

Geospatial Technology

Class XI



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 बढ़ते जाएँ
बस आगे बढ़ते जाएँ
बस आगे बढ़ते जाएँ.....





Geospatial Technology

Class XI

CBSE, Delhi - 110092

Copies - 1500

Price : Rs. 200/-

**This book or part thereof may not be reproduced by any person
or agency in any manner.**

Published by Secretary, C.B.S.E. 'Shiksha Kendra', 2, Community Centre, Preet Vihar, Delhi-110092.

Design and Printed by :

Akashdeep Printers, 20 - Ansari Road, Daryaganj, New Delhi - 110002

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 (Academic) 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 को:

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 हजार छह विक्रमी) को एतद्वारा 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.

List of contents

S. No.	Chapter	Page No
1.	Geospatial Overview	1-9
1.1	Introduction to Geospatial Technology	
1.2	Why to study Geospatial Technology ?	
1.3	Importance of Geospatial Technology	
2.	Mapps & Cartography	10-32
2.1	What are Maps what their importance	
2.2	Map Scale and Types	
2.3	Types of Maps	
2.4	Elements of Maps and Indexing	
2.5	Map Coordinate system	
2.6	Interpretation of Satellite Images	
3.	Remote Sensing	33 - 56
3.1	Overview of Remote Sensing	
3.2	Fundamentals of Remote Sensing	
3.3	Physics of Electro Magnetic Energy	
3.4	Remote Sensing Platforms, Sensors and Data Products	
3.5	Indian Remote Sensing Satellite Systems	
3.6	Remote Sensing Applications	
4.	Geographic Information System	57 - 72
4.1	Fundamentals of GIS	
4.2	Components of GIS	
4.3	GIS Data Acquisition	
4.4	Data Types of GIS	
4.5	Applications of GIS	
5.	Global Positioning System	73- 80
5.1	Overview of Global Positioning System	
5.2	Functions of GPS	
5.3	Segments of GPS	
5.4	Factors affecting GPS Data	
5.5	GPS application	
	Geospatial Technology Practicals	82-96

CHAPTER 1

Geospatial Overview

Learning Objectives

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

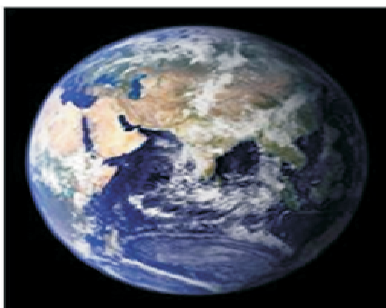
- 1.1 Introduction to Geospatial Technology.
- 1.2 Why to study Geospatial Data
- 1.3 Importance of Geospatial Technology.

1.1 Introduction to Geospatial Technology (GT)

Earth is composed of various landforms. The Geospatial Technology captures, studies, and analyzes these features for better management of the resources. We live on a living planet called earth. The earth is composed of various Natural features and Manmade features.

Natural Features

The landscape features that were created by natural processes are called Natural Features. For example, rivers, mountains, hills, valleys, trenches, lakes, deserts, oceans, glaciers, forests etc.



OUR PLANET EARTH



MOUNTAINS



FOREST



RIVER

Fig. 1





Manmade features

The features which are made by human beings are called Manmade Features. For Example, roads, buildings, reservoirs, dams etc.



Building



Road



Agriculture Land



Dams and Reservoirs

Fig. 2

These Natural and Manmade features can be represented on various maps such as physiographic maps, topographic maps, administrative maps, atlas, road maps, city maps or can be viewed within a computer system in terms of various map data layers. Different layers of information like vegetation, water, forest, soils of the same place can be placed one above the other and shown on a single map.

All the features of earth surface whether Natural or Manmade occupy space and have definite geometric shape and size on the surface of the earth. Therefore these features are called Geospatial ('Geo' means Earth and 'Spatial' implies definite Shape and size in space).



PHYSIOGRAPHIC MAP OF INDIA

Fig. 3



TOPOGRAPHIC SHEET

Fig. 4

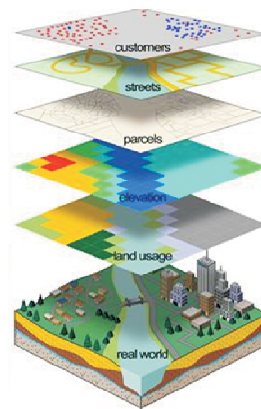
Topographical Maps:

Topography is a pictorial representation of a place. This is normally represented in maps. It shows small areas with lots of details like manmade and natural features.



ROAD MAP OF INDIA

Fig. 5



DATA LAYERS IN GIS

Fig. 6

Map Data Layer

It is a combination of different type of data set and overlaid as shown in Picture. It is maintained as separate datasets. For example, roads could be one layer, water feature another and building still another.





Geospatial technology is used for visualization, measurement and analysis of features or phenomena that occur on the earth. This technology captures and stores the geospatial data along with its Spatial and Non-Spatial Information.

1.2 Why to study Geospatial Technologies (GST)?

Geospatial is a term widely used to describe the combination of spatial software and analytical methods with geographic datasets. Traditional technique to generate natural resources status is time consuming and expensive. The natural resources status includes area, production, productivity of crops, irrigation facilities, rain fed area etc. This information can be generated using GIS and Remote Sensing technology and would be cost effective and time saving.

Geospatial technology includes three different technologies that are all related to mapping features on the surface of the earth. These three technologies are Remote Sensing (RS), Geographical Information Systems (GIS) and Global Positioning Systems (GPS).

A Remote Sensing (RS)

Remote sensing is the term used to describe the act of gathering data from a distance. This distance can be small or large. Remote sensing uses electronic sensors without direct contact; some means of transferring information through space must be utilized.

Remote Sensing is the science and art of acquiring information (spectral, spatial and temporal) about material objects, area, or phenomenon, without coming into physical contact with the objects, or area, or phenomenon under investigation.

Remote sensing uses satellites to acquire information about earth's surface. Satellite provides a means for looking at a very large area of the World in a very short time. Satellite Sensors collate pictures of the earth from space using electromagnetic radiation covering a range of frequencies, from radio waves to gamma rays. As Remote

sensing gives the picture of a very large area in a short time, it helps to plan and manage the natural resources. For details about Remote Sensing refer to Chapter 3.

