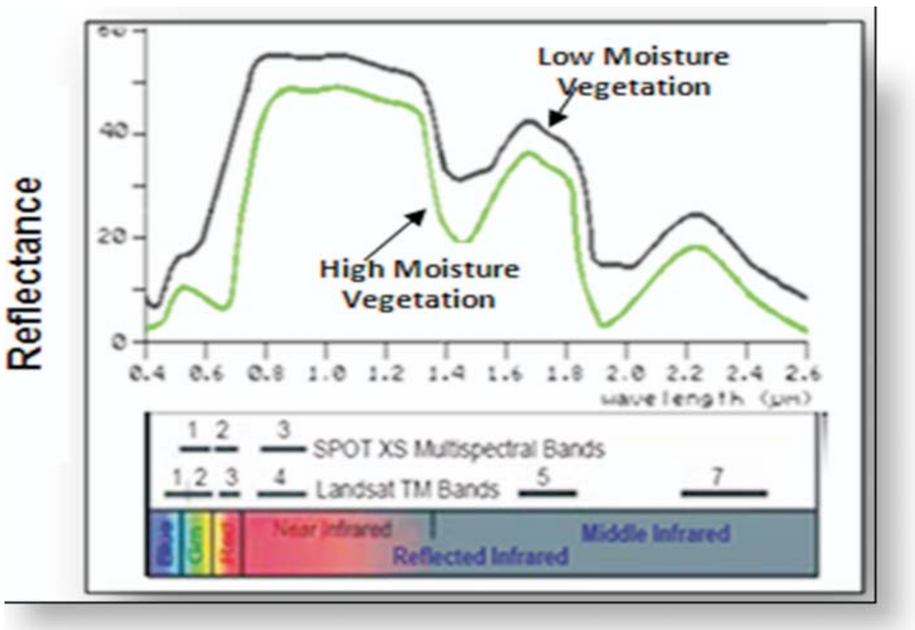


Fig. 11

Reflectance curve for low and high moisture vegetation

The reflectance of healthy green vegetation is shown in graph above. In the visible band of EMR the healthy vegetation will have absorption in the blue and red bands because of the presence of chlorophyll. This wavelength ranges from 0.45 ìm and 0.65 ìm. If the plant is turned to yellow it results in less chlorophyll so there will be less absorption in blue and red band. As we move from visible to near infrared portion of the spectrum which is about 0.74 ì m to 1.3 ì m the plant leave reflects 40 to 50% of the energy incident upon it. If the moisture is low in leaves of the plants then it reflects more energy in all the bands compared to the leaves with high moisture as shown in the graph (Fig 11).

The plant stress in graph shows, decrease absorption in NIR as compared to the healthy vegetation. Due to less moisture, disease, and pest contents the crops reflectance are more.

3. Water

The reflectance from water depends on various factors

- Depth
- Suspended particles in water
- Floating vegetation
- Sun angle

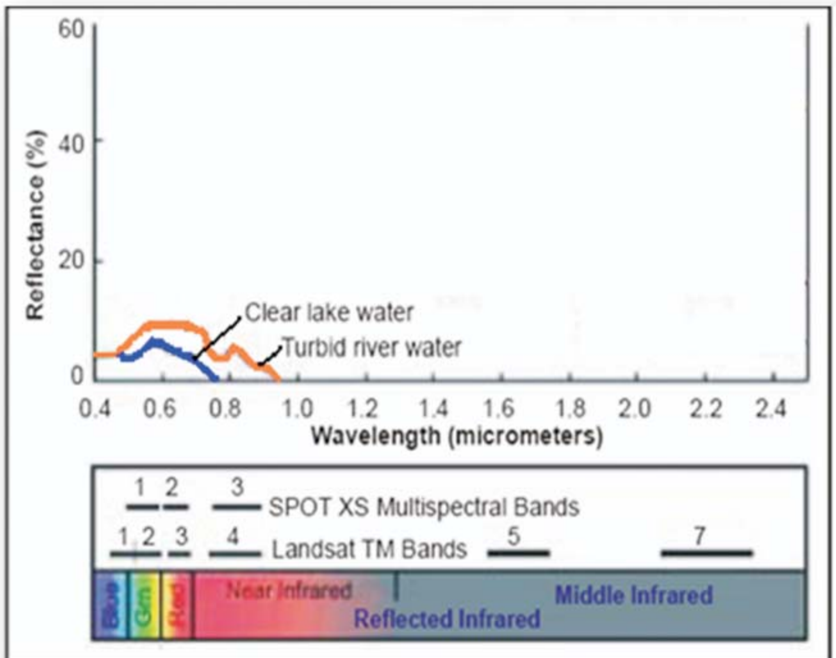


Fig. 12

Reflectance curve for clear lake and turbid river water

Pure clear water has a relatively high reflectance in the visible wavelength ranges from 0.4 and 0.6 ì m. There is no reflectance in the near-infrared (0.7 ìm) and higher wavelengths. So in infra red Image shows the water body in dark color. Clear water absorbs little energy in 0.6 ì m. If the water contains of suspended sediments it has higher reflectance in visible as compared to clear water.

Heavy sediments load (high turbidity) prevent radiation penetrating water bodies. So it reflects the energy. In Near Infra Red (NIR) and Middle Infra Red (MIR) wavelengths water strongly absorbs radiation and very little energy will be reflected or transmitted. The presence of algae in water affects the spectral response of the water. The chlorophyll contents of algae increases the reflectance of water body in the green band as shown in the figure below reduces the reflectance in red and blue band, therefore water looks green.

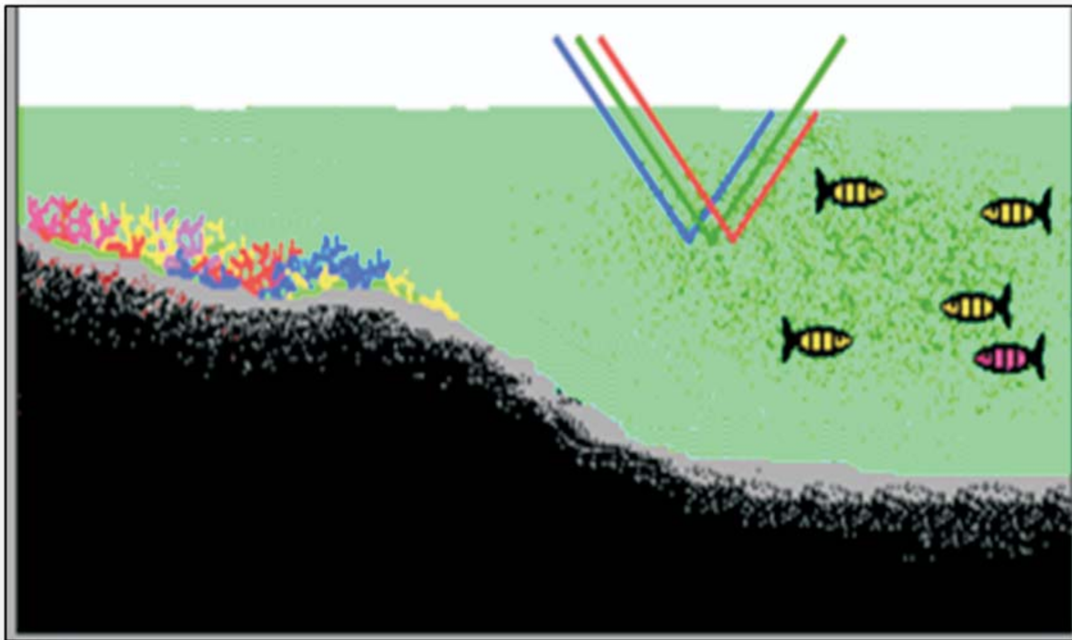


Fig. 13

Reflectance in green band due the presence of algae in water body

4. Rock

The rock constitutes of different minerals and textural properties. The absorption and reflectance basically depends on mineral composition in rocks. Different rocks such as biotile granites and granite have less water contents therefore, they reflect more in infrared. The rock which contains more water content will absorb more. The rocks which contains Iron will exhibit more absorption in ultraviolet and blue band and reflection in infrared band. This is due to the contents of metals such as Iron Manganese, Copper, Nickel and Chromium. The other factors which affect the reflectance of the rock are;

- Nature of the rock
- Top cover
- Topography / shadow
- Surface roughness

Curve given below shows reflectance behavior of various rocks such as Concrete, Asphalt, Bare soil, Gravel, and Shingles.

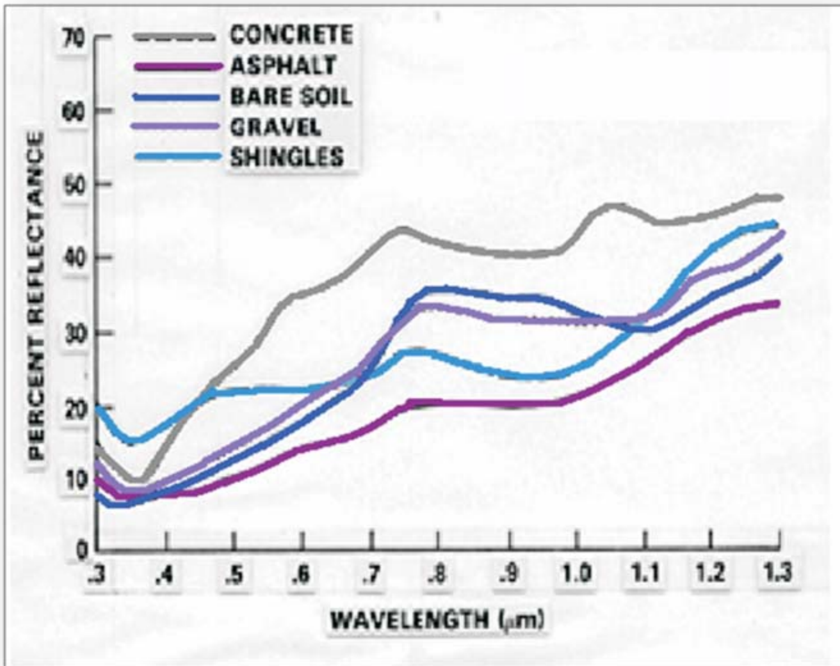


Fig. 14

Reflectance curve for various rock types

Source: rst.gsfc.nasa.gov

The reflectance of all the rock types is gradually increasing in all wavelengths such as with Visible, NIR, and MIR. Concrete is light and bright in color as compared to asphalt. Therefore it shows higher reflectance as compared to all rocks. The shingles are bluish in color so it reflects more in 0.4 to 0.5 μm

Resolution:

Resolution is defined as the ability of the sensor to detect the information at the smallest meaningful element, in terms of distance (spatial), wavelength band of EMR (spectral), time (temporal) and radiation quantity (radiometric). There are four types of resolutions which are listed below;

(i) Spatial,

(ii) Spectral,

(iii) Radiometric,

(iv) Temporal.

(i) Spatial Resolution: It is the minimum element area that the sensor can detect to measure. Spatial resolution is classified into three types. High spatial resolution which covers (0.6 – 4m), medium spatial resolution covers from 4-30 m & low spatial resolution covers 30 > 1000 m. This resolution element is called Pixel. The various examples and pictures of spatial resolution are given below.

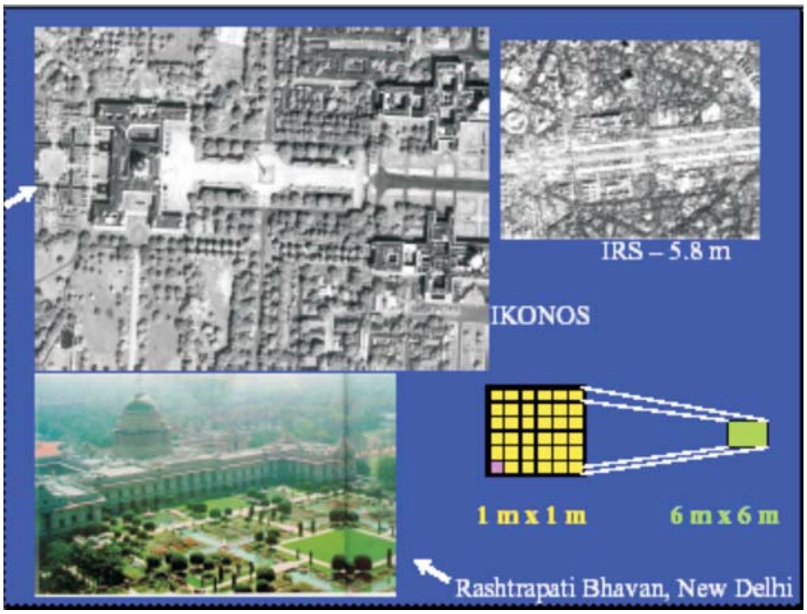


Fig. 15

Example for Pixel

LISS III Band 2 to 4	23.5 m
Band 5	70.5 m
WiFS	188.3 m
AWiFS	56 m
LISS III + PAN	5.8 m
LISS IV	2.5 m
IKONOS	1 m
Cartosat -2	0.8 m
SPOT- MSS	30 m, 80 m

Table : 1

Spatial resolution of various Satellites

Fig. 16

10 m Resolution Pixel size 10 m

Fig. 17

30 m Resolution Pixel size 30 m

Fig. 18

80 m Resolution Pixel size 80

Fig. 19

1 m Pan (IKONOS)

Source: NRSC Hyderabad

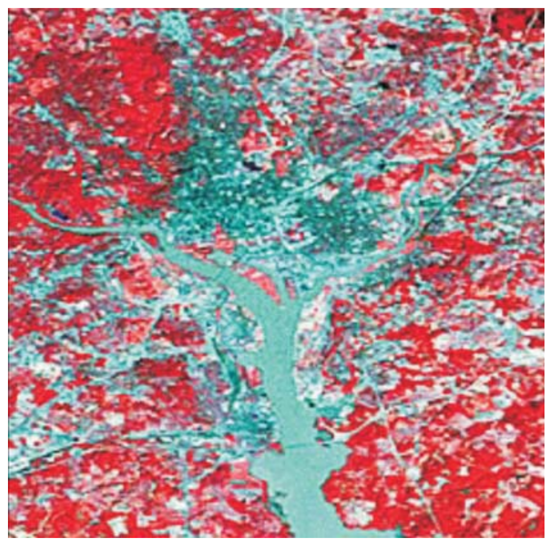


Fig. 20

30 m Multispectral (LandSat)

Source: NRSC Hyderabad

(ii) Spectral Resolution: It refers to the sensing and recording power of the sensor in the different bands of EMR. The sensor can observe object separately in different bands and colors or in one band which is panchromatic (Black-White). For example, Landsat MSS - 7 Bands, SPOT – 4 Bands, IRS - 4 Bands.

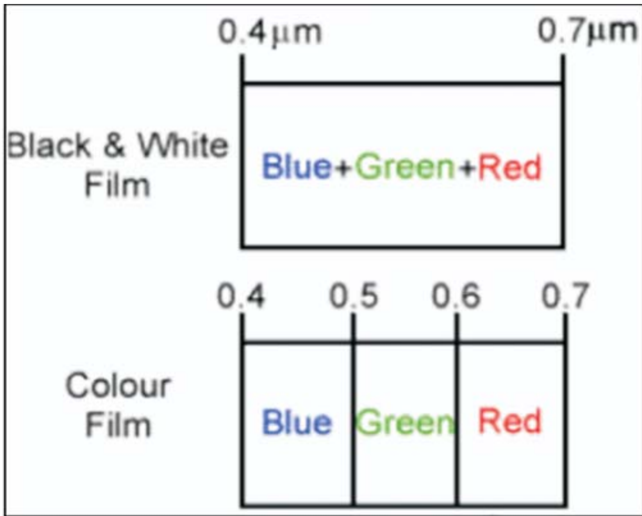


Fig. 21

LISS III	
Bands	**Wavelengths**
Band 2	0.52-0.59 µm
Band 3	0.62-0.68 µm
Band 4	0.77-0.86 µm
Band 5	1.55-1.70 µm
PAN	0.5-0.75 µm

Spectral Resolution of various Satellites

The spatial resolution specifies the pixel size of satellite images covering the Earth Surface.

(iii) Radiometric Resolution: It is determined by the number of discrete levels into which signals may be divided. It is recorded in Digital Number (DN) for different bands of Satellites. In another words it is dividing the total range of the signal output of the sensor into a large number of distinct colors to enable distinguish ground features which are differing slightly in a radiance or reflectance. The various examples are given in below table:

Table : 2

Sensor	Radiometric Resolution	Color
LISS III	7 bit / 128 levels	0 -1 27 Colors
WiFS	7 bit / 128 levels	0 - 127 Colors
PAN	6 bit / 64 levels	0 - 63 Color
AWiFS	10 bit/1024 levels	0 -1023 Color
Cartosat-1	10 bit/1024 levels	0 -1023 Color

Radiometric Resolution of various Satellites

Radiometric resolution describes the ability of a sensor to discriminate very light differences in energy. The finer the radiometric resolution of a sensor more sensitive it is to detect small differences in reflected or emitted energy.

(iv) Temporal Resolution: The ability to collect imagery of same area of the Earth's surface at different periods of time is one of the most important elements of RS. Temporal resolution is also called as the repetitive cycle which is the capability of the satellite to record the same area at the same viewing angle at different periods of time. Spectral characteristics of features may change over time & these changes can be detected by collecting & comparing multi-temporal imagery. For example, Spot revisits the same area in 26 days. Temporal imagery helps us to identify the change occurred over a period of time. The various examples are given in the table given below.

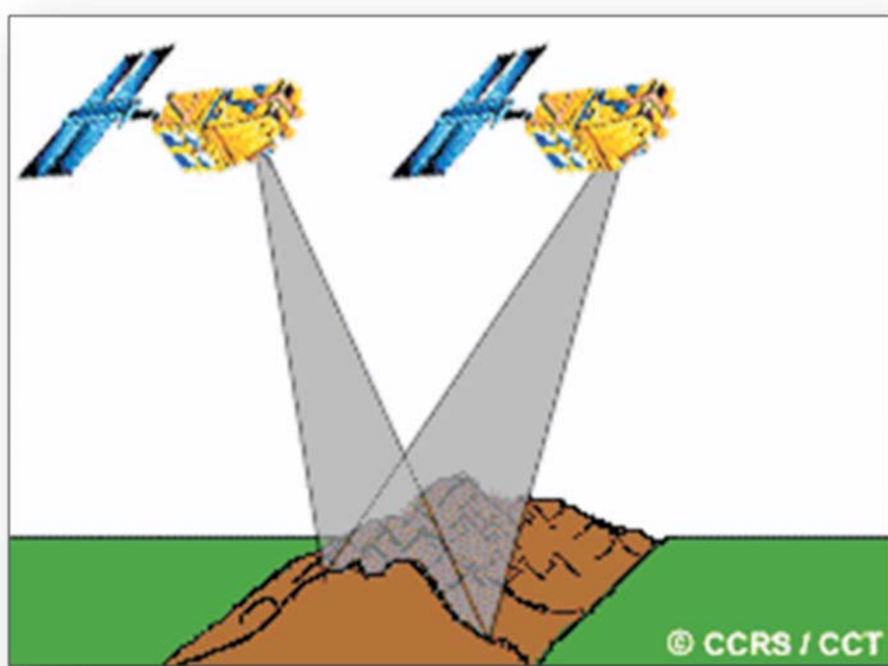


Fig. 22

Sensor	**Revisit Period (No of days)**
IRS 1A/1B	22
IRS 1C/1D	24
Pan	5
WiFS	3
AWiFS	5
Landsat	16 - 18

Table : 3

Temporal Resolution of various Satellites

1.3 Digital Image Processing (DIP)

The spatial data is acquired by remote sensing technology in the form of Images / Photographs. The raw data received from the imaging sensors on the satellite platforms contains inaccuracies. To overcome these inaccuracies it needs to undergo several steps of processing. Various techniques are used to enhance quality of the images. This technique is called as Digital Image processing. Digital processing has the greatest potential for preserving the correct radiometry and the maximum resolution of the images.

> DIP is the collection of algorithms processed by the computer system to enhance the quality of raw data in order to get enhanced Images for further process of iInterpretation and data extraction.

The steps involved in DIP.

A. Image restoration
B. Statistical analysis
C. Image enhancement
D. Image classification

A. Image Restoration

It refers to correct the distorted or degraded image to represent original scene. The steps included in image restorations are;

(i) Geometric correction (Image Rectification)
(ii) Radiometric correction
(iii) Noise removal

> Image restoration processes are designed to identify noise, geometric distortion introduced into the data during scanning, transmission & recording processes. The objective is to map the image resembled to original scene.

(i) Geometric Correction

The geometric errors in image occur due to perspective of the sensor, scanning system, the motion of platform and curvature & rotation of the Earth. Because of these the image exhibits some sorts of scaling, skewing, rotation errors. This correction procedure is called as geometric corrections or rectification.

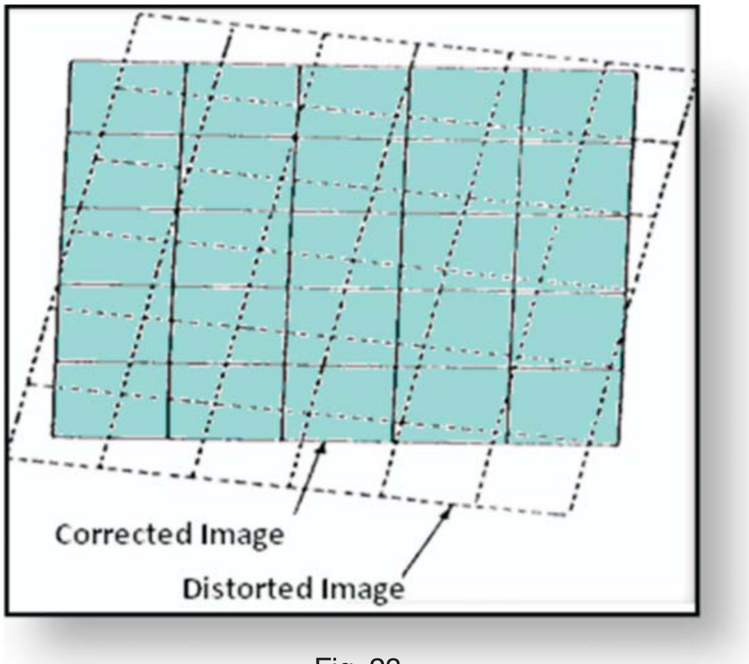


Fig. 23

An example for Geometric Correction

Rectification is the process of assigning the geo locations to the Image / Photograph to remove the geometric distortion. The figure shows an example of corrected and distorted image.

Geometric distortions include nonsystematic distortion such as variation in spacecraft altitude, velocity & altitude. These distortions must be corrected from ground control points.

(ii) Radiometric correction

The reflectance of the ground features varies as the time and location varies. While mosicking two different images acquired at different time and location it is necessary to apply sun elevation and earth sun distance corrections to normalize the reflectance of the images. This process is called radiometric corrections.

(iii) Noise Removal

Image noise is any unwanted disturbance in the image data due to limitation in the sensing instrument or data recording process. Resampling method is used to remove the noise from images.

Image enhancement processes consist of different techniques employed in the calibration of image data for the correction or reduction of errors occurring during capture or transmission of the data. It increases the ability of the analyst to recognize features of interest.

Raw Image
Source: nasa.gov

An example of Low Pass Filter
Source: nasa.gov

B. Statistical Analysis

Histogram

Histogram is a graph showing the number of pixels in an image at each different intensity value. For an 8-bit grayscale image there are 256 different possible intensities. Thus the histogram will graphically display the range from 0-255 numbers showing the distribution of pixels.

Histogram equalization is the technique by which the dynamic range of the DN

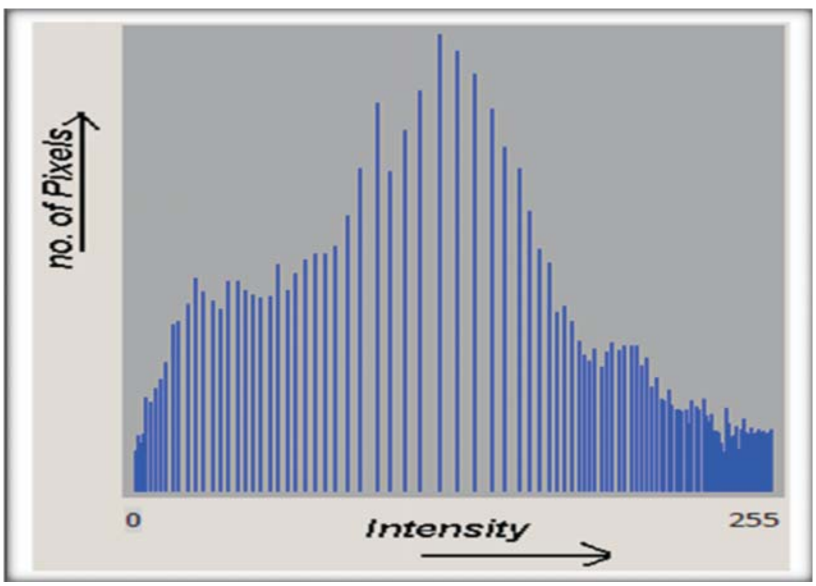


Fig. 24

Histogram Source: www.codersource.net values of an image is increased. Histogram equalization assigns the intensity values of pixels in the input image in such a way that the output image contains a uniform distribution of intensities. It improves contrast and obtains a uniform histogram. By modifying this histogram it enhances the image which is often called Contrast stretching or histogram normalization. It is a simple image enhancement technique that improves the contrast in an image by 'stretching' the range of intensity values. The examples are shown in the figure below. After applying the histogram manipulating techniques image looks clearer than the raw imege.

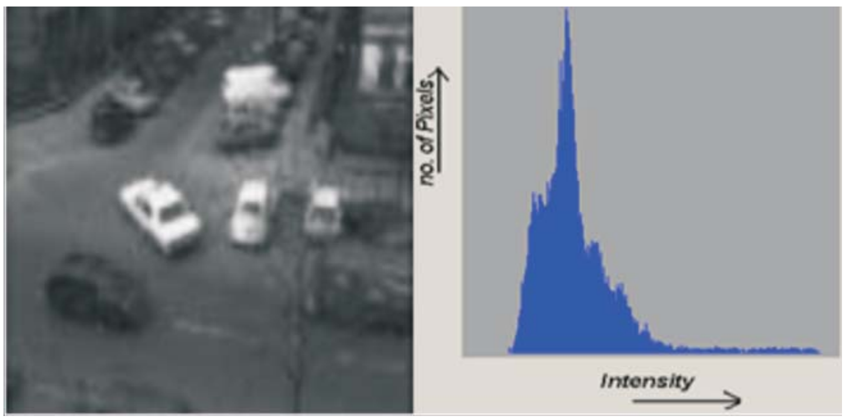


Fig. 25

Original image with Histogram

Source: www.codersource.net

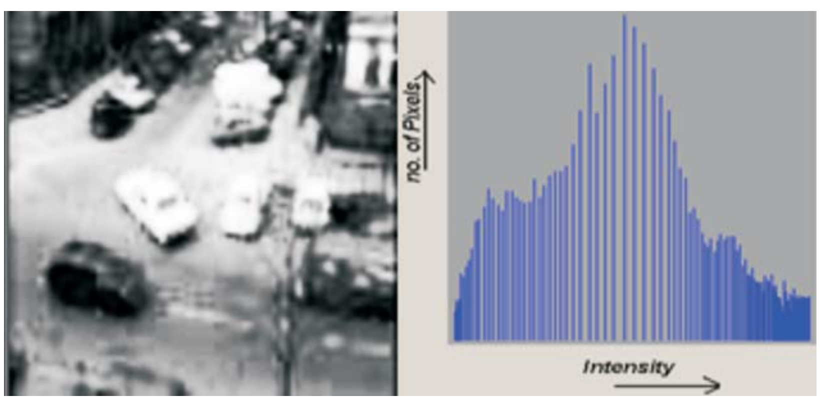


Fig. 26

Modified image after equalized histogram

Source: www.codersource.net

Histogram shows the number of pixels that correspond to each DN

Contrast generally refers to the difference in grey level values in an image. In other words it is the ratio of the maximum intensity to the minimum intensity over an image. Larger ratio makes easy interpretation of the image. Satellite images lack in adequate contrast and require contrast improvement. Contrast enhancement techniques expand the range of brightness values in an image so that the image can be efficiently displayed..

Linear Contrast Stretch is the simplest contrast stretch algorithm. The grey values in the original image and the modified image follow a linear relation. A density number in the low range of the original histogram is assigned to extremely black and a value at the high end is assigned to extremely white. The remaining pixel values are distributed linearly between these extremes. The features or details that were unclear on the original image will be clear in the contrast stretched image. Linear contrast stretch operation can be represented graphically as shown in the Figure given below.

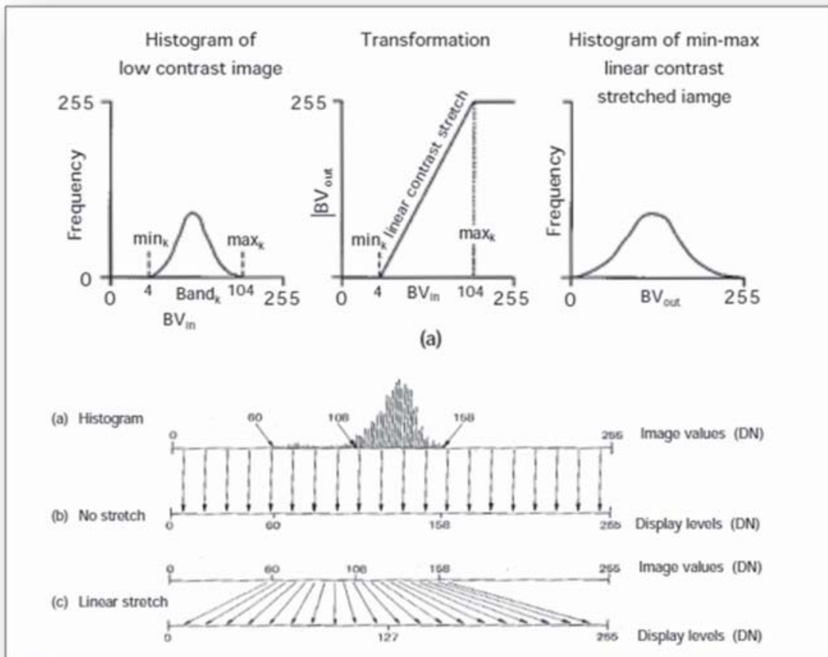


Fig. 27

Linear Contrast Enhancement Source: nasa.gov

Linear contrast greatly improves the contrast of the original brightness values but there is a loss of contrast at the extreme high & low ends of DN values.

In Non-linear contrast enhancement, the input and output data values follow a non-linear transformation. Non-linear contrast enhancement is defined by y = f (x), where x is the input data value and y is the output data value. The non-linear contrast enhancement techniques have been found to be useful for enhancing the color contrast between the nearby classes and subclasses of a main class.

Spatial filtering is another technique of digital processing functions. It is used to enhance the appearance of an image to derive valuable information. In the real world there are boundaries between features which cannot be seen in raw images. These boundaries can be emphasized using several computer algorithms. Algorithms for this purpose are called "filters". Spatial filters are designed to highlight or suppress specific features in an image based on their spatial frequency.

A low - pass filter blocks the high spatial frequency details. It is designed to emphasize larger, homogeneous areas of similar tone and reduce the smaller detail in an image. Low-pass filter generally serve to smooth the appearance of an image and reduce "salt and pepper" noise as shown in below figure. The most commonly used low pass filters methods are mean, median and mode

Fig. 28

Raw Image

Source: nasa.gov

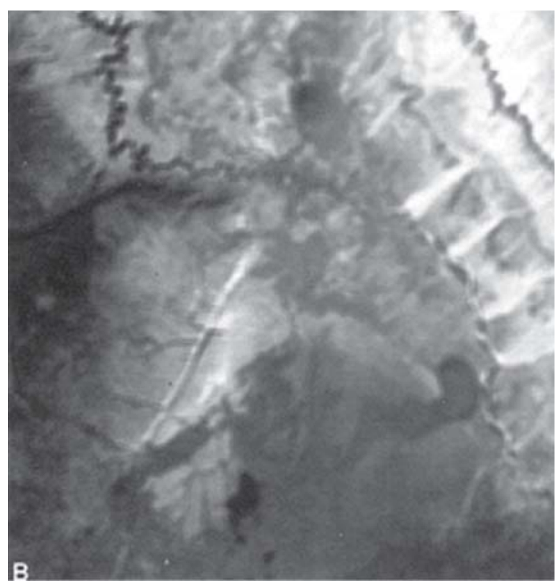


Fig. 29

An example of Low Pass Filter

Source: nasa.gov

High pass filet are used to emphasize fine details and edges. Figure given below shows the example for High pass filter in an Image. This filter enhances details and clear edges and abrupt discontinuities. Therefore rock joints, faults, field boundaries, and street patterns are clearly visible as compared to raw image

Fig. 30

Raw Image

Source: nasa.gov

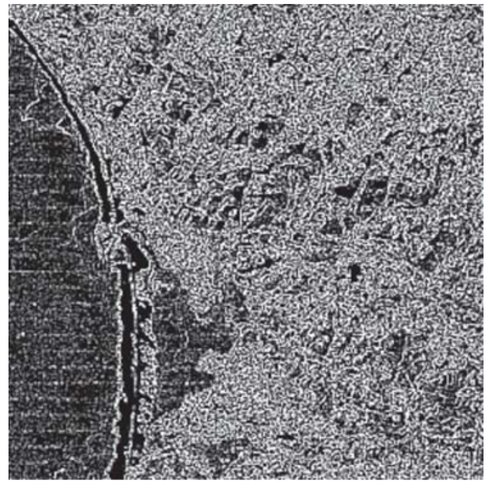


Fig. 31

An example of Low Pass Filter

Source: nasa.gov

c) Image Enhancement

Image enhancement techniques are applied to improve the quality of an image. Image enhancement is applied after correcting geometric and radiometric distortions. There are various types of techniques available to improve image quality for father analysis and interpretation. The contrast stretch, density slicing, edge enhancement, and spatial filtering are commonly used image enhancement techniques.

Band ratioing

Image division or spectral ratioing is one of the most common techniques applied to image data. Ratio Images are division of DN values of one spectral band by corresponding DN of another band. The ratio has been used to identify different features. For example the ratio of near-infrared / red is less than 1 it represents water and greater than 1 it represents vegetation. NIR / R images are used to identify vegetated area. Image ratioing highlights slight variations in the spectral responses of various surface features. Healthy vegetation reflects strongly in the near infrared portion of the spectrum while absorbing strongly in the visible red. Other surface types, such as soil and water, show nearly equal reflectance in both the near-infrared and red portions. A ratio image of Landsat MSS Band 7 (Near- Infrared - 0.8 to 1.1 mm) divided by Band 5 (Red - 0.6 to 0.7 mm) would result in ratios greater than 1.0 then it will

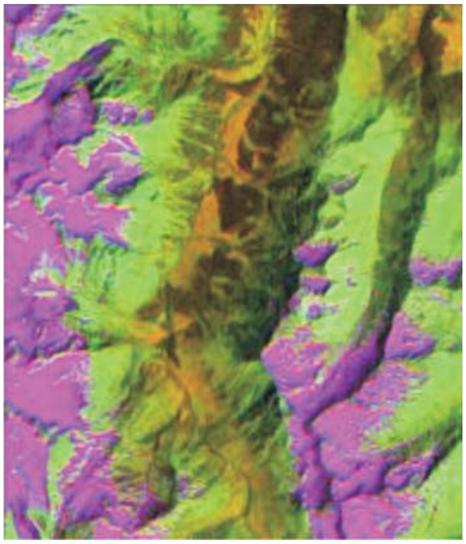


Fig. 32

Original Image

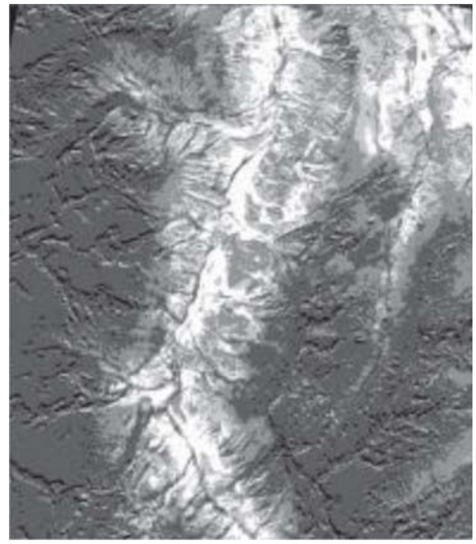


Fig. 33

NIR/R (TM4/TM3), with values ranging from 0 to 8, soil to vigorous vegetation, vegetated areas shown in white.

be easy to identify the vegetation, soil and water. This is the most common arithmetic operation applied to images in geological, ecological and agricultural applications of remote sensing.

Normalized Difference Vegetation Index (NDVI)

NDVI is used to assess, analyze and estimate live green vegetation, crop yields, pasture etc. NDVI is directly related to various parameters

- Ground cover
- Photosynthetic activity of the plant
- surface water
- Leaf area index.

Several algorithms are used to extract such information from remote sensing data, which are referred as vegetation indices. NDVI is a numerical indicator that uses the visible and near-infrared bands of the electromagnetic spectrum. Healthy vegetation absorb in visible band and reflects in near-infrared band. Unhealthy vegetation reflects more visible band and less in near-infrared band. On the other hand bare soils reflect moderately in both the red and infrared band of the electromagnetic spectrum. By knowing the behavior of plants across the electromagnetic spectrum NDVI information can be derived by using following formula. Near-infrared and red bands are most sensitive to deriving vegetation information by the sum of near-infrared and red bands.

$$NDVI = (NIR - RED) / (NIR + RED)$$

Where NIR - >Near Infrared band

RED - >Red band from visible range

The NDVI algorithm subtracts the red reflectance values from the near-infrared and divides it. NDVI values are represented as a ratio ranging from -1 to 1. Extreme negative values represent water; values around zero represent bare soil. The bigger the difference between the near-infrared and the red reflectance, healthy will be the vegetation. In the figure below the NDVI is calculated in Kharif Season in Punjab from May to November months. The dark green, yellow color shows less vegetation (May, June ,October) and dark red color shows healthy vegetation.