Geographic Information System (GIS)

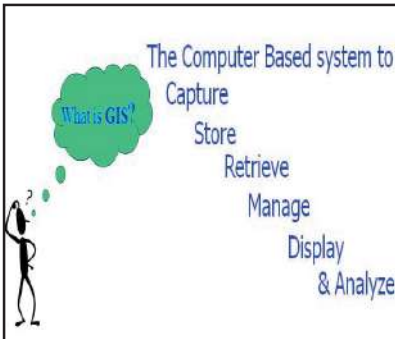


Fig. 7

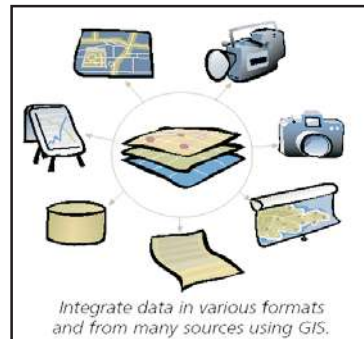


Fig. 8

GIS is a computer system for capturing, storing, checking, integrating, manipulating, analyzing and displaying data related to positions on the Earth's surface. GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns and trends in the form of maps, globes, reports, and charts. Therefore, GIS helps to answer questions and solve problems. GIS stores information about the real world as a collection of thematic layers that can be used together. Layer can be anything that contains similar features such as Buildings, Streets, Rivers, Vegetation etc. Details are discussed in Chapter 4



Concept of GIS

Fig. 9

GIS is defined as an information system that is used to store, retrieve, manipulate, analyze and output geographically referenced data or geospatial data in order to support decision making for planning and management of land use, natural resources, environment, transportation, urban facilities and other administrative records.





B. Global Positioning System (GPS)

The Global Positioning System (GPS) is a U.S. space-based radio navigation system that provides reliable positioning, navigation, and timing services to civilian users on a continuous worldwide basis. Details are discussed in Chapter-5

Global Positioning System:

A Navigational system involving satellites and computers that can determine the Latitude and Longitude of a receiver on Earth by Computing the time difference for signals from different satellites to reach the receiver

1.3 Importance of Geospatial Technology

Geospatial Technology is the combination of GIS, GPS and RS technologies. Traditional techniques of collecting and analyzing the natural resources are time consuming and time expensive. The information on the status of natural resources includes area, production, productivity of crops, irrigation facilities, rain fed area etc. This information can be created and analyzed using GIS and RS technologies.

i Improved Organizational Integration

One of the main benefits of Geospatial Technology is improved management of an organization and resources. A Geospatial Technology can link data sets together by common location data, which helps departments and agencies share their data. By creating a shared database, one department can benefit from the work of another; and data collected once can be used many times.

ii Better Decisions

A Geospatial Technology is not just an automated decision making system but a tool to query, analyze the Geospatial data in support of the decision making process. For example, Geospatial Technology can be used to help to reach a decision about the location of a new housing development that has minimal environmental impact, is located in a low risk area, and is close

to a population center. The information can be presented in a few words clearly in the form of a map and an accompanying report, allowing decision makers to focus on the real issues rather than trying to understand the data, because Geospatial Technology products can be produced quickly & multiple scenarios can be evaluated efficiently and effectively.

iii Create Maps

In simple words, we often call Geospatial Technology “*Mapping Software*.” We most often connect maps with physical geography, but Geospatial Technology is flexible enough to map any kind of terrain, even the human body. GIS helps to map any data as you wish. Creating and updating of maps with GIS is much faster than traditional manual or automated cartography approaches.

iv Cost Effective and Time Saving

As remote sensing gives pictures of very large areas in a short time and GIS manages them effectively, it is cost effective and time saving.

Let us wrap up what we covered in this chapter

- Geospatial Technology is used for visualization, measurement and analysis of phenomena that occur on the earth.
- We live on a living planet called earth. The earth is composed of natural and manmade features.
- Natural and Manmade features are represented on various maps these can be viewed in physiographic, topographic, administrative, road maps, city maps, atlas or can be viewed through computer system in terms of various map data layers.
- Various Spatial features overlaid on one another to prepare an integrated map are called map data layers.





- All Natural and Manmade features have definite geometric shape and size on the surface of the earth. Therefore, they are called Geospatial features.
- Geospatial technology captures and stores geospatial data along with its spatial and non-spatial information.
- Spatial information provides the size, shape and location of the features whereas non-spatial data provides related information about the data such as road's name, road's width etc.
- Geospatial technology includes three different technologies that are all related to mapping features on the surface of the earth.
- Geospatial technology includes three different technologies, i.e. Geographical Information Systems (GIS) Global Positioning Systems (GPS), and Remote Sensing (RS).
- GIS is defined as an information system that is used to store, retrieve, manipulate, analyze and output geographically referenced data or geo-spatial data in order to support decision making for planning and management of land use, natural resources, environment, transportation, urban facilities and other administrative records.
- Global Positioning System: a navigational system involving satellites and computers that can determine the latitude and longitude of a receiver on Earth by computing the time difference for signals from different satellites to reach the receiver.
- Remote Sensing is the science and art of acquiring information (spectral, spatial and temporal) about material objects, area, or phenomenon, without coming into physical contact with the objects, or area, or phenomenon under investigation.
- In our daily life this technology helps us as a decision making tool

Review

Very Short Answer Questions

1. Name the various features of earth?
2. Give examples for natural land features.
3. Give examples for manmade features.
4. Geospatial technology captures and stores the data in two ways. Name them.
5. Geospatial Technology includes three different technologies. Name them?
6. GIS captures and stores different layers of the same area such as forest, water, soil etc. True or False?
7. GPS is a navigation system which does not provide latitude and longitude. True or False?

Short Answer Questions

1. How would you represent Manmade and Natural Features? Give example.
2. What do you mean by Geospatial Features?
3. What is map data layer?
4. What is Geospatial Technology?
5. What is Geographic Information System (GIS)?
6. What is Remote Sensing (RS)?
7. What is Global Positioning System (GPS)?

Long Answer Questions

1. What do you understand by Geospatial Technologies? Discuss each of these in brief.
2. Explain the need, importance and scope of geospatial technology.



CHAPTER 2

Maps & Cartography

Learning Objectives

By the end of this chapter students would be able:

- 2.1 To know about maps and their importance
- 2.2 To know about scales of maps and their types
- 2.3 To know about types of maps
- 2.4 To understand elements of maps and indexing
- 2.5 To understand map coordinate systems.
- 2.6 To interpret the satellite images

2.1 What are Maps and what's their Importance?

1. Map Concepts

The word '*mapi*' comes from the Latin word '*mappai*' and means napkin, cloth or sheet. The first map to represent the known world was created by Anaximander, a Greek philosopher in the 6th century B.C. Globe is a three dimensional model of whole earth whereas map is a two-dimensional graphical representation of the earth or a specific area.

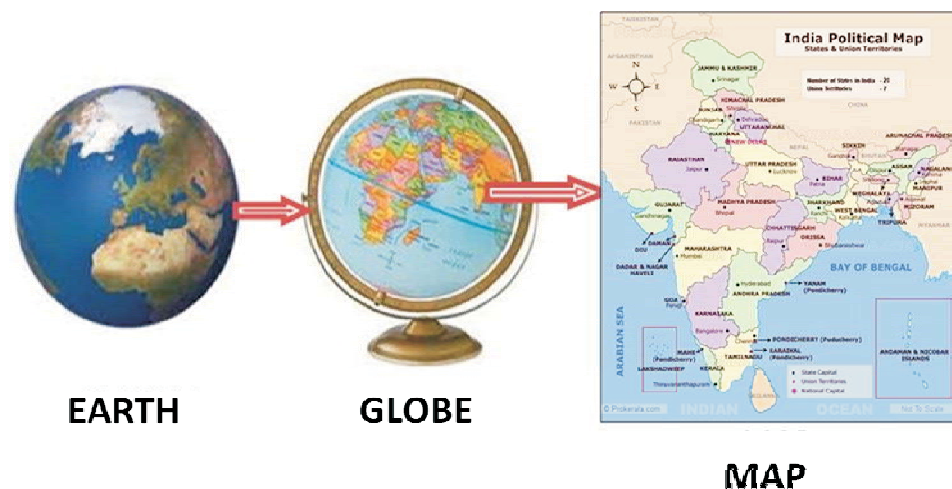


Fig. 10

2. What is Map?

Map is a two dimensional graphical representation of the earth to provide the information of the location and distance between the ground features, such as populated places and routes of



travel and communication. The primary purpose of a map is to convey information or “get across” a geographical concept or relationship between the features. It also indicates variations in terrain, heights of natural features, and the extent of vegetation cover. It communicates locational and descriptive information. For easy understanding, features must be represented by conventional signs and symbols. Maps help us to understand directions, landmarks, distances and heights.

What is Map?

A map is a graphical two-dimensional representation of a portion of the earth's surface drawn to scale & uses colors, symbols and labels to represent features found on the ground.

3. Importance of Map

(a) Location

Maps identify what is at a location, where you are. For example, If you want to locate house, school, religious places, museum etc., how would you guide people to locate these places? One option is that you can draw the direction and route map showing different landmarks on a piece of paper like temple, park, school etc. This drawing guides your friend to reach his destination using the landmarks and directions. We use the knowledge of the area, landmarks and direction to locate any place. These landmarks are represented on the map through symbols.





Fig. 11

(b) Navigation:

When you are travelling in an unknown place, maps guide you the proper path. For example, If you want to visit city museum then you need to look into the city map & find out possible routes to reach the destination. Maps also provide distance information so that we can select the shortest path for our travel.

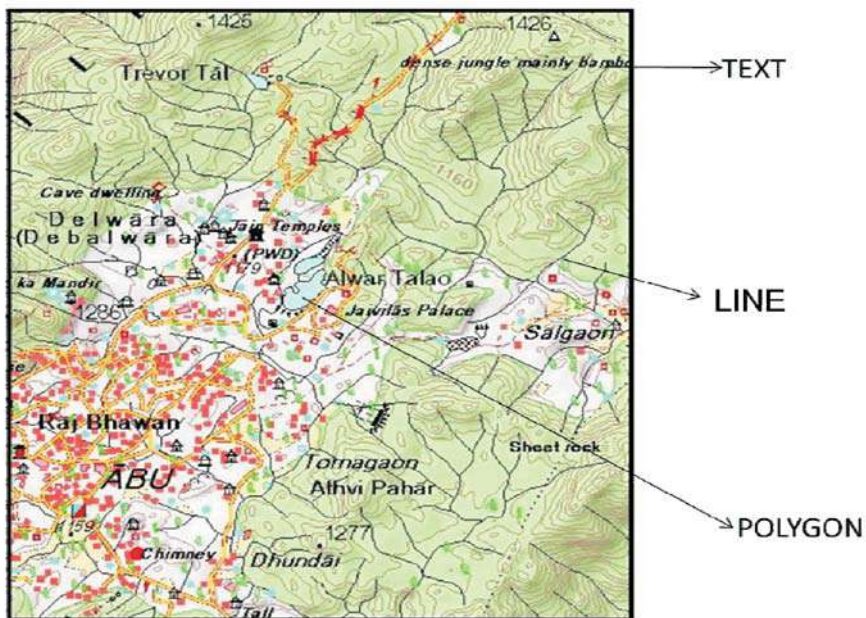
(c) Planning

Along with the location information maps also shows us the important landmarks nearer to that location which help us for planning. For example if administrative department wants to construct a new road then before starting the job they can visualize the area, how much buildings are existing in that area, what are the measuring acts that need to be taken to evacuate the place etc, These types of plans can easily be done by the help of proper maps

(d) Map Features:

Look at any map you will find different shapes and symbols used to illustrate maps. There are four types of symbols used to depict different features types. i.e. points, lines, polygons and text.