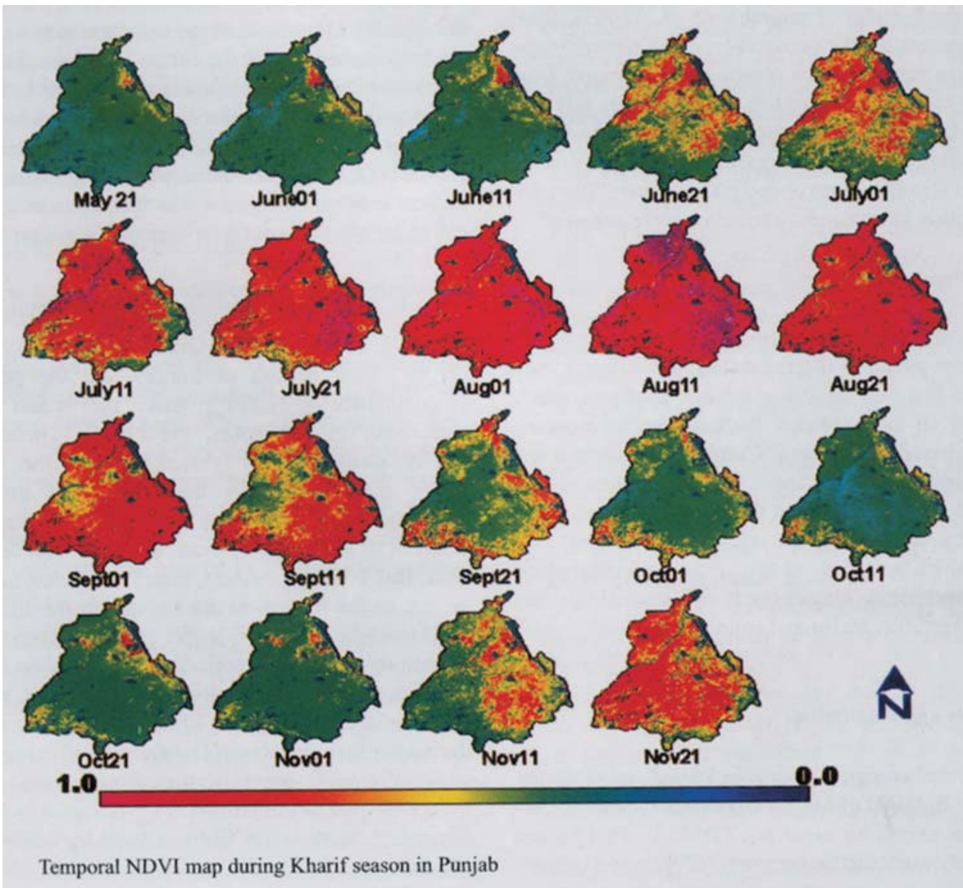


Fig. 34

NDVI Map for Punjab during Kharif Season Source: PRSE

Perpendicular Vegetation Index (PVI)

The plot of reflectance in the red and near infrared bands, of bare soil, under various degrees of wetness, is the baseline for the vegetation index. The illustration is shown in figure. PVI is measured perpendicularly from this soil baseline. Point A has a higher PVI than point B. mathematically this measure is represented below

Perpendicular vegetation index: $\sqrt{(soil^{R} - veg^{R})^2 + (soil^{IR} - veg^{IR})^2}$

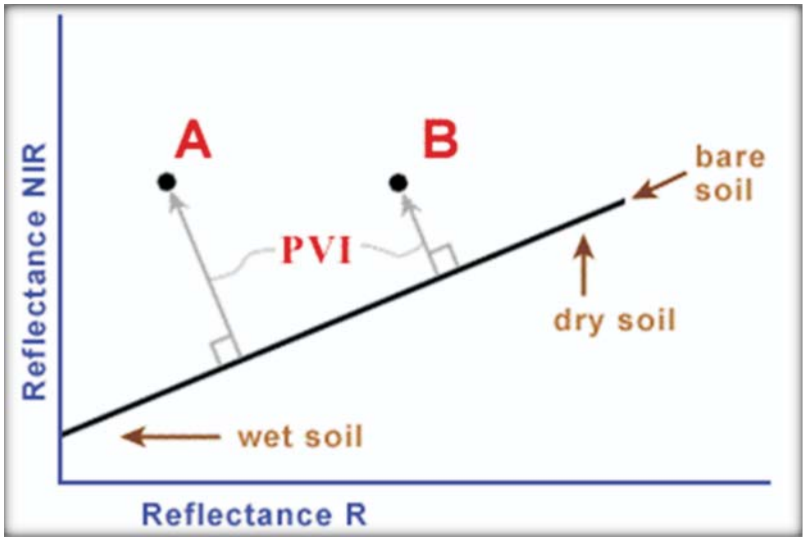


Fig. 35

D. Image Classification

Classification is a process to categorize all pixels in a digital image into one or several land cover classes, or "themes". Digital image classifications use the spectral information represented by the digital numbers in one or more spectral bands, and classify each individual pixel based on this spectral information. Classification techniques are generally applied to

> Image classification is a process of automatically categorization of all pixels in an image into different land cover classes or themes

the single-date image or series of multi-date images for change detection. Normally, multispectral data are used to perform the classification. Grouping of the pixels are based on their spectral information (DN) present within the data. The objective of image classification is to identify different features occurring in an image to identify different land features. These groups are called as classes. Based on DN values we can create the classes like Vegetation, Water body, Barren Land, Buildup Area etc. Broadly we can use two approaches for classification:

1. Unsupervised classification
2. Supervised classification

In Unsupervised classification spectral classes are grouped first, based on the numerical information in the data. Clustering algorithms are used to determine the natural classes in the data. Algorithms examine the unknown pixels in an image and group them into a number of classes. Unsupervised Classification method does not utilize training data as the basis for classification. Based on the reference data, area knowledge and experience, user compare the classified data and identify the features and name them as shown in the figure. There are numerous clustering algorithms that can be used to determine the natural spectral groupings present in data set. The most used algorithm is "K-means" approach also called as ISODATA (Interaction Self-Organizing Data Analysis Technique). Unsupervised classification is not complete without human involvement.

Unsupervised classification is popular in industries involved in long term GIS database maintenance because it uses clustering procedures which are extremely fast.

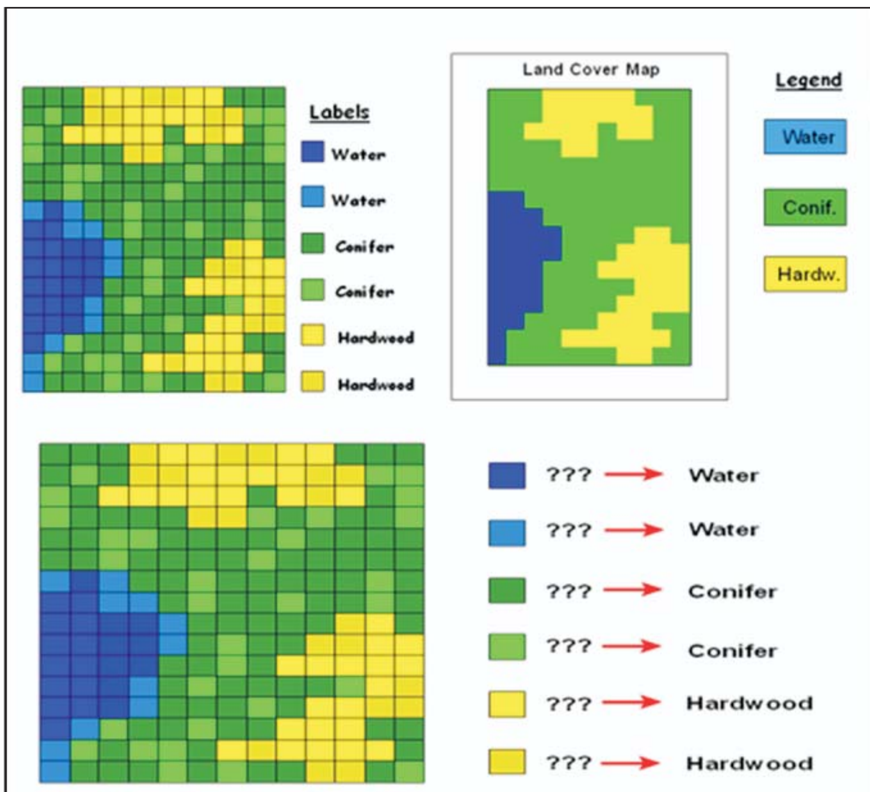


Fig. 36

Unsupervised Classification Process

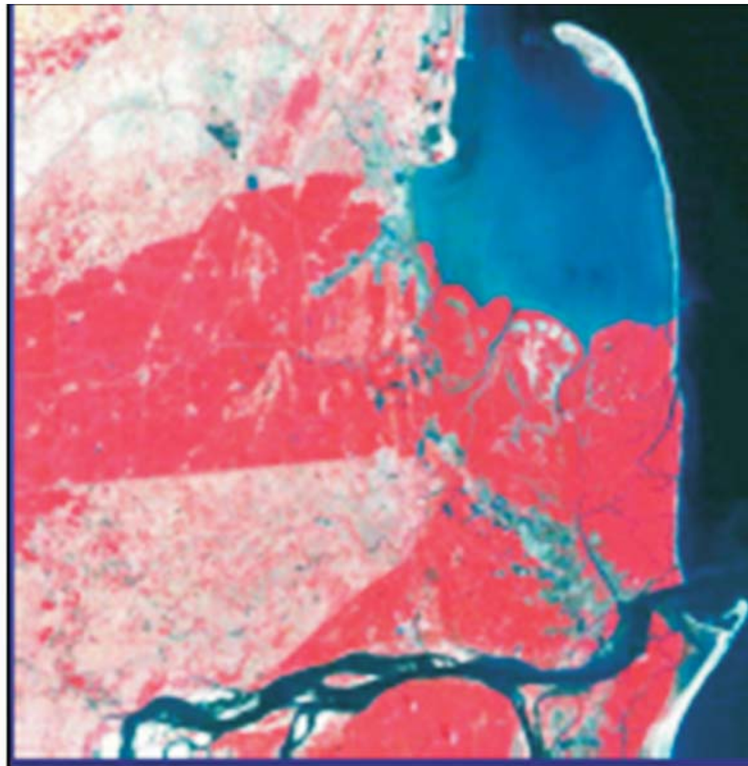


Fig. 37

Supervised classification is more accurate for mapping classes, but it depends heavily on the area knowledge and skills of the analyst. The analyst should recognize classes in an Image based on prior knowledge and assign them class names. These are called as training sites. The training sites areas representing known land cover category that appear homogeneous on the image. Image processing software categorizes of the reflectance of each class. This process is called "signature analysis". The entire image is classified based on this signature assigned. Most frequently used algorithms for supervised classification are parallelepiped, minimum distance and maximum likelihood. The basic steps involved in a typical supervised classification procedure are as given below.

(i) Defining training site

(ii) Featuring selection (signature analysis)

(iii) Selection of appropriate classification algorithm

(iv) Post classification smoothening

(v) Accuracy assessment

(vi) Classified Image (Result)

(vii) Statistical report generation for different landuse and landcover

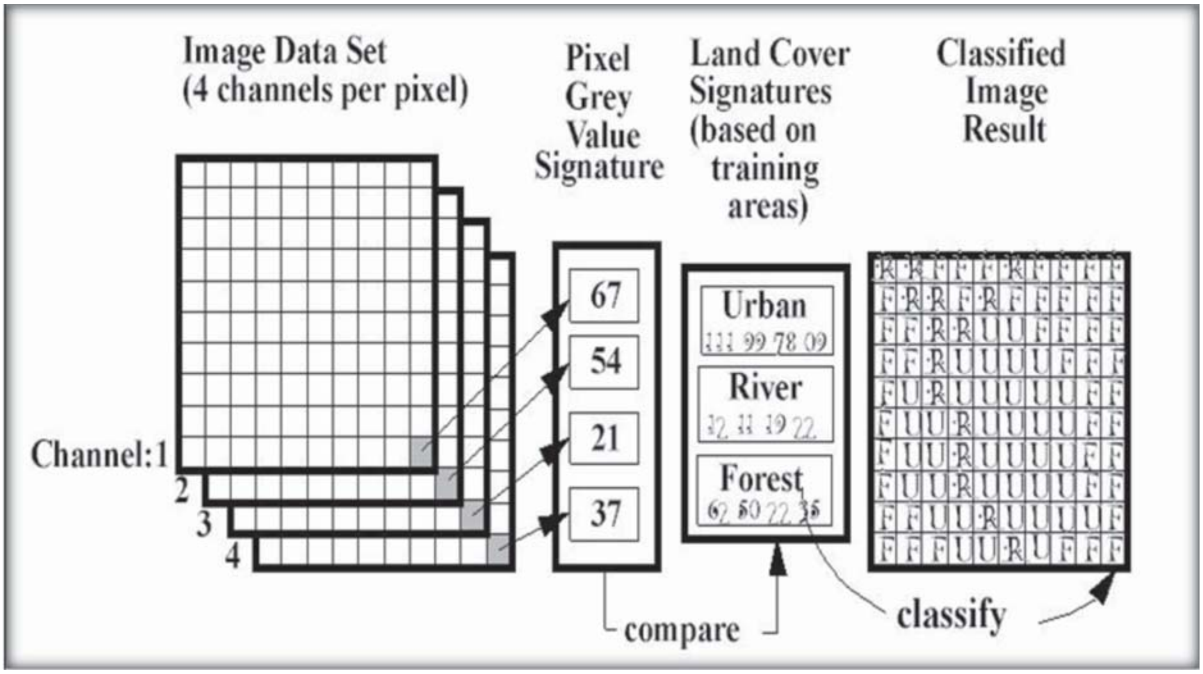


Fig. 38

Steps in Supervised Classification

Source: www.sc.chula.ac.th

In the figures given below the training sites are shown and names are assigned such as Turbid Water, Deep Water, Shallow Water, Wet Land, Barren Land, Agriculture and Forest. Based on these training sites the raw Image is classified and final output is shown fig. 40.

After classification the classified map needs to be compared with other maps of same area to assess and verify the accuracy. In areas of complex terrain, the unsupervised approach is preferable as compared to supervised classification. In such conditions if the supervised classification is used, the user will have difficulty in selecting training sites because of the variation of spectral response within each class. As unsupervised classification distinguishes classes based on spectral response, ground truthing requirements are reduced for some extent. Unsupervised classification reveals separate classes of unknown places without visiting the site.

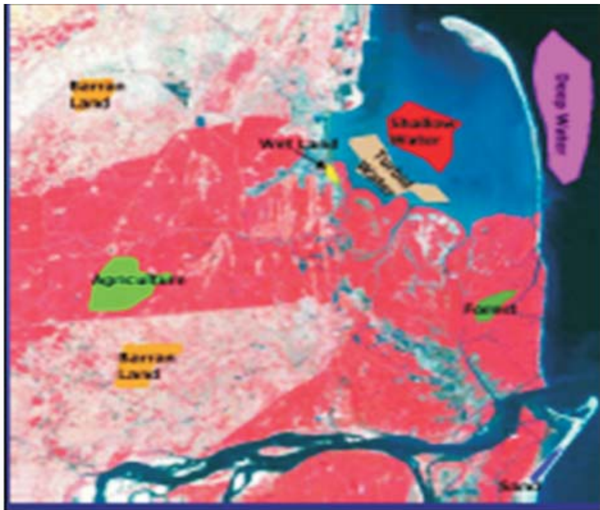


Fig. 39

Image with Training Sites

Source: NRSC Hyderabad

Fig. 40

Classified Image

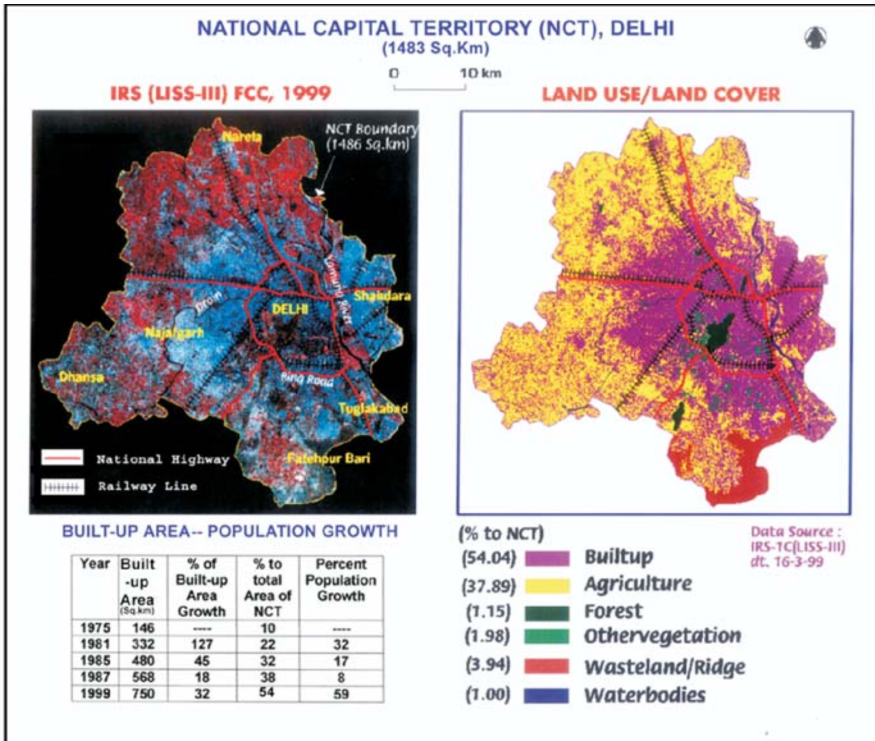
Source: NRSC Hyderabad

1.4 Visual Interpretation of Satellite Data

Imagery obtained by remote sensing is used in various applications. By studying the qualitative and quantitative aspects of images one can derive useful information by having knowledge about the area for further interpretation and analysis. Image interpretation is the art and science of examining image to identify the objects and evaluates their significance. Identifying features in remotely sensed images are based on following;

a) Tone
b) Shape
c) Size
d) Pattern
e) Texture
f) Shadow
g) Association

Image interpretation is defined as examining images to identify objects and judge their significance.



Year	Built -up Area (Sq.km)	% of Built-up Area Growth	% to total Area of NCT	Percent Population Growth
1975	146	----	10	----
1981	332	127	22	32
1985	480	45	32	17
1987	568	18	38	8
1999	750	32	54	59

Fig. 41

An example for supervised classification along with the Statistical report on Land use/ Land covers (Source: ISRO Report)

a) Tone

Tone refers to the relative brightness (color) of objects in an image. The term is used for each distinguishable shade from black to white, such as dark, medium, light gray as shown in picture. Tone is the important element for identifying different features. Variations in tone also help identification of shape, texture, and pattern of objects. For example dry sand will appear in light shades of grey, while wet sand appears in dark shades of grey. In figure road looks brighter than the wet field.

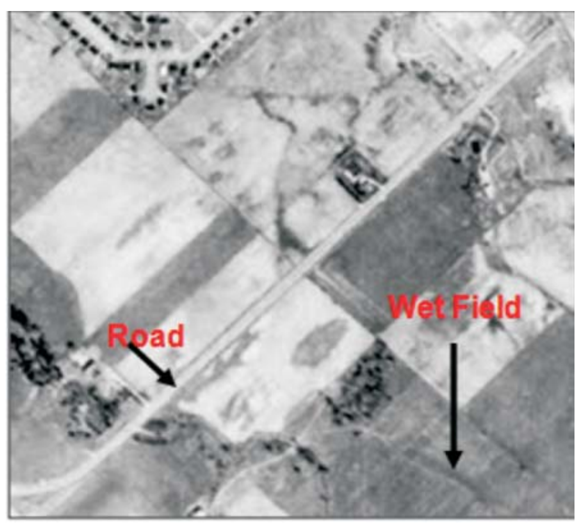


Fig. 42

Tonal Variation in an Image
Source: CCRS

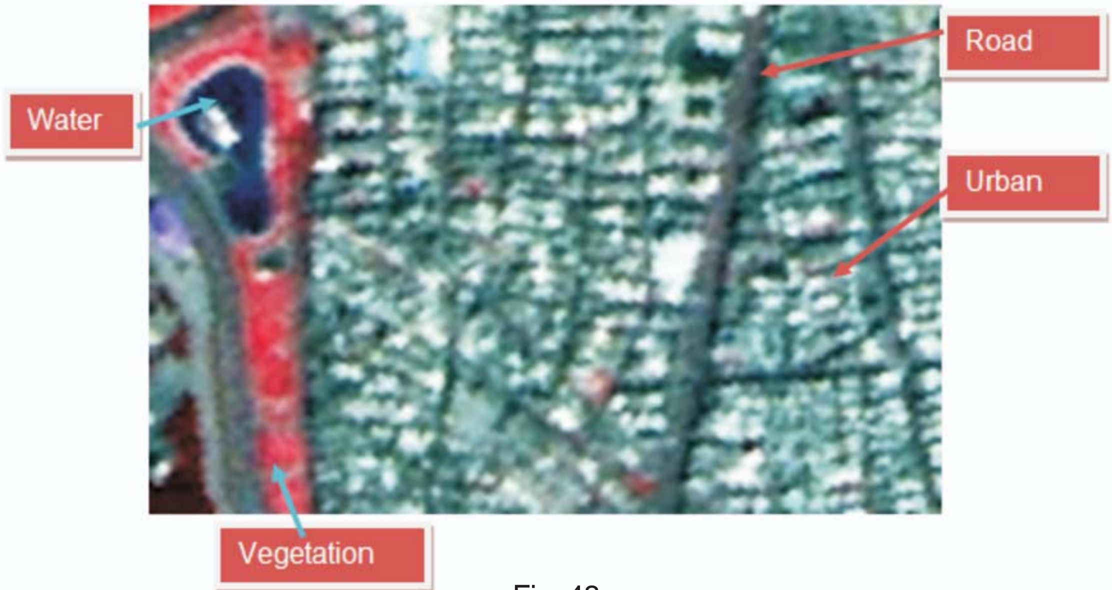


Fig. 43

Features indentified based on tonal Variation

b) Shape

Shape refers to the general form, structure, or outline of individual objects. Shape is an important element for interpretation. Straight edge shapes represent urban or agricultural fields. Natural features, such as forest edges, are generally more irregular in shape. Farm or cropland irrigated by rotating sprinkler systems would appear as circular shapes. Many geomorphologic shapes are identified, such as sand dunes lakes, volcanic cones etc. For example in the above figure (44) the tennis court is visible.

Fig. 44

Indentified feature based on Shape

Courtesy: J.M Piwowar

c) Size

The size of a feature is also significant element in image interpretation. Size of objects in an image is a function of scale. Size when considered along with shape and association, helps in easy identification of the features. For example in this figure large buildings such as factories or warehouses would suggest commercial property, whereas small buildings would indicate residential use.

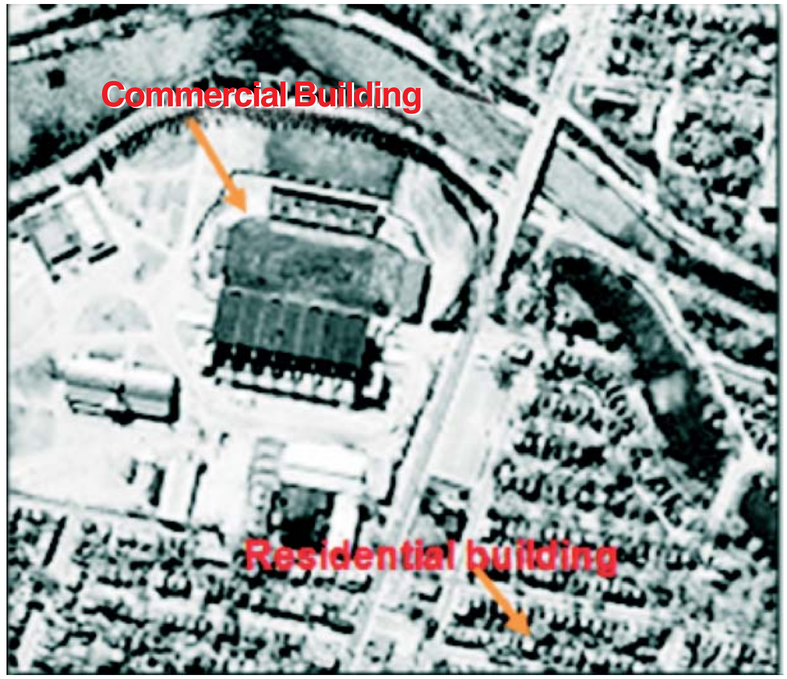


Fig. 45

Feature identified based on Size
Source: CCRS

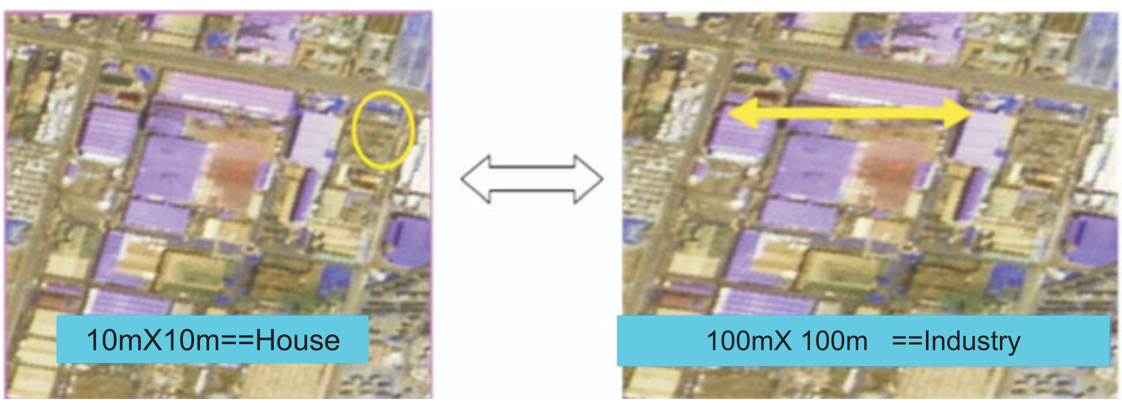


Fig. 46

Identification of House and Industries based on Size

d) Pattern

Pattern refers to the spatial arrangement of visibly separate objects. An orderly repetition of similar tones and textures will produce a distinctive and recognizable pattern. Urban streets with regularly spaced houses are good and orchards with evenly spaced trees as shown in figure are good examples of pattern.

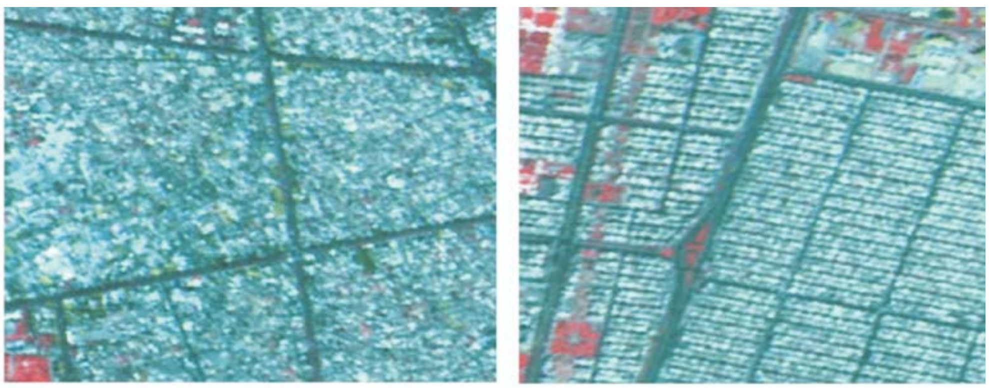


Fig. 47

Example of Planned and unplanned urban area based on pattern

e) Texture

Texture is closely associated with tone. This includes smooth, and rough surfaces. Rough surfaces have a spotted tone where the grey levels change abruptly in a small area. For example forest canopy shows rough texture in an image. Smooth surfaces have very little tonal variation. For example fields or grasslands appear smooth and uniform in image.

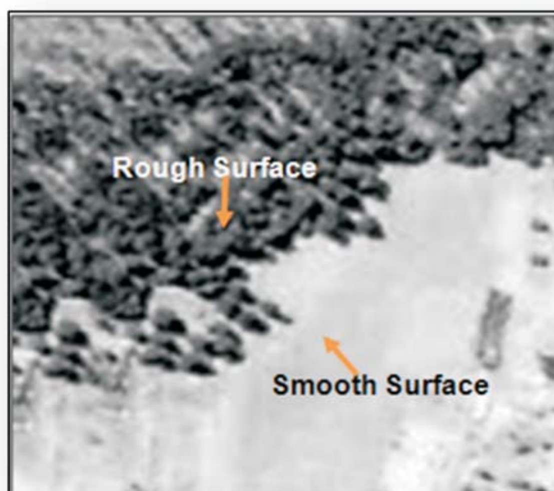


Fig. 48

Feature indentified based on Texture Source: CCRS

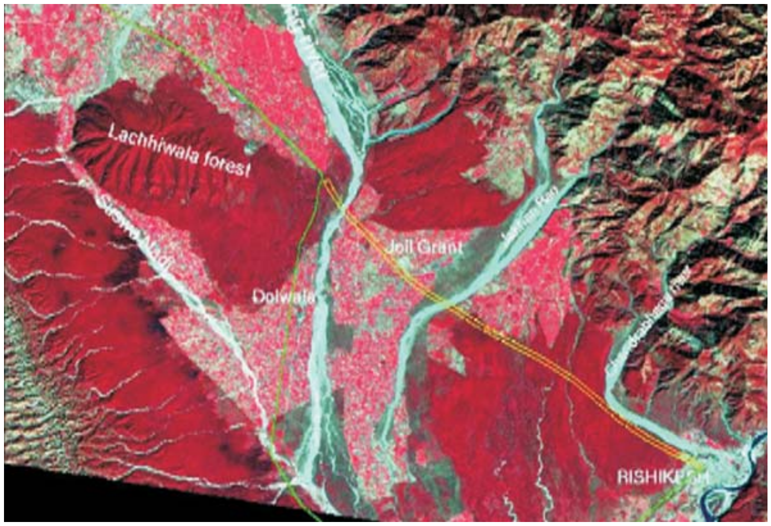


Fig. 49

Feature indentified based on Texture

(Source: RRSC North)

f) Shadow

Shadow is an important element for Image interpretation. It makes identification easier because it provides profile of the features. Shadow length can be used for height measurements. Shadows reduce interpretation in that area because of non visibility of features. Shadow is useful for identifying topography and landforms. Figure shows that the shadows of the tall building which covers the features from other side of the building which cannot be seen due to this information cannot be derived.

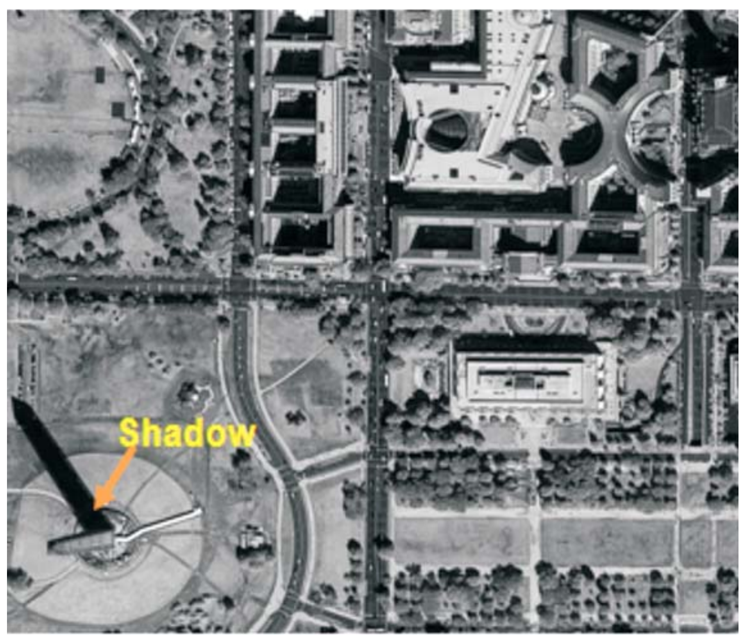


Fig. 50

Shadow in an Image

g) Association

Association of objects is one of the most important elements of image interpretation. It takes into consideration the relationship between other objects which are near to the target. For example commercial properties may be associated with major transportation routes, whereas in residential areas if we see an open space it would be associated with schools, playgrounds, and sports fields. In above figure, a lake is associated with boats, a marina, and adjacent recreational land.

Fig. 51

Features are indentified by their association
Source: CCRS

1.5 Aerial Photo and its Interpretation

Aerial photography is obtained by using aircraft as platforms. Aerial photographs give Bird's eye view of a large area enabling view of the earth is surface features which can not be possible to obtain through ground observation. Aerial photograph can record earth features in visible, ultra violet and near infrared in the form of a visible image. With proper selection of camera films and flight parameters it is able to record more spatial details on photographs as compared to human eye. With proper ground reference data it can obtain accurate measurements of positions, distances, directions, areas, heights, volumes and slope etc. Aerial photography is the permanent record of existing condition which can be studied whenever required. Single image can be used by a large number of users for different types of applications such as geology, agriculture, soil, crop study. Aerial photos are also useful to study dynamic phenomenon such as floods, wildlife population, traffic, oil spills and forest fires.

The films used in aerial camera are of two types

(i) Panchromatic (B & W) – It is cheap and commonly used in Photogrammetry.

(ii) Color- it is easy to interpret but fuzzy due to atmospheric scattering

A) Determining the Photo scale:

Scale of the Photo can be derived by the following formula

$$S = f / H$$

Where: S = Scale of Aerial Photograph

f = Focal length of Camera (normally 152 mm)

H = Flying height

If 1mm on a photograph represents 25 meter on the ground then the scale of photograph is represented as 1mm = 25 m (represents equivalents). If it is 1/25000 (it represents fraction) 1:25000 (represents the ratio).

Flights are usually scheduled between 10 am to 2 pm to have low wind, clear sky with maximum illumination and minimum shadow to obtain clear weather picture. February to April months is optimal period to acquire the aerial photographs. Aerial Photographs can be used for flood, vegetation mapping, and soils study

The various factors which affect the qualities of the aerial photos are:

(i) Clouds, haze, shadows/sun angle, snow

(ii) Distortion due to tip & tilt, relief distortion, radial distortion

(iii) Storage and handling can be a problem

(iv) Limited to 0.3 - 0.9 μm (UV-NIR)

Aerial Photographs are classified as follows:

i) Vertical

ii) Oblique

   a) High

   b) Low

iii) Stereo/3D

i) Vertical

Vertical photographs are made with the camera axis directed as vertically as possible. The photographs made by single lens frame camera. This is the most common type of aerial photography used in RS application. The vertical air photos with less than 3° tilt are considered as vertical photographs. To achieve this, it requires the special equipment to maintain the lens axis vertically and to the ground. Vertical photos are used for planning and redesigning industrial sites.

Fig. 52

An example of Vertical Photo

ii) Oblique

When the aerial photographs are taken with an intentional inclination of the camera axis is called oblique photographs. Oblique photographs are easy to understand because it allows identification of structural and topographic variation. It is easy and cost effective to acquire. The photographs with more than 3° tilt are considered as oblique. It is used to study commercial, residential, industrial, and transportation buildings and infrastructure.

There are two basic types of oblique aerial photography.

1. High angle oblique
2. Low angle oblique.

In a high angle oblique, the apparent horizon is shown, while in a low angle oblique the apparent horizon is not shown. In high oblique photo the camera inclination angle is from 30 to 60 degrees where in Low oblique the inclination angle is 5 to 30 degrees.

Fig. 53

An example of Low Oblique Photo
Source: www.heliphoto.net

Fig. 54

An example of High Oblique Photo
Source: www.aboveallphoto.com

iii) Stereo 3D

Stereo photography is a technique to make two photographs of the same subject, from slightly different positions. These two positions should differ approximately about 10 cm. These images are called stereo images and can be viewed using stereoscope or by stereo computer graphics devices. The resultant image appears to be 3 dimensional and depth can be seen. This depth can be controlled by increasing or decreasing the distance between photography locations.

> Stereo photography involves taking a photograph from two positions, which corresponds to two "eye" positions.

Photographs are taken generally with some percentage of overlaps. For stereoscopic coverage the general overlap is:

- Forward Overlap : 60% (for stereoscopic studies)
- Lateral Overlap : 20-30% (for edge matching)

B) Interpretation of Aerial Photo

The interpretation of aerial data is quite similar with Satellite images. The Interpretation keys for aerial photographs are listed below

- Shape
- Size
- Pattern

- Texture
- Shadow
- Association

The details about these keys are already discussed in Visual Interpretation of Satellite data.

Fig. 55

Aerial Photograph Panchromatic

1.6 Advanced Remote Sensing Technologies

a) Hyper Spectral Imagery

Hyper spectral sensors collect information as a set of 'images'. Each image represents a range of the electromagnetic spectrum and is also known as a spectral band. These 'images' are combined and form a three dimensional hyper spectral cube for processing and analysis. Hyper spectral cubes are generated from airborne sensors like the NASA's Airborne Visible/Infrared Imaging Spectrometer (AVIRIS), or from satellites like NASA's Hyperion. Hyper spectral imaging collects and processes information from visible as well as

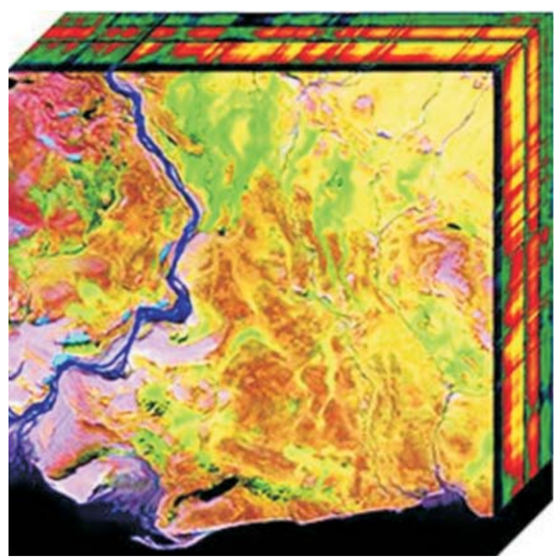


Fig. 56

Hyper Spectral Images with multiple bands
Source: rst.gsfc.nasa.gov

from the ultraviolet to infrared band. These data can be used for application in agriculture, mineralogy, physics and surveillance.

Hyper spectral images are acquired at entire spectrum. So it does not require prior knowledge of sample data, and post-processing allows all available information from the dataset to be used. Hyper spectral allows preparing more accurate models and classification of image. The disadvantages of these data are cost & complexity. Fast computers, sensitive detectors, and large data storage capacities are needed for analyzing hyper spectral data.

b) Thermal Remote Sensing

Remote sensors cover two thermal intervals that are 3 - 5 µm and 8 - 14 µm broad bands. It allows sensing of thermal emissions from the land, water, ice and the atmosphere. Many of the meteorological satellites include at least one thermal channel. A thermal band is included on the Landsat Thematic Mapper.

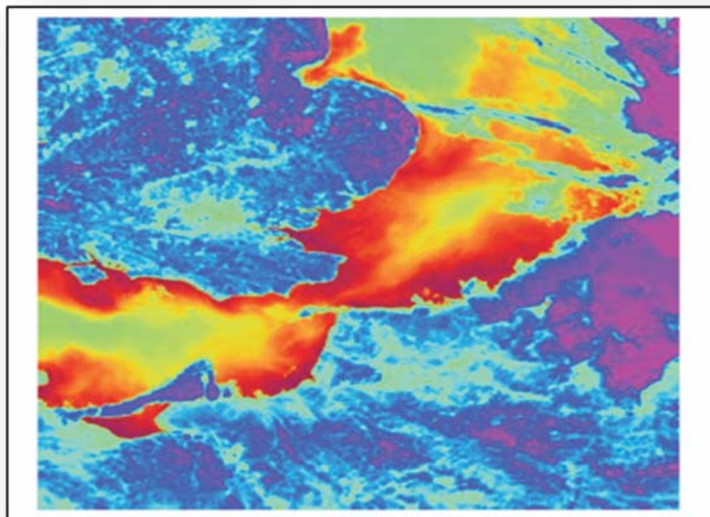
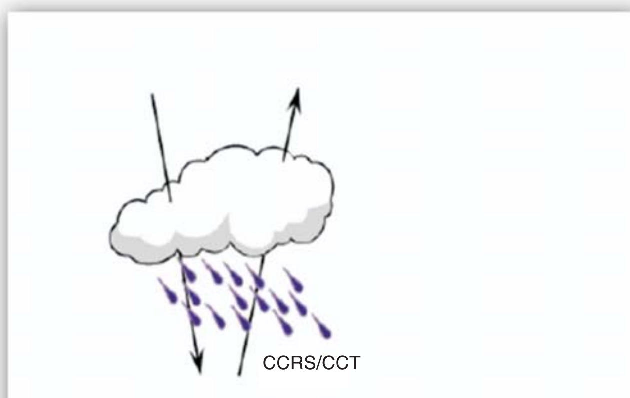


Fig. 57

Thermal Image Source: rst.gsfc.nasa.gov

c) Microwave Sensing

Microwave band in EMR radiation is used in remote sensing to provide useful information about the Earth's atmosphere, land and ocean. Microwave region in EMR ranges from 0.1 to 30 centimeters is called the. Because of their long wavelengths microwave radiation can penetrate through cloud cover, haze and dust. The microwave sensing detects microwave energy under



Penetration of microwave through clouds

Fig. 58

almost all weather and environmental conditions so that data can be collected at day and night both.

Microwave Remote Sensing is classified in two categories namely: active and passive microwave remote sensing.

- Passive microwaves Remote sensing uses emitted energy from thermally activated bodies of earth surface.
- Active remote sensing uses manmade device such as RADAR, SONAR, Lidar etc. Active microwave remote sensing system provides their own illumination.

The basic principle of the Imaging radar is to emit electromagnetic radiation towards the earth surface and record the quantity and time delay of energy backscattered.

Radar is also called as a distance measuring device.