- (i) **Points:** Points define discrete locations of geographic features which are too small to be depicted as lines or areas, such as locations of wells, telephone poles, or buildings. etc.
- (ii) **Lines:** Lines represent the shape of geographic objects too narrow to depict as areas, such as streets and streams, or linear features that have length but no area, such as elevation contours, roads and pipelines.
- (iii) **Polygons/ Areas:** Areas are closed features that represent the shape and location of homogenous, real-world features such as states, cities, parcels, soil types, or land use zones.
- (iv) **Text:** Text provides brief descriptions of different features. For example: names of landmarks, roads, rivers etc.



Map with Map Features

Fig. 12





4. Map Directions

Map direction is usually indicated on a map by a North-South line with north represented by an arrowhead. A short line perpendicular to this is drawn to show the east and west directions. North, South, East and West are main directions. Northeast lies between North and East. In the same way, we have directions like Southeast, Southwest and Northwest.



Fig. 13

5. Map Symbols

Map symbols are used to represent the real world objects. Without symbols, we wouldn't have maps. Survey of India (SOI) is an organization that regularly draws and updates different types of maps in India. Map uses a lot of symbols to represent different features. How will you know which features are located at which place? To solve this, maps have a key at a corner that explains the symbols. If you find a symbol on the map that you do not know, simply look for it in the key.

Both shapes and colors can be used for symbols on maps. Map Legend is a key to all the symbols used on a map. It is like a dictionary through which we are can understand the meanings of various symbols used in the map.

Legends for Survey of India Toposheet

CONVENTIONAL SYMBOLS	
Express Highway: with toll; with bridge; with distance stone	
Roads, metalled: according to importance	
Roads, double carriageway: according to importance	
Unmetalled Road, Cart-track, Pack-track and pass, Foot-path	
Streams: with track in bed, undefined, Canal	
Dams: masonry or rock-filled; earth work, Weir	
Rivers: dry with water channel; with island & rocks; Tidal river	
Submerged rocks, Shoal, Swamp, Heeds	
Wells: lined, unlined, Tube-well, Spring, Tanks: perennial, dry	
Embankments: road or rail; tank, Broken ground	
Railways: broad gauge; double, single with station; under construction	
Mineral line or ironway, Kin, Cutting with tunnel	
Contours with sub-features: Rocky slopes, Cliffs	
Sand features: flat (2) sand-hills (permanent) (2) dunes (shifting)	
Towns or Villages: inhabited, deserted, Fort	
Huts: permanent, temporary, Tower, Antiquities	
Temple, Chhatra, Church, Mosque, Idgah, Tomb, Graves	
Lighthouse, Lighthouse Buoy, lighted, unlighted, Anchorage	
Mine: Vine on trellis, Grass, Scrub	
Palm: palm tree, other: Plantain, Conifer, Bamboo, Other trees	
Area: cultivated, wooded, Surveyed tree	
Boundary: International	
state: demarcated, undemarcated	
district: subdivision, tahsil or taluk; forest	
Boundary Pillars: surveyed, unlocated, village bijunction	
Heights, triangulated station, point, approximate	
Bench-mark: geodetic, tertiary, canal	
Post office, Telegraph office, Overhead tank	
Rest house or inspection bungalow, Clinic, house, Police station	
Camping ground, Forest: reserved, protected	
Spaced names: administrative, locality or tribal	
Hospital, Dispensary, Veterinary hospital	
Aerodrome, Helipad, Tourist site	
Power line: with pylons surveyed; with poles unsurveyed	

Map Legends from SOI Toposheet

Fig. 14

6. What is Cartography?

Cartography comes from two Greek words, '*chartis*' meaning map, and '*graphos*', meaning to draw or write. Cartography is the art and science of map making, practiced by cartographers. Humans have been drawing maps to understand their environment. In ancient times, cartographers drew maps manually with limited information and indicating location information in relation to something else, nowadays cartographers have the advantage of GIS tools to assist them, making their maps more precise using geographical coordinates such as latitude and longitude to orient their features

What is Cartography?

Cartography is the art and science of map making technique. The persons who prepare maps are called cartographers.





2.2 Map Scale and Types

1. What is Map Scale?

Map is a graphic representation of a portion of the earth's surface plotted on paper with some ratio. This ratio is known as representative fraction (R.F.). The scale of a map is defined as the ratio of a distance on the map to the corresponding distance on the ground. If we are drawing a map of India, we cannot draw a map as huge as India. The actual distance is shortened and represented in scale on the map. The explanation of the scale is given at one corner of map in a box called scale bar. Scale is represented in three different ways. Different countries measure the distances in different units such as miles, Kms. etc. As the denominator of the representative fraction gets larger and the ratio gets smaller, the scale of the map decreases

The scale of a map is defined as the ratio of a distance on the map to the corresponding distance on the ground.

(a) Statement such as 1 cm = 0.5 Km.

In the scale of 1:50,000

1 cm represents 0.5 km on the ground.

(b) Representative fraction (RF) like 1:10,000. Representative Fraction makes measurement in units. Unit can be millimeter, centimeter or a meter. For example if a village map has the representative Fraction 1:50,000 and the distance between the temple and school is 1 cm, the actual distance on ground is 500 meters. To calculate the scale, the following formula is used.

R.F. (Scale) = Map distance / Ground distance

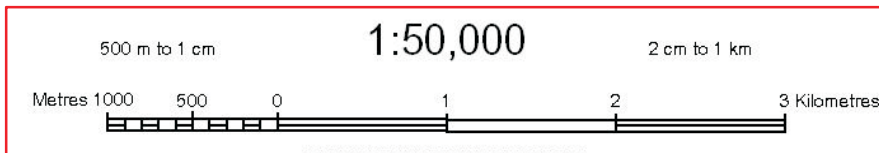


Fig. 15

If 2 cm. on the map represents 1 Km on the ground

The scale would be calculated 2 cm = 1Km

Distance on the map / Distance on the ground = 2 cm /10, 0000

Therefore scale = 1:50,000.

(c) Graphical or linear scale: The graphical scale or a linear scale is a line of convenient length divided in regular intervals and graduated in terms of distances on the ground. Using the linear scale the distance between any two points can be measured directly in terms of distances on the ground.

Using the linear scale, distance between any two points on the ground can be measured directly in terms of distance on the map.

2. Classification of Maps:

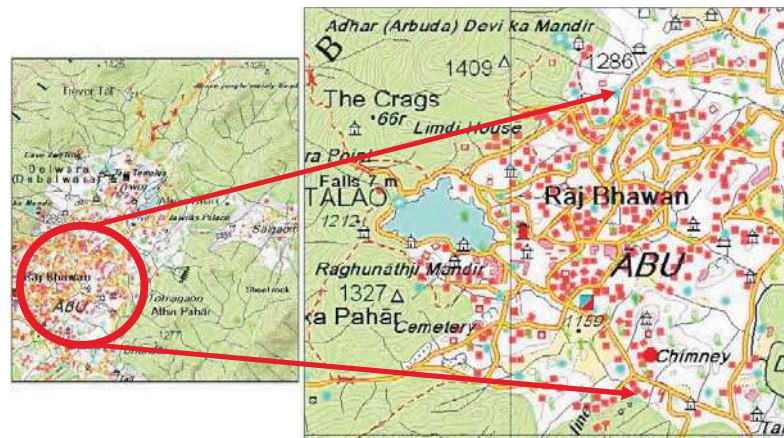
Maps are classified into two types of scales. Scale describes the details and amount of area covered by a map on the ground.

(a) Large Scale Map: Large-scale of 1:5,000 maps shows the greater details and represents the small area as compared to the scale of 1:10,000 of same area

(b) Small Scale Map: A small scale of 1:10,000 map shows lesser details and represents more area as compared to the scale of 1:5000 of same area

Large and small scale maps differ in area coverage and amount of information





Small Scale map: 1:10,000

Large Scale map: 1:5,000

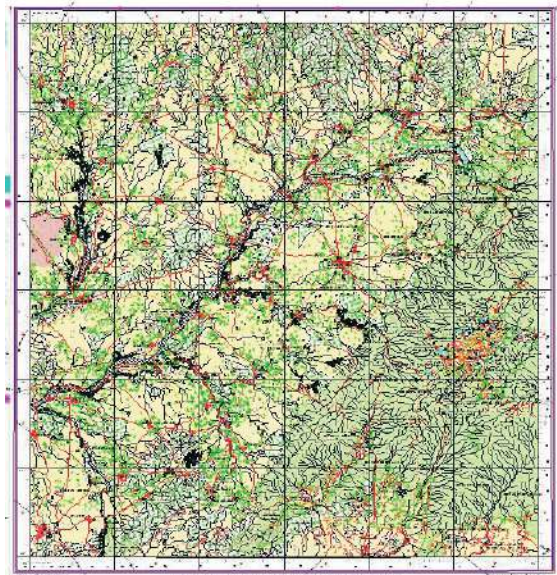
Fig. 16

2.3 Types of Maps

Why do you need different types of maps? Maps help you to understand the spatial patterns. Various types of maps are used for effective planning and management of resources. Some of the types of maps are discussed below:

(i) Topographic maps

Topographic maps are commonly called contour maps or topomaps. Topographic maps are prepared based on topographical surveys performed at large scales. Indian topographic sheets are prepared and managed by Survey of India (SOI).



Topographic Map

Fig. 17

They are published as map series and are made up of two or more map sheets that cover a village or district depending on scale. A topographic map is on scale.

A topographic map is a detailed and accurate graphic representation of Natural and Man-made features on the ground. These maps usually include elevation, relief, major geographical features, contour lines and other information



Contour lines showing changes in elevation

Fig. 18

Contour is an imaginary line drawn on maps joining the places that have same heights. This method of showing heights through contours is perhaps most accurate, common and popular. Contours are drawn on the basis of an actual survey conducted in the field. A map showing contours is called a contour map. Contours are numbered to indicate their height above Mean Sea Level (MSL). Contour which is CLOSE indicates STEEP terrain whereas, contours which are OPEN indicate FLAT terrain.

(a) Benefits of Topographic Maps

Topographic maps provide a wide range of information which is used for residential and commercial planning, engineering, energy exploration, environmental management, public works design, natural resource conservation, and outdoor activities such as fishing, camping, hiking. etc.





(b) What type of information should be collected from a topographic map?

A topographic map identifies numerous cultural and natural ground features, which can be divided into the following categories: roads, buildings, boundaries, railways, power transmission lines; water bodies, lakes, rivers, streams, mountains, valleys, slopes, depressions; and forests, names of places, names of water features, names of highways. All these features can be identified in the legend from the corresponding symbols.

(c) Topographic Map Elements and Interpretation:

The various features shown on the map are represented by conventional signs or symbols. Maps use significant colors to identify the features for example, blue often means water, green means forests, and white means bare land. Colors can be used to indicate classification of roads. These signs are usually explained in the legend of the map, or on a separately published characteristic sheet. The title of the topomap is printed in the upper and lower right corners of the map. Adjacent topomaps names are displayed in Index to Sheets which helps to find out the neighboring maps.

Every map has a scale which reads distance on the map with respect to the ground. Topomaps also show the information about the Grids as latitude and longitude which are used to identify exact location of any point on the earth. Along with this information, Contour intervals & Projection information are displayed in degrees and minutes. In topomaps North is at the top, South at the bottom, West to the left and East to the right.