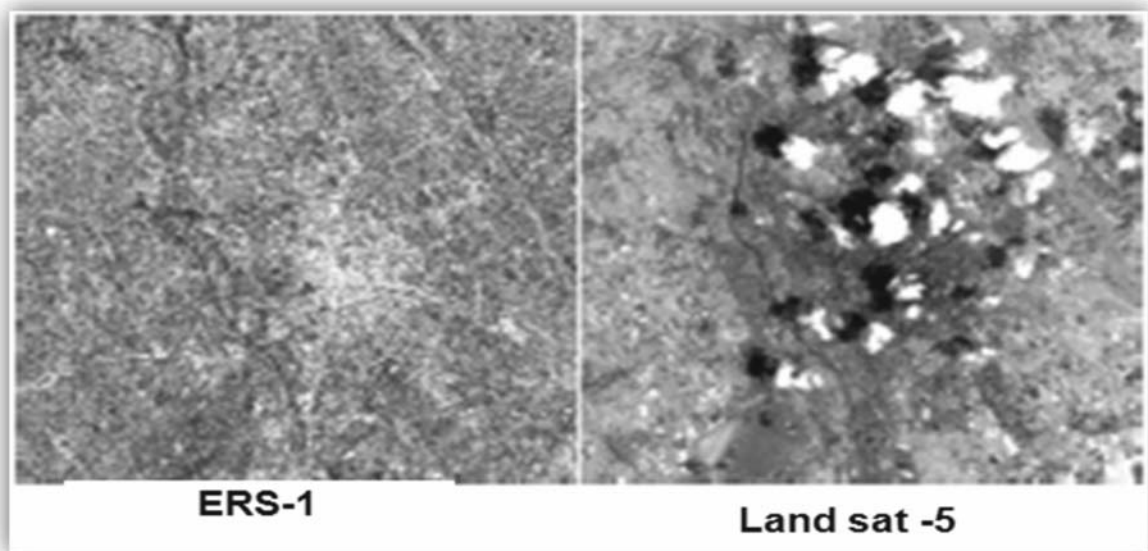


Fig. 59

The example for Radar images acquired by ERS-1 and Landsat-5 on the same date on the fourth of July 1998

(Source NRSC-Hyderabad)

Radio Detection and Ranging (Radar) is an active sensor system. It consists fundamentally of a transmitter, a receiver, an antenna, and an electronics system to process and record the data.

It generates its own illumination to interact with the surface features. Some features backscattered the energy which is collected by radar antenna. The backscattered signal is measured to discriminate between different targets and the time delay transmitted and reflected energy. The transmitter generates successive pulses of microwave (A) at regular intervals which are focused by the antenna into a beam (B) as shown in the figure. The radar beam illuminates the surface at a right angle to the motion of the platform. The antenna receives a portion of the transmitted energy reflected / backscattered from various earth surface objects within the illuminated beam (C). The location of the object can be determined by measuring the time delay between the transmission of a pulse and the reception of the backscattered "echo" from different features. Thus it creates two-dimensional image of the surface.

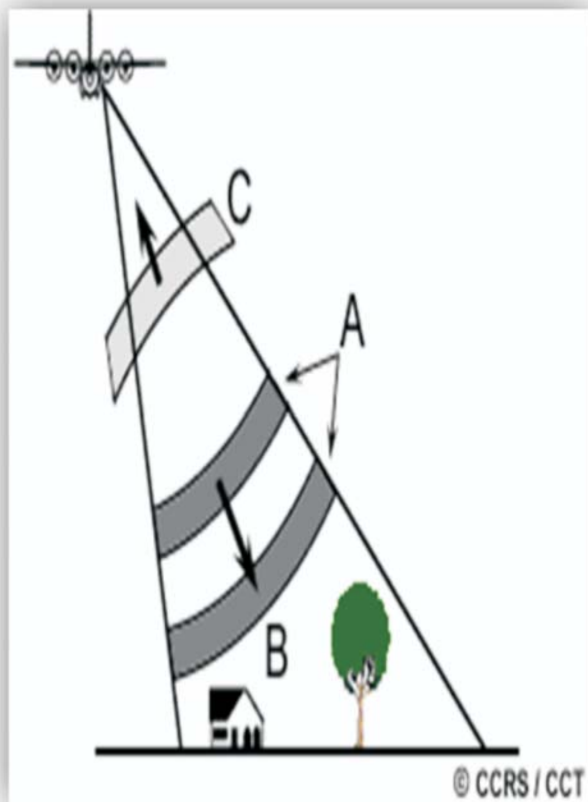


Fig. 60

RADAR Mechanism

Radar operates in part of the microwave region of the Electro Magnetic Specturm specifically in the frequency ranges from 40,000 to 300 megahertz (MHz) and higher frequencies of the broadcast-radio region. The table given below shows the frequencies and their corresponding wavelengths used in RADAR.

Table : 4

Sl. No	Band	Frequency	Wavelength Range
1	Ka	40,000-26,000 MHz	0.8-1.1 cm
2	K	26,500-18,500 MHz	1.1-1.67 cm
3	Ku	18,000 – 12,500 MHz	1.67-2.4 cm
4	X	12,500-8,000 MHz	2.4-3.8 cm

5	C	8,000-4,000 MHz	3.8-7.5 cm
6	S	4,000-2,000 MHz	7.5-15.0 cm
7	L	2,000-1,000 MHz	15.0-30.0 cm
8	P	1,000- 300 MHz	30.0-100.0 cm

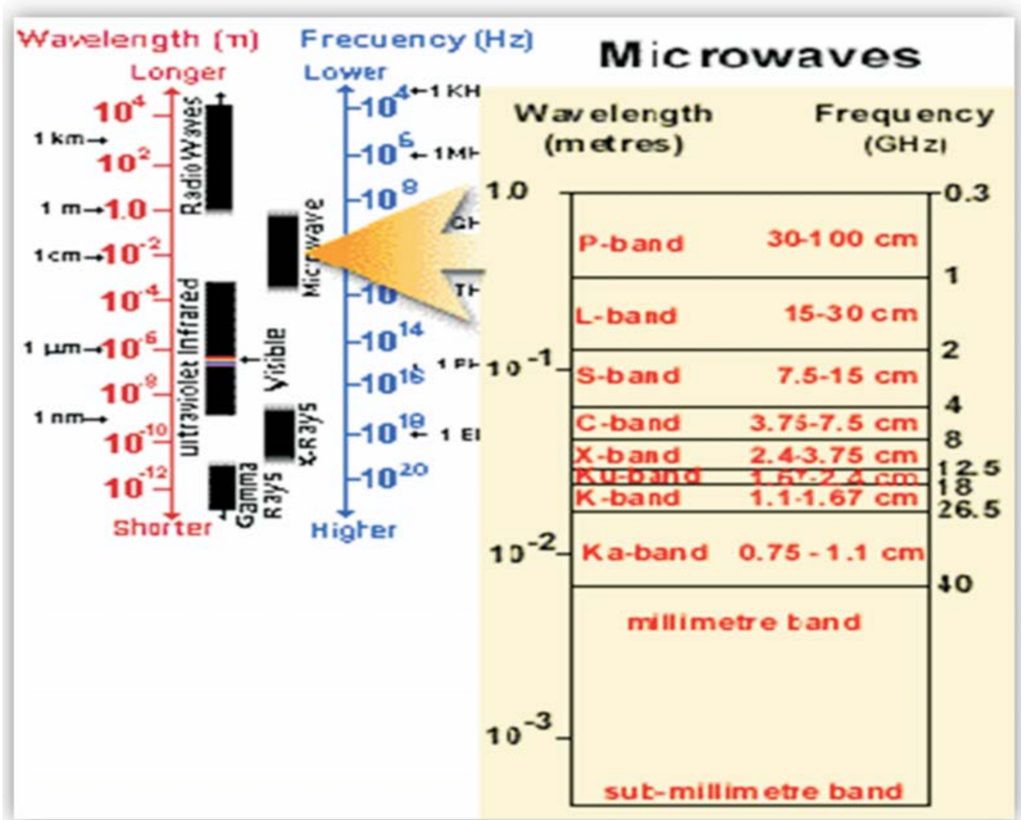


Fig. 61

This chart summarizes the above information on Bands in the Microwave segment of EM spectrum

Source: rst.gsfc.nasa.gov

d) Interaction between Microwaves and Earth's Surface

When microwaves strike a surface, the proportion of energy scattered back to the sensor depends on many factors:

- Physical factors such as the dielectric constant of the surface materials which also depends strongly on the moisture content

- Geometric factors such as surface roughness, slopes, orientation of the objects relative to the radar beam direction;
- The types of land cover (soil, vegetation or man-made objects).
- Microwave frequency, polarization and incident angle.

Microwave remote sensing used in various types of application such as meteorology, hydrology, and oceanology. Meteorologists can use microwave to measure atmospheric profiles and to determine water and ozone content in the atmosphere. Hydrologists use microwaves to measure soil moisture. Oceanographic applications include mapping sea ice, currents, and detection of pollutants, such as oil slicks.

e) Light Detection and Ranging (Lidar)

Lidar is an active remote sensing technique. This technology involves the use of pulses of laser light coming to ground measuring the time of pulse returning to sensor as shown in the figure. The return time of each pulse back to the sensor is processed to calculate the variable distance between the sensor and the object. There are three basic generic types of Lidar

- Range Finders
- Differential Absorption Lidar (DIAL)
- Doppler Lidars.

* Range finder Lidars are the simplest Lidars. They are used to measure the distance from the Lidar instrument to a solid or hard target.
* DIAL is used to measure chemical concentrations such as ozone, water vapor and pollutants in the atmosphere.
* Doppler Lidar is used to measure the velocity of a target. Lidar can create High-resolution DEMs with 10 cm accuracy. Lidar is also able to map bare earth elevations in dense canopy in forested or vegetated areas .

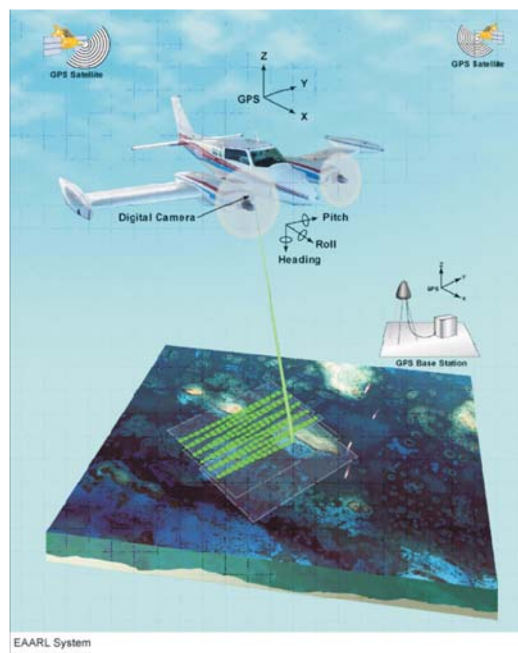


Fig. 62

LIDAR Remote Sensing
Source EAARL System

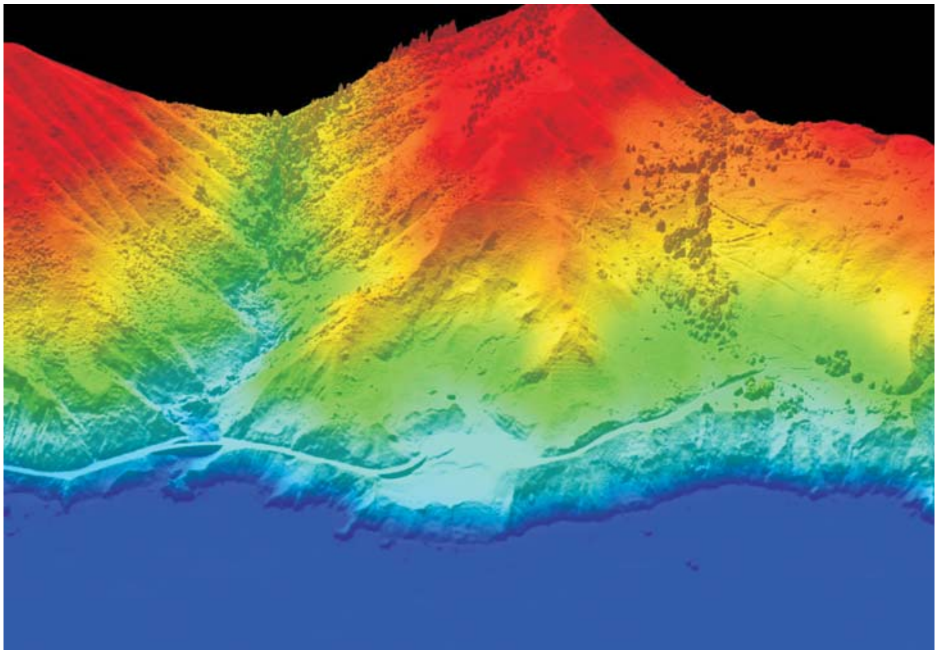


Fig. 63

DEM prepared by Lidar Data

1.7 Advantages and Benefits of Remote Sensing (RS)

During last two decades the satellite remote sensing has been effectively utilized in acquiring and analyzing valuable information about the earth resources. Remote sensing has dramatically enhanced men's capabilities for resource exploration, mapping and monitoring of the earth resources environment on local as well as global scales. It has brought tremendous changes both quantitative and quantitative in various areas such as communication, television, radio broadcast, meteorology, agriculture, education, disaster management, environmental monitoring and natural

Advantages of Remote Sensing

- Synoptic view
- Repetitive coverage
- Continuous acquisition of data
- Coverage of inaccessible areas
- Up-to-date information, accurate and reliable data
- Quantifiable data
- New information
- Multi disciplinary applications
- Time, manpower saving
- Quick assessment of resources
- Service as a large archive of historical data

resource inventory. These are important for strong database for planning, process and implementation of various programs and project both at the national and regional levels. Few benefits of Satellite remote sensing are listed below

Data collected using satellite remote sensing can be used for following purposes

- Assessing and observing vegetation types
- Conducting soil surveys
- Carrying out mineral exploration
- Map making to facilitate easy study of information
- Constructing thematic maps based on requirement
- Planning and monitoring water resources
- Carrying out urban planning
- Assessing crop yields and other agriculture management
- Assessing and managing natural disasters, etc.
- Studying the various spatial features in relation to each other and delineation of regional features trends, phenomenon etc.

Overview of Digital Imaging Softwares

Digital image processing softwares allows the use of algorithms for image processing to perform following processes:

- Image modification
- Pixelization
- Projection
- Image enhancement
- Linear filtering
- Classification
- Feature extraction
- Pattern recognition
- Principal components analysis
- Independent component analysis and many other spatial analysis and modeling

Some of the popular Image processing softwares are listed below;

Table : 5

Sl. No	Software Name	Vendors Name
1	Rolta Geomatica	Rolta India Ltd
2	Erdas Imagine	Erdas Inc
3	Image Analyst	Intergraph
4	ENVI	ITT Visual Information Solution

Important websites to get more information on Remote Sensing

- www.isro.org
- www.iirs-nrsc.gov.in
- www.india.gov.in
- www.esriindia.com
- www.gisdevelopment.net
- www.en.wikipedia.org/wiki/remote_sensing
- www.ias.ac.in
- www.nrsc.gov.in/
- www.ccrs.nrcan.gc.ca

Let us wrap up what we covered in this chapter

- Remote sensing is the process of acquiring the information about earth features without being into direct contact
- Remote sensing (RS) deals with inventory, monitoring and assessment of natural resources through the analysis of data obtained from remote sensing platforms.
- RS enables continuous acquisition and receives up-to-date information. The techniques also help in saving time and manpower.
- The energy emitted from is called as electromagnetic radiation.
- A blackbody is an ideal body which absorbs all radiation without any reflection.
- All object matter that has temperature higher than absolute zero or -273 degrees emits EMR continuously

- Sun is the primary source of energy. The incoming radiation goes through various modes of energy interaction, for example, transmission, absorption, reflection and scattering.
- In case of dust cloud and fog all wavelengths in the visible band are equally scattered, that is why all looks white in color.
- Uneven (rough) surface scatters in multiple direction.
- The shorter wavelengths are scattered more than longer wavelengths. These types of scattering are seen more in ultra violet and blue. That's why sky appears in blue.
- When energy passes through the glass windows it transmits all the energy so it appears transparent in color.
- The radiation reflected as function of the wavelengths is called as spectral signature of the surface.
- The reflectance from a feature depends on the atmospheric condition, season, time of a day, and physical & chemical properties of the feature.
- Smooth surface has low reflectance as compared to rough surface.
- The reflectance of the vegetation depends on various factors such as leaf pigmentation, leaf cell structure, moisture, and crown architecture and plant physiology.
- The healthy growing vegetation reflect in green band that's why color appears as green.
- The healthy vegetation will have abortion in blue and red band because of the presence of the chlorophyll.
- The reflectance of the soil depends on soil moisture, texture, color, grain size, sand, silt and clay composition and mineral composition.
- The reflectance from water depends on depth, suspended particles, floating vegetation
- Pure clear water has a relatively high reflectance in the visible wavelength bands between 0.4 and 0.6 ìm because it absorbs all the energy therefore, it appears darker in color.
- Heavy sediments in water prevents radiation penetration thats why it reflects the energy in NIR.
- The absorption and reflectance in rocks depend on the various factors such as nature of the rock, top cover, topography, shadow and surface roughness.
- Resolution is defined as the ability of the sensor to detect the information at the smallest meaningful element.

- There are four types of resolutions, these are, spatial, spectral, radiometric, and temporal
- The spatial resolution is the minimum element area that the sensor can measure. The resolution element is called pixel. For example LISS III has 23.5 m resolution, Pan 5.8 m
- Spectral resolution refers to sensing and recording power of the sensor in the different bands of EMR. For example Landsat – MSS 7 bands, IRS- 4 Bands.
- Radiometric resolutions recorded in digital number of different bands of sensors. For example LISS-III 7 bit (128 levels) color is 0-127 colors.
- Temporal resolution obtains the spatial and spectral data at a certain time interval. For example IRS-1A/1B revisits the same at 22 days, where as Pan revisits at 5 days.
- DIP is the collection of algorithm processed by the computer system to enhance the quality of the raw data for further interpretation and data extraction
- The steps involved in DIP are Image restoration, statistical analysis, Image enhancement and Image classification
- Image restoration includes geometric, radiometric & noise removal
- Geometric errors in the image is due to sensor, scanning system, motion of the platform, curvature and rotation of the earth
- Radiometric distortion is corrected by applying sun elevation and earth and sun distance corrections
- Resampling method is used to remove the noise from the images
- Image enhancement technique is used to improve the quality of the image
- Image enhancement technique includes histogram, histogram equalization, linear & non-linear contrast stretch, spatial filtering, band ratioing and NDVI
- Histogram is the graph showing the number of pixels in an image at different intensities
- Histogram equalization is the technique by which the dynamic range of the histogram of an image is increased
- Histogram manipulation improves appearance of the image
- Spatial filtering is used to enhance the appearance of the image to derive the valuable and detailed information
- Band rationing is used to dentify the various earth features such as healthy vegetation, soil, water

- NDVI is used to assess analyze and estimate green vegetation, crop yield etc
- NDVI is calculated as NIR-R / NIR+R
- NDVI values are represented as a ratio ranging from -1 to +1. Negative values represent water, zero represents bare soil
- Classification is the process of automatic categorization of all pixels in an image into different land cover classes or themes.
- Broadly there are two approaches of classification unsupervised and supervised.
- The basic steps involved in supervised classification are defining the training sites, feature selection, selection of classification algorithm, post classification, smoothening, accuracy assessment, final classified image and statistical report generation
- Visual Image interpretation is the art and science of examining image to identify the objects and evaluates their significance.
- The identification of the features is based on the shape, size, pattern, texture, shadow and association
- Aerial photographs give a bird's eye view of a large area enabling to view earth surface features which cannot be possible to obtain through ground observation
- Aerial photographs are categorized as vertical, low oblique, high oblique, and stereo 3D
- The photographs are taken generally with some percentage of overlaps for stereoscopic coverage
- Generally the forward overlap is about 60% and lateral overlap is about 20-30%
- There are two types of films used in aerial photographs, panchromatic, and color
- The scale of the photo can be calculated by formula s=f / H where s is photo scale and f is the focal length of camera and H is flying height
- The various factors that affect the quality of the aerial photographs are cloud, haze, sun angle and snow distortion due to relief, tilt, and radial
- Flights are usually scheduled between 10 am to 2 pm to have low wind, clear sky with maximum illumination and minimum shadow to obtain clear weather picture
- The interpretation keys for aerial photos are shape, size, pattern, texture, shadow, and association
- Advanced remote sensing technology includes, hyper spectral, thermal, microwave and Lidar

- Advantages of Remote sensing are synoptic view, repetitive coverage, continuous acquisition of data, coverage of inaccessible areas, up-to-date information, accurate and reliable data, Quantifiable data, new information, multi disciplinary applications, time, manpower saving, quick assessment of resources, service as a large archive of historical data

Questions

Vey Short Questions

1. Explain Wien's displacement law.
2. The radiation reflected as a function of wavelength called the spectral signature is true or false?
3. Heavy sediments in water transmit the radiation. True or false?
4. Why water looks green?
5. What is Resolution?
6. Name different types of resolution
7. List the steps involved in DIP
8. What is supervised classification?
9. What is unsupervised classification?
10. List down basic elements of image interpretation
11. Name the advanced remote sensing technology.
12. What are the basic Image Interpretation keys for aerial photographs?
13. How many types of films are used to take photograph?
14. Radar is passive sensor system? True or False
15. Radar operates in which part of electromagnetic region?
16. What is the microwave region?
17. Visible and infrared radiation can penetrate through cloud, haze and dust. True or false?
18. List down the application of microwave remote sensing
19. Which remote sensing system allows the study in all weather condition? And why?
20. What is full form of Lidar and RADAR?
21. What are the three basic types of Lidar?

Short Questions

1. Describe why dust cloud, and fog look white and sky looks blue?
2. Define the following
   a. Spectral Signature
   b. Transmission
   c. Absorption
   d. Reflection
   e. Scattering
3. What are the various factors effecting the reflectance of various earth feature?
4. Define the following with examples
   a. Spatial resolution
   b. Spectral resolution
   c. Radiometric resolution
   d. Temporal resolution
5. Define the following with examples
   a. Radiometric correction
   b. Geometric correction
   c. Image restoration
   d. Noise removal
   e. Image enhancement
6. Define the following with examples
   a. Low pass filter
   b. High pass Filet
   c. Supervised classification
   d. Unsupervised classification
7. What is Image classification?
8. What is the linear and nonlinear contrast stretch?
9. What are the basic elements of Image Interpretations keys for aerial photographs?

10. Why Stereo 3D is used? What is difference between normal and 3D photo?
11. Why stereoscopic coverage is taken with some percentage of overlaps? Explain.
12. Explain about photo scale of aerial photo with formula.
13. How many types of microwave remote sensing? Explain

Long Questions

1. Draw a curve for spectral distribution of energy by a black body
2. Solar rays strike the land and ocean and atmosphere targets the incoming radiation go through various modes of energy interaction, what are the different interaction mechanism? Explain with diagram
3. Describe the energy interaction mechanism for glass window, soil and roof and explain how the color of this objects effect?
4. Explain the about a typical spectral reflectance curve of different features wet soil, dry soil, turbid water, clean water and healthy vegetation, stressed vegetation and rock with graphs.
5. What is digital image processing? Why this technique is used? Explain the steps involve in DIP
6. What is histogram? Explain in detail with various techniques
7. Explain the various enhancement techniques to improve the quality of the image?
8. What is the purpose of filtering?
9. What are advantages and disadvantages of linear, non linear contrast stretch?
10. What is the difference between supervised and unsupervised classification?
11. What is NDVI? Explain with formula? Why it is used?
12. What are the difference between satellite images and Aerial photographs?
13. What are advantages of Remote Sensing?
14. Define the following elements used in visual interpretation of aerial and satellite data with examples

    a. Shape e Shadow

    b. Size f Association

c. Pattern

d. Texture

15. Explain benefits and applications of

a. Satellite images

b. Aerial Photographs

16. Discuss about the aerial photographs? Explain in details about types of aerial photographs?
17. What is difference between High and low angle oblique photographs?
18. What factors affect the qualities of aerial photograph? Explain.
19. What is microwave remote sensing system? Why it is used?
20. Explain about Radar Sensor?
21. Explain the frequency range of Microwave remote sensing system.

CHAPTER - 2

Geographic Information System (GIS)

Learning Objectives

After completing this chapter students would be able to :

2.1 Understand Introduction about Geographic Information System (GIS)

2.2 Learn about GIS Data Element and Data Structure

2.3 Know about the Fundamentals of Database and its Concept

2.4 Understand about Data input to GIS system

2.5 Learn about GIS Data Editing

2.6 Understand Attribute Data Linking

2.7 Know about Spatial and Non Spatial Data Analysis

2.8 Understand about Map Projection and Coordinate System

2.9 Learn about Digital Cartography

2.10 Understand Advantages and Benefits of GIS

2.1 Introduction

GIS is a computer based system used to digitally represent and analyze the geographical features and events taking place. In Class XI we studied about the fundamentals of geographic information system (GIS). In ancient time people used maps as a tool to represent and share information about earth surface. Geographic surveyors, navigators, explorers have made many efforts to collect map data for various purposes. Science of map making has undergone many changes. Today there is a new dimension of spatial data handling with respect to various natural resources, and features.

What is GIS?
GIS is a powerful tool for solving real world problem. It is also called as Geo based information System. In another words it is a technology and a concept to manage the natural resources to improve the decision making.

A GIS is a collection of computer hardware, software, and geographic data for digitally capturing, managing, analyzing, and displaying all forms of geographically referenced information. It allow us to capture, view, understand, aquere, interpret, and visualize data. The various themes of the same area such as Land cover/ land Use, water, soil, street can be integrated to reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts.

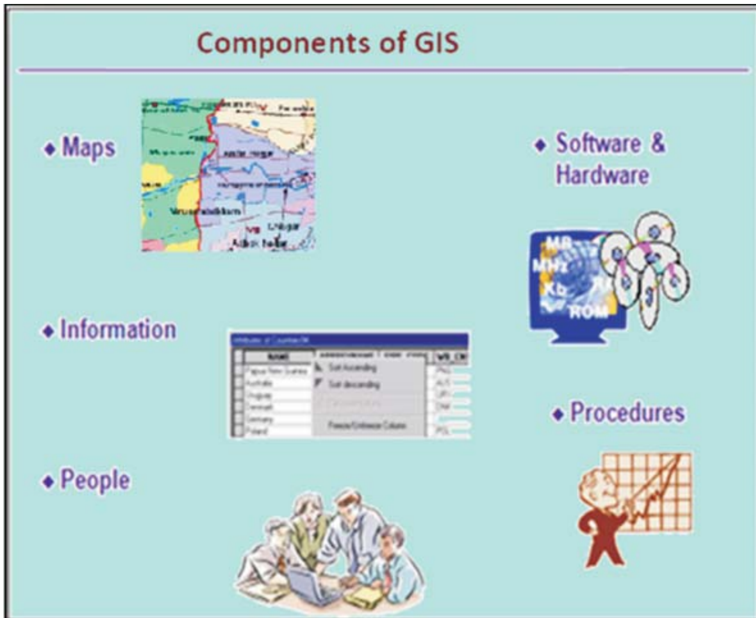


Fig. 64

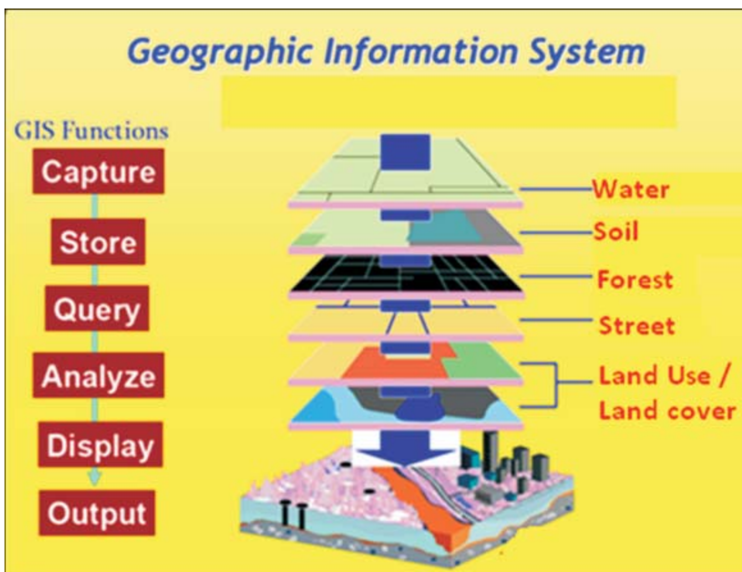


Fig. 65

A GIS is a computer application program that stores Spatial and Non-Spatial information in a digital form. Location Information describes where a particular geographic feature is situated on Earth. Attribute Information describes the feature details like what it is, how much it is, what it contains, etc. Non-Spatial data, also called as attribute data, which refers to information like demographic distribution of a town or a village, daily discharge of a river at a particular place, Traffic contiguity of a road etc.

The fundamental key of GIS is that, the association of Geographic features present on earth' surface, which can be geo-referenced with a database related to it. The figure shows the tree location and its description such as age, height, and species

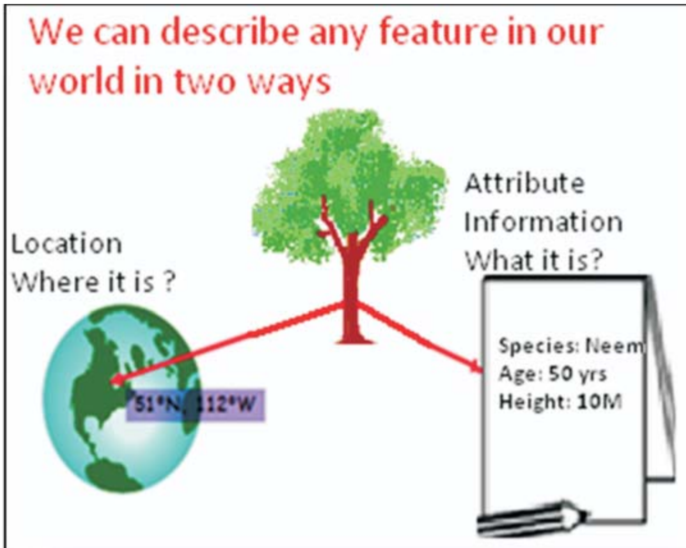


Fig. 66

Why GIS is needed?

- Makes dynamic maps
- Displays map information in detail about features Interactively
- Builds the spatial relationship between features
- Analyzes and answers real-world problems

GIS is used in detailed planning, decision making, better visualization and improving organizational integration.

The Geographic Information system is an effective tool for implementation and monitoring of municipal infrastructure, urban planning, public safety, utility services, transport services etc. as shown in figure 67.

Fig. 67

GIS Application

GIS manages all variety of data in a single electronic file in a computer by storing different spatial features as sub-files. These sub-files are called map layers / themes (soil, water, street etc) These map layers are conveniently stored and accessed with the computer in a same scale which are very much helpful for regional planner or any administrative body to accurate study of the earth features. GIS can open all the layers showing all features. It can be displayed and overlaid depending on the requirements. For example, the land-use layer may be displayed along with elevation contours by keeping other layer off.

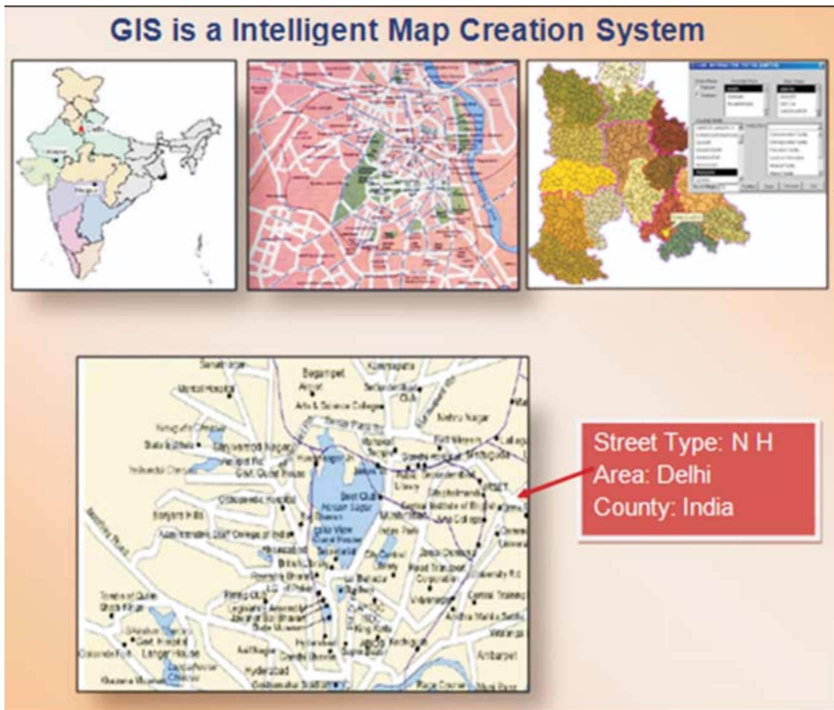


Fig. 68

GIS System

2.2 GIS System

A. GIS Functions

(i) Data Capture:

GIS is a tool which integrates the data from various sources into a common format which can be compared and analyzed. Various Input sources are mainly obtained from

- Manual digitization
- scanning of aerial photographs, paper maps
- Existing digital data sets
- Remote-sensing satellite imager
- GPS

ii) Data storage and Manipulation:

After data are collected and integrated into GIS it can store and maintain data. Data management includes data security, data integrity, data storage, retrieval, and data maintenance abilities.

iii) Data Analysis:

GIS has an ability to interpret and analyze the collected information quantitatively and qualitatively. For example, satellite image can assist an agricultural scientist to project crop yield per hectare for a particular region. For the same region, the scientist also has the rainfall data for the past six months collected through weather station observations. After integrating both the information farmer can get better idea to manage the crop yield.

iv) Data presentation: One of the most important functions of GIS is to present the data in the variety of ways such as maps, report and three dimensional images.

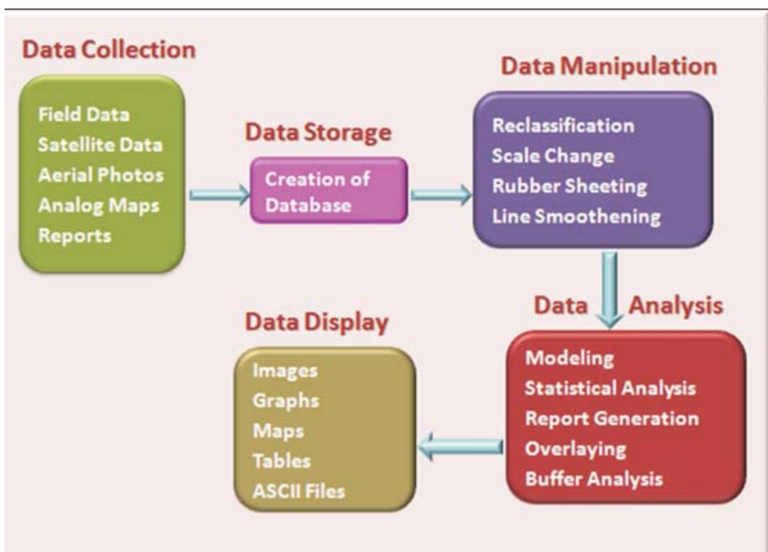


Fig. 69

The functions of GIS

B. Data Structure

As we discussed in Class XI the GIS stores the data in to two ways such as raster and vector format.

In Raster format the space is divided into a grid of cells, with a certain value attached to each cell according to the features. In vector format data stores the features in the form of Point, Line and Polygon with the coordinates of the location. The various feature representation with vector and raster format is shown in below figure.

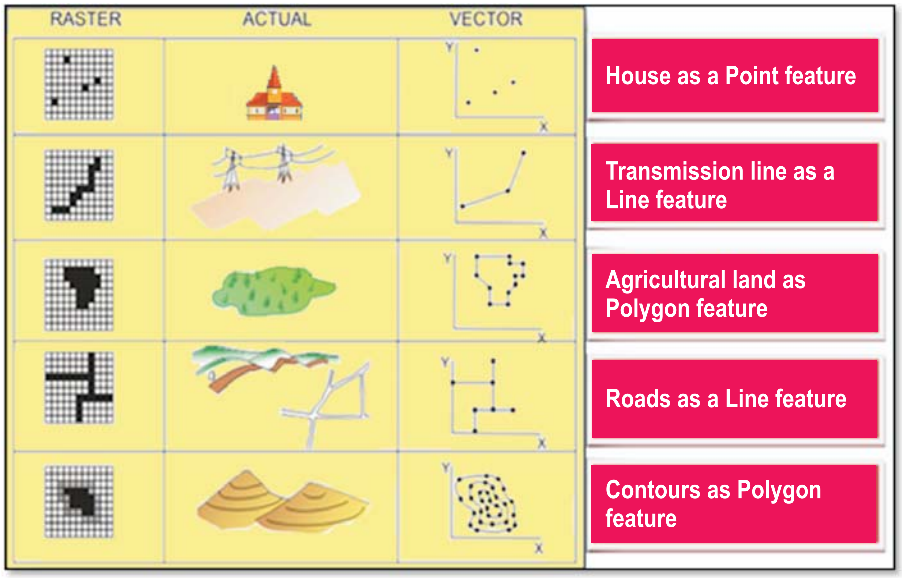


Fig. 70

Representation of various data storage by GIS system in Raster and Vector Formats

1. Vector Data Structure

In vector data structure attribute information is always associated with point , line and polygon as spatial entities that describe features occurring in real world. For example a point representing a city associated with its total population, number of houses, and number of schools and so on. A linear feature such as river represented by line is associated with name, mean discharge etc. A land use represented by polygon feature is associated with its past land use, soil type etc

Vector data structure is categorized as

(i) Spaghetti data structure

(ii) Topological data structure

(i) Spaghetti Data Structure

The spaghetti data model is the most simple data structure. In this model each entity on a map becomes one logical record in digital file and is defined as a string of x, y coordinates. Spaghetti vector data structure is not optimal because it does not take into consideration shared lines and points. All entities are spatially defined, without any spatial relationships. This creates a limitation to perform any type of spatial analysis. The spatial relationship between entities is derived through computation. Different lines and polygons are stored as independent objects. Lines between adjacent polygons must be digitized and stored twice. No clear topological information is coded to show the connectivity and neighboring relationship. This type of format is efficient for cartographic display for CAD Database.

(ii) Topological Vector data Structure

Topological model is the most widely used method to reveal spatial relationships. For example, an area or polygon is defined by a set of lines which makes up its boundaries. In this case the line is the border between two polygons. Each line can represent part of a path connecting other paths. For example, lines can be used to represent streets and the routes. The connectivity of these features is referred as their topology structure. Topology is the mathematical method used to define spatial relationships. The model is also termed Line / Arc - Node data model. The advantage of this method is data redundancy which is reduced because of shared nodes and lines which are stored only once. Attributes are linked to each feature. The attribute data is stored in separate relational tables therefore; more files are maintained for this purpose. Data Base Management System (DBMS) is used so access is more efficient.

Line (Arc): It is a series of point that start and end at a node.
Node: is an intersection point where two or more lines meet. A node can also occur at the end of a dangling line that is not connected to another line.
Polygon: It is comprised of a closed chain of lines that represents the boundary of the area.
Point: It is encoded as a single XY co-ordinate pair. Point is considered as the polygon with no area information

a) Properties of the Topological data structure

- **Connectivity:** Indicates which geographic features connect to others or which geographic features intersect each other. For example line 1 is connected to line 2, 3 and 4 as shown in figure below.
- **Adjacency:** Indicates which geographic features are adjacent to others. For example Polygon A is adjacent to Polygon C as shown in the figure below.
- **Containment:** Indicates which geographic features (node, arc, and smaller polygon) are contained within a polygon. For example, the polygon D is inside the polygon B as shown in the figure.

- **Proximity:** Indicates which geographic features are near to others. For example to travel from Node B to Node A the shortest path is Line 3 as shown in above figure.
- **Relative Direction:** It indicates the relative position between the geographical features. This can be used to study the direction of slope and water shed management.