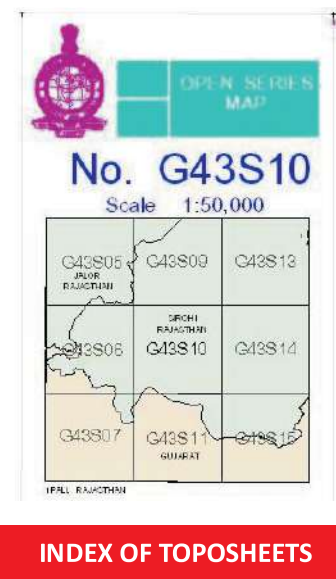


Fig. 19

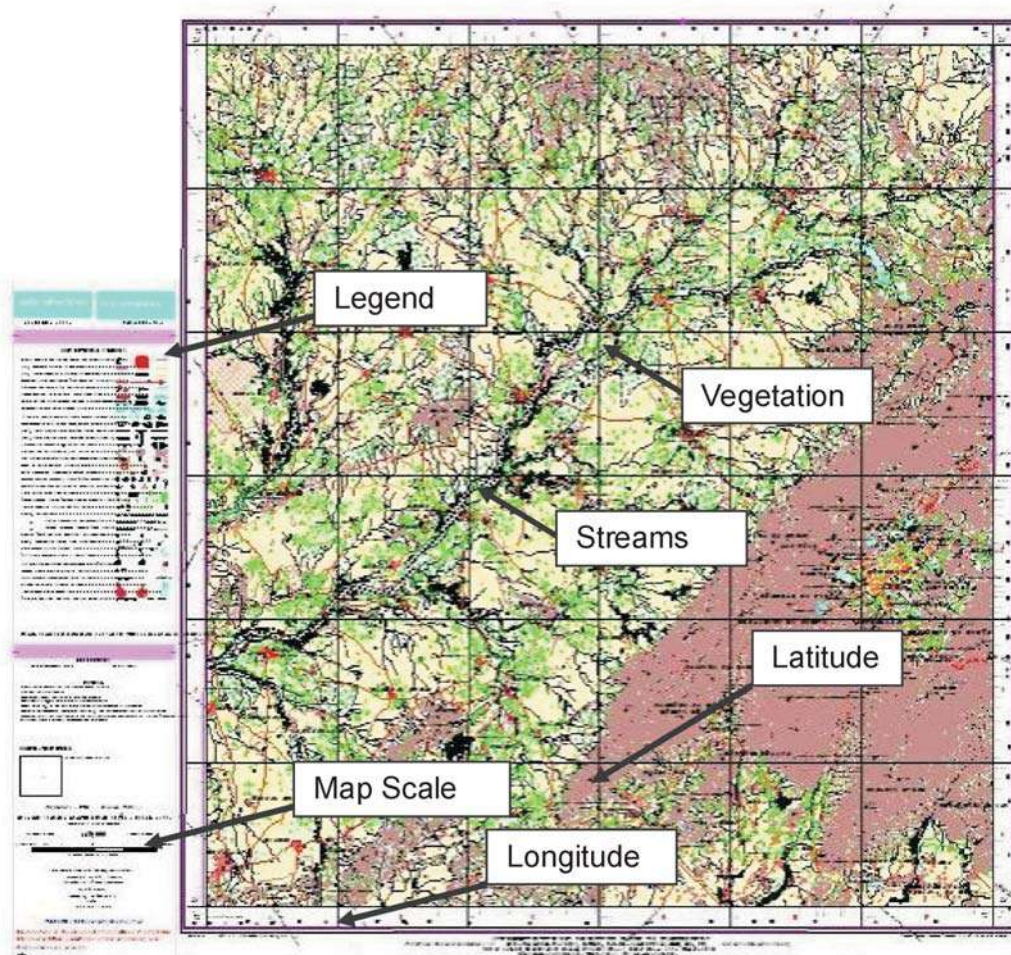
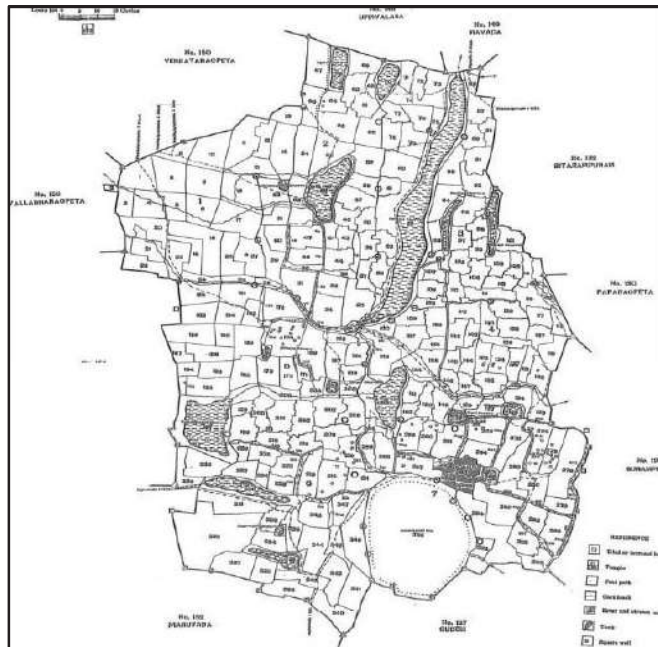


Fig. 20

(ii) Cadastral Maps

Cadastral maps are village maps which show individual plots. These maps show the boundaries of properties owned by different people. These maps are the basis for maintaining revenue records of villages and towns.





Cadastral Map

Fig. 21

(iii) Physical Maps

Physical maps illustrate the physical features of an area such as mountains, rivers and lakes. The maps use lines, shading, tints, spot elevations, and different colors to show elevation and distinguish the mountains from the lowlands. Colors are used to show relief differences in land elevations. Green is typically used for lower elevations and orange or brown indicate higher elevations. This kind of map often has some road, city and cultural information but mostly functions as a view of the land surface.



**Physical Map
(Survey of India)**

Fig. 22

(iv) Political Maps

Political maps show boundaries that divide one political entity from another, such as townships, counties, cities and states. Some maps emphasize the boundaries by printing the areas of each political division in different colors, for example world maps usually show each country in a different color. A political map can be created for a country, state, district, village, block, municipality.