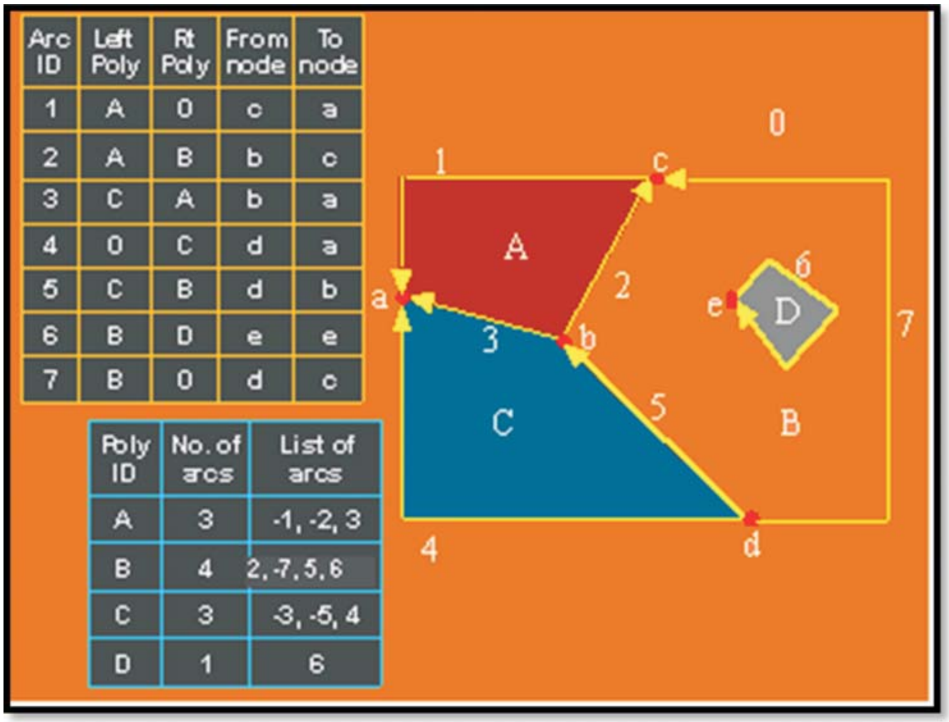


Fig. 71

An example of Connectivity, Adjacency, Containment, Proximity, Relative Direction

1.a Advantages of Vector data model

i) It is precise and allows no error in line area, perimeter etc.

ii) It requires less storage requirement as compare to raster format .

iii) This method is more appropriate for social economic, demographic and resource variation analysis.

1.b Disadvantages of Vector data model

i) It takes too much time in computing time for overlaying vector based information

ii) It cannot represent continuous data

2. Raster Data Structure

Raster model divides entire area into regular grids in a specific sequence. It is generally sequenced row by row from top left corner. Each grid cell contains a single value. In most cases, the values are to be assigned each and every grid in the raster data model as shown in the figure below. It is often coded in ASCII format. It is relatively a simple approach for data integration both conceptually and operationally. Digital elevation model use the cell by cell data structure because the neighboring elevation values are rarely same. Satellite images also use this method for data storage. The advantage of raster GIS model is easier to interface with remote sensing images

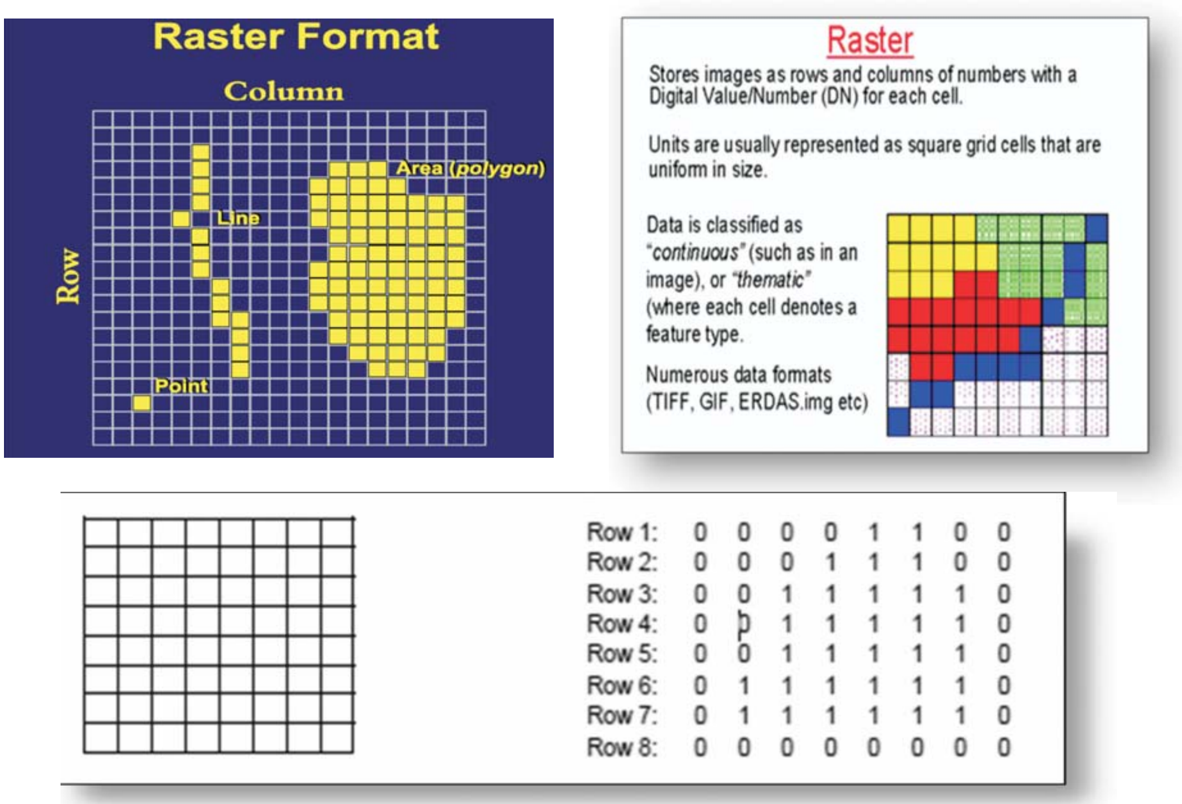


Fig. 72

The cell by cell data structure records each cell value by row and column

2.a Advantages of raster data structure

- Raster data quickly processes queries most analytical operations such as overlay, buffer, proximity and Boolean queries. .
- It is good for representing continuous surfaces.
- Raster data formats are appropriate for remote sensing data.
- It is easy to understand, read, write and draw on to screen.

2.b Disadvantages of raster data structure

- This format is poor at representing points, lines and area
- It uses pixel based data processing which affects the accuracy especially for point and linear features.
- Lines can become (vider) broader.
- It is good at localized topology such as adjacency and weak at others
- This format faces mixed pixel problem which creates the problem in identification of different features
- It includes redundant and missing data which affects the interpretation
- Each cell can be owned by one feature
- It requires more storage space.

2.3 Fundamentals of Database concept

Database creation is the most important, expensive and time consuming part of any GIS project. The database system is a computer based record keeping system to maintain information. Spatial database is a collection of spatially referenced data which can be utilized for querying and obtaining information to integrate different type's of analytical models and application.

Database creation in vector model involves three stages

i) Spatial data input

ii) Attribute data Input

iii) Linking spatial and attribute data

Spatial data or any thematic map can be captured via digitalization in the form of point, line and polygon. Once data has been captured editing and topology building is carried out for further process to remove overshoot and undershoot. Attribute data is key-in or imported from external platform such as excel sheet, word table, etc. Finally the spatial data is linked with associated attribute data with means of a common key called unique id. This attribute data is stored and used for analysis.

Spatial database is a collection of spatially referenced data. The GIS provides a linkage between spatial and non spatial data.

GIS is a computer system that links the database with spatial and their attributes through software tools that graphically display query and maintain those features and attributes.

The purpose of database design is to save time and resources. Unplanned or un designed database end up with a poorly constructed and functionally unsatisfied database which can result in

- Unnecessary data
- Missing data
- Unsupported application
- In appropriate feature representation
- Lack of consistency between various parts of the database

2.4 Data input to GIS system

Data input is the operation of encoding data into a database. The user of a GIS has to input Spatial data either in Raster or Vector formats. Spatial data are obtained from different sources with different formats. For example, maps would usually be supplied in a hard copy but the satellite image of an area in digital form. The digital data can be directly transferred to a GIS but the hardcopy maps have to be scanned and digitized. Non-Spatial data usually in the form of tables, reports as shown in the figure below.

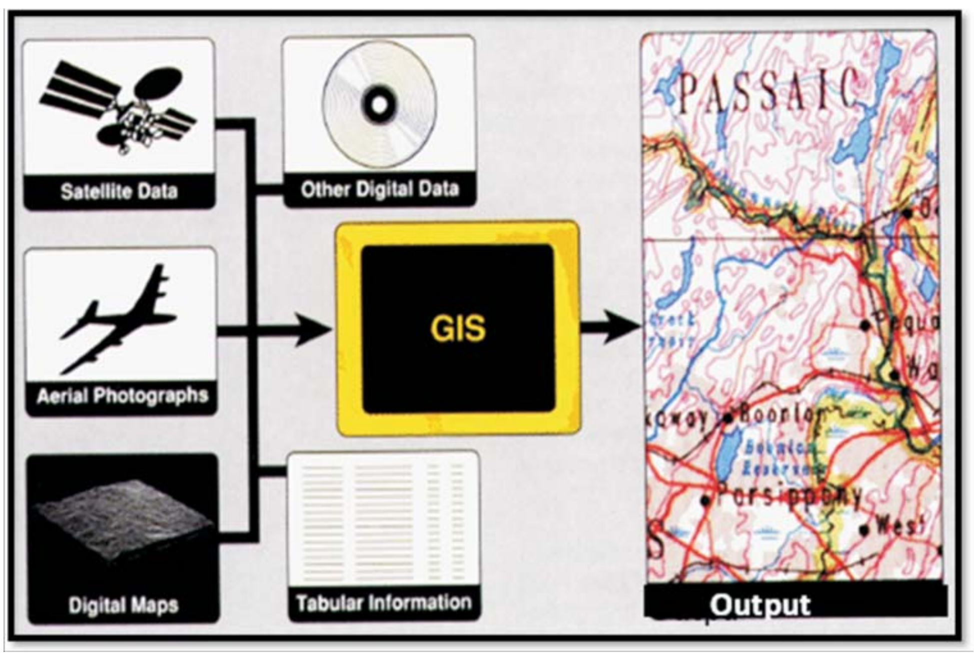


Fig. 73

Spatial and Non-Spatial data inputs to GIS Systems

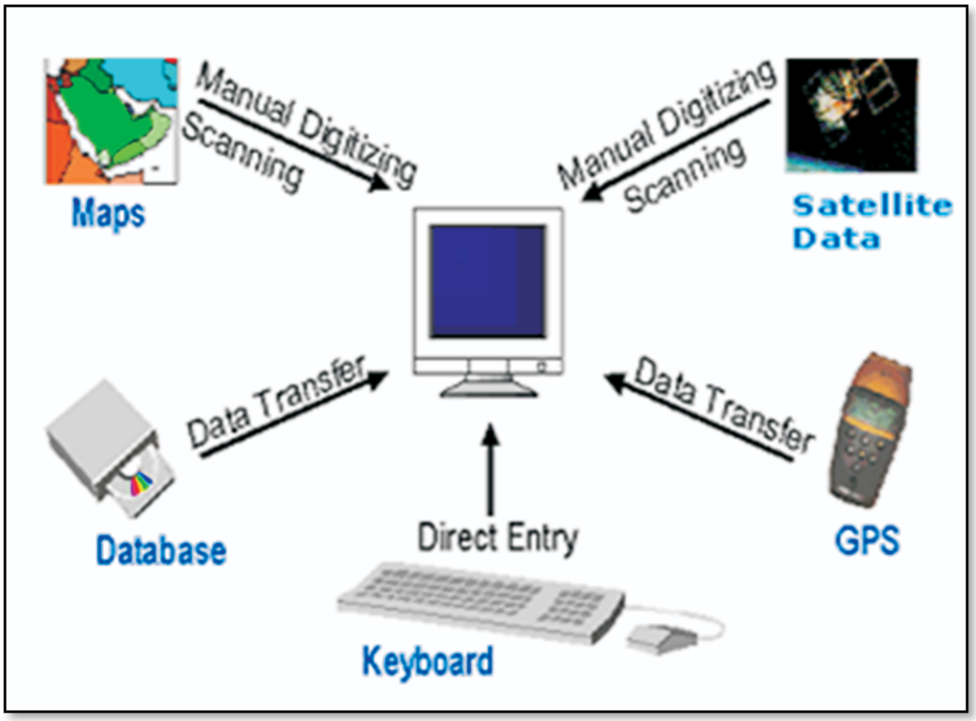


Fig. 74

Methods of data input in to GIS system

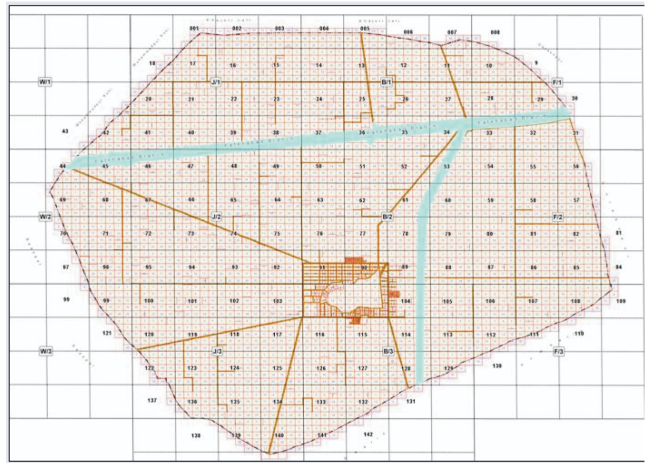
The spatial data can be entered into GIS system in following methods as shown in figures

A. Digitizing
   i) Scanning of analogue maps
   ii) Vectorization
B Data Transfer
   i) From existing data
   ii) From Survey or GPS
C Key Board Entry

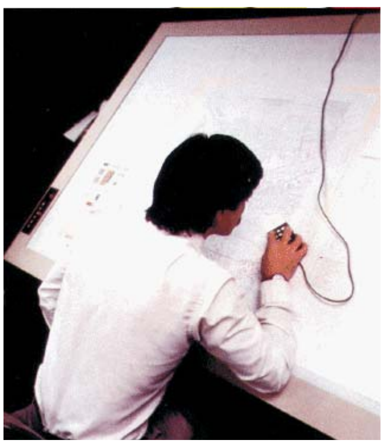
A. Digitization

Digitizing is the transformation of information from analog format (paper map) to digital format to store and displayed with a computer. The data collected from remote sensing such as satellite images and aerial digital photographs are fed directly to the GIS system for digitization. Paper maps (Top sheets, cadastral maps, geological maps etc), analog photographs (Taken from analog camera)need to be scanned and then fed to GIS system for digitization

Scanning the paper maps



Cadastral map (Paper map)



Manual Digitization using Digitizer table (Semi automated)

Existing map (Digital)

Manual Digitization using computer (Manual)

Satellite Imagery

Fig. 75

B. Data Transfer

Data collected from survey, GPS or with existing digital maps are directly transfer to the GIS system. GPS is a very effective tool for collecting spatial data. This data can directly import to the GIS system as shown below.

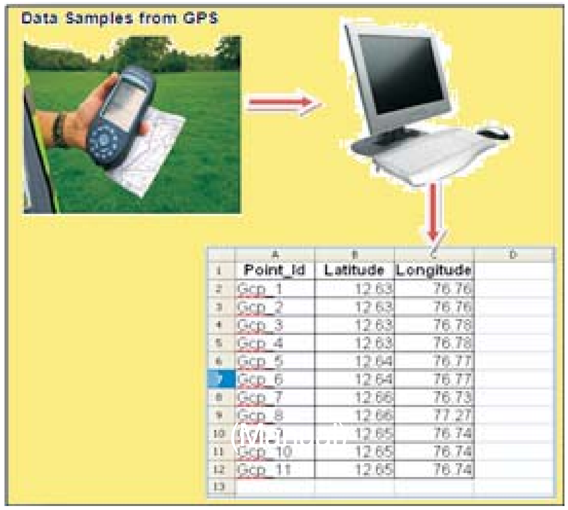


Fig. 76

GPS data transfer to the GIS system

C. Key Board Entry

Locational data and associated non Spatial Data (Attribute data) such as report/table are entered into GIS System by key board Entry.

1.1 STATEWISE NUMBER OF DISTRICTS, POPULATION BY SEX, SEX RATIO AND DECADAL GROWTH RATE OF POPULATION - 2001 (PROVISIONAL)

Sr. No.	India/State/ Union Territory	No. of Districts	Population (in '000) Persons	Males	Females	Sex ratio (females per 1000 males	Density (per Sq.km.)	Decadal growth rate
1	2	3	4	5	6	7	8	9
	INDIA	**593**	**1027015**	**531277**	**495738**	**933**	**324**	**21.34**
	States							
1	Jammu & Kashmir	14	10070	5301	4769	900	99	29.04
2	Himachal Pradesh	12	6077	3085	2992	970	109	17.53
3	Punjab	17	24289	12963	11326	874	482	19.76
4	Uttaranchal	13	8479	4316	4163	964	159	19.20
5	Haryana	19	21083	11328	9755	861	477	28.06
6	Rajasthan	32	56473	29382	27091	922	165	28.33
7	Uttar Pradesh	70	166053	87466	78587	898	689	25.80
8	Bihar	37	82879	43154	39725	921	880	28.43
9	Sikkim	4	540	288	252	875	76	32.98
10	Arunachal Pradesh	13	1091	574	517	901	13	26.21
11	Nagaland	8	1989	1042	947	909	120	64.41
12	Manipur	9	2389	1207	1182	978	107	30.02
13	Mizoram	8	891	460	431	938	42	29.18
14	Tripura	4	3191	1636	1555	950	304	15.74
15	Meghalaya	7	2306	1168	1138	975	103	29.94

Fig. 77

Attribute data entered into GIS by Key board

2.5 GIS data editing

Spatial data editing refers to the building relationship between the entities for the removal of errors and updating of digital maps. Spatial data editing includes;

a) Topology Building

b) Topological Errors

c) Locational Errors

d) Edge Matching

a) Topology Building

Topology is geometric relation of point, line & area which is used for establishing spatial relationships that exist between geographical data. Topology structures provide an automated way to handle digitizing and editing errors, and enable advanced spatial analysis such as adjacency, connectivity and containment. Building topology means setting rules and behaviors that model how points, lines, and polygons share geometry. When topological relationships help in performing analysis such as modeling network flow line, combining adjacent polygons that have similar characteristics and overlaying geographic features. Topological Editing process begins with constructing the topology of the map to be edited. This step ensures that the computer can recognize individual nodes arcs and polygons on the map. Building the topology between map features can remove some of the digitizing errors.

> Topology is the mathematical representation of the physical relationships that exists between the geographical elements.

The ability to create and store topological relationships has a number of advantages.

- Topology stores data more efficiently
- This allows processing of larger data sets
- Helps in faster processing.

b) Topological Errors

Topological errors emit the topological relationships. A common digitizing error occurs when two lines that are supposed to meet at a node, do not meet perfectly. If a gap exists between the It is called undershoot. If line is over extended as shown in below figure is called under-shoot. The result of both cases is a dangling line, which has the same polygon on its left and right sides. It is called dissolve polygons. Dangling node also occur when a polygon is not perfectly

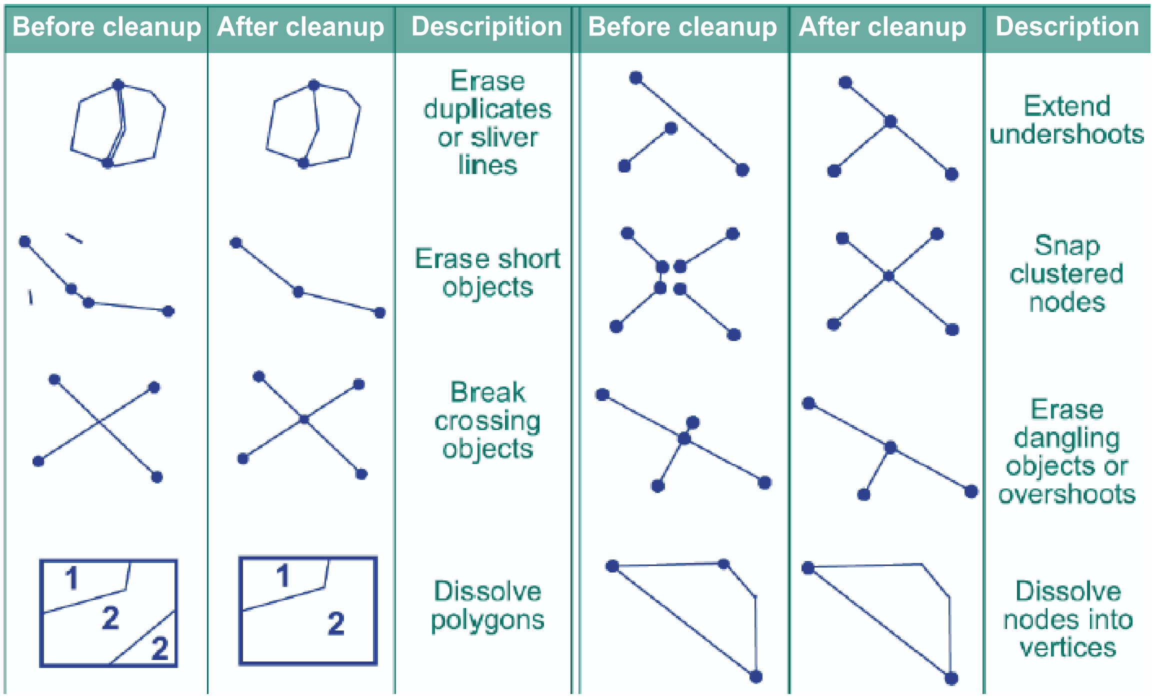


Fig. 78

An example for topological errors

c) Locational Errors

The shift in location and change in shape of the features is called as locational errors. These errors occur due to various reasons which are listed below

a) Geo-referencing Errors

b) Scanning Errors

c) Human Errors

Geo-referencing errors occur by selecting wrong control points and wrong source points during process of geo-referencing. It causes change in shape and scale of the resultant map. To correct such type of location errors, it must re-digitize or re-select control points and re-run geometric transformation.

The second scenario consists of errors in scanning and tracing. These errors occur because of intersection lines being too close, wide, thin or broken. Digitizing errors from tracing includes collapsed lines, misshapen lines and extra lines. To overcome this error one need to go for re scanning and re digitization.

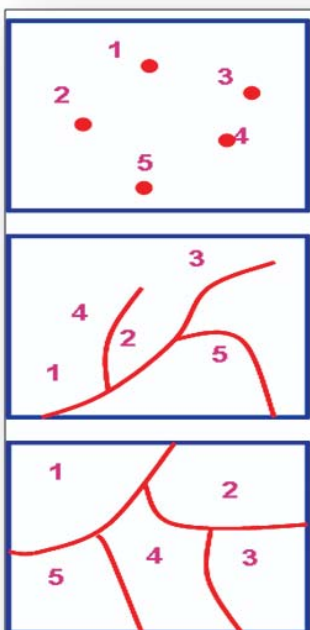
The human error occurs during the process of digitizing manually. Human error is not difficult to understand: When a source map has hundreds of polygons and thousands of lines, it can easily miss some lines or connect the wrong points. Duplicate lines occur frequently in tracing because semi-automatic tracing follows continuous lines even if some of the lines have already been traced. Quality checking and correction is needed to overcome these errors.

d) Edge Matching

GIS projects use multiple maps, which are digitized and edited separately. After all maps are finished, they must be mosaiced to make the final seamless map. Edge matching is a necessary operation before joining maps because lines from two maps rarely meet perfectly along the border.

2.6 Attribute Data Linking

GIS requires both spatial data and non spatial data, which are entered through various methods as discussed above. Before using spatial data as a basis for exploring attribute data it needs to be linked with each other. The geo-relational data model links spatial and non spatial (attribute data) by the unique feature ID. To "connect" data from another database (e.g., an



Point ID	Item1	Item2	......
1			
2			
3			
4			
5			

Line ID	Item1	Item2	......
1			
2			
3			
4			
5			

Polygon ID	Item1	Item2	......
1			
2			
3			
4			
5			

Fig. 79

Attribute data linked to Spatial data by the Unique ID

excel file) to the map and attribute table in the GIS it needs a linking field — a field with an identifying number or text string that matches the record from one database to a record from the other. Each map feature has a unique label ID Attribute data are stored in a attribute table, which contains the label ID and a default set of attributes, such as area and perimeter which are shown as item1 and item2 in below figure for point, line and polygon features. Each row of the attribute table represents a map feature and each column describes characteristics of the map feature. A row is also called record and a column is called field or an item. If the unique Id does not match it won't attach with the database.

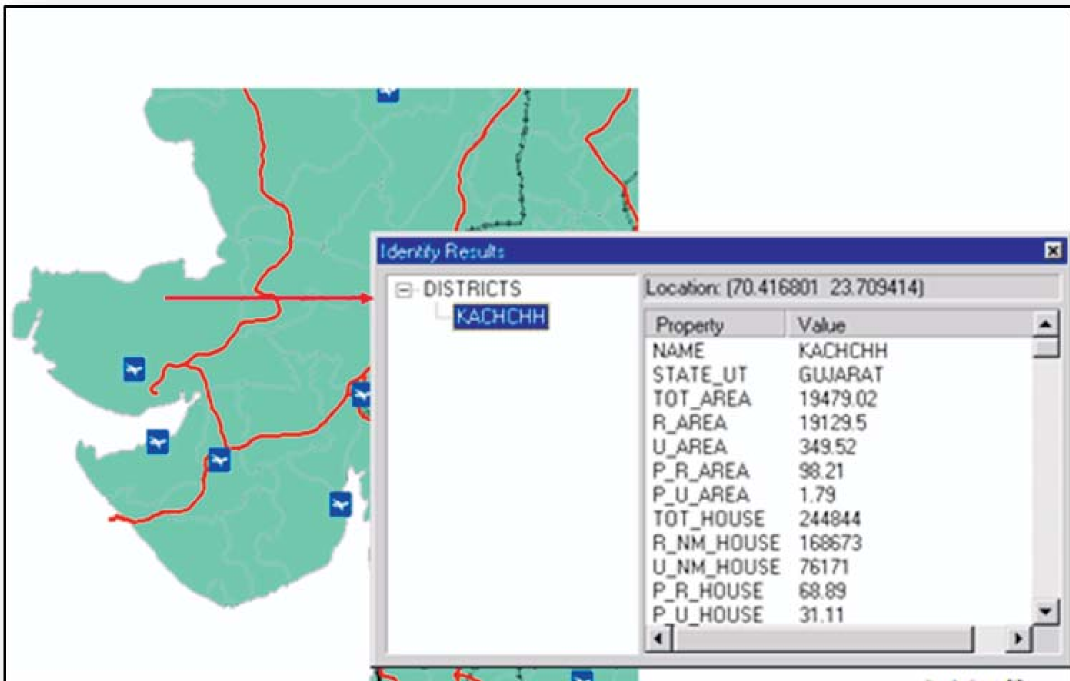


Fig. 80

Spatial data linked with non spatial Data

2.7 Spatial and non spatial data Analysis

It is a powerful tool for comprehensive, raster-based spatial modeling and analysis. Using this tool it can derive new information from existing data, through analyzing spatial relationships and building spatial models. It is used to increase better understanding of real world in different scenarios to take better decisions. To derive new information either one or more inputs and spatial operations can be used as shown in below figures.

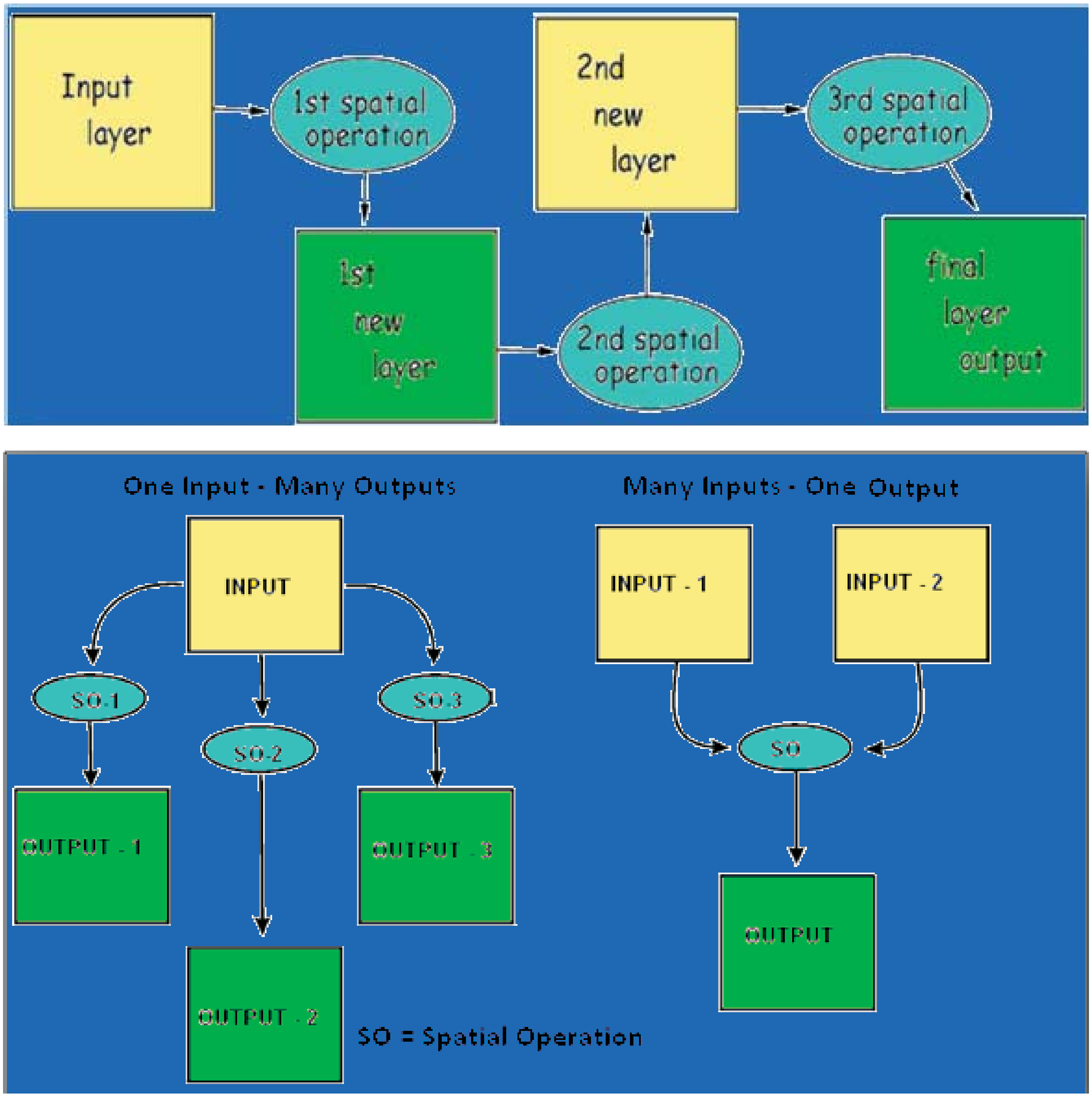
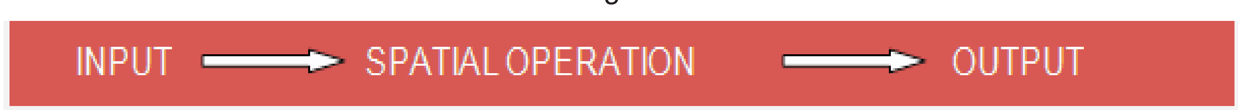


Fig. 81



Results of analysis can be communicated in the form of maps reports or both. A map is used to display geographical relationships, whereas a report document for summarizing the tabular data.

Spatial Data analysis is a process to look at geographic patterns in data and relationships between features.

a) Spatial data analysis usually involves manipulations or calculation of coordinates or attributes variables with a various spatial operations tools. Some of them are discussed below.

i) Query (based on spatial and non spatial data)

ii) Dissolve

iii) Overlay

iv) Merge

v) Buffer Analysis

vi) Triangulated Irregular Network (TIN)

i) Query:

Once GIS project is created, it is possible to apply different types of queries to obtain results to meet expectations. In GIS simple as well as complex queries are possible based on spatial and non spatial data.

A question or request used for selecting features. A query often appears in the form of a statement or logical expression.

These Queries can be applied using:

- On-screen
- Based on specific conditions
- Operations based on attribute tables: It selects the features based on their attributes. Below figure displays the resultant of various attribute queries

Following queries are used to select the features based on state name, area and population density.

State= Vermont (Based on specific condition)
State=Newyork (Based on specific condition)
Area =>1000 sq mi (Based on specific condition)
Population density <250 /sq mi (Based on attribute table)
The resultant map is shown in below figure.

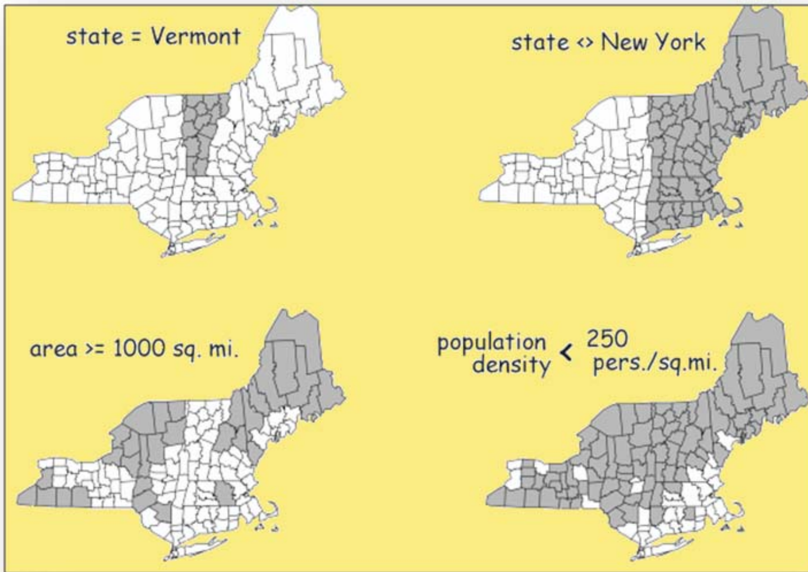


Fig. 82

An example for selection based on various query
Courtesy: Dr. Jawad Al-Bakri

Following are the different Boolean algebra expressions that are used to get output. Example are shown in figure 83.

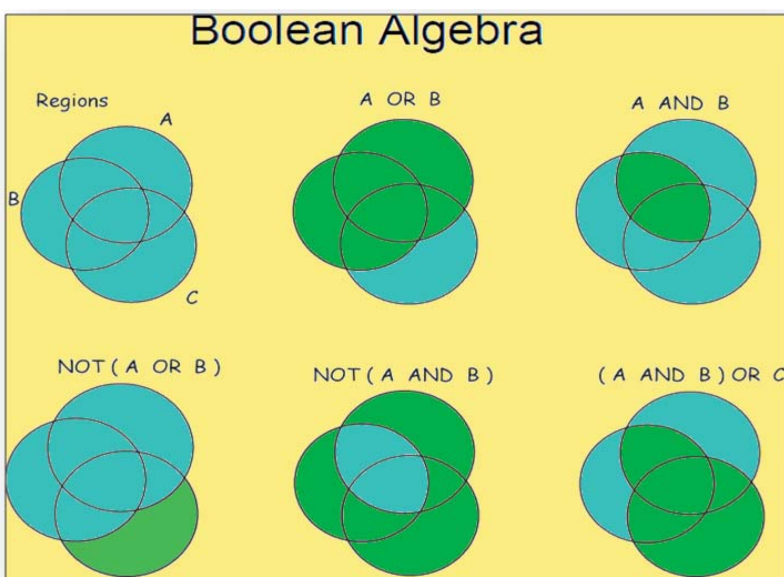


Fig. 83

An example for different Boolean expression
Courtesy: Dr. Jawad Al-Bakri

In spatial selection features are indentified based on spatial criteria such as Adjacency, connectivity, containment

The below figure 84 shows all the states adjacent to Missouri

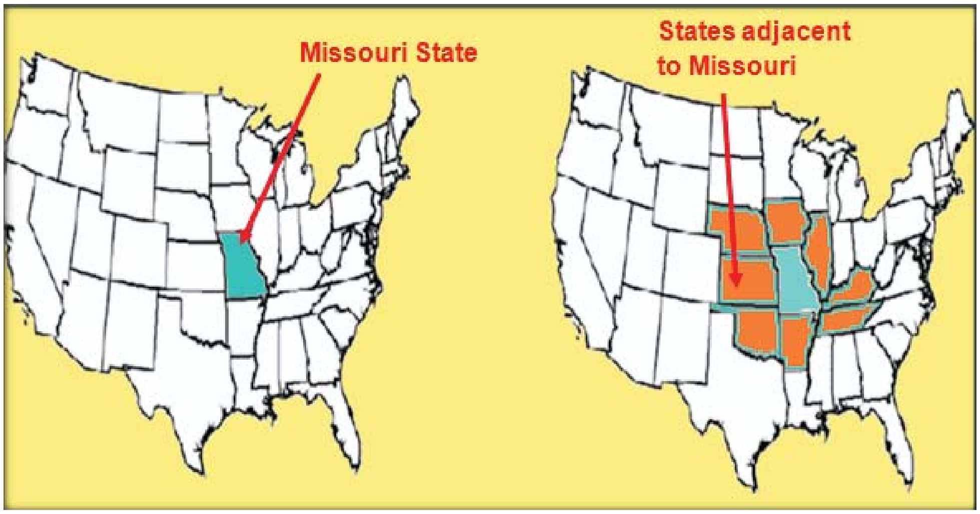


Fig. 84

An example for Adjaceny:

Courtesy: Dr. Jawad Al-Bakri

The states which are containing the river network are shown as an example of containment in this figure 85.

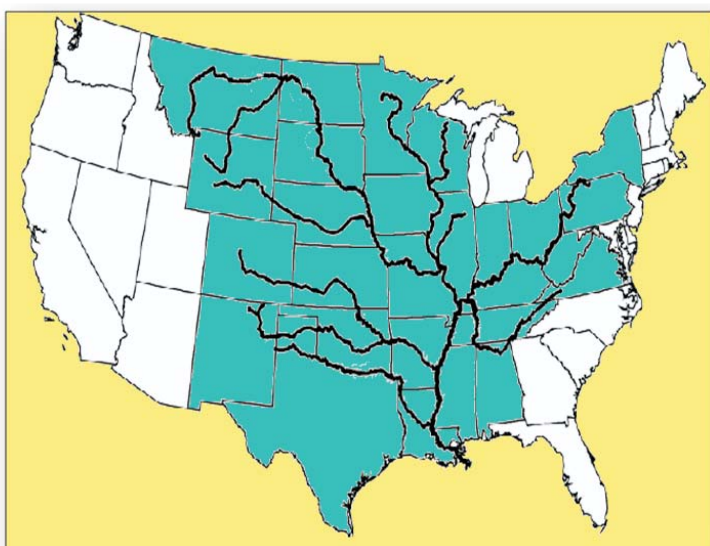


Fig. 85

An example for Containment

Courtesy: Dr. Jawad Al-Bakri

ii) Dissolve

Dissolve is a function which combines similar features within a data layer. Adjacent polygons may have identical values. Dissolve function removes the common boundary. Removing of common boundary of the same class reduces the number of polygons. Below figure shows an example of dissolve function. In this figure the numbering is done based on west and east side of the Mississippi river. West side is assigned number 1 and East side is assigned number 2. Then the dissolve function is applied. The resultant map will have only 2 polygons which are named as west and east side of the river.

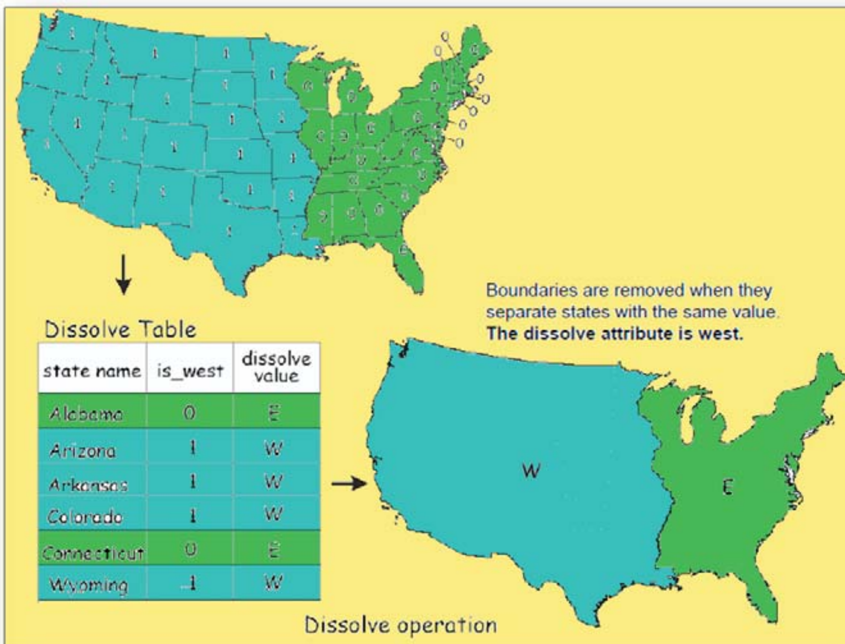


Fig. 86

An example for Dissolve Function

Courtesy: Dr. Jawad Al-Bakri

iii) Overlay

- Spatial Overlay

One basic way to identify spatial relationships is through the process of spatial overlay. Spatial overlay is accomplished by joining and viewing together different layers of same area. The result of this combination is creation of new data set that identifies the spatial relationships. figure 87 shows combination of layer - A & Layer - B and produce an overlaid map produced which has the information of both layer A & B. Overlay is the important part of GIS analysis and is performed in both vector and raster domain.

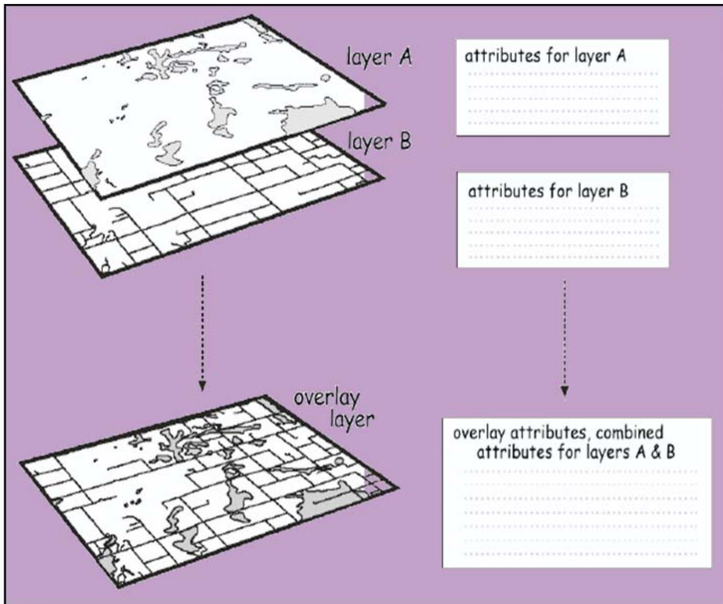


Fig. 87

An example for Overlay Operation
Courtesy: Dr. Jawad Al-Bakri

- **Raster Overlay**

Raster overlay mainly applied to nominal or ordinal data with cell by cell process which results in the combination of the two input layers. Two inputs layers are combined in raster overlay. Nominal variables for corresponding cells are joined and creating a new output layer for example soil layer is combined with land use layer to create a composite output layer as shown in below figure.

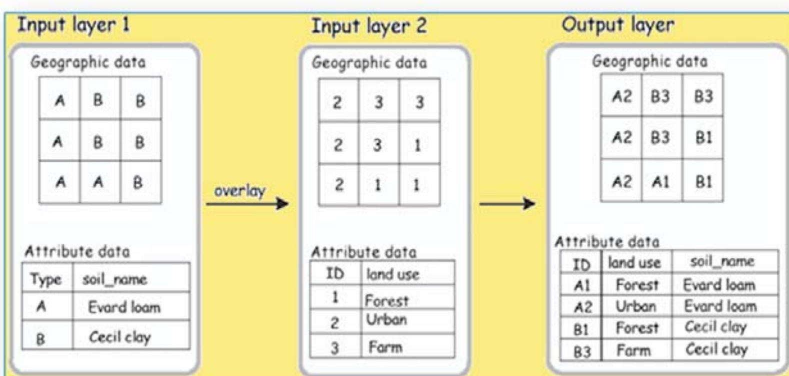


Fig. 88

An example for Cell - by cell Raster Overlay
Courtesy: Dr. Jawad Al-Bakri

- **Vector Overlay**

Vector overlay function identifies line intersection points automatically. Intersecting lines are split and a node is placed at the intersection point. Topology must be recreated for later processing. For example Polygon output from point & polygon overlay is shown in fig which results in uncertainty regarding the source for combining attribute data because there are many points corresponding to each polygon, where clarity is not there. But in case of point output resultant point is having one polygon and gives more clarity.

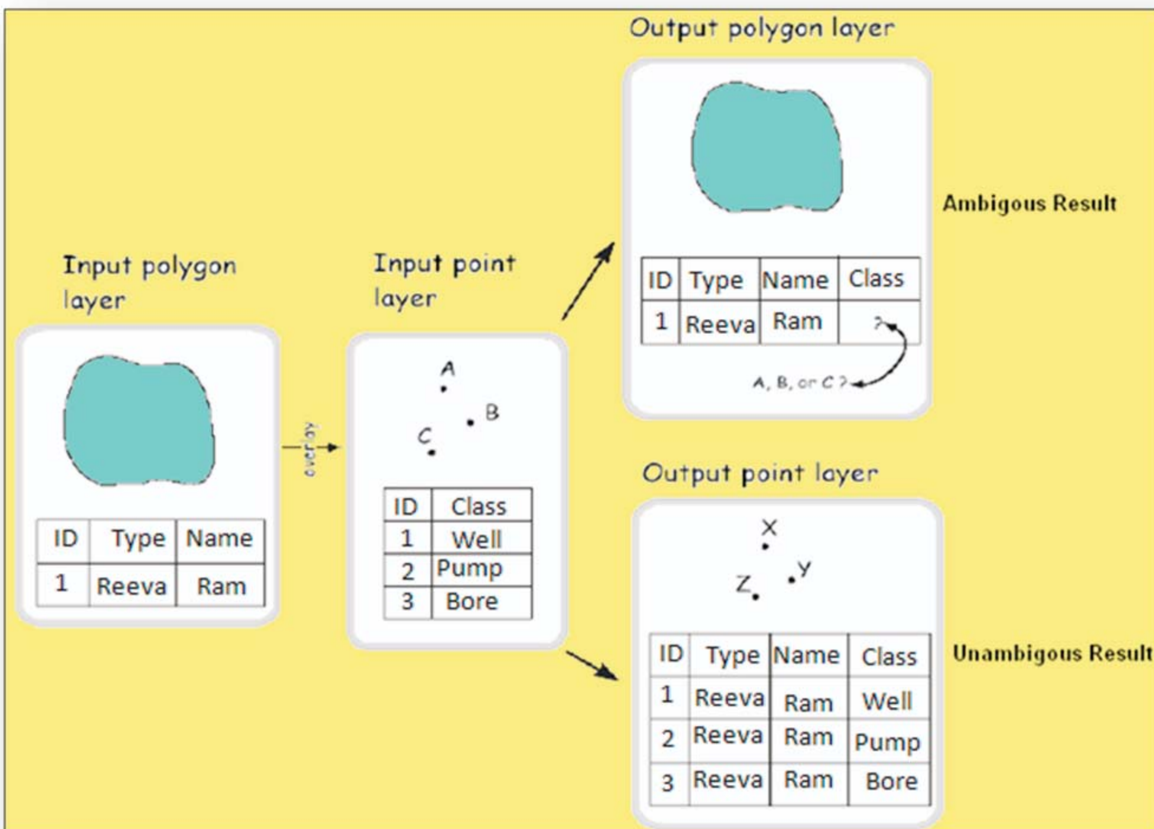


Fig. 89

An Example for Vector overlay

Common vector overlay methods are discussed below with illustration

a) Clip
b) Intersection
c) Union

a) Clip

The boundary polygon defines clipping area. The data layer elements are clipped from the boundary layer. In the output layer the features belong to data layer within the clipped area which are visible but boundary layer is not visible.

b) Intersection

It combines data from boundary layer and the features of data layer which falls within the boundary layer. The output layer shows boundary layer and the features of data layer within the boundary. Data outside the boundary layer is discarded.

c) Union

It includes all the data from boundary and data layer.

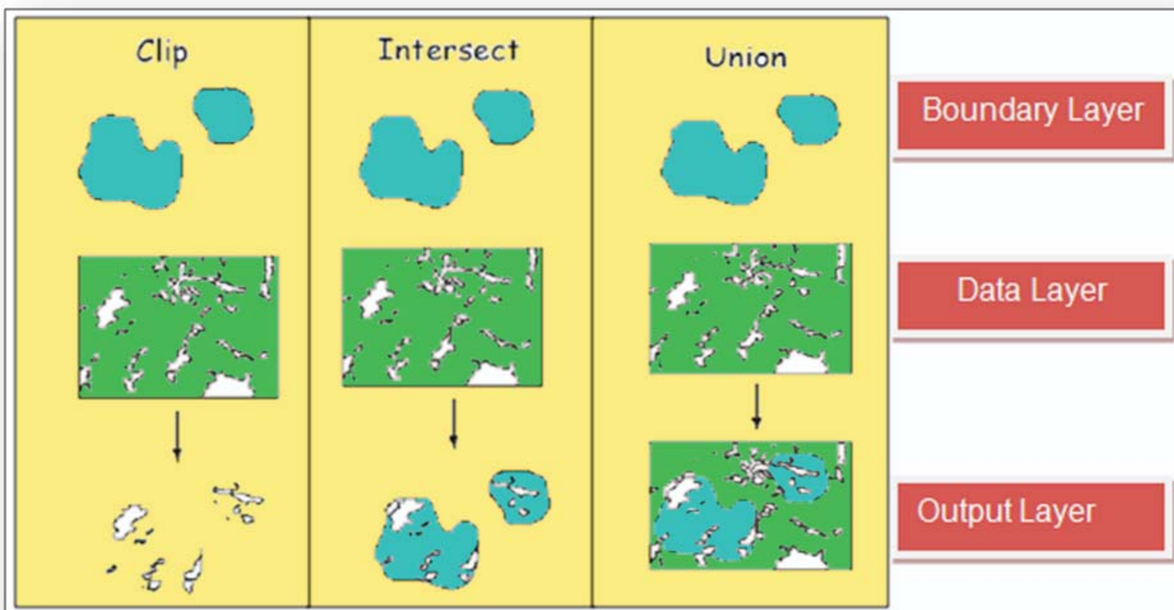


Fig. 90

An Example for Clip, Union and Intersection method

Courtesy: Dr. Jawad Al-Bakri

iv) Merge

This operation appends the features of two or more layers into a single output layer. Attributes will be retained if they have the same name otherwise discarded.

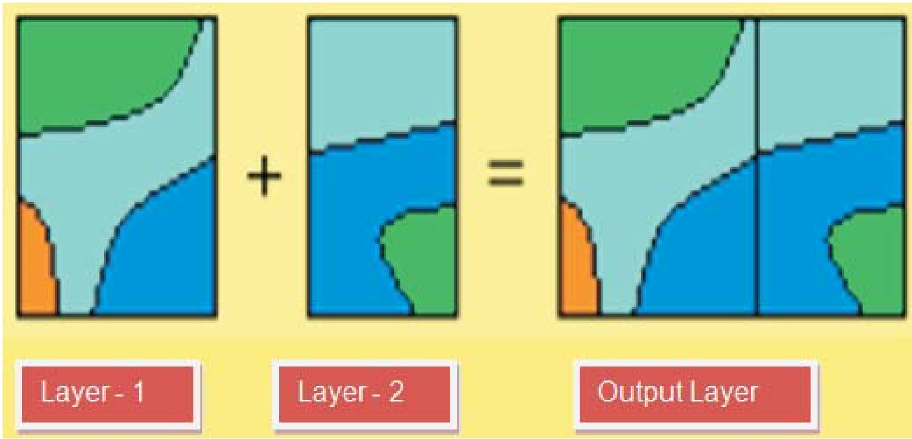


Fig. 91

An Example for Merge Operation

Courtesy: Dr. Jawad Al-Bakri

v) Buffer Analysis

Buffer analysis is used for identifying areas surrounding geographic features. The process involves generating a buffer around existing geographic features and then identifying features based on whether they fall inside or outside the boundary of the buffer. . Buffer operation is applied to points, lines and polygons. Buffer distance can differ among spatial objects based on requirements. An example is shown of buffering around points, lines and polygon. Buffering around points creates circular buffer zones. Buffering around lines create a series of elongated buffer zones. Buffering around polygons creates buffer zones extending outward or inward from the polygon boundaries.

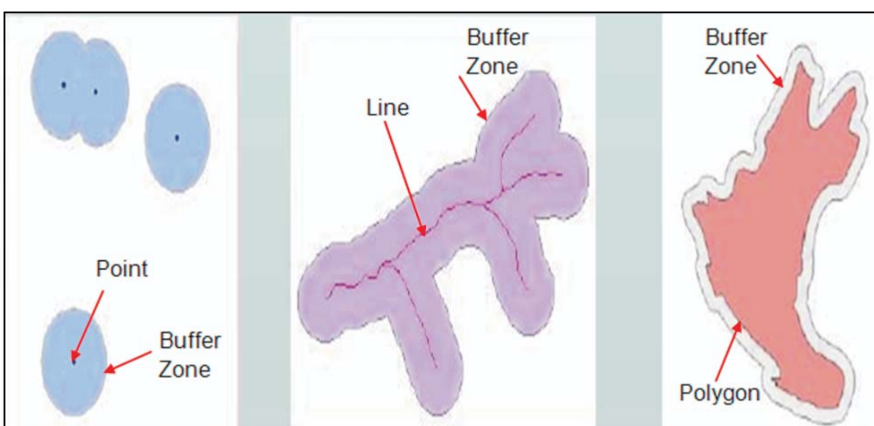


Fig. 92

Buffering around Point, Line & Area

How much area will be getting affected if Cyclone hits at Andhra Pradesh Coast? Buffer is created along with coast line at a distance of 5 km. The highlighted green area shows the affected region. Resultant map is shown in below figure.

Fig. 93

Example for Buffer

vi) Triangulated Irregular Network (TIN)

A TIN is a vector based representation of the physical land surface or sea bottom. It is generally used to create digital terrain models (DTM). A tin connects adjacent data point vertices by lines to create a network of irregular triangles. First the TIN of sampled location is computed then the triangle containing the specified unsampled location is determined from the TIN using the predicate point inside the triangle. The 3D distance between the data points along vertices and unsampled location computed using trigonometry. The value of unsampled location is the geometric mean of the

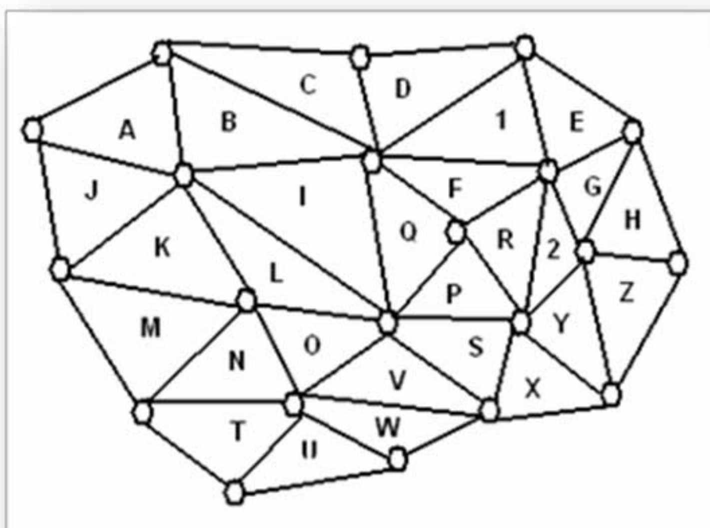


Fig. 94

TIN

values of the vertices of triangle containing. TIN's are often derived from the elevation data of a rasterized digital elevation model (DEM). A TIN can be used to analyze surface's slope and aspect.

There are basically two ways of storing triangulated networks:

- Triangle by triangle
- Points and their neighbors

The triangle by triangle method is better for storing attributes for each triangle for example slope and aspect. But it uses more storage space. Points and their neighbors methods is better for generating contours and uses less storage space, but slope, aspect , etc must be calculated and stored separately.

TIN is a series of triangles constructed using elevation data points taken from coverages. These triangles are used for surface representation and display TIN usually associated with 3-dimensional data (x,y, and z) and topography,

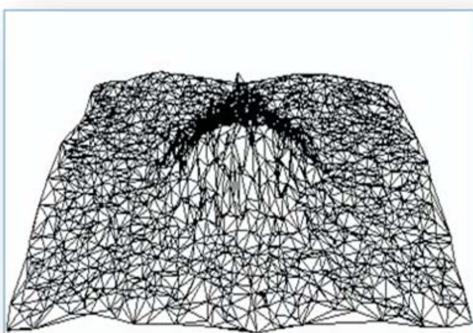


Fig. 95

TIN

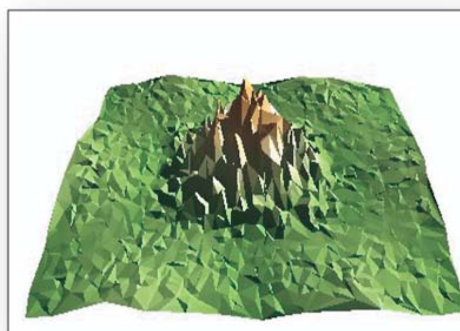


Fig. 96

Surface Model

Modeling

The process of creating new GIS product from existing products is known as "GIS Modeling" Models Integrate different data sources such as Maps, DEMs, GPS data, images, and tables. In models all these data displayed together & dynamically linked to generate valuable information for better decision, Models are vector-based or raster based. Raster based model is used where spatial phenomenon varies continuously for example, Soil erosion, snow accumulation, DEM etc. Vector data model is used in spatial phenomena that involve well-defined locations. For example, Travel demand modeling uses road network.

2.8 Map Projection and Coordinate System

> "Map Projection is a procedure which transforms the features and locations from a 3D platform that is surface of earth to a 2D platform that on paper in a defined and consistent way."

GIS user works with map features on the plane surface. These map features represents spatial location on the earth surface. The location of the map features are based on coordinate system. In Class XI we have studied about Geographic Coordinates system where the location of the map features are defined in the form of latitude and longitude. Map projections are used to transfer geographical coordinates onto a flat surface. The outcome of the transformation is a systematic construction of lines on a plane surface representing the geographical grid. But the transformation from the Earth's surface to a flat surface always involves distortion no map projection is perfect. Several map projections have been developed for map making.

a) Some common types of Projection types

There are three types of projection system are available in the world.

i) Cylindrical projection
ii) Conical projection
iii) Planar/Azimuthal projection

> Globes are the most accurate way to represent the surface of the Earth. It is not practical to carry a globe into the field, That is why map makers figure out how to represent a round map on a flat piece of paper. That is called as Map projection.

b) Some of the common GIS Projection used

i) Mercator
ii) Transverse Mercator
iii) Universal Transverse Mercator
iv) Lambert Conformal

v) State Plane
vi) Lambert Equal Area
vii) Albers Equal Area Conic

c) Coordinate Systems

How we can locate our self on earth? There should be some system which can calculate the location information by some known reference point. This system is called as Coordinate system.

> Coordinate system which uses a set of numbers, or co-ordinates, to determine the position of any given point by using some references

Coordinate system ar divided into two types

i) Geographic coordinate systems.
ii) Projected coordinate systems

i) Geographic coordinate system

Geographic coordinate system is a three-dimensional reference system that locates points on the Earth's surface. The unit of measure is decimal degrees. A point at earth has two coordinate values, latitude and longitude. Latitude and longitude measure angles. Latitude is defined as the angle formed by the intersection of a line perpendicular to the Earth's surface at a point and the plane of the Equator. Points north of the Equator have positive latitude values, whereas points towards south have negative values. Latitude values

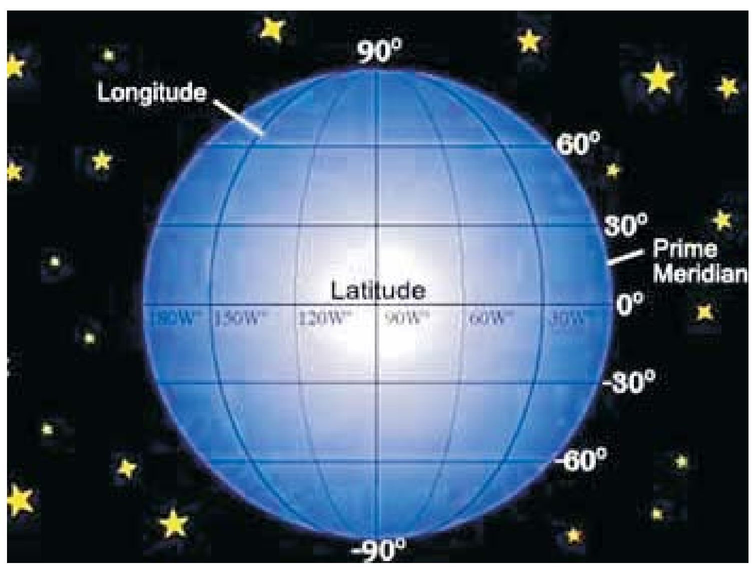


Fig. 97

Location information in geographic coordinate system

ranges from - 90 to + 90 degrees. Lines of latitude are also called parallels. A meridian is formed by a plane that passes through the point and the North and South poles. The longitude value is defined by the angle between that plane and a reference plane. The reference plane is known as the prime meridian. The most common prime meridian passes through Greenwich, United Kingdom.

ii) Projected coordinate system

A two-dimensional coordinate system is commonly defined by two axis. At right angles to each other, they form a **XY**-plane. As shown in figure below

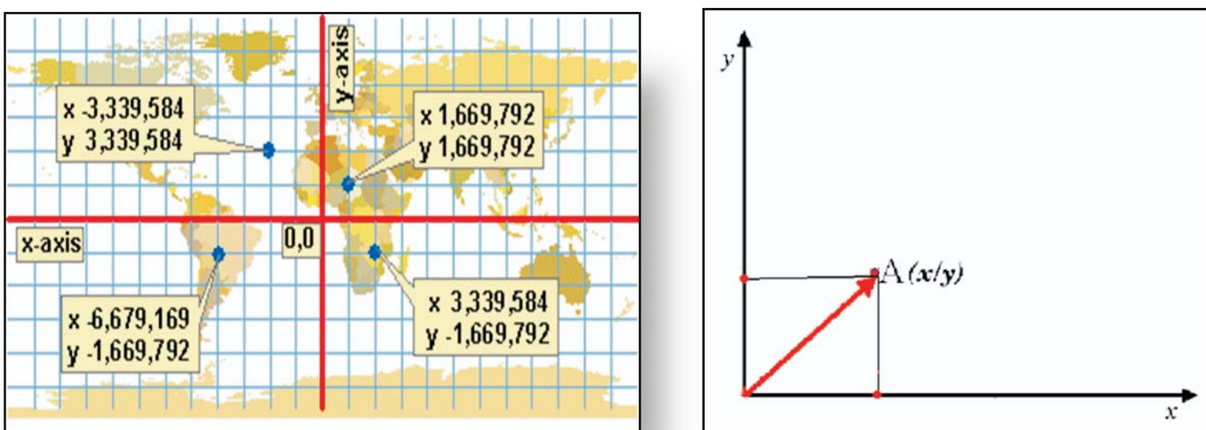


Fig. 98

Location information in projected coordinate system

A projected coordinate system in the southern hemisphere normally has its origin on the equator at a specific longitude. This means that the Y - values increase southwards and the X - values increase to the West. In the northern hemisphere the origin is also the equator at a specific longitude. Y - values increase northwards and the X - values increase to the East.

Some Examples of Popularly Accepted Coordinate System in the World.

a) Universal Transverse Mercator (UTM)

It is most comomnly used international plane coordinate system developed by the U. S Army. The Universal Transverse Mercator Coordinate (UTM) system provides coordinates on a world wide flat grid for easy computation. This system divides the World into 60 zones, each being 6 degrees longitude wide, and extending from 80 degrees south latitude to 84 degrees north latitude, the polar regions are excluded. The first zone starts at the International Date Line (longitude 180 degrees) proceeding eastward. High digree of accuarcy is possible due to separate projection for each UTM zone . India falls under 42 - 47 zone.

Fig. 99

Zone numbers of India

UTM is frequently used, consistent for the globe and is a universal approach to calculate accurate geo referencing

b) Datum

A reference datum is a known and constant surface which can be used to describe the location of unknown points. On Earth, the normal reference datum is sea level. There are many datum sytems are available. Based on projection and location we can choose realated datum system. For example for working India data set conical projection and Everest datum is used. But globally most commonly used projection type is UTM and WGS 84 datum.

c) WGS84 (world Geodetic System)

The World Geodetic System is a standard for use in cartography, geodesy, and navigation purpose. The origin of WGS-84 System is the centre of mass of the earth. This system has come into existence only towards the end of 20th Century, and prior to that the local coordinate system such as Everest or Indian System had been in use in India for more than 150 years.

2. 9 Digital cartography

In class XI we have studied about the cartography. Cartography is the art and science of map making technique. The person who prepares the maps is called as cartographer. The digital cartography is also called as map creation. The map features are map scale, north arrow, map Keys, cartographic grid etc.

Cartographic functions:

- It produces graphics on the screen or on paper that conveys the result of analysis to the people who make decisions about resources.
- Wall maps and other graphics can be generated, to visualize and understand the results of analysis
- Database information can be generated for further analysis. An example would be a list of all addresses within one mile of a toxic spill.

The below table shows the relationship between the map scale and the respective feature dimension on the ground

Sl No	Map Scale	Ground distance corresponding to 1cm on map
1	1:500	5 m
2	1:1000	10 m
3	1:5000	50 m
4	1:25,000	250 m
5	1:50,000	500 m
6	1:1,00,000	1 Km
7	1:250,000	2.5 Km
8	1:1,00,00,000	10 m

Table : 6

2.10 Advantages and Benefits of GIS

GIS is becoming essential tool for government and many large corporations to understand recent developments. Senior administrators and executives at the highest levels of government use GIS information products to communicate. These products provide a visual framework for conceptualizing, understanding, and better decision. GIS can be used in many areas such as land use, crime, the environment, and defense/security situations. GIS is a very popular tool in current era due to its various advantages as discussed below

i) Planning of project:

The maps generated by different agencies are likely to be in different scales and projections. In order to compare data from maps they have to be converted into same scale and projection. In past mapping of different scale and projection were done manually. But with the help of GIS, the maps can be stored in digital form in real world co-ordinates, therefore the conversions of map projections can be done easily and quickly. The spatial analysis functions of GIS applied to visualize the different scenarios to planner to facilitate the planning of different projects. The extensive data handling capabilities during the studies of different scenarios increase depth of knowledge and wide span of information.

- **Better decision making**

The better information leads to better decision. The various spatial and non spatial data analysis results better decision. Common examples include real estate site selection, route / corridor selection, zoning, planning, conservation, natural and resource extraction, etc.

Fig. 100

ii) Visual analysis

Visualizations of GIS Based maps help in understanding different scenarios and situations. Maps improve communication between different teams, departments, disciplines, professional, organizations, and the public& private organization.. Digital Terrain modeling is an important utility of GIS. DTM, 3D modeling and landscape can be better visualized, resultse to better understanding of various features of the earth

iii) Improving organizational integration

Much organizations have implemented GIS to improve the management of their resources. GIS has the ability to link datasets. It facilitates intra departmental information sharing and communication. By creating shared database one department can benefit from the work of other department. Data can be collected and created once and used several times. Communication increases among individuals and different departments, therefore redundancy is reduced and productivity is improved and enhanced, which leads the overall organization efficiency

iv) Efficient data storage and management

In past people were using the paper maps which were static, covered limited area. It was difficult to update. It took lots of space to store data. Over a period of time it was detroited . It is unable to interpret the relationship between different features through static map. After implementation of GIS it is easy interpret the relationship of hidden features. Once the data are created through GIS it is in digital format which is easy to store, update interpret and manage.

v) Cost and time saving

GIS facilitates sharing data within the departments which reduce the cost and resources. Due to automated functionalities of GIS it saves the time of data processing.

vi) Better data management

GIS is increasingly being implemented as enterprise information systems. GIS enables the organization to organize and manage their resources and assets more efficiently. For examples utilities, forestry and oil companies, the assets and resources are now being maintained as an enterprise information system to support day-to-day work. GIS enables management tasks and provide a broader context for assets and resource management.

vii) Accessibility

To access data prepared by GIS is easy and faster as compare to conventional method which result in better decision making.

viii) Database driven

Paper maps represent earth features graphically without any attribute information. Since GIS works with different types of database with a attribute information which helps to understand geo features and their relationship efficiently. New information can be created with existing data to represent various scenarios for better decission

Let us wrap up what we covered in this chapter.

- GIS is a computer application program that stores spatial and non spatial information
- It is also called as Geo based information system
- GIS is a collection of computer, hardware, software system for digitally capturing, managing, analyzing, and displaying all forms of geographically referenced information
- GIS allows us to view, understand, question, interpret and visualize the data and its relationship, pattern and trends in the form of maps, globes, reports and charts.
- GIS is an effective tool for implementation and monitoring of municipal infrastructure, urban area planning, public safety, utility services, transport services etc.
- Non spatial data also called as attribute data, refers to information like demographic distribution of a town or a village, daily discharge of a river at a particular place etc.
- Inputs for GIS is obtained from, manual digitization, scanning of aerial photographs, paper maps, existing data sets, remote sensing satellite imagery and GPS.
- GIS data management includes data security, data integrity, data storage and retrieval and data maintenance abilities
- GIS has a ability to analyze the collected information quantitatively and qualitatively
- GIS present the data in various ways such as maps and three dimensional images
- GIS stores the data in Raster and Vector format
- Raster format the space is divided into grid cells, with a certain value attached to each cell according to the features
- Vector stores the data in the form of Point, Line and polygon with the coordinates of the location

- Vector data structures are categorized as Spaghetti structure and Topological structure.
- Spaghetti data structure is not optimal because it does not take into consideration shared line and points. Due to this problem analysis is not possible
- Topology is used to define spatial relationships between entities
- Properties of Topological structure are connectivity, adjacency, containment, proximity, relative direction
- Raster GIS model is easier to interface remote sensing images
- Raster data structure processes quickly to answer most analytical operations and it is good for representing continuous data
- Database is a computer based system to record and maintain the information
- Spatial database is a collection of spatially referenced data which can be utilized for querying and obtaining information to integrate different types of analytical models and application.
- Database creation in vector model involves Spatial data input, Attribute data input and Linking spatial and attribute data.
- The aims of database design is to save time and resources.
- Poorly constructed database results in unnecessary data, missing data, unsupported application, inappropriate feature representation and lack of consistency.
- Data input is a operation of encoding data into a database
- The digital data directly transferred to a GIS but the hardcopy maps have to be scanned and digitized.
- The spatial entered into GIS by manual digitization, scanning, direct data entry, survey, GPS, satellite data and transfer of data from existing map
- The non spatial data entered into GIS system by key board entry
- Spatial data editing covers topology building, fixing of topological & locational errors and edge matching
- Topology is the mathematical representation of the physical relationships that exist between the geographical elements
- Topological relationship helps in performing analysis such as modeling network, combining adjacent polygons with similar characteristics and overlaying
- Topological error includes overshot, undershoot, dangles, slivers etc.

- Locational errors occur during the process of georeferencing, scanning and digitization.To overcome these errors re digitization, rescanning or re georeferencing can be done. Quality checking and correction is needed
- To create a single seamless map from a multiple maps edge matching is required.
- Each row of the attribute table represents a map feature and each column describes its characteristics.
- The geo-relational data model links spatial and non spatial data by the unique feature ID.
- Spatial and non spatial data analysis includes analyzing of existing data and its spatial relationship through building spatial model to derive new information.
- Spatial data analysis involves various spatial operation tools such as query, dissolving, overlay, TIN, merge, buffering and GIS modeling
- Query is applied using on screen, based on specific condition and based on attribute tables through Boolean algebra expressions.
- Dissolve is a function which aims to combine similar features within data layer. Dissolve removes the common boundary and reduces the number of polygons
- Spatial overlay is accomplished by joining and viewing together different layers of same area. The result of this combination creates new dataset that indentifies spatial relationship
- There are two types of overlay Raster and Vector Overlay
- Vector overlay includes clip, intersection and union
- Merge operation appends the features of two or more layers into a single output layer
- Buffer analysis is used for indentifying area surrounding geographic feature
- TIN is made up of irregularly distributed nodes and lines with three dimensional coordinates
- TIN are derived from elevation data of a rasterized elevation model. TIN is used to create digital terrain models
- The process of creating new GIS products from existing products is known as GIS modeling. Models are vector or raster based.
- GIS model integrates different data sources such as maps, DEMs GPS data, iImage and tables. All these data displayed dynamically to generate valuable information for better decision.

- Map projection is a procedure which transforms the feature and location from a 3 D platform to a 2 D platform.
- Common types of projections includes Cylindrical, Conical and Planar/Azimuthal
- In general Geographic and Projected coordinate systems are commonly used to create maps
- Datum is known and constant which can be used to describe the unknown points. The common reference datum is Sea level
- Digital cartographic is an art and science of map making technique.
- Planning, better decision making, visual analysis, improving organizational integration, efficient data storage and management, cost and time saving, bettr data management, accessibility and database driven are the, advantages and benefits of GIS

Questions-

Vey Short Questions

1. What is GIS?
2. Only spatial data is stored in GIS. True or false?
3. What is non spatial data?
4. Name some application of GIS
5. What are the data sources to GIS?
6. How the data stored in GIS?
7. What is the basic element of vector data structure?
8. Topology is used to define the spatial relationship between the entities. True or false?
9. What is database?
10. List the stages involved in database creation
11. Paper maps are directly fed into GIS system. True or False.
12. What data can be directly transferred to GIS system?
13. What data can be entered into GIS thru key board entry? Name it.
14. Buffer can only applied to pint data layer. True /False.
15. Overlay is used to create digital terrain model. True/ False.

16. What is a map projection?
17. List the common types of projections. Name them.
18. How we can locate our self on earth?
19. What is the range of Latitude values?
20. What are parallels?
21. How many zones are in UTM?
22. India falls in which zone?
23. What is datum?
24. What is cartography modeling?
25. GIS is based on database driven. How it helps user to understand the relation between the geo features.

Short Questions

1. What are the difference between paper and GIS map?
2. What data management includes?
3. Define the following
    a. Raster data structure
    b. Spaghetti data structure
    c. Topological data structure
    d. Row
    e. Column
4. Why database is required in GIS?
5. Name the methods used for digitization?
6. What are the advantages of building Typology?
7. How spatial data can be links with non spatial data? Explain the method?
8. Spatial selection features are identified based on spatial criteria. What are these name them?
9. Define the following
    a. Query

b. Dissolve

c. Overlay

d. Merge

e. Buffering

f. TIN

g. GIS Modeling

10. Define the following

    a. Clip

    b. Intersection

    c. Union

    d. Merge

11. What is Geographic coordinate system?

12. What is projected coordinate system?

13. How GIS helps in improving organization integration and saving cost & time?

14. How GIS helps in managing data efficiently

15. How GIS helps in planning and better decision making?

Long Questions

1. Why GIS is needed?

2. Explain in detail about GIS functions with flow chart.

3. Define the properties of spaghetti data structure

4. What are the properties of topological data structure?

5. What is difference between vector and raster data structure?. Specify what applications are used in each data structure.

6. What are the advantage and disadvantages of Raster data?

7. What is the purpose of database designing? How it helps in GIS? What are the affects of unplanned and undersigned database?

8. Describe in detail about different types spatial query

9. What is buffer analysis? Why it is used?

10. How much area is getting affected by Cyclone? What type of spatial analysis will be used to get answer? Explain with diagram.
11. North East Government would like to prepare Digital Terrain model of the area. What method would you suggest to prepare and why? Describe in detail.
12. You want to study about spatial phenomena such as soil erosion, rainfall and road net work. What type of model is helpful to analysis the phenomena and provide better decisions?
13. Explain in detail the advantage and benefits of GIS

CHAPTER - 3

Global Positioning System (GPS)

Learning Objectives

By the end of this chapter students would be able to understand:

3.1 Introduction about Global Positioning System (GPS)

3.2 GPC Accuracy and Accuracy Factors

3.3 Types of GPS

3.4 List of Global Navigation Satellite Systems

3.5 GPS Today & its Limitations

3.6 Uses of GPS Technology

3.1 Introduction

Since the beginning of time, mankind has been trying to figure out a dependable way to know answer Where am I? How do I get to my destination and get back? These questions are as old as the history of mankind. Stones trees, mountains are used as reference to Identifying and remembering objects and different landmarks. Major developments in navigation were the stones, star, radio, and satellite age based GPS.

GPS stands for Global Positioning System and it allows users to determine their location on land, sea and in the air using Satellite and receiver.

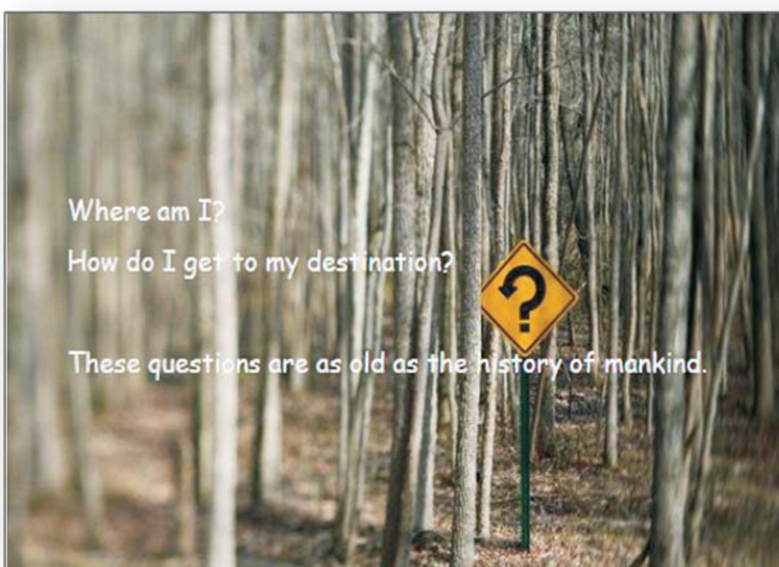


Fig. 101

The Stone Age man used to find his way through jungles and deserts. In stone age people navigated only by means of landmarks - mountains, trees, or leaving trails of stones. This would only work within a local area. Seamen followed the coastline to keep them from not getting lost. For traveling across the ocean a process called dead reckoning, which used a magnetic compass and required the calculation of how fast the ship was going. The measurement tools were crude and inaccurate. It was also a very complicated process.

Fig. 102

Stone Age Navigation
Courtesy: Sumit Sabarwal

Fig. 103

Star Age Navigation
Courtesy: Sumit Sabarwal

In the Star Age man started exploring the oceans, where only visible objects are the sun, moon and the stars. The relative position of stars and shape of constellations look different from different locations on Earth. Major developments in early navigation were compass and the sextant. The needle of the compass always points north. So even if they did not know where they were, at least they knew in what direction they were travelling. The sextant measures the exact angles of stars, moon and sun above the horizon by the use of adjustable mirrors. Early sextant measures the latitude; it could not measure the longitude.

To overcome the problem of identifying location information in terms of longitude and latitude radio based navigation systems are discovered and used in World War - II. Both ships and airplanes were used in ground based radio navigation system. Radio Navigational System uses radio signals to measure distances from several transmitting towers located at known points. The first ground-based radio navigation system was developed after 20th century. The users (receivers) calculate how far away they are from a transmitting tower whose location is known. The accurate locations are calculated by using several towers.

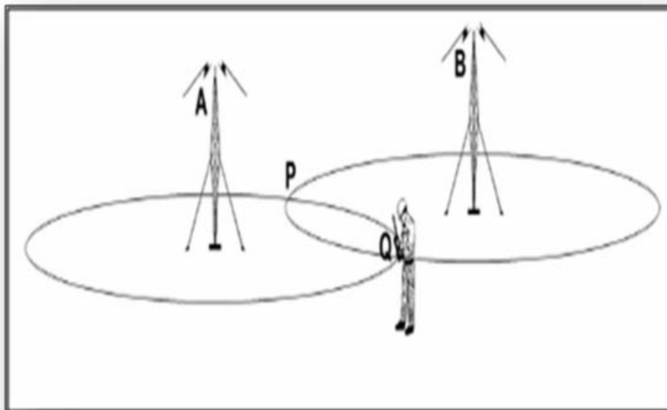


Fig. 104

Radio Navigation System

In the Satellite Age improved radio transmitters were put aboard satellites orbiting the earth to give wider coverage. A limitation of ground based radio waves is that it is difficult to make them accurate as well as provide wide area coverage. Therefore the only way to provide coverage for the entire world was to place high-frequency radio transmitters in space. Satellite navigation systems can provide high frequency signals allowing for high accuracy, as well as global access. The first satellite system developed was called Transit. It was made operational in 1964. Transit had no timing devices aboard the satellites and the time it took a receiver to calculate its position was about 15 minutes.