**Political Map
(Survey of India)**

Fig. 23

(v) Thematic Maps

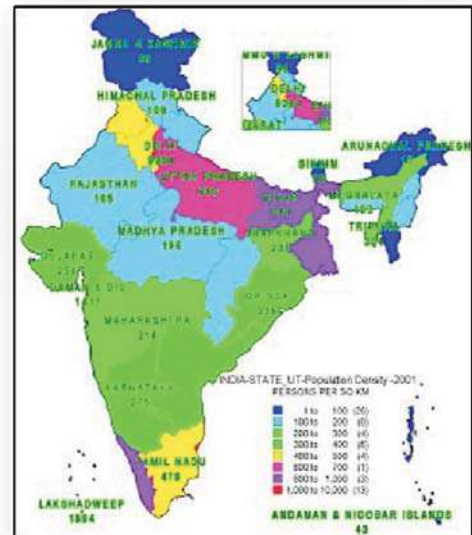
Thematic maps are grouped according to the subject; these maps can portray physical, social, political, cultural, economic, agricultural, or any other aspects of a city, state, region, nation, or continent. For example, if you draw a map showing ponds, wells and water bodies of the village it will be named thematic map of the water resources of your village. Similarly if a map is drawn based on state wise population of India, it is called a demographic map of India. A thematic map can be created based on population density, as shown below: (Fig. 24)





Purpose of Thematic Map

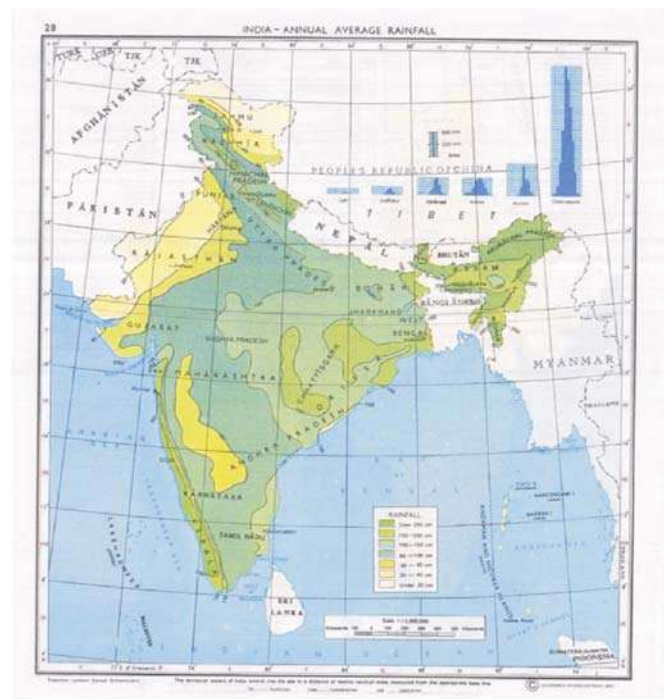
Thematic maps serve three primary purposes. First, they provide specific information about particular locations. Second, they provide general information about spatial patterns. Third, they can be used to compare patterns on two or more maps.



Population Density map of India
(Survey of India)

Fig. 24

(vi) **Meteorological Map** A meteorological map shows different climatic parameters like rainfall, wind velocity, direction etc.



Metrological map of India
(Survey of India)

Fig. 25

2.4 Elements of Maps & Indexing

Maps enable us to depict spatial phenomenon on paper. There are conventions used in cartography which allow a map to be read efficiently and quickly.

(a) Legend

A good map will have a legend or key which will describe the map features with different symbols. For instance, a square with a flag on top usually represents a school and roads are represented by a variety of widths and combinations of lines.

(b) Scale

Scale represents ratio between map distances to ground distance.

(c) North Arrow

It depicts the true north. Without a north arrow, it is difficult to determine the orientation of a map. With a north arrow (pointing in the correct direction), a user can determine direction.

(d) Neat line

It is the border of a map. It helps to define the edge of the map area and obviously keeps things looking "neat."

(e) Projections

Since the map is a flat representation of the curved surface of the earth, all maps are inherently inaccurate. There are a variety of projections which have been formulated for different uses.

(f) Source

The map source shows the details about the source of information of the contents of the map.

(g) Title

The title represents the theme of the map. A map's title provides important clues about the cartographer's intentions and goals.



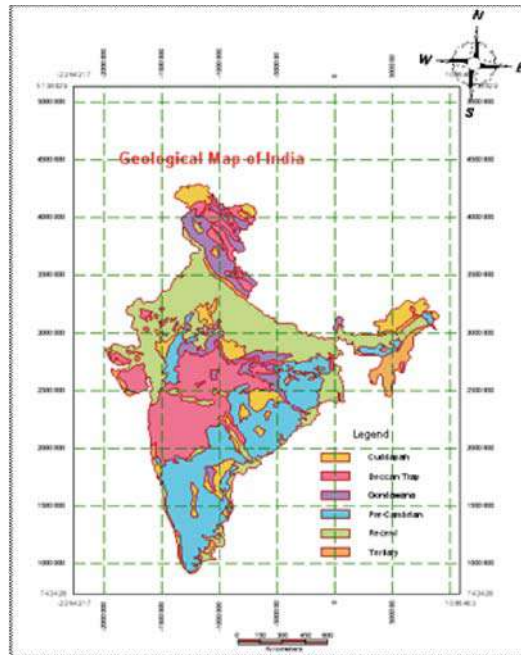


Fig. 26

2.5 Map Coordinate System

How can you locate yourself on earth? There should be some system which can calculate the location information by some known referencing point. That system is called Coordinate system. The coordinates systems are of two types viz. Geographic coordinate system and projected coordinate system. In this chapter we will be discussing the Geographic coordinate system. Projected coordinate systems will be discussed in Class-XII

(1) Geographic Coordinate System: The use of Geographic Coordinate System is very common. It uses degrees of latitude and longitude and Sometimes also a height value to describe a location on the earth's surface.

On the spherical earth, geographers used imaginary vertical and horizontal lines and numbered them. Latitudes are horizontal lines and longitudes are vertical lines. Geographers have taken equator as a starting point for latitude and the prime meridian for longitude. In the same way lines to the right of prime meridians show the east and those to the left of prime meridian show the west. Any location on Earth is described by

two numbers, latitudes and longitude. If pilot or a ship's captain wants to specify position on a map, these are the "coordinates" they would use. Actually, these are two angles, measured in degrees, "minutes of arc" and "seconds of arc." These are denoted by the symbols ($^{\circ}$, $'$, $"$) e.g. $35^{\circ} 43' 9"$ means an angle of 35 degrees, 43 minutes and 9 seconds;

2. Latitude: Imaginary Line drawn from West to East. Latitude runs parallel to the equator and divides the earth into 180 equally spaced sections from North to South (or South to North). Latitudes above the equator are in the northern hemisphere and those below the equator are in the southern hemisphere.