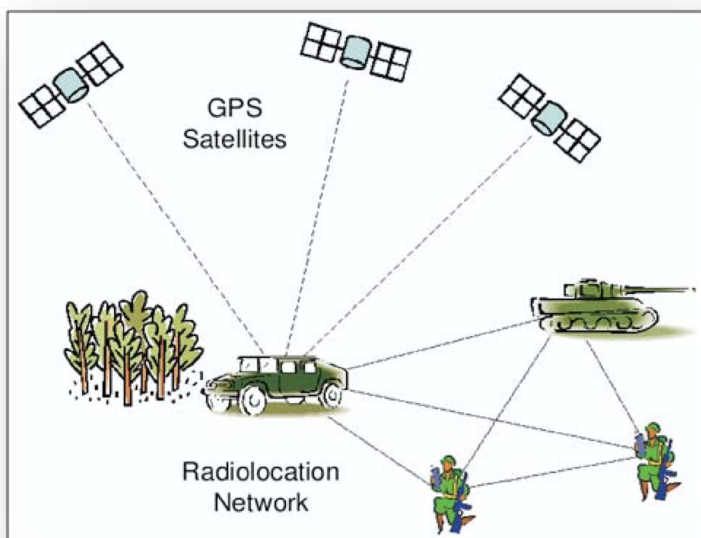


Fig. 105

Satellite Navigation System

The GPS was mainly used for military positioning, navigation, and weapons aiming system. It has higher accuracy and stable atomic clocks on board to achieve precise time transfer. The first GPS satellite was launched in 1978 and the first products for civilian consumers appeared in the mid 1980's. In 1984 the capabilities of GPS was available to the civil community. The system is still being improved and new, better satellites are still being launched to replace older ones.

Fig. 106

GPS

GPS is a network of satellites that continuously transmits coded information which makes it possible to precisely indentify location on earth by measuring distance from the satellites

In class XI we have discussed on basic fundamentals of GPS. GPS is a satellite-based positioning system operated by the United States Department of Defense (DoD). GPS include three segments

- Space Segment
- Control Segment
- User Segment

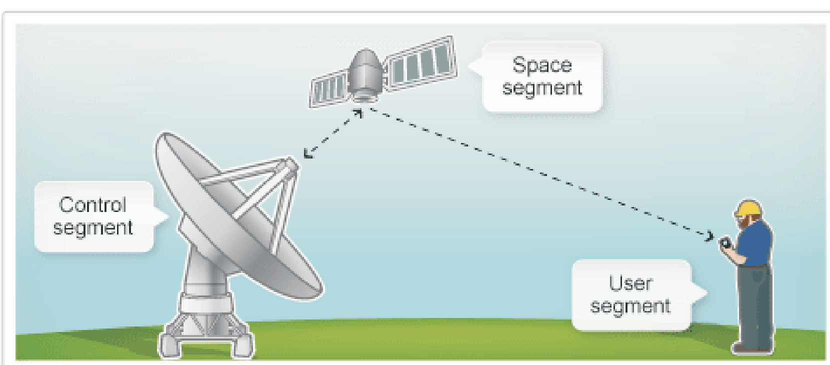


Fig. 107

Segments of GPS – Control, Space & User

The space segment includes the 24 operational NAVSTAR satellites that orbit the earth every 12 hours at an altitude of approximately 20,200 kilometers. Each satellite contains several high-precision atomic clocks and constantly transmits radio signals using a unique identifying code.

Control segment basically makes sure that the satellites are working properly. It includes one Master Control Station, five Monitor Stations and a Ground Antenna. The Monitor Stations passively track each satellite continuously and provide this data to Master Control Station. The Master Control Station calculates any changes in each satellite's position and timing. These changes are forwarded to the Ground Antennas and transmitted to each satellite daily. This ensures that each satellite is transmitting accurate information about its orbital path

The user segment, comprised of both civilian and military users worldwide, acquires signals sent from the NAVSTAR satellites with GPS receivers. The GPS receiver uses these signals to determine where satellites are located. With this data and information stored internally, the receiver can calculate its own position on earth.

Official name: Navigation System for Timing and Ranging (NAVSTAR)
Generic/common name: Global Positioning System (GPS)

Fundamental principle GPS is based on using radio waves received from multiple satellites to measure the distance to each satellite. A GPS receiver's job is to locate four or more of these satellites, figure out the distance to each, and use this information to calculate its own location. This operation is based on a simple mathematical principle called Triangulation or Trilateration.

Trilateration is a basic geometric principle that allows you to find the location of unknown place by knowing distance from known place.

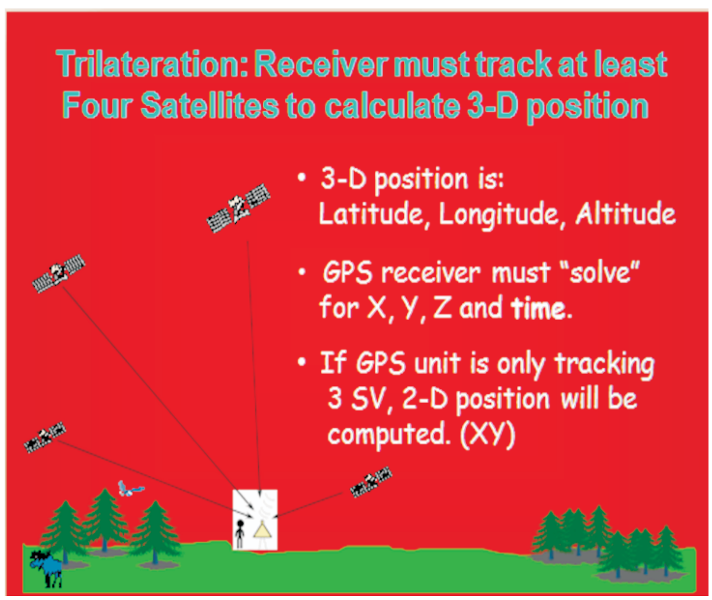


Fig. 108

Trilateration

Courtesy: Sumit Sabarwal

Trilateration uses electronic distance measuring equipment to directly measure the lengths of the sides of triangles from which the angles can be calculated. It is a very useful method for rough terrain where positions can be accurately carried forward and is seen as an alternative method to triangulation

The calculation process is as follows

- Receiver activates the GPS system
- The receiver picks up the signals from the satellites (minimum of four). If more than four satellites it increases the accuracy.
- Uses signal travel time to calculate distance to the satellites
- Triangulates to determine position of the receiver.

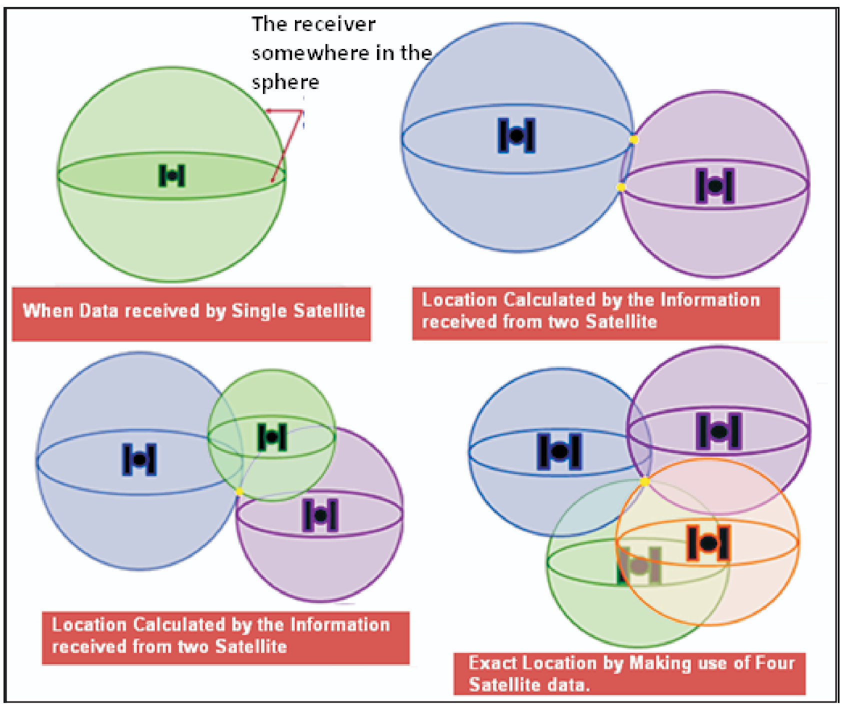


Fig. 109

Trilateration process

This positional information can be used in many applications such as mapping, surveying and navigation.

3.2 GPC Accuracy and Accuracy Factors

The position calculated by GPS is affected by several factors. Each of the following errors has an impact on the accuracy of our GPS positions. The GPS system has been designed to be accurate as possible. But still there are some errors occur which are added together, these errors can cause a deviation of **+/- 50 -100** meters from the actual GPS receiver position. There are several sources for these errors, the most significant of which are discussed below:

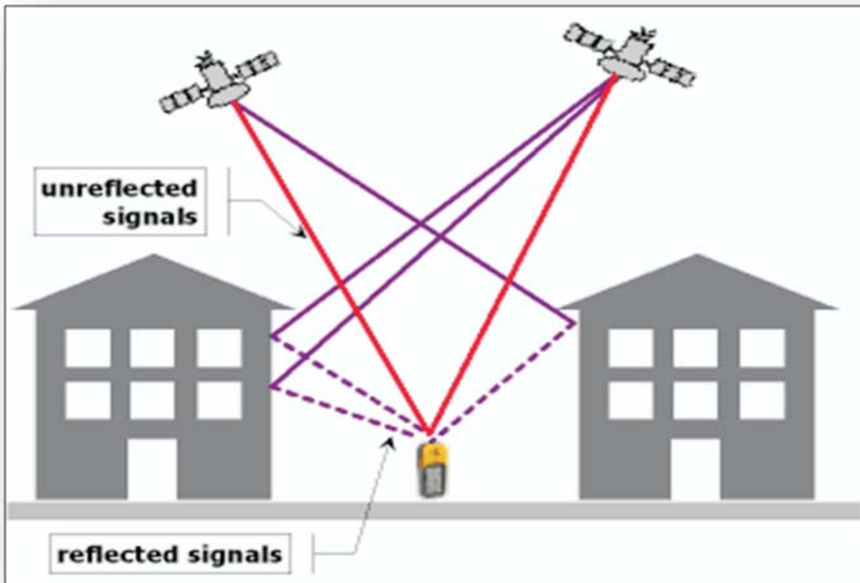


Fig. 110

Accuracy affected by atmosphere layers
Source: www.kowoma.de

Errors

- Minimum Number of satellites required
- Ionosphere - Change in the Travel Time of the Signal
- Troposphere - Change in the Travel Time of the Signal
- Satellite Geometry - General Distribution of the Satellites
- Satellite Health - Availability of Signal
- Signal Strength - Quality of Signal
- Distance from the Reference Receiver
- Radio Frequency (RF) Interference
- Loss of Radio Transmission from Base
- Orbital errors (ephemeris errors) these are inaccuracies of the satellite's reported location.

- Satellite geometry/shading - poor geometry results when the satellites are located in a line or in a tight grouping.
- A receiver's built-in clock is not as accurate as the atomic clocks onboard the GPS satellites.
- GPS units typically will not work indoors, underwater or underground.
- Multipath - Reflection of GPS signals near the Antenna

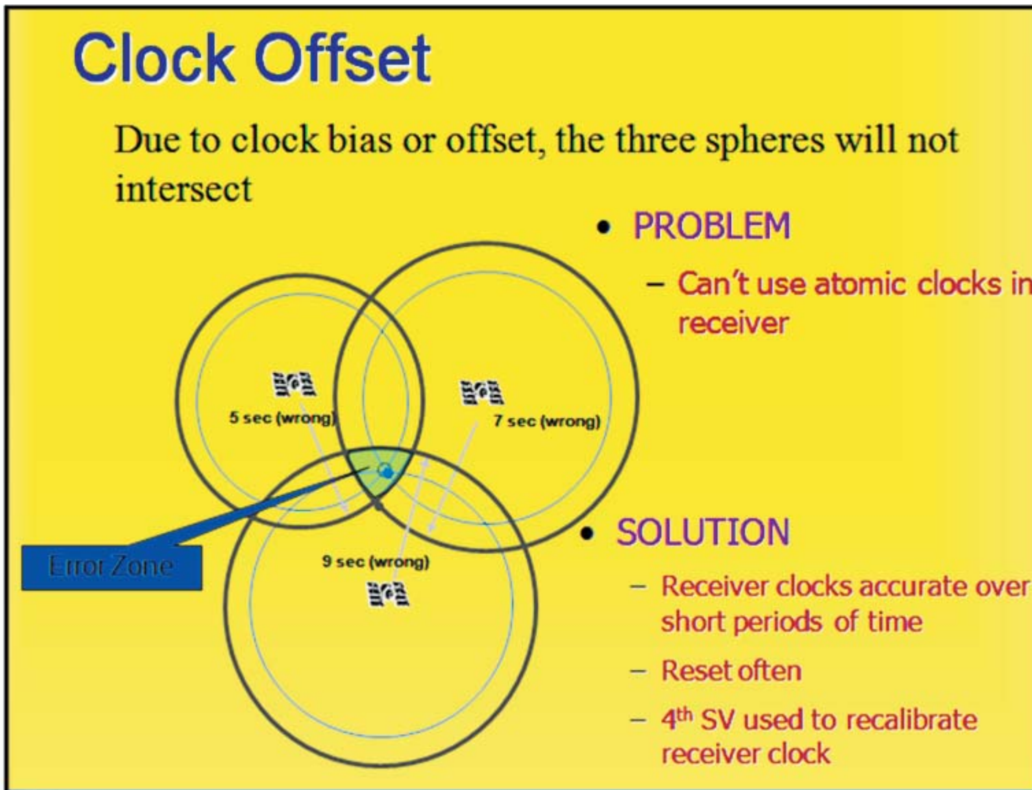


Fig. 111

Accuracy affected by Clock difference
Courtesy: Sumit Sabarwal

Details of these factors have been discussed in Class XI, Various types of GPS provides different levels of accuracy for exampleGarmin® GPS receivers can provide at accuracy within 15 meters on average. Newer Garmin GPS receiver with Wide an Area Augmentation System (WAAS) provides accuracy less than 3 meters. Below table shows the accuracy of GPS with various modes of operation

Table : 7	
Mode of operation	**Accuracy**
Autonomous	15 m – 100 m
Differential GPS (DGPS)	0.5 m- 5 m
Real-Time Kinematic Float (RTK Float)	20 cm – 1 m
Real-Time Kinematic Fixed (RTK Fixed)	1 cm - 5 cm

Accuracy of GPS reading with various modes

Fig. 112

Surveying GPS Instrument

The global positioning system (GPS) has become the most extensively used positioning and navigation tool in the world. The positional and elevation accuracy of any given GPS location is prone to error, due to a number of parameters. GPS accuracy can be significantly improved with additional data, possibly from multiple sources, and especially from multiple receivers. In the case of a single GPS receiver, its position and elevation can be considerably improved with the use of spatial data. In general, the position quality provided by GPS alone was extremely poor, due to multipath effects caused by the urban area.

Generally, altitude error is specified to be 1.5 x Horizontal error specification. This means that the user should consider + / - 23meters (75ft). Altitude error is always considerably worse than the horizontal (position error). These errors are due to the matter of geometry. If we consider just four satellites, the “optimum” configuration for best overall accuracy is having the four Space Vehicle (SV) at 40 to 55 degrees above the horizon and one in each general direction N, E, W, and S. The similar “best” arrangement for vertical position is with one SV overhead and the others at the horizon and 120 degrees in azimuth apart. This type of arrangement is very poor and not accurate because it is at horizontal position.

To improve the accuracy of GPS readings DGPS are used. The DGPS operation will dramatically improve the performance of even low cost GPS receivers. In DGPS we get the Horizontal accuracy of + / - 5 meters and altitude accuracy of + / - 10 meters.

3.3. Types of GPS

a) DGPS

b) Recreational

c) Mapping

d) Survey

a) Differential Global Positioning System (DGPS)

Differential Global Positioning System (DGPS) is an enhancement to GPS. It works by canceling out most of the natural and manmade errors. Enable precision applications by reducing the overall Errors

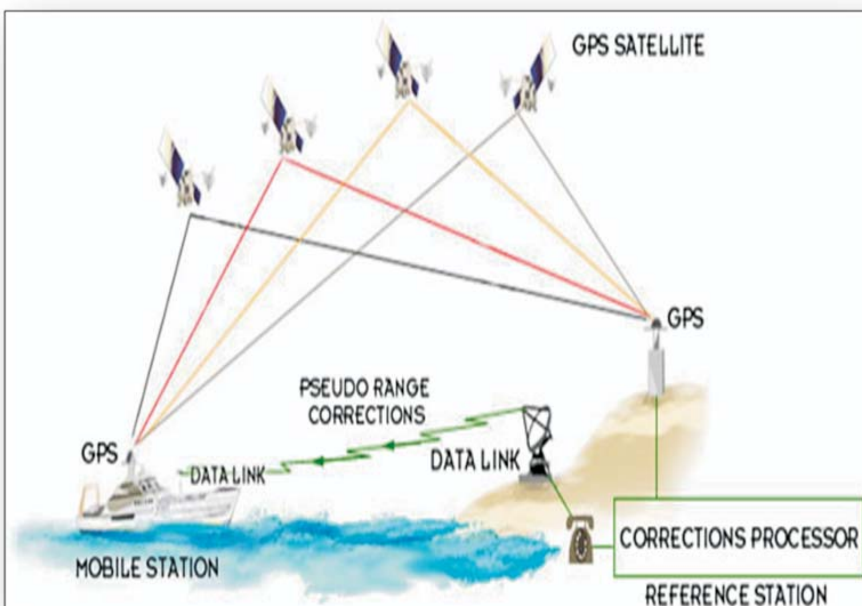


Fig. 113

DGPS System

Source: Blogspot.com

How does it work?

It uses a network of fixed, ground-based reference stations to broadcast the difference between the positions indicated by the satellite systems and the known fixed positions. Two GPS receivers are used for DGPS. A high precision "Base" GPS receiver (Base Receiver or Base Station) is placed at a known "controlled" point of reference such as a National Geodetic Survey marker.

DGPS is providing more accuracy than GPS system.

This receiver collects GPS signals and compares the results to the actual known coordinate of the Base. A "rover" receiver collects autonomous information in the field. Software / Hardware at the base station calculates the difference (differential) between the known position and the GPS position. This differential is an effective measurement of positional offset, in both direction and distance. The differential data can be used to correct the positional errors in the data collected from the Rover GPS receivers in either real-time or after the fact (post processing). This system works pretty well, but inaccuracies do pop up. For this method the radio signals cross through the atmosphere at a consistent speed of light. The electromagnetic energy passes through the Earth's atmosphere (Ionosphere and Troposphere) and slows down. DGPS can generate errors resulting from the distortions produced in the troposphere and ionosphere.

The ephemeris errors may also lead to the users receiving incorrect information. Thus, the information provided by the DGPS loses accuracy as it move away from the reference station. The errors in the DGPS may range from 0.22 to 0.67 km per 100 km. Problems can also occur when radio signals bounce off large objects, such as skyscrapers. Sometimes satellites send out bad almanac data, misreporting their own position. DGPS helps to correct these types of errors. DGPS already knows its own position at fixed station it can easily calculate its receiver's inaccuracy.

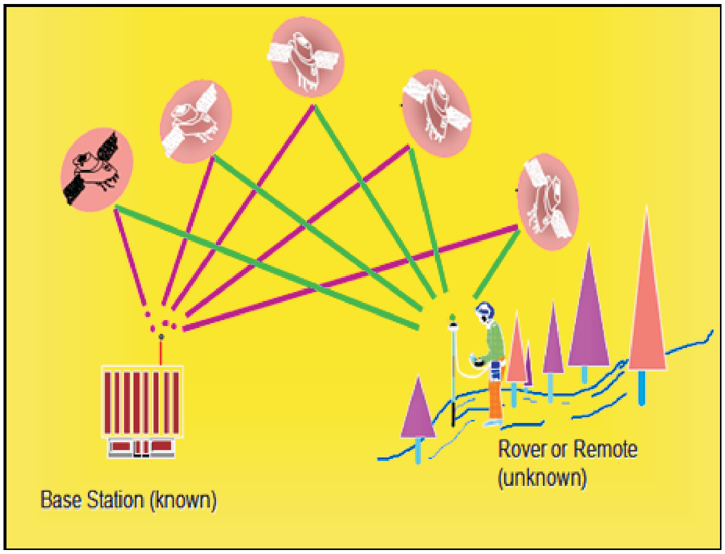


Fig. 114

Differential Global Positioning System (DGPS)
Courtesy: Sumit Sabarwal

The station then broadcasts a radio signal to all DGPS equipped receivers in the area, providing signal correction information for that area. Post Processing the DGPS system finds out the exact locations of unknown points by using reference points, known as 'survey markers'. This technique is called as Post - Processing. Depending on the amount of data being sent in the DGPS correction signal, correcting for these effects can reduce the error significantly offering accuracies of less than 10 cm. That is why DGPS has ability do make better decisions, in locating and improving survey cost effectiveness and time management. DGPS Technology has many other applications on Land Sea and in the Air.

b) Recreational Grade GPS

This unit is designed to acquire a location quickly without the need for pinpoint accuracy. Typically the accuracy is < 15 meters (49 feet) with no differential correction. Recreational products are not specifically designed for GIS mapping, they can be used successfully in some applications such as outdoor sports, hiking, geocaching, etc. It is comparatively cheaper than other GPS.

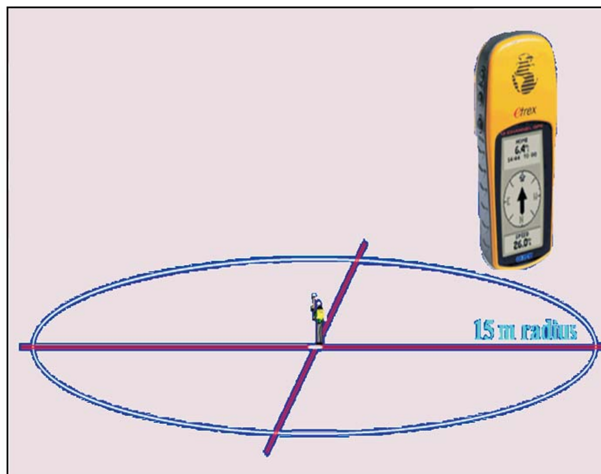


Fig. 115

Recreational Grade GPS
Courtesy: Sumit Sabarwal

c) Mapping Grade DGPS

These GPS receivers are typically less user-friendly than the recreational GPS, and they cost significantly more. Mapping grade GPS are more accurate than recreational units, commonly to within a meter (~3 feet). Mapping grade GPS receivers are most often used by government agencies, researchers, and other users who require more accurate and dependable coordinate fixes than a recreational GPS can provide.

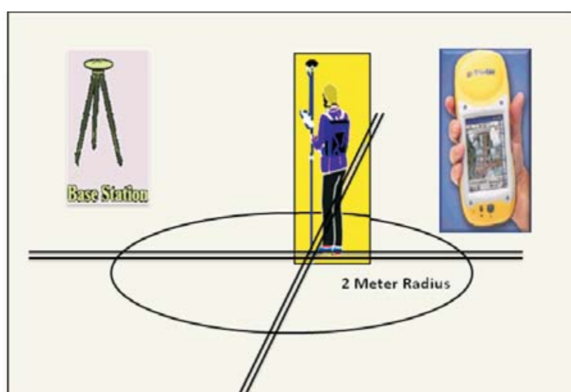


Fig. 116

Mapping Grade DGPS
Courtesy: Sumit Sabarwal

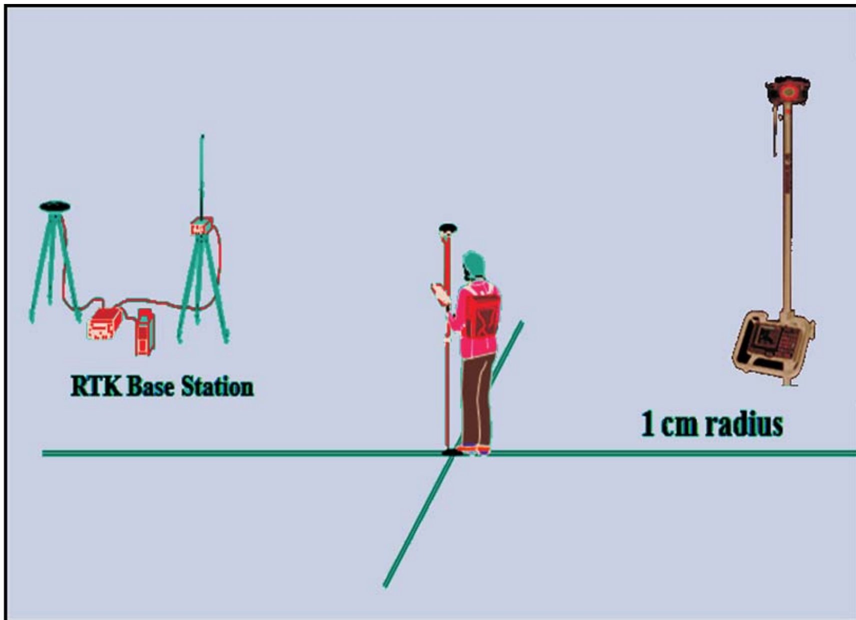


Fig. 117

Real-Time Kinematic (RTK)
Courtesy: Sumit Sabarwal

d) Survey Grade DGPS

Survey grade units are used where accuracy is crucial such as cadastral surveys, Highway construction and other engineering projects. They are capable of providing horizontal accuracy to within a centimeter. Survey grade GPS receivers are the most accurate and the most expensive. These GPS receivers are most often used by professional surveyors. It is more accurate. A survey grade GPS is used to establish a known point. From there, total station laser instruments are used to lay out measurements for other positions in the neighborhood of the known point.

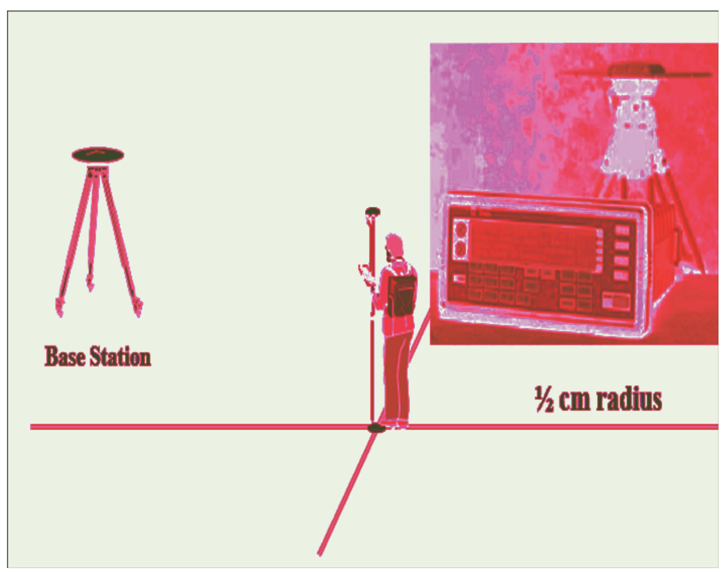


Fig. 118

Survey Grade DGPS
Courtesy: Sumit Sabarwal

3.4 List of Global Navigation Satellite System

There are currently three global navigation systems in operation

a) Navigation Satellite Timing and Ranging system (NAVSTAR)
b) GLONASS (Global'naya Navigatsivannaya Sputnikovaya Sistema)
c) GALILEO is under development by the European Community .

a) NAVSTAR:

NAVSTAR commonly referred to as the Global Positioning System (GPS) and owned by the United States of America. The NAVSTAR GPS was developed by the U.S. Department of Defense (DoD). It consists of a constellation of 24 to 27 satellites in operation and placed in six orbital planes. These satellites are orbiting the earth at a high altitude (approximately 20,200 meter). Each plane is inclined 55 degrees relative to the equator. The satellites complete an orbit in approximately 12 hours. The signal from the satellite requires a direct line to GPS receivers and cannot penetrate water, soil, walls, or other obstacles such as trees, buildings, and bridges.

b) GLONASS

GLONASS constellation is composed of 24 satellites in three orbital planes whose ascending nodes are 120 degrees apart. Each satellite operates in circular 19,100-km orbits at an inclination angle of 64.8 degrees, and each satellite completes an orbit in approximately 11 hours and 15 minutes. The spacing of satellites in orbits is arranged so that a minimum of five satellites is in view to users worldwide. The GLONASS constellation provides continuous and global navigation coverage. Each GLONASS satellite transmits a radio-frequency navigation signal containing a navigation message for users. The first GLONASS satellites were launched into orbit in 1982. The deployment of the full constellation of satellites was completed in 1996, although GLONASS was officially declared operational on September 24, 1993. GLONASS is managed for the Russian Federation government by the Russian Space Forces.

c) GALILEO

GALILIO is the global navigation satellite system being developed by an initiative launched by the European Union and the European Space Agency (ESA). GALILIO will be fully operable by 2014. The navigation system is intended to provide measurements down to the meter range including the height (altitude) above sea level, and better positioning services at high latitudes as compared to GPS and GLONASS. As a further feature, GALILIO will provide a global Search and Rescue (SAR) functions which is able to transfer the distress signals from the user's transmitter to the Rescue Co-ordination Centre, which will then initiate the rescue operation. At the same time, the system will provide a signal to the user, informing him that his situation has been detected and that help is on the way. GALILIO services will be free and open to everyone. The high-accuracy capabilities will be available for paying commercial users and for military use. Below figure shows all three types of Global navigation and Satellite System (GNSS)

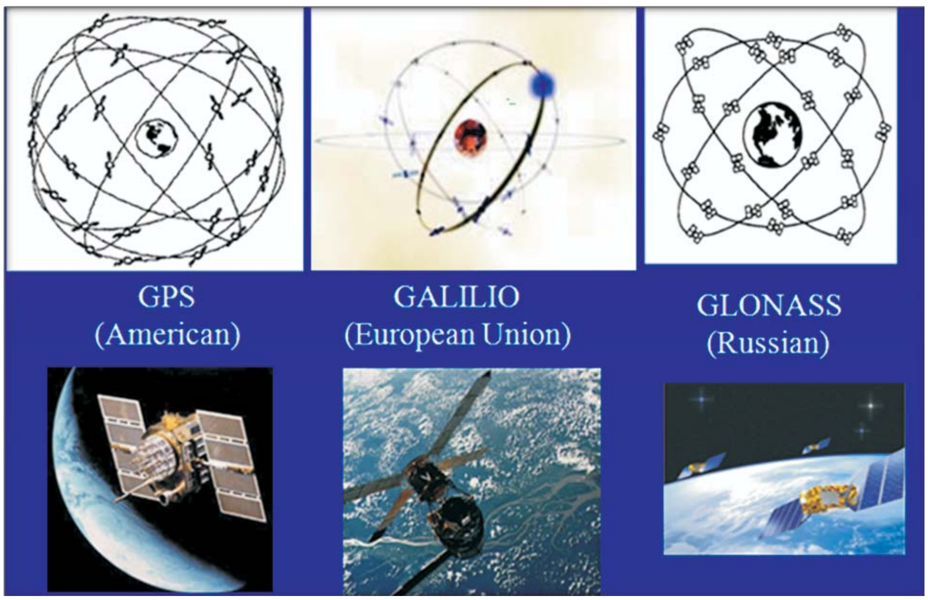


Fig. 119

Global Navigation Satellite Systems
Courtesy: Sumit Sabarwal

3.5 GPS Today & its Limitations

GPS technology has matured into a resource that goes far beyond its original design goals. Used by scientists, sportsmen, farmers, soldiers, pilots, surveyors, hikers, sailors, dispatchers, firefighters etc. GPS makes their work more productive, safer, and easier.

- It will not work in Tunnels, Underwater, Inside the building
- It needs Clear sky to see satellites
- It gives out coordinates in WGS 84, must be transformed to local datum
- It produces ellipsoidal not orthometric heights.

3.6 Uses of GPS Technology

GPS Today used by variety of professional to make the work more productive, safer and easier. Commonly GPS used in fields are listed below

i) Survey and Mapping
ii) Height and Location
iii) Vehicle Tracking
iv) Navigation
v) Timing

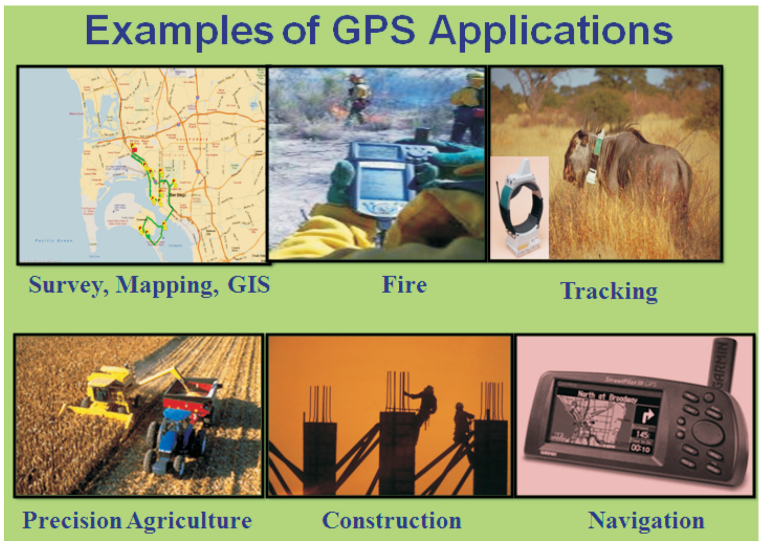


Fig. 120

B Areas of GPS application

- Precession Agriculture
- Geo tagging
- Vehicle tracking
- Construction
- Navigation
- Emergency services such as fire
- Survey mapping
- Fishing
- Security & Defense
- Utility management
- Geo tagging
- Forestry
- Public Safety and services

- Train Control
- Sport and Recreation
- Oil and mineral explosion
- Nature conservation and protection

Fig. 121

(i) GPS used for Survey and mapping

Surveying is the first and foremost step conducted before doing any large-scale activities, such as utilities, and civil construction. Traditionally surveying has been performed by highly qualified personnel and is a very tedious and labor intensive effort. Traditional methods are time-consuming and often require multiple trips to the same site to gather accurate data as human tends to make mistake. At the same time surveyors were not

Fig. 122

DGPS Receiver

always able to work under certain weather conditions, such as snow, rain, or extreme temperatures.

Fig. 123

GPS Survey

Survey teams had to work hard for months together in assessing the land. Use of modern technology such as GPS survey can enhance the quality and increases the productivity of conventional survey team, reduces data collection time, and improves survey accuracy. GPS provide a very accurate coordinates of the surveyed points and this can be transferred to any existing digital map database. This provide very precise digital survey record. This accuracy can be improved further to few centimeters by post processing GPS data through advanced surveying software. By using a single GPS receiver a surveyor can obtain the precise coordinates of a location within a minute and can move on to the next location. The coordinates then be stored and can be downloaded to a computer with Map database. The GPS coordinates can are be imported into the database and the survey report for the entire area is generated within a short time. GPS coordinates are obtained by mounting a GPS receiver on a vehicle and survey is performed as the vehicle moves. This provides a very dense survey coordinates with very little additional effort. GPS/ DGPS are an excellent data collection tool for creating and maintaining a GIS data.

(ii) Use of GPS in height and Location

Each GPS satellite broadcasts a high power, narrow bandwidth signal that may be received by receiver antenna. Receiver receives signals simultaneously from all the visible satellites. Each satellite has an on-board timing clock it is able to transmit signals down at exactly known instants. The signals come down to receiver at the speed of light and the time of arrival of the signals at receiver. A computer program in receiver notes the time of arrival of the signals received from the various visible GPS satellites and is able to work out latitude, longitude and height. If position is changing, by observing the changes it is possible to work out the speed of movement and the direction in which object is moving. The system needs at least 3 satellites to obtain a latitude and longitude. Fourth satellite determines the height. More satellites achieve higher accuracy of the results. The accuracy varies according to the location of the satellites. If satellites were visible but all close together in the sky then the accuracy would be worse. Many GPS receivers have an optional display that shows where the satellites are located. By keeping the receiver still, it will average readings over a long time to improve the accuracy. The above figure shows the measurment of height by using GPS reciever.

Fig. 124

Height and location by GPS

(iii) Use of GPS in Vehicle tracking

A vehicle tracking system combines the installation of an electronic device in a vehicle, with designed computer software, to enable, to track vehicle's location.

> Modern vehicle tracking systems commonly use GPS or GLONASS technology for locating the vehicle.

Today GPS are fitted in cars, ambulances, fleets and police vehicles such as Automatic Vehicle Locating System (AVLS), Vehicle Tracking and Information System (VTIS), Mobile Asset Management System (MAMS), these systems offer an effective tool for improving the operational efficiency and utilization of vehicles. A GPS tracking unit is a device that uses the Global Positioning System to determine the precise location of a vehicle, person, or other asset to which it is attached and to record the position of the asset at regular intervals. This device keeps server updated about the location of vehicle. The server maintains a record of these updates. The recorded location data can be stored within the tracking unit, or it may be transmitted to a central location data base, or internet-connected computer, using a cellular (GPRS or SMS), radio, or satellite modem embedded in the unit. At any point of time one can log into our portal to access this data in form of maps, charts and analytical reports. This allows the asset's location to be displayed against a map backdrop either in real time or when analyzing the track later, using GPS tracking software as shown in below figure. A GPS tracker essentially contains GPS module to receive the GPS signal and calculate the coordinates. For data loggers it contains large memory to store the coordinates. Further the GSM/GPRS modem to transmit this information to a central computer either via SMS or via GPRS in form of IP packets. Tracking systems enable a base station to keep track of the vehicles without the intervention of the driver where, as navigation system helps the driver to reach the destination. The navigation system will have a graphic, display for the driver which is not needed for a tracking system. Vehicle Tracking Systems (VTS) combine a number of well-developed technologies. Irrespective of the technology being used, VTS consist of three subsystems: a) In-vehicle unit (IVU), b) Base station and c) Communication link. The IVU includes a suitable position sensor and an intelligent controller together with an appropriate interface to the communication link. Network Overlay Systems use cell phone infrastructure for locating vehicles. In India GPS systems are used in various departments such as police, emergencies, jal board, transportation system for example bus and truck, Tsunami disasters.

Fig. 125

Real time fleet monitoring and analysis

(iv) GPS in Navigation

GPS helps to determine exactly where you are and to how to get somewhere else. This technology is very useful in Air and on the land.

(v) GPS in Timing

GPS can be used to determine precise timing, time intervals and frequency.

Let us wrap up what we covered in this chapter

- Stone Age people navigated by means of Landmarks
- Magnetic compass are used to travel across the ocean,
- People also used stars as guidelines to travel over the ocean
- The first ground-based radio navigation system was developed after 20th century.
- Satellite navigation systems provide high frequency signals allowing for high accuracy, as well as global access.
- The first satellite system Transit was developed in 1964.
- The GPS is mainly used for military positioning, navigation, and weapons aiming system.
- The first GPS satellite was launched in 1978 and maintained by DoD USA.
- After 1980 GPS would be made available to the civil community
- GPS encompasses three segments i.e. is space, control, and user.
- The space segment includes the 24 operational NAVSTAR satellites that orbit the earth every 12 hours at an altitude of approximately 20,200 kilometers.
- The global positioning system (GPS) has become the most extensively used positioning and navigation tool in the world.
- The position calculated by GPS is affected by several factors, such as Satellite Geometry, atmospheric layers, Number of Satellites, Satellite health, Signal Strength, Orbital errors, Multipath etc.
- Trilateration method is used to find the location in GPS system
- Trilateration uses electronic distance measuring equipment to directly measure the lengths of the sides of triangles from which the angles can be calculated. It is a very useful method for rough terrain where positions can be accurately carried forward and is seen as an alternative

- GPS accuracy can be significantly improved with additional data, possibly from multiple sources, and especially from multiple receivers.
- DGPS, Recreational, Mapping, Survey are four grades in GPS system
- Differential Global Positioning System (DGPS) is an enhancement to Global Positioning System that uses a network of fixed, ground-based reference stations to broadcast the difference between the positions indicated by the satellite systems and the known fixed positions.
- DGPS is providing more accuracy than GPS system.
- Use of modern technology such as GPS survey can enhance the quality and increases the productivity of conventional survey team, reduces data collection time, improves survey accuracy, and allows survey team to work under a broad range of weather conditions.
- Currently three global navigation systems are in operation those are NAVSTAR, GLONASS, and GALILIO.
- India has launched GAGAN navigation System
- Some of the limitations of GPS are it will not work in tunnels, underwater, inside the building, needs clear sky to see satellites, gives out coordinates in WGS 84, must be transformed to local datum, produce ellipsoidal not orthometric heights.
- GPS used for mapping. suveying, vehicle tracking, timing and to find the location.
- GPS provide a very accurate coordinates of the surveyed points which is transferred to any existing digital map database.
- A vehicle tracking system combines the installation of an electronic device in a vehicle, with designed computer software, to enable, to track vehicle's location.
- GPS is used in vehicles for both tracking and navigation. A device with GPS and Wireless communication capabilities are installed on vehicle.

Very Short Questions

1. What is GPS?
2. Name segments of GPS
3. What is the altitude of GPS satellites?
4. Height and Accuracy Estimation is possible: True\False?

5. GPS is used to find location information: True\False?
6. Surveying is the primary work for any Utility projects: True\False?
7. GPS cannot provide a very accurate coordinates of the surveyed points: True\False?
8. Name types of GPS system
9. Name currently operational navigation satellite systems

Short Questions

1. How people used to navigate in Stone and star age?
2. What is ground based navigation system?
3. What is Global Positioning System?
4. What is trilateration? Explain
5. Define the use of GPS in Vehicle tracking.
6. What is the GPS survey accuracy?
7. Define use of Surveyed points through GPS.

Long Questions

1. Explain the segments of GPS
2. Explain the factor affecting the accuracy of GPS
3. How DGPS does works?
4. Explain the difference between GPS and DGPS
5. Explain Global Positioning System (GPS) Survey.
6. What is NAVSTAR system?
7. What are different types in GPS system explain with application
8. How GPS work in survey and mapping?

CHAPTER 4

Trends in Geospatial Technology (GT)

Learning Objectives

By the end of this chapter students would be able to understand:

4.1 Introduction

4.2 Remote Sensing Trends & Technology.

4.3 GIS Trends & Technology

4.4 GPS Trends & Technology

4.1 Introduction

The fundamental goal of Geospatial Technology is to provide up-to date information, at lowest cost and highest quality. In this decade, Information System is being spatially enabled to cope up with the needs of users always wants to know location and events happened on the earth, which enables them to make spatial decisions. In this Chapter, we have discussed trends of geospatial technology which includes RS, GIS and GPS, that helped to show how development trends are meeting the needs of the public and users.

4.2 Remote Sensing Trends and Technology

Remote sensing technology plays a crucial role to monitor and study the natural resources and environmental conditions. A remarkable progress has been made in utilizing remote sensing data to study, monitor and model the earth's surface as well as sub surface. Improvements in sensor technology, especially in the spatial, spectral, radiometric and temporal resolution, have enabled. The trend of development of remote sensing is listed below.

1. Aerial Photographs through balloons, kites, and aircrafts
2. Panchromatic satellite images (PAN)
3. Multispectral Satellite images (MSS)
4. High Resolution data
5. Manual interpretation
6. Digital Image Processing (DIP)
7. Integration of satellite data with GIS

8. Integration with GPS data
9. Hyperspectral Images
10. Digital Photogrammetry (DP)

Below figure shows the Trends in Remote Sensing Technology from 1960-2010

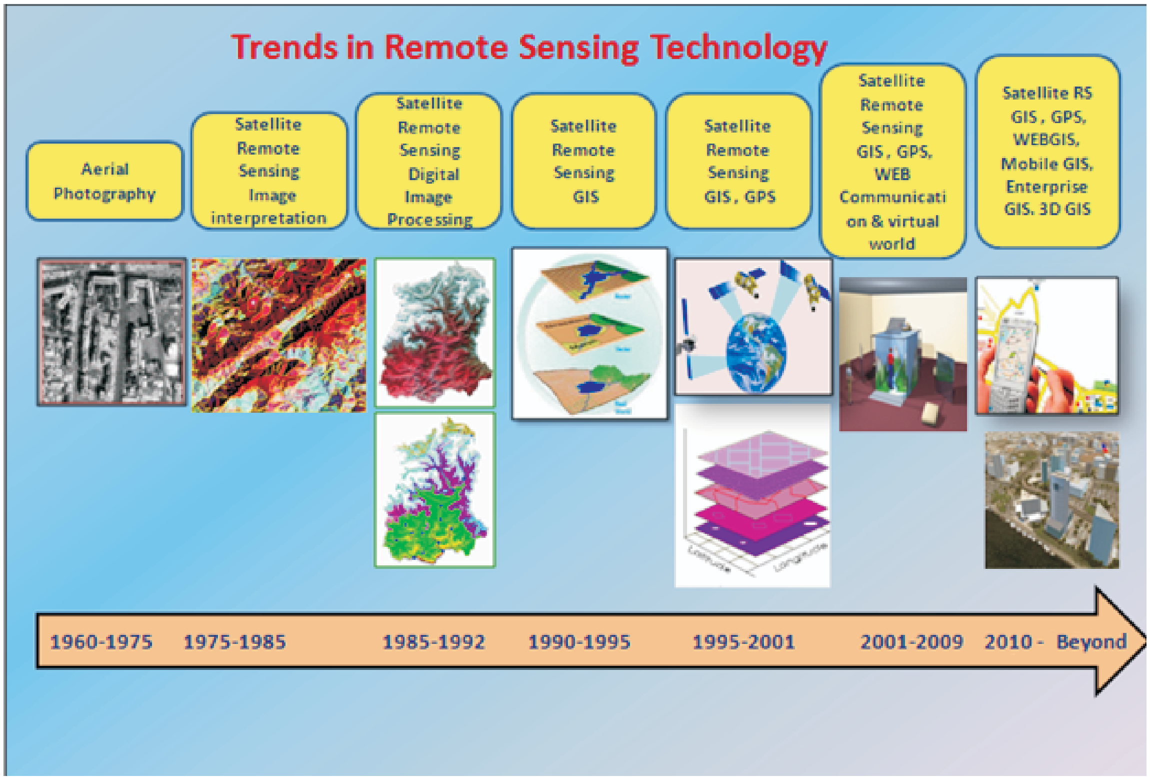


Fig. 126

Trends in Remote Sensing

1. Aerial Photographs

Photography was born in 1839. In early 1840 Argo, Director of the Paris Observatory advocated the use of photography for topographic surveying. The first aerial photograph was taken in 1858 by Parisian photographer. He used balloon to obtain the photograph in near Paris. Remote sensing technology started with photographs in the early nineteenth century. The photographic camera has served as a prime remote sensor for more than 150 years. It captures an image of earth from a balloon through a lens onto a recording medium.

Fig. 127

Photographs are captured by Balloons Courtesy: http://rst.gsfc.nasa.gov

Meanwhile, an alternate approach, mounting cameras on kites, became popular in the last two decades of the 19th Century.

Fig. 128

Photographs are captured by Kites Courtesy: http://rst.gsfc.nasa.gov

After the First World War, cameras mounted on airplanes, commonly handled by aviators, provided aerial views of fairly large surface areas that were valuable for military reconnaissance.

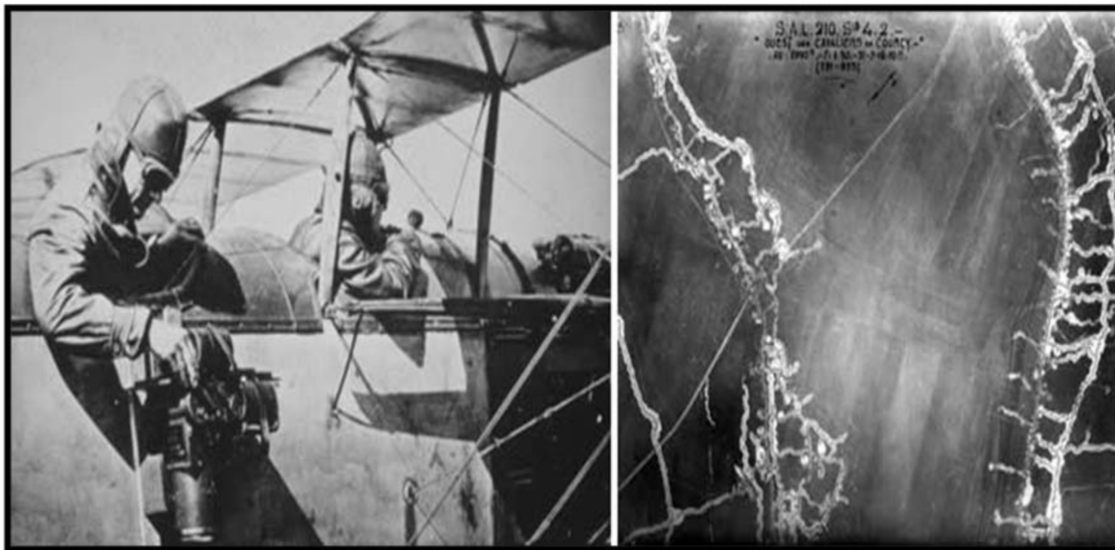


Fig. 129

Photographs are captured through Aircrafts by Handheld Camera
Courtesy: http://rst.gsfc.nasa.gov

The aerial photographs are used for pictorial representation of earth surface, mosaicing, photo interpretation and for photogrammetric survey.

2. Panchromatic Satellite Images

Remote sensing above the atmosphere originated at the starting of the Space Age. The first U.S. meteorological satellite, TIROS-1, was launched by an Atlas rocket into orbit on April 1, 1960. In 1960s the first sophisticated imaging sensors were incorporated in orbiting satellites. At first, these sensors were providing low resolution black and white pictures of clouds and Earth's surface as shown in figure. The advancement in technology has a capability to get the high resolution Pan Images such as Cartosat 2 (80 cm Resolution)

Fig. 130

Pan Image

3. Multispectral Remote Sensing

Multispectral remote sensing is defined as the collection of reflected, emitted, or backscattered energy from an object or area of interest (AOI) in multiple bands of the EMR. Multi-spectral imaging allows extraction of additional information that the human eye cannot to capture. Usually satellites have 3 (LISS-III) to 7 (LandSat) or more bands. Each band acquires one digital image in a small range of visible spectra called red-green-blue (RGB) region, Near Infrared (NIR), Middle Infrared (MIR) and Microwave

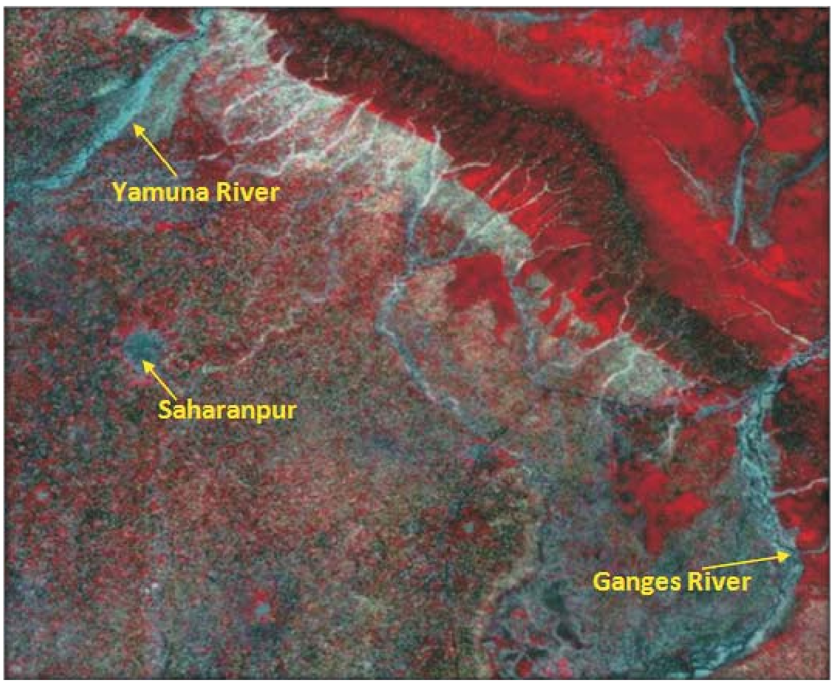


Fig. 131

MSS Image with three bands (RGB) - LISS III (Source: RRSC North)

Characteristics of MSS

- It has 4 or 7 bands
- It consists of broad Bandwidth from Visible to Microwave
- Ground sampling is easy
- Easy Display
- It is easy to do classification
- Availability of data is easy

4. High Resolution data

In the past remote sensing was providing low resolution data. As technology advancement took place space remote sensing has brought a new dimension to develop sensors which provides high resolution data to better understand the earth features .The examples for high resolution for different satellites are presented in below table.

Fig. 132

An example of High Resolution Data (Quckbird)

Sensor	Resolution
LISS III PAN	5.8 m
LISS IV	2.5 m
IKONOS	1 m
Cartosat-2	0.8 m
Quckbird	0.6 m
Geoeye	0.5 m

Table : 8

5. Manual interpretation

In initial stages of remote sensing the interpretation was made visually and manually. This interpretation was made based on knowledge, familiarity with area and personal interpretation skills. The interpreter examines the images based on the supporting materials such as maps, reports of field observation. The success in image interpretation varies with the experience of the interpreter or depends on the nature of the object, phenomenon, or quality of the image being utilized. The interpreter was using interpretation keys such as tone, texture, shape, size, shadow pattern, and association.

6. Digital Image processing

Digital Image processing involves the manipulation and interpretation of images with the help of computer. During 1985 it started with limited organization due to high cost of the computers. The computers were very costly and their performance was low. Today low cost efficient computer, hardware, software are available. Many organizations are implementing digital image processing techniques. By using computer algorithms image quality has been enhanced to increase the distinctions between the features to increase the amount of information that can be visually interpreted from the data. Various image processing technologies such as histogram stretching, contrast enhancement, spatial filtering and classifications are used

7. Integration of satellite data with GIS

The procedures are used to combine the image data of a same area with other geographical referenced data set. For example image data are combined with soil, ownership, zoning and, topographic information. The evolution of GIS integrated these satellite images for better understanding of spatial phenomenon and for need based analysis. GIS categories the satellite data with various thematic layers and makes the utilization of information effectively in vector format.

8. Integration with GPS data

The evolution of GPS system during 1995 added additional values in Geospatially technology which can accurately determine the location of any spatial feature. Due to GPS system the GIS analysis capabilities are enhanced.

9. Hyper Spectral Imagery

Hyperspectral sensor collects 200 or more bands of data which enables the construction of an effectively continuous reflectance spectrum of every pixel in the scene. This system can discriminate among each surface features that have absorption and reflection characteristic over a narrow wavelength intervals that are lost within the coarse bandwidth of various bands of the multispectral scanners. Hyper spectral imaging collects and processes information from visible as well as from the ultraviolet to infrared band. Hyper spectral images can be used for application in agriculture, mineralogy, physics, and surveillance. More details about hyperspectral imagery is discussed in Chapter-1

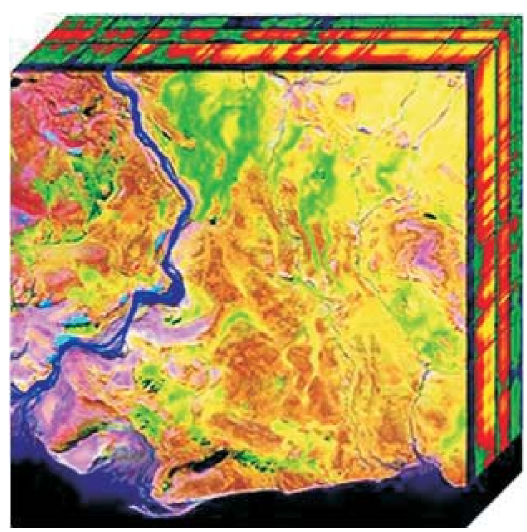


Fig. 133

Hyper Spectral Images with Multiple bands Source:rst.gsfc.nasa.gov

More than 200 bands are available so it is difficult to select the useful bands. Narrow Bandwidth reveals hidden ground character, which is not understood. Laboratory spectra of ground sampling is needed, Difficulty in display (Which 3 bands to choose for R G B),Hyperspectral data are difficult to classify because of High Processing time, more memory needed.

10. Digital Photogrammetry

Historically the most common use of Photogrammetry is hardcopy topographic map. Today Photogrammetry procedures are used to create GIS data products such as precise raster vector images and digital elevation models. Earlier the photographs are collected through analog camera and processed through hardcopy format. Now advanced technology is developed. In digital Photogrammetry the digital photographs are used. Modern technology provides direct digital images by digital camera or by satellite sensors. So the process of conversion from analog to digital is minimized. Digital Photographs are radiometrically more accurate than analog data, therefore the interpretation is simpler and accurate

Trends in Remote sensing Application

Earlier remote sensing data has been used only to create the topographic maps, but nowadays the data acquired by the remote sensing system are used in various applications. Some of the trends in application are listed and shown in below figure.

1. Topographic Mapping
2. Thematic map creation
3. Widening thematic resolution
4. Integration with GIS
5. Spatial Modeling
6. Decision Support system

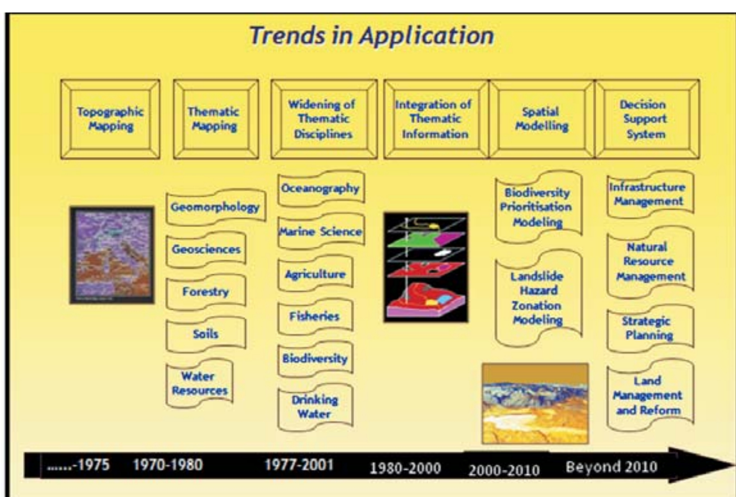


Fig. 134

Trends in Remote Sensing Application

Earlier the remote sensing data was used to create topographic maps. But due to the advancement in technology like digital image processing the remote sensing data is used to create the thematic maps for a limited area such as geomorphology, soil, forestry, geosciences water etc. The advancement in spatial, spectral and radiometric resolution in remote sensing data trend has developed to interpret more features and to create more number of thematic layers in wide area such as fishery, oceanography, agriculture, marine science, biodiversity etc. During 1980 when GIS emerged, integration of GIS and remote sensing data became possible. GIS is used more in spatial modeling to manage the natural disasters. Nowadays the GIS acts as spatial decision support system in many areas.

4.3 GIS Tends and Technology

GIS has developed from traditional map making technique. Modern GIS dramatically increase the amount of information that can be contained and manipulated in a map interactively. In the past it was very difficult to draw and interpret multiple information themes from a hardcopy map. Before computers became widely available, thematic maps on plastic Mylar (tracing) sheets was laid on top of each other to reveal more information about an area. The process was cumbersome and the amount of data received was limited. But this method looks like the output of contemporary GIS. A grid-based mapping program called SYMAP, developed at the Laboratory for Computer Graphics and Spatial Analysis at the Harvard Graduate School of Design in 1966, was widely distributed and served as a model for later systems. These early GIS packages were limited for specific applications and required the mainframe computing systems. Mainly these systems were used in government and universities. In the 1970s, private vendors began offering GIS packages. Currently Intergraph and Environmental Systems Research Institute (ESRI) are the leading vendors of GIS software. In the late 1990s, GIS is being adopted by many private and government organizations. The recent development of Web GIS provides distributed mapping and spatial analysis over the Internet. Some of the recent trends in GIS are listed below;

1. Web Based GIS
2. Enterprise GIS
3. Mobile GIS
4. 3D GIS visualization and flythrough
5. Open GIS

The development of Internet GIS is also called web GIS. It has played a major role in expanding the GIS usage and helping the users to access the geo information at low cost in client-server environment

1. Web based GIS

Web based GIS is the process of designing, implementing, generating and delivering maps on the *World Wide Web* (www) and its product. Below Figure shows an example of Web based GIS.

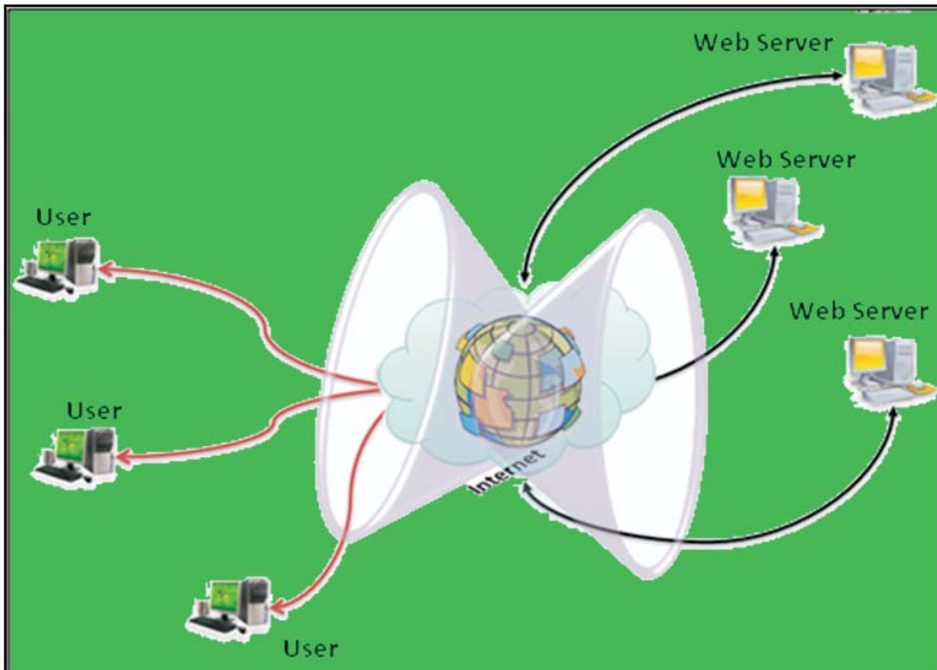


Fig. 135

Web Based GIS

In past an individual would have to buy an expensive software package to use and manipulate the data needed for GIS, the same is not correct today. With the use of Java based programming, and availability of software applications for web-based GIS, requires the user to buy some software, where as others require plug-ins to be added to web browsers. Web based GIS emphasis more on analysis, processing of project specific geo database and exploratory aspects. It is often used as a presentation media. Web GIS has the potential to Distribute Geographic Information (DGI) to a very large worldwide audience. Internet users will be able to access GIS applications from their browsers without purchasing proprietary of

GIS software. Web GIS makes it possible to use GIS as a wide range of network-based applications in different departments such as, town planning, government, transport and airport authority. Many of these applications will run on intranets within departments as a means of distributing and using geospatial data. Because of these advancements, many people who were not able to easily get information now they can easily access this information. Web-based GIS allows and controls the amount of information that can be transferred over the Internet and made available to the public. With web-based information distribution, it will not be misused by users. Analysis of data by a widely scattered group can also be accomplished in a faster, more efficient manner when the information is available almost everywhere in the world. Below figure shows general architecture of Web Based GIS.

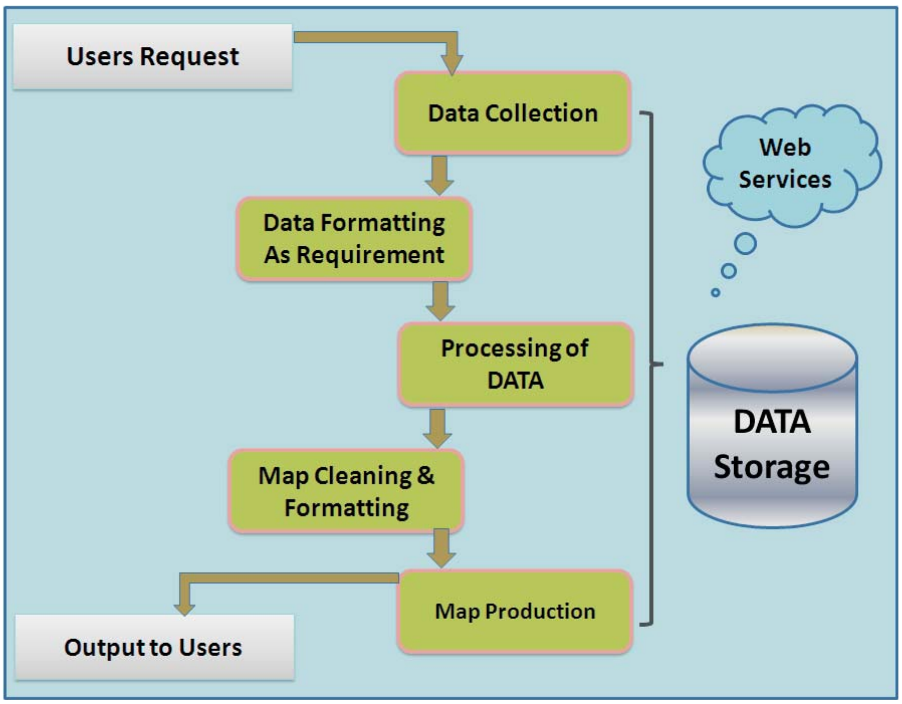


Fig. 136

Typical Web Based GIS Architecture

a) Advantages of Web Based GIS

- Web based GIS deliver latest and up–to-date information. For example a map displaying election results, as soon as the election results become available and a map displaying the real-time traffic situation using traffic data collected by sensor networks.
- Software and hardware infrastructure for web based GIS is cheap.
- Data and product updates are easier, cheaper, and faster.

- It allow for personalization by using user profiles, personal filters and personal styling and symbolization. Users can configure and design their own maps.
- It supports hyper-linking to other information on the web.
- It acts like an index to other information on the web. Any sensitive area in a map, a label text, etc. can provide hyperlinks to additional information. For example map showing public transport options can directly link to the corresponding section in the online train time table.
- It is easy to integrate multimedia in and with web maps. Today's web browsers also supports the playback of video, audio and animation

b) Disadvantages of Web maps

- Reliability issues - the reliability of the internet and web server infrastructure is not yet good enough. Especially if a web map relies on external, distributed data sources, the original author often cannot guarantee the availability of the information.
- Bandwidth issues – Web maps usually need a relatively high bandwidth.
- Limited screen space –web based GIS maps have the problem of limited screen space. This is in particular a problem for mobile web maps and location based services where maps have to be displayed in very small screens with resolutions as low as 100×100 pixels.
- Quality and accuracy issues – Many web maps are of poor quality, both in symbolization, content and data accuracy.
- Privacy issues – With detailed information available and the combination of distributed data sources, it is possible to find out and combine a lot of private and personal information of individual persons. Properties and estates of individuals are now accessible through high resolution aerial and satellite images throughout the world to anyone.

2. Enterprise GIS

An Enterprise GIS is a system that integrated through an entire organization so that a large number of users can manage, share, and use spatial data and related information to address a variety of problems, such as data creation, modification, visualization, analysis, and distribution. In recent years more and more organizations have started adopting GIS to manage spatial information in support of spatial decision making, which can improve the working efficiency and also reduces the enterprises operating costs. With GIS software capability, users are allowed for the integration of enterprises into other enterprises through a type of internet service. Enterprise can integrate the applications to the utmost flexibility with reusable cost in both internal and external aspects.

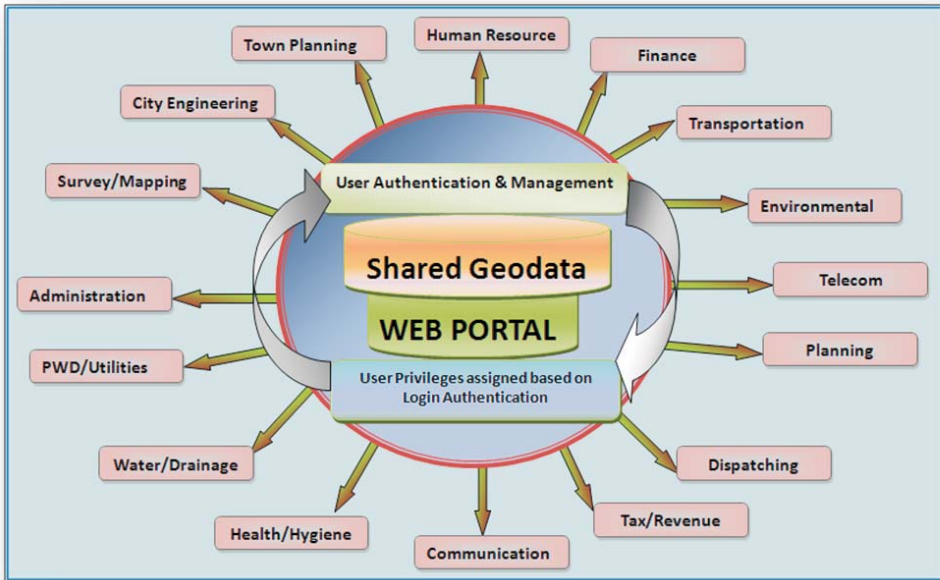


Fig. 137

Enterprise GIS System

a) An Enterprise GIS should be capable of:

(i) It supports large number of simultaneous transactions; many people can access information at the same time.

(ii) It Integrates with other Enterprise Systems (such as ERP, Billing Systems etc.)

(iii) It enables easier integration with other systems / software formats.

(iv) Maintains the uniform display pattern of the data like style, symbol, color etc. for Desktop, Web and Mobile users.

(v) It offers reusable functionality across Desktop, Web and Mobile platforms.

Above figure 137 shows Enterprise GIS system where geospatial data is shared by various departments such as Town planning, environmental, human resources, finance, transportation etc

3. Mobile GIS

Fig. 138

Mobile GIS System

Mobile GIS is the expansion of GIS technology from the office into the field. A mobile GIS enables field-based officer to capture, store, and update, manipulate, analyze, and display geographic information. Mobile GIS integrates one or more of the following technologies: Mobile devices, Global positioning system (GPS), Wireless communications for Internet GIS access. In past, the process of field data collection and editing were time consuming and tends to have more errors. The paper maps were used in field to mark the locations of ground. The sketches and the notes are drawn on paper to edit the field data. Once back in the office, these updates made in the field were checked and manually entered into the GIS database. Mobile GIS enables organizations to add real-time information to database and applications to create more accurate data and analyze spatial data.

a) Advantages of Mobile GIS

- Creates, edit, and uses GIS maps in the field.
- Creates and maintains an inventory of asset locations and attribute information.
- Updates asset location and condition and is used for schedule maintenance.
- It maintains digital records and locations of field assets for legal code compliance and ticketing.
- Documents the location and circumstances of incidents and events for further action or reporting.
- Performs measuring, buffering, geo processing and other GIS analysis during field survey.

4. 3D Visualization

A large number of human activities utilize 2D geo - data using paper or digital maps to complete various kinds of activities like creating mapping and analysis. In many cases the two dimensions maps are not sufficient because 2D maps may lose some of their properties and relations to other objects. 2D maps create difficulties to understand, analyze and evaluate the surrounding world for example urban city planning, landscape planning, road, railway, building construction, utility management. For such type of activities it requires three-dimensional and the 3D objects presentation. 2D objects only have length and width but 3D objects have an extra dimension called depth. In a 2D GIS, a feature is represented as an area of grid cells. But in case of 3D GIS, it deals with volumes and information about what includes inside the cube. 3D GIS and Flythrough applications need more advanced tools for representing and analyzing the 3D world. 3D GIS application is tool to model, store, analyze and visualize 3D data in an efficient and effective way in different areas. 3D GIS viewer allows users to experience the power and flexibility of desktop 3D GIS. There are already few

Fig. 139

3D Map created for Delhi Chandini Chowk Area
Source: Bhoop Singh

systems available in the market that can be categorized as systems providing 3D solutions i.e. Rolta Geomatica, ArcView 3D Analyst, (ESRI), Imagine VirtualGIS (ERDAS), and GeoMedia Terrain (Integraph Inc.). All the systems provide excellent tools for 3D visualization, animation and navigation through 3D textured models. Below figure shows the representation of spatial feature in 3D GIS in city / town Planning of Chandini Chowk Area. Delhi.

Fig. 140

3D Representation of Buildings

Source: Bhoop Singh

5. Open GIS

Open GIS is the full integration of geospatial data into mainstream information technology. It means that GIS users would be able to exchange data to a GIS software systems and networks without format conversion. Open GIS facilitate the exchange of information between individual GIS systems as well as other systems, such as statistical analysis, image processing, document management, or visualization. The Open GIS should have following fundamental requirements.

- Interoperable application environment – a user environment that is configurable to utilize the specific tools and data necessary to solve a problem.
- Shared data space – a generic data model supporting a variety of analytical and cartographic applications.
- Heterogeneous resource browser – a method for exploring and accessing the information and analytical resources available on a network.

The Open Geospatial Consortium (OGC), an international voluntary consensus standards organization, originated in 1994. In the OGC, more than 400 commercial, governmental, nonprofit and research organizations worldwide collaborate in a consensus process encouraging development and implementation of open standards for geospatial content and services, GIS data processing and data sharing.

4.4 GPS Trends and Technology

Since the beginning of time people used to navigate by means of different landmarks such as mountains, trees and traveling across the ocean they used to follow the coastal line. Later they used position of stars and moon for navigation and compass was used to find the direction. Later they discovered radio based navigation systems which were used in world war–II. As the technology advancement took place the satellite based navigation system was introduced which is commonly known as GPS. Now GPS can be used for personal positioning, national defense, commercial and scientific purpose. Nowadays GPS enabled cell phones are used for navigation. India is also planned to launch a GPS satellite system named as Gagan in near future

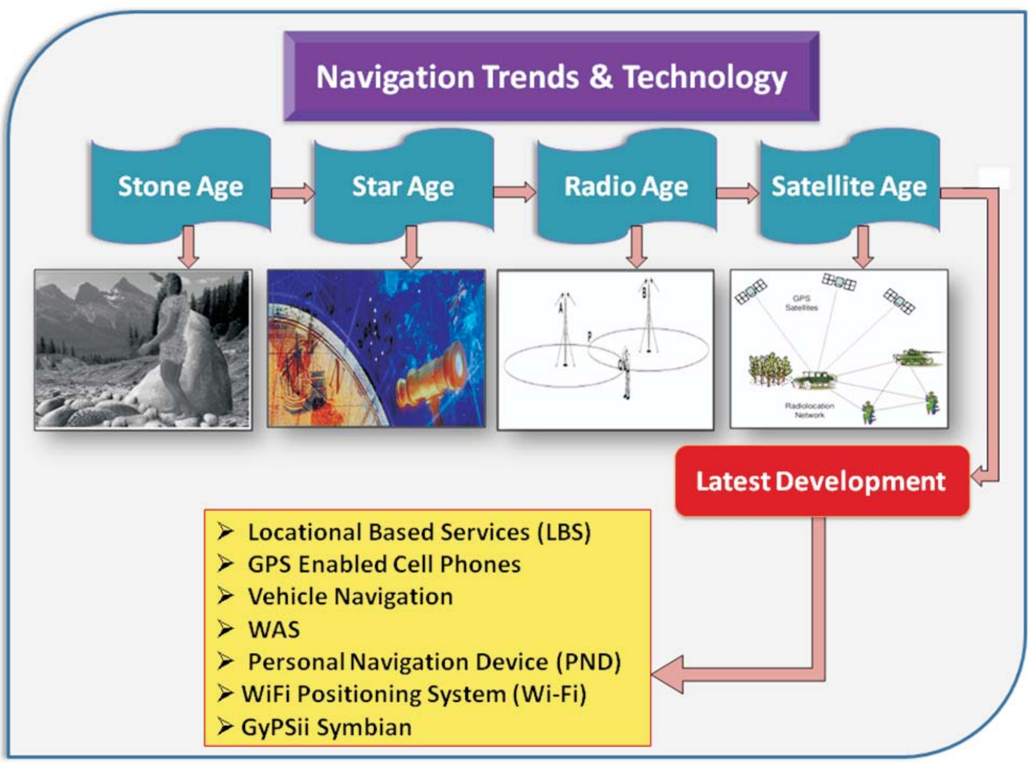


Fig. 141

Trends in GPS Technology

The benefit of having GPS in the cell phone is that anything can be tagged with geographical location with the accuracy of 10 meters. Presently the Locational Based Services (LBS) are used for locating specific information such as restaurant, ATM's, hospitals, traffic conditions and weather information. This mobile content is obtained using GPS which utilizes a constellation of satellite in Earth's orbit that transmit precise microwave signals enabling a GPS receiver in a mobile device to determine its location, speed, direction and time. LBS consist of five basic components such as mobile device, positioning, communication network, service provider and content provider. These all components interact in the processing chain of service request sent by the user. If user had a GPS enable cell phone it is capable of establishing location. When user seeks emergency services (communication network) from the location (positioning), the agent provide voice telephony service (service provider) which directs the request to a database (content provider) containing the emergency services information for the location. It is then returned to the cell phone along with the corresponding navigation instructions. There are several digital map information providers such as Navteq, Teleatlas, Tom-Tom for providing the data for automated navigation system, mobile navigation devices and internet based mapping application, government and business solutions. The Google has launched MyLocation which uses information which is broadcasted by cell towers to find the location of Mobile device using the triangulation method. SiRF a manufacturer of GPS chip cells has licensed skyhook's WPS (Wi-Fi positioning system) which is a single position system by Wi-Fi network for wireless carrier that includes GPS and Wi-Fi technology. For social networking and mobile gaming GyPSii symbian which is geo location and social networking platform that provides location based news and services. The universal address system developed & introduced by NAC Geographic product inc. which represents the entire earth, using latitude, longitude and altitude information of any given place. An eight character universal address can uniquely specify every building in the world and a 10 character universal address can uniquely specify any square meter. Recent technology such as Personal Navigation devices (PND) has been developed and used in the cars, pedestrian navigation and outdoors. It offers advanced features such as MapMyIndia Navigator and SatGuide. Currently brands like Airtel, Google, MapMyIndia, Nokia and Yahoo provides navigational maps for Indian cities. With the MapMyIndia navigator people will have more knowledge and safety on the roads. It also allows for seamless turn by turn navigation from any point to any point in the country. According to the new technical market research report from BCC the vehicle navigation, surveying and mapping machine are using GPS technology. Wide Area Augmentation (WAS) systems or hybrid systems like wireless assisted GPS (WA-GPS) which will be used in the future.

Let us wrap up what we covered in this chapter

- The fundamental goal of Geospatial Technology is to provide up - to date information, at lowest cost and highest quality.
- Remote sensing technology plays a crucial role in monitoring and studies the natural environmental conditions.
- A remarkable progress has been made in utilizing remote sensing data to study monitor and model the earth surface
- The trend of development of remote sensing is from Aerial, Panchromatic, multispectral, High resolution data, Manual interpretation, Digital image processing, Integration of RS data in GIS & GPS, Hyperspectral images and Digital Photogrammetry.
- Multispectral remote sensing uses multiple bands of EMR which allow the extraction of additional information that the human eye fails to capture.
- In MSS each band acquires one digital image. It has broad bandwidth; it includes three or more bands depending on the satellites. such as visible, NIR, MIR & microwave
- MSS images have capabilities of easy ground sampling, display, classification and availability of data.
- In initial stage image interpretation was made using visual interpretation keys. Later various image processing algorithms are developed to carried out digital image processing
- Integration of satellite data with GIS and GPS leads better understanding of spatial phenomenon and need based analysis to use as decision support system
- Hyperspectral sensor collects information as set of images. Each image represents a range of EMS and known as spectral band. These images are combined to form of 3 dimensional hyperspectral cubes for further processing and analysis.
- Hyperspectral images are acquired at entire spectrum so it does not require prior knowledge of sample data. Post processing allows all available information from the database to be used
- Hyperspectral sensors allow preparing more accurate models and classification of the images.
- Earlier the photographs were taken through analog camera, but nowadays the technology with improved digital camera and fine resolution are used
- Digital photographs are more accurate than analog photograph which enables simple and accurate interpretation

- The trends in application of remote sensing started with topographic mapping, later the trend has come to prepare thematic mapping for limited areas. Further it widened preparation of thematic maps for more areas. As the advancement in GIS technology has developed as a tool to integrate RS data to prepare various spatial modeling to understand and mapping landslide, hazard, zonation, modeling. Recently GIS is used as a decision support system.
- The World-Wide-Web (WWW) is a useful tool for the gathering, displaying visualization, and manipulation of data over the internet.
- Web GIS has the potential to Distribute Geographic Information (DGI) to a very large worldwide audience. Web-based GIS allows and controls the amount of information that can be transferred over the Internet and made available to the public.
- Software and hardware infrastructure for web based GIS is cheap.
- An Enterprise GIS is a geographic information system that is integrated through an entire organization so that a large number of users can manage, share, and use spatial data and related information to address a variety of problems, such as data creation, modification, visualization, analysis, and dissemination.
- Mobile GIS is the expansion of GIS technology from the office into the field. A mobile GIS enables field-based officer to capture, store, and update, manipulate, analyze, and display geographic information.
- A large number of human activities utilize 2D geo-data using paper or digital maps to complete various kinds of activities like create mapping and analysis.
- 2D objects only have length and width but 3D objects have an extra dimension called depth.
- Open GIS refers to exchange data to GIS software systems, network without format conversion
- Open GIS facilitates to exchange information between individual GIS and other systems such as statistical analysis, image process, document management and visualization.
- In past people used to navigate using different landmarks such as mountain, tree, stars, compass. As the technology advancement took place the radio based and satellite based navigation system was introduced.
- Currently GPS enabled cell phones are used for navigation. The benefit of having GPS in the cell phone is anything can be tagged with geospatial location with accuracy of 10 meters.

- The LBS are used to get location specific information such as Restaurant, ATMs, Hospital, Traffic Condition and Weather information
- Navteq one of the leading providers of comprehensive digital map information for automated navigation, Mobile navigation devices, and internet based mapping application
- Airtel, Google, MapMyIndia, Nokia, and yahoo provide navigational maps of India.
- With MapMyIndia navigator people will have more knowledge and safety on the road. It also allows by seamless turn by turn navigation at point to any point in the country.

Review

Very Short Questions

1. List down the recent trends in RS
2. Multispectral image can allow extraction of additional information that the human eye fails to capture. True or false?
3. Hyperspectral remote sensing uses broad bandwidth from visible to microwave true or false?
4. What is EMR rage for Multispectral Image, and hyperspectral Image?
5. Why hyperspectral images do not require prior knowledge of sample data?
6. Why hyperspectral imaging helps in preparing more accurate models and classification of the image?
7. Define digital Photogrammetry
8. List down the recent trends in GIS
9. Define the term Web Based GIS.
10. Web-based GIS allows and controls the amount of information that can be transferred over the Internet and made available to the public. True or False?
11. Software & hardware infrastructure for web based GIS is cheap. True or False?
12. A mobile GIS enables field-based officer to capture, store, and update, manipulate, analyze, and display geographic information. True or False?
13. Open GIS is the full integration of geospatial data into mainstream information technology. True or False?
14. List the systems available in the market that can provide 3D solution.
15. What are LBS? Where it is used?
16. What do you mean my location? What is its role?
17. By using GIS anything can tagged with geographical locations with accuracy of 10 matters. True or False?

Short Questions

1. What is the fundamental goal of Geospatial Technology? Give example .
2. What are the characteristics of MSS?
3. Explain hyperspectral Image.
4. Difference between multispectral and hyperspectral imageries.
5. What are the disadvantages of hyperspectral Imageries?
6. What is difference between low and high resolution explains with example?
7. Why RS data is integrated with GIS and GPS?
8. Define digital Photogrammetry.
9. What is the deference between analog and digital photographs?
10. Define the functionality of Web Based GIS.
11. What are the advantages and disadvantages of Web Based GIS?
12. What are the capabilities of Enterprise GIS?
13. What is the difference between Web GIS and Enterprise GIS?
14. Why 3D GIS is used?
15. What are the advantages of 3D GIS?
16. What are the roles of OGC?
17. Explain the components of LBS, How it works?
18. Define MapMyIndia Navigation System.

Long Questions

1. Explain the trends of Remote sensing in data acquisition and application
2. Define the following
    a. Web GIS
    b. Enterprise GIS,
    c. Mobile GIS
    d. Open GIS
3. Explain the trends in GPS.
4. Health officer would like to collect data on diseases. What type of GIS technology would be used to capture store and manipulate the data. How he would provide real time information to create more accurate data.

CHAPTER 5

Application of Geospatial Technology (GT)

Learning Objectives

By the end of this chapter students can understand some of the case studies related to:

- 5.1 Introduction about application of Geospitial Technology (GT)
- 5.2 Watershed studies
- 5.3 Flood studies
- 5.4 Health Issues
- 5.5 Utility studies
- 5.6 Security and Defense studies
- 5.7 Urban and infrastructure development studies
- 5.8 Disaster Relief / management

5.1 Introduction

Geospatial Technology is commonly known as geomatics. The technology is used for visualization, measurement, and analysis of features or phenomena that occur on the earth. Geospatial technology is used in various organizations such as civilian, business, government and military.

The advancement of these technologies helps in effective management of natural resources. These Technologies helps in many applications like soil, geomorphology, hydrogeology, land use, agriculture, land records, urban, infrastructure development, water resources, watershed management, disaster management, health, education, security and defense etc . In this chapter we are discussing some of the case studies are discussed below

> Geospatial is a term widely used to describe the combination of spatial software and analytical methods with geographic datasets.

5.2 Watershed Studies

Watershed management is an integration of technologies within the natural boundaries of a drainage area for optimal development of land, water and plant resources to meet the basic needs of people in sustainable manner. Watershed management refers to balanced utilization of land water resources for best possible production with minimum risk to natural resources. Due to increased demand on water resources and its utilization the management is essential.

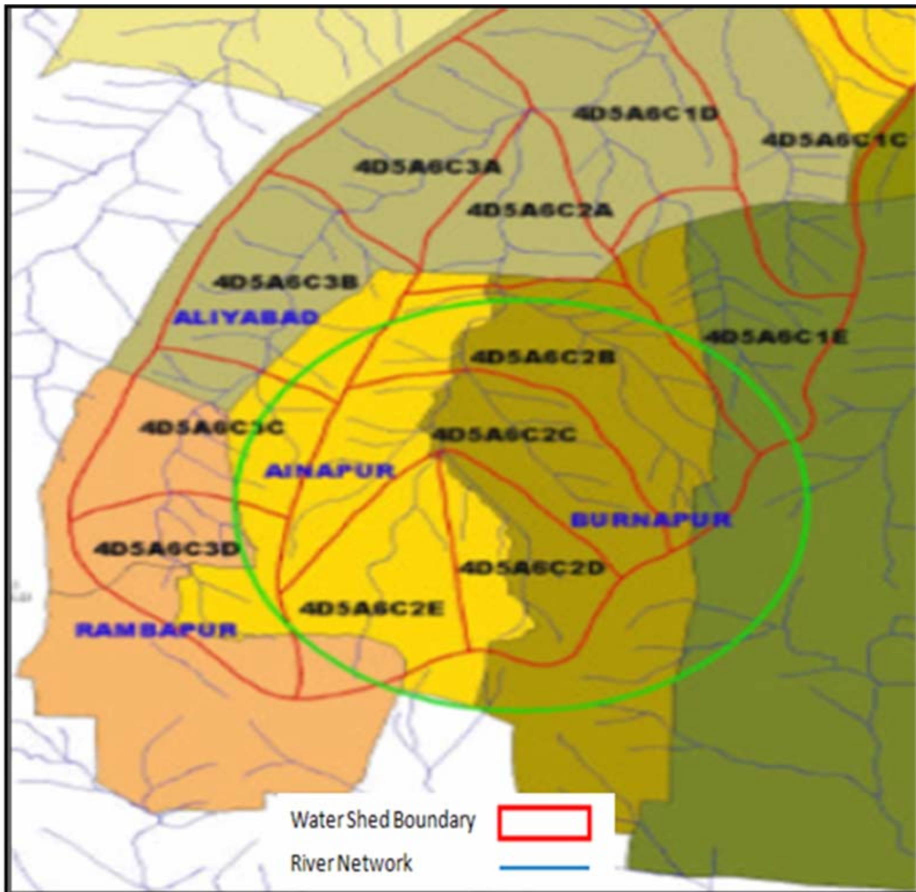


Fig. 142

Doddahalla watershed and village Boundaries

Keeping this in view the study entitled "GIS-based technologies for watershed Management" by Mr. A. K. Gosain & Ms. Sandhya Rao (Current Science, Vol. 87, No. 7, 10 October 2004). This study demonstrates the use of GIS-based modeling framework for local-level planning, incorporating the sustainability aspects of watershed development. The study has been conducted in Bijapur district, Karnataka to demonstrate the implementation and use of Geospatial technology for watershed prioritization. This study has been developed on the Doddahalla watershed, wherein micro-watershed prioritization has been carried out using hydrological, demographic and socio-economic parameters. The Doddahalla watershed in Bijapur district, northern Karnataka, with an area of about 61,000 hectare has been modeled. This is a chronically drought-prone district with a large agrarian population predominantly depending on rain fed agriculture. Upstream watershed with an area of 31,000 hectare is being treated and the remaining 30,000 hectare area belonging to the downstream watershed has been used for detailed analysis in the present study. This part of the watershed covers 30 villages of Indi and Bijapur taluks.Watershed prioritization is an important aspect of planning for implementation of the watershed management program. Implementation of the hydrological model estimates of water and sediment yield at the micro-watershed level which is being used in the planning process. The spatial tool helps in estimating the related parameters such as water spread area and available water storage capacity at that location. This application is also useful to help the watershed managers in prioritizing the watersheds with respect to the predetermined norms. The application was also be used for monitoring and evaluation of the watershed programs.

5.3 Flood Studies

Floods are the most recurring, widespread, disastrous and frequent natural hazards of the world. India is one of the worst flood-affected countries. In India about 40 million hectares of geographical area falls under flood-prone. The plains of north Bihar are some of the most flood prone areas in India. Flood Hazard Mapping is a vital component for appropriate land use planning in flood-prone areas. It creates easily-read, rapidly-accessible charts and maps which facilitates the administrators and planners to identify areas of risk and prioritize their mitigation/ response efforts.

Fig. 143

Effects of Kosi River (Bihar) Flood in 2008

- Over 2.5 million people affected
- Over a million rendered homeless
- Approx. 80 deceased
- Loss of 4000 acres of fertile land
- Railway tracks submerged
- Electricity disrupted
- Roads damaged
- Loss of cattle

The study entitled “GIS in Flood Hazard Mapping of Kosi River Basin, India” by G.Venkata Bapalu & Rajiv Sinha, GISdevelopment.net This Case study presents an efficient methodology to accurate delineate the flood-hazard areas in the Kosi River Basin, North Bihar, using Remote sensing GIS technology. One of the multi-criteria decision-making techniques, Analytical Hierarchical Process (AHP) were used to assess and integrating the impact of various factors. The study presents novel methodology for computing a composite index of flood hazard, derived from various factors such as topographical, land cover, geomorphic and population related data. All data are finally integrated in a GIS environment to prepare a final Flood Hazard map. This flood hazard index computed from AHP method for all flood prone area. It has also considered of various factors that are inherently related to flood emergency management. Below figures shows the overview of the methodology and flood hazard map of the study area.

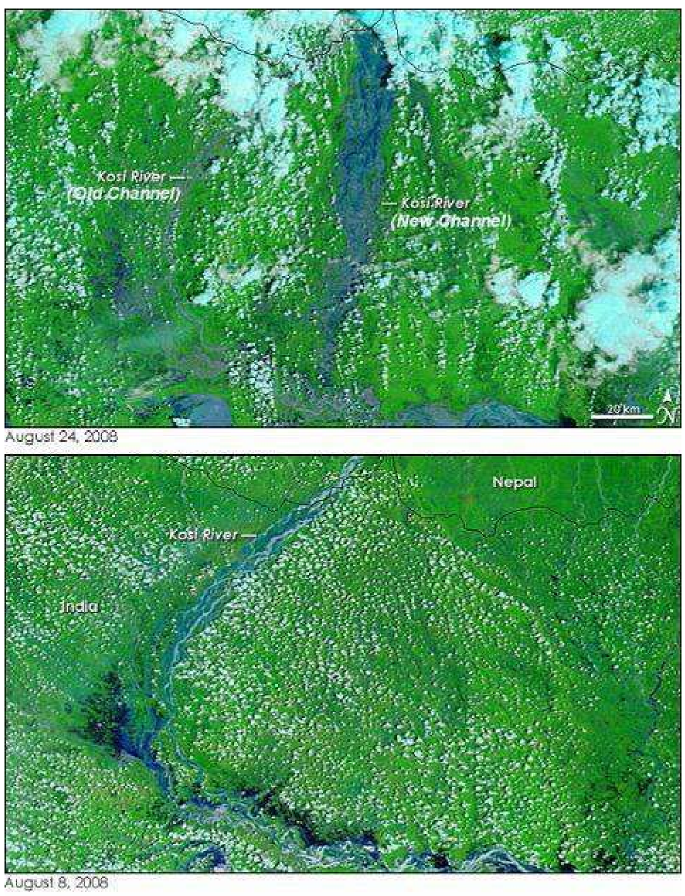


Fig. 144

Significant portion of the Kosi (75%) is flowing through embankment. Around 25% flowing through in the main channel. The Current flow of the river after the embankment breach is following the old course of 1926 Source: Dr. S.K Srivastav, ISRO

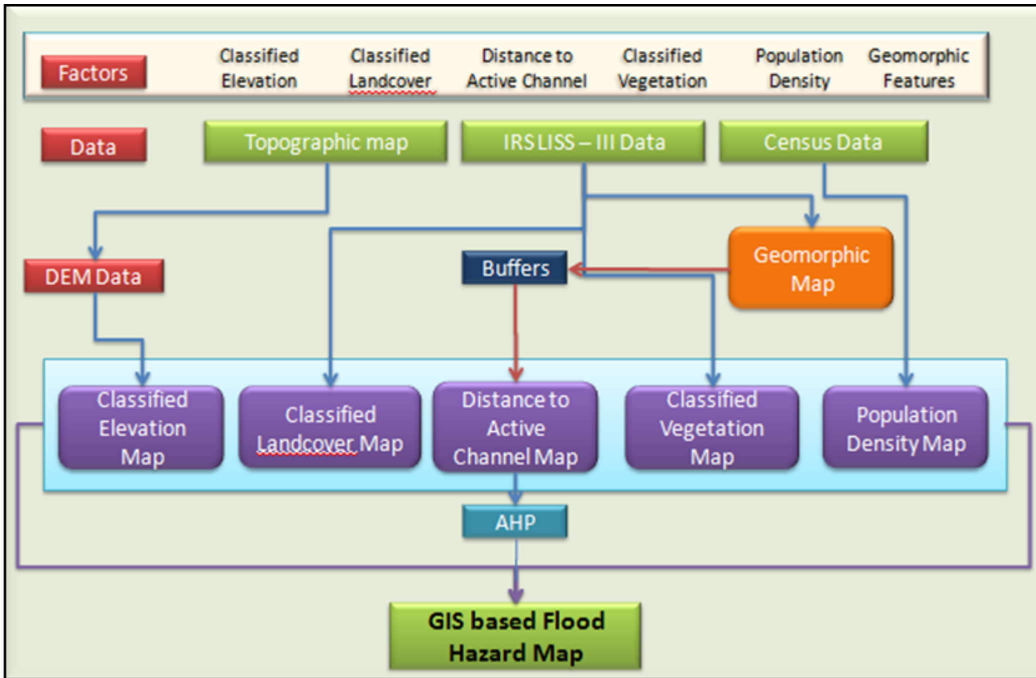


Fig. 145

Methodology followed by the Flood Hazard Mapping

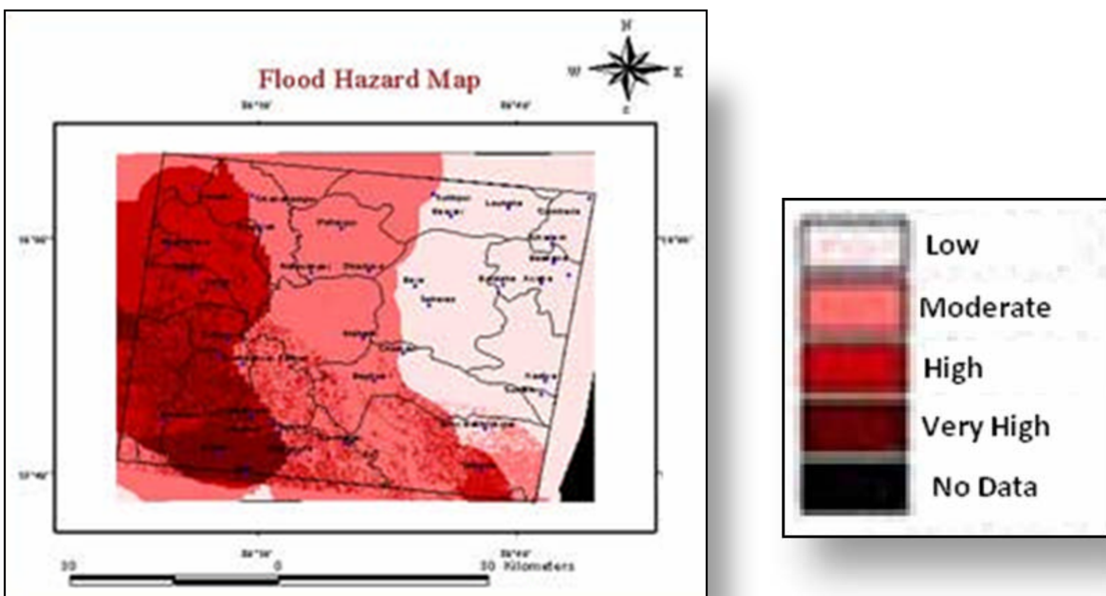


Fig. 146

Flood Hazard Map of Kosi River Basin

The study represents some exploratory steps towards developing a new methodology which is inexpensive and easily accessible charts and maps of flood hazard based on morphological, topographical, demographical related data? The study has also focused on the identification of factors controlling flood hazard in the study area to reduce short term and long-term damages. The basic merit of this methodology is its simplicity and low cost.

5.4 Health issues

Dengue fever (DF) associated with dengue hemorrhagic fever/dengue shock syndrome DHF/ DSS) has emerged as an important public health problem in the countries of the South-East Asia and Western Pacific regions. In India dengue fever has been known since the 19th century and epidemics have been reported from almost all part of the country. The study entitled “Application of GIS in Modeling of Dengue Risk Based on Socio-cultural Data: Case of Jalore, Rajasthan, India” by Alpana Bohra & Haja Andrianasolo, (Dengue Bulletin – Vol 25, 2001).

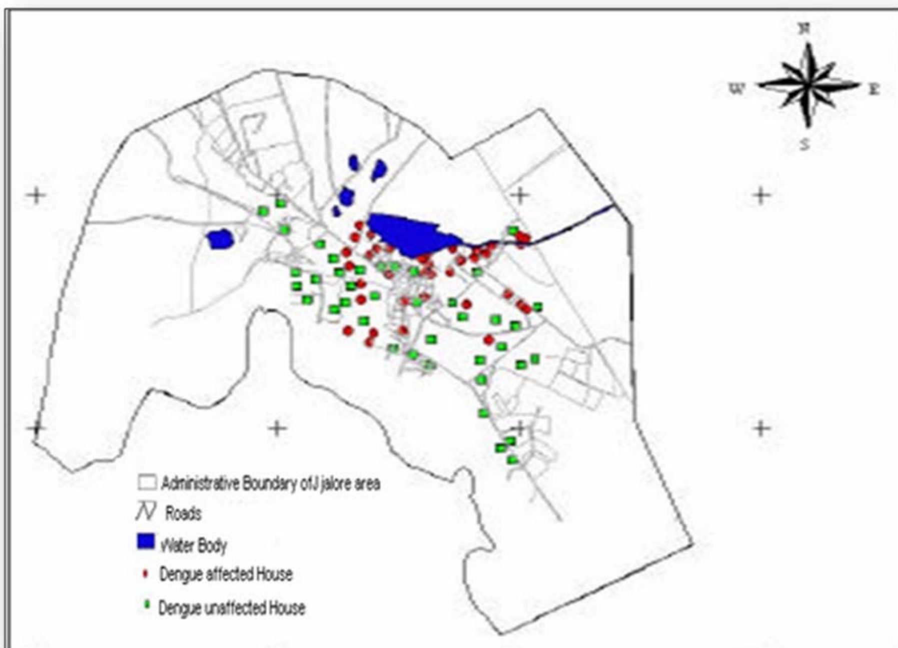


Fig. 147

Spatial location of dengue affected and unaffected houses in Jalore

The data collected through personal interviews from both dengue –affected samples (DAS) and unaffected samples (UAS). Findings indicated that out of sixty socioeconomic and socio-cultural variables, only sixteen were co-related significantly with Dengue. These sixteen variables were used in the stepwise regression model; only eight variables, namely, frequency of days of cleaning of water storage containers, housing pattern, use of evaporation cooler, frequency of cleaning of evaporation cooler, protection of water storage containers, mosquito protection measures, frequency of water supply and waste disposal made a significant contribution to the incidences of DF/DHF/DSS. The geographical information system (GIS) has been used to link the spatial and significant socio-cultural indicators with the disease data. Using factorial discriminate analysis and spatial modeling with these eight socio-cultural indicators, five classes of risk categories ranging from “very low” to “very high” were identified based on the analysis of socio-cultural practices adopted by DAS and UAS and from the application of GIS. Below figure shows the affected and non- affected household and Dengue risk levels associated with social and cultural parameters in Jalore

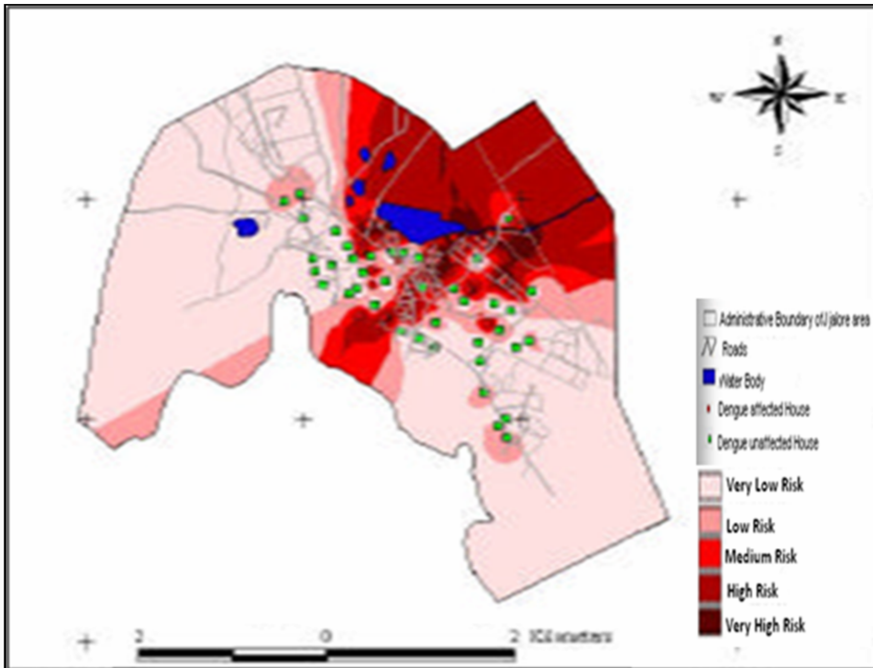


Fig. 148

Dengue risk levels associated with social and cultural parameters in Jalore

5.5 Utility Studies

Utility departments are responsible for maintaining, updating & storage of land base map and Electric network for operations area. For effectively carrying out the maintenance and updating related drawings the various sections carrying out different activities such as preparing layout plan, route plan, substation details, extension sketch, service cards, validation schemes. Utility departments follow the manual drafting method which is time consuming and Inherent human errors. These Paper based drawings have a limitation of providing details for small area. Paper based drawings are perishable and deteriorate over a period of time. It requires continuous re-work to maintain data legibility & condition. At the same time data sharing is difficult. It requires laborious methods like tracing etc for data sharing. Data storage and retrieval is cumbersome & are prone to deterioration. Due to the manual drafting method other works are pending because it takes time. Editing of paper maps are cumbersome & lengthy process. Remote sensing and GIS helps in atomization of these activities. GIS helps to convert the paper maps into digital maps. Remote sensing helps to updating the land and electrical database. GIS integrated with utility department helps to Measure the Cable length Locate Block, Pole, Transformer, location of distribution substation etc as shown in below figure. This type of study was implemented and entitled "Digitization & Automation of Drawings for Facility Management" at Mumbai, Maharashtra by Brihan Mumbai Electric Supply & Transport Undertaking (BEST, 2010-2011). Study involves automate the Drawing & Planning Department activities.

Fig. 149

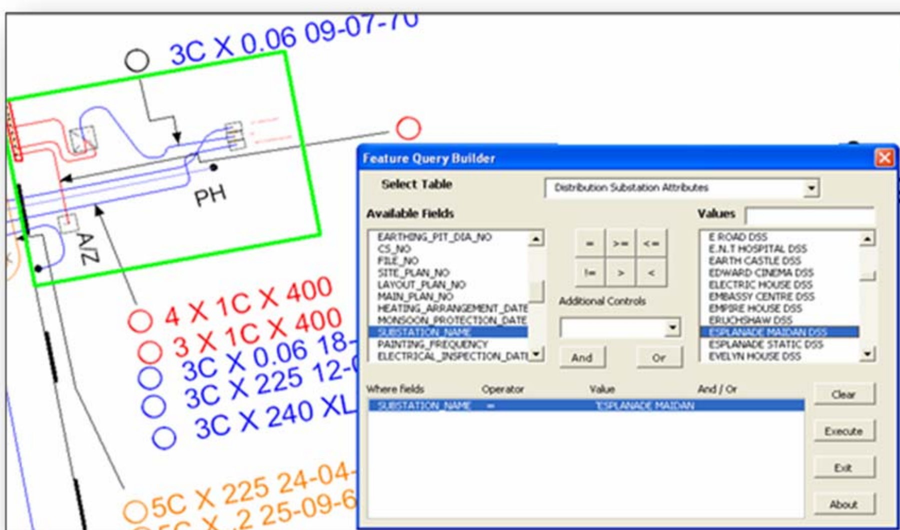


Fig. 150

GIS helps in identifying the location of Distribution Substation

Use of GIS & RS in Utility projects is very significant. It offers tangible and intangible benefits. Some of the benefits are listed below

- Significant improvement in time.
- Laborious task of edge matching of drawings are eliminated, Re-work for various drawing office activities are eliminated
- Enhanced outputs & Prints
- Easy updating of various drawings
- Process of generation blue prints & coloring of blue prints is eliminated
- Tangible Benefits includes, productivity enhancements, capability developments, quick response to unanticipated events or emergencies, possibility to interface with ERP & other business systems in the organization
- Some of Intangibles benefits are revenue generation through improved productivity and less operating costs.

5.6 Security and Defense Studies

Geospatial technology uses latest computer technology to assist the police in responding faster to distress calls with greater accuracy. It would improve the quality of services to the public. Using this new technology Police force will now able to quickly identify the location of a fixed line Dial 100 distress call within seconds on a map of area. The study entitled "Dial 100/103 Distress Call Management with GIS/GPS based Vehicle Tracking & Dispatch" is operational in Maharashtra. The system records related information of any emergency event. While the distress call details are being registered, operators can quickly locate the nearest police patrol vehicle to the reported site of crime/ incident with help of GPS and GIS. This would help

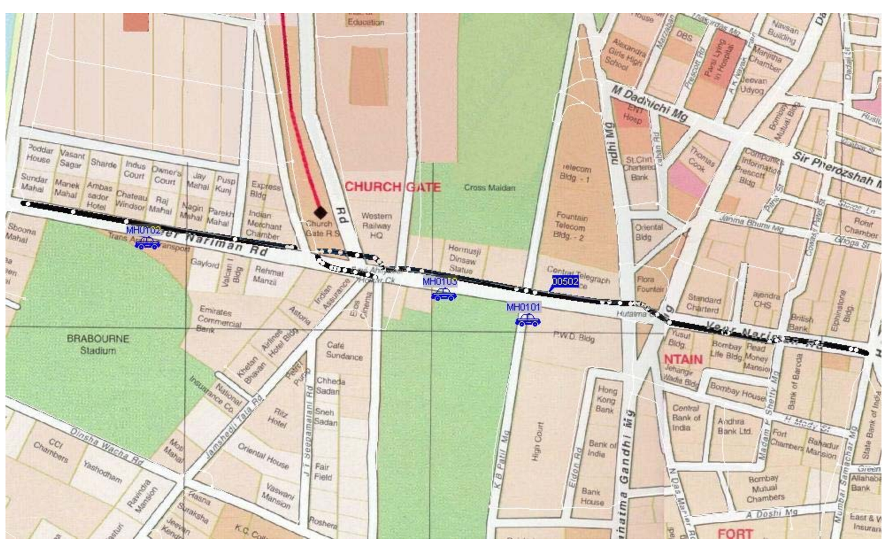


Fig. 151

Finding the location of nearby police vehicle by GIS Maps

the control room officials to immediately alert the patrol teams on field. This high-end technology improves its reaction time to any emergency incident and betters services to the common public. With the introduction of this system, the Call taker will have immediate access to address and map data, allowing them to accurately verify the incident location. Once the Call taker has accepted the incident, an icon is placed on the map view which represents location of the incident. The incident details are recorded in the central database and the information automatically forwarded it to the Dispatcher for action. The map view provides a real-time display of the location of the police vehicles (AVL) and the location. GPS unit is installed in each police vehicle so the location of the vehicle is available in the digital map as shown in above figure. Therefore Dispatcher can quickly assign a police vehicle to attend an incident using all the information collected by the Call taker. All decisions made by the Dispatcher are also time-stamped and recorded in the central database to confirm the response to distressed call. Similar types of studies are operational in Chandigarh, Punjab, and in Rajasthan police. By implementing this system the police force can provide Quick response to Public Distress Calls. Earlier to this system there was no real time tracking for nearby patrolling vehicle. So the quick response was not possible. It was slow. Police force also struggling a lot to collect the information about the distressed call. By enabling this system the resource management in police department is improved. Police could do the effective crime analysis of certain area. Traffic planning is improved. Multi Emergency & Security agency support such as Police, Fire, Medical, and Municipal can be achieved. Below figure shows the work flow of dispatch call tracking.

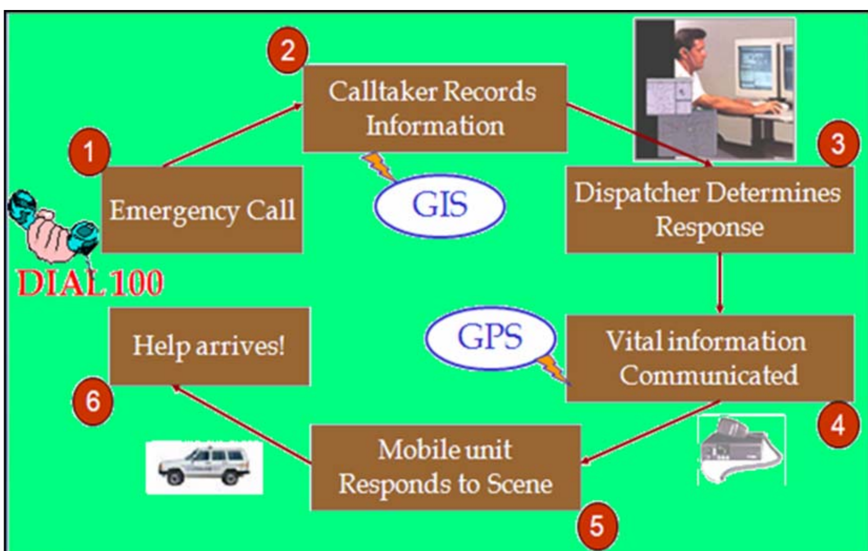


Fig. 152

Dispatch call tracking Work Flow

5.7 Urban and Infrastructure Studies

The urban development authorities need the automation of the day-to-day functioning requirements of the civic body. Remote sensing and GIS is required for the effective working of the Municipalities and facilitating the local public with the best of their services. These technologies help for efficient, economical and meaningful municipal administration, including the tax administration (house tax, water tax, sewerage tax etc.) Satellite data helps in creating large scale maps using ground truthing and attribute data collection of property and utility taxes. GIS based urban planning system can be Implementation both desktop and Web based platform. This study entitled "Urban Planning for Municipalities /Urban Development" is functioning in Nasik Municipal Corporation. Similar type of projects also implemented in Town & Country Planning Dept., Haryana State & Authorities Using such system municipalities are have access to large scale maps with latest information, GIS / MIS tools help in day- to-day administration and maintenance. System provides the customized tools for Assets inventory for best possible resources. System increases revenue of the department. GIS tools also helps in visualization for future growth in different areas such as road network, water supply, public health, sanitation, and solid waste management, slum improvement and up-gradation, public amenities including ,parks, gardens, and playgrounds, street lighting, parking lots.

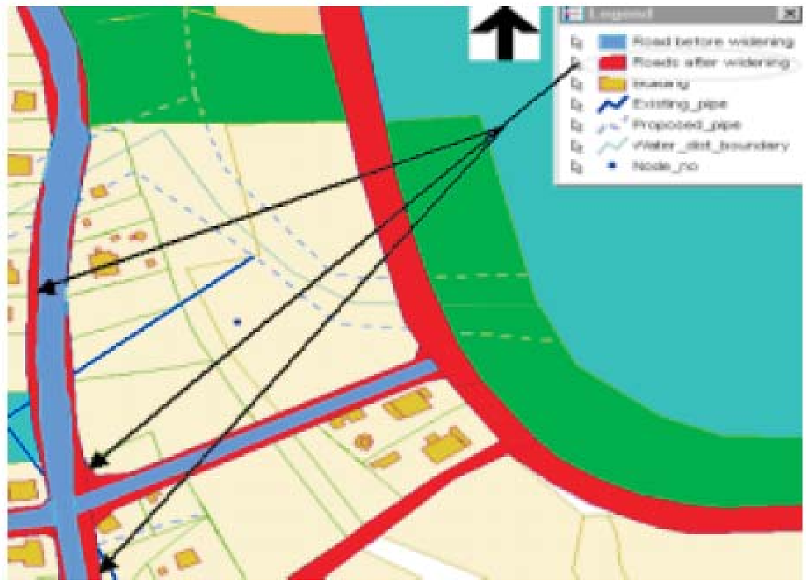


Fig. 153

Urban and Infrastructure Planning thru GIS

5.8 Disaster Relief / management

Satellites help to identify disaster prone areas like droughts, floods and landslides. Satellite communications can be used for early warning of people at risk, when other communication network fails. Satellite images may be used to assess damage resulting from earthquake, landslides, floods, oil spill and other disaster.

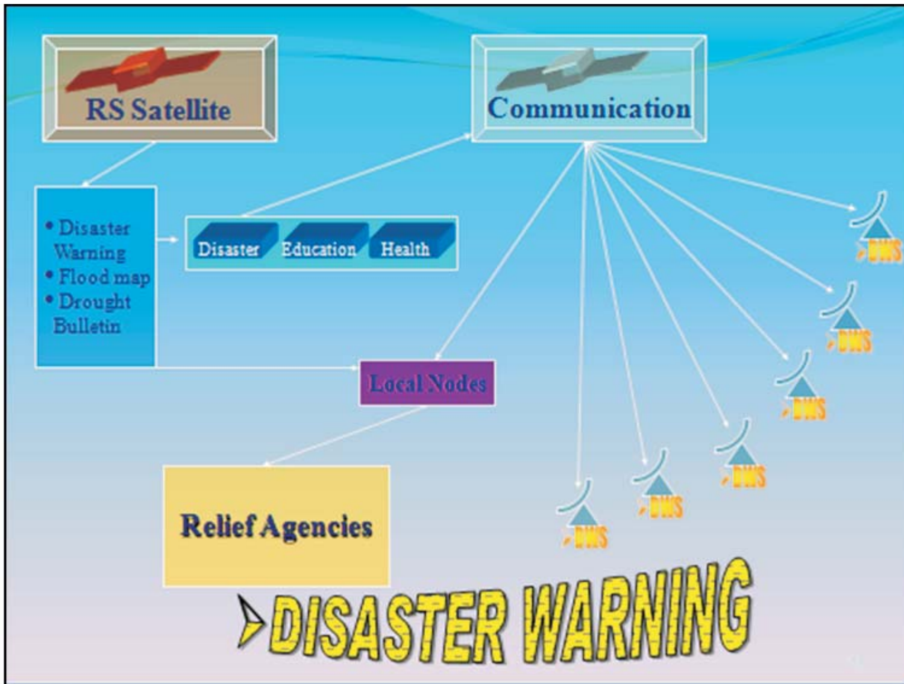


Fig. 154

Role of Geospatial Technology in disaster management

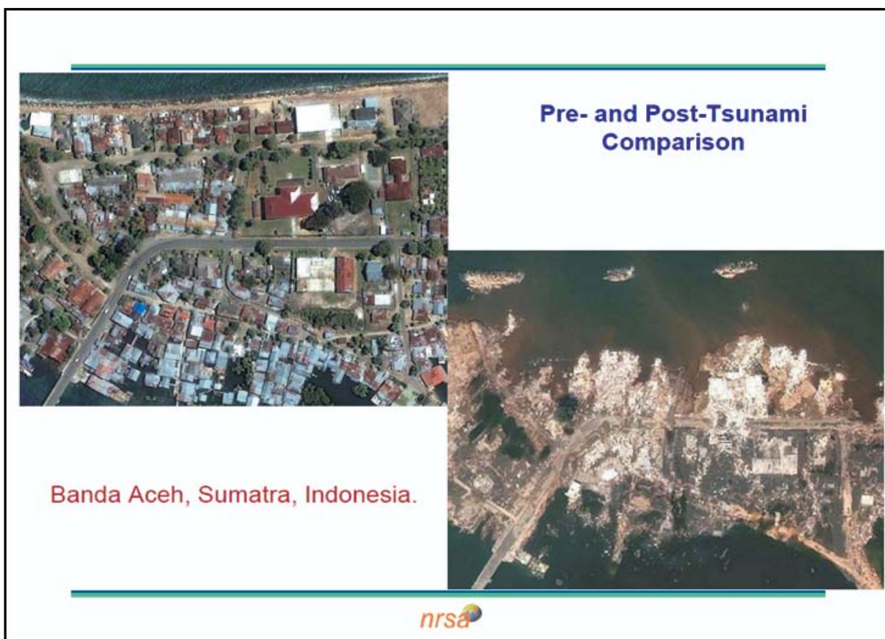


Fig. 155

Effects of Tsunami in Sumatra Indonesia - 2004

The earthquake 8.9 magnitude recorded in Japan (March - 2011) the satellite Imagery shows the Tsunami affected areas

Fig. 156

Effects of Earthquake in Japan – 2011
Souce: Newyork Times 15 March 2011

Whole neighborhoods were in ruin and cars and debris were piled high around Iwaki.

Fig. 157

Before

Fig. 158

After

Effects of Earthquake in Iwaki area Japan – March 2011

Souce: Newyork Times 15 March 2011

Let us wrap up what we covered in this chapter

- The Geospatial Technology helps in many applications like soil, geomorphology, hydrogeology, land use, agriculture, land records, urban and infrastructure development, water resources and watershed management, disaster management, health and education, security and defense.
- Watershed management is an integration of technologies within the natural boundaries for optimum development of land, water and plant resources to meet basic needs of the people
- The watershed management can also be used for monitoring and evaluation of watershed programs
- Flood hazard mapping is a vital component for appropriate land use planning in flood prone area.
- Flood hazard mapping creates easy reach, rapidly accessible charts and maps which facilitate for the administrator and planers to indentify the areas for risk and prioritize their mitigation and response efforts.

- Flood hazard mapping in identification of factors controlling flood hazard in the study area.
- The objective of spatial modeling in Health management system was to create linkage between household, socio-cultural practices and dengue incidents. This model is capable of indentifying different risk levels.
- Uses of GIS and Remote Sensing in utility projects very significant. It offers tangible and intangible benefits.
- Geospatial technology uses latest computer technology to assist the police in responding faster to distress call with greater accuracy. It improves the quality of services to the public
- GIS, MIS tools helps in urban planning for municipalities and urban development authorities. It automates day to day functioning requirements of civic body
- These technology helps for efficient ,economical, and meaningful municipal administration including Tax administration

Review

Very Long Questions

1. Explain how Geospatial Technology helps in following area
   a) Watershed management
   b) Flood Hazard Mapping
   c) Groundwater Management
   d) Health Management
   e) Utility Mapping
   f) Security and Defense
   g) Urban and infrastructure development
   h) Disaster and relief management

CBSE

CONTINUOUS AND COMPREHENSIVE EVALUATION

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CENTRAL BOARD OF SECONDARY EDUCATION
Shiksha Kendra, 2, Community Centre, Preet Vihar, Delhi - 110092, India
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