3. Longitude: Imaginary Lines drawn from North to South Pole. Longitude runs perpendicular to the equator and converges at the poles. Longitude covers 180 degrees for east and 180 degree for west.

4. Prime Meridian: The longitude which passes through Greenwich, England is called Prime Meridian or Greenwich Meridian. It is zero degree longitude (0°), used as a reference line to measure the longitudes.

5. Equator: The equator is referred to as zero degree Latitude (0°), as a reference line from where the latitude measurements begin.

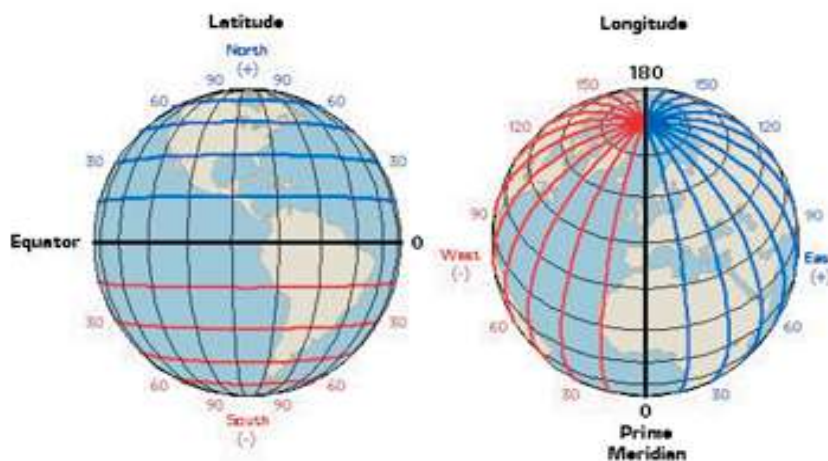


Fig. 27





2.6 Interpretation of Satellite Images

The act of examining Satellite Images for the purpose of identifying objects and judging their significance is called “Image Interpretation”. The type and amount of information that can be extracted is based on the knowledge, skill and experience of the analyst.

Eight fundamental parameters are used in the interpretation of remote sensing images. In some cases, a single element alone is sufficient for successful identification; in others, the use of several different elements will be required. The following elements are used for interpretation of satellite image. The elements of image interpretation are location, size, shape, shadow, tone/color, texture, pattern, height/depth and site/situation/association.

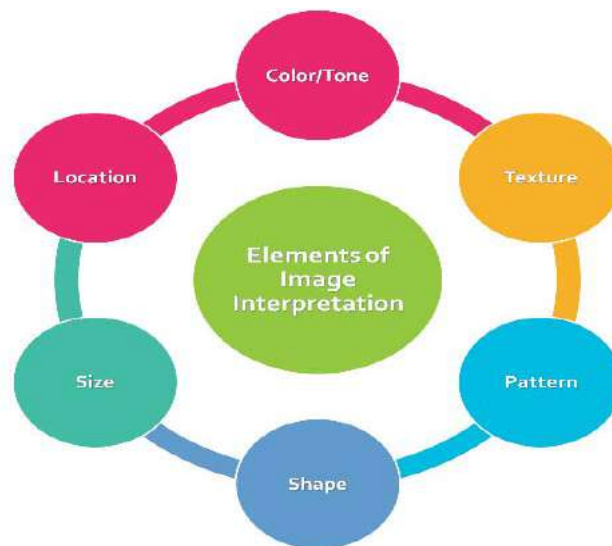


Fig. 28

Elements of Image interpretation

In Landsat satellite image, given below (Fig. 29) many features are recognizable by color, shape and texture. The blue color shows river, the green areas are forest, the variations in green relating to tree species. The black indicates the water body. The reddish pink shows the forest burn area. White lines indicate the road network.

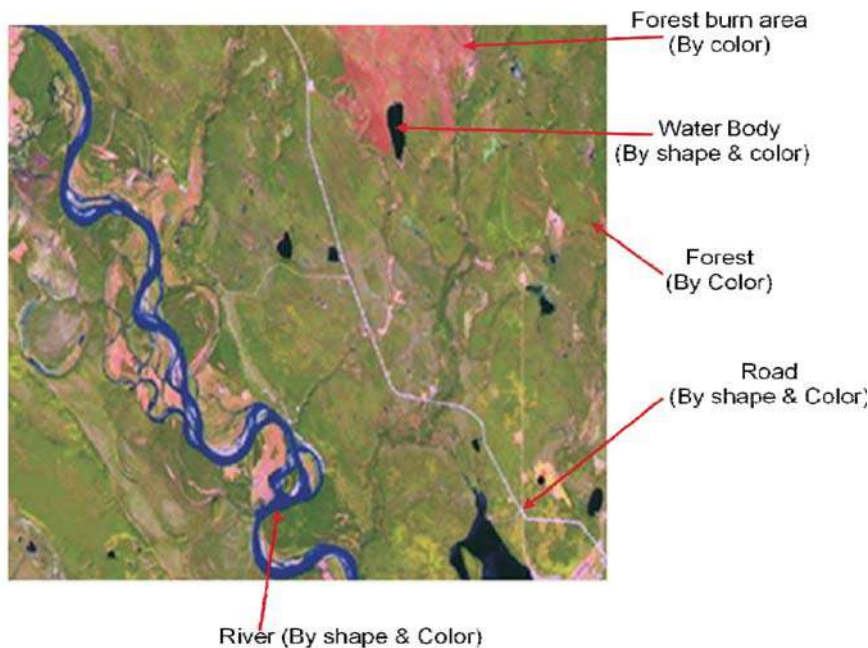


Fig. 29

Let us wrap up what we covered in this chapter

- Globe is a three dimensional model of whole earth.
- A map is a graphical & two dimensional representation of a portion of the earth's surface drawn to scale and uses colors, symbols, and labels to represent features found on the ground.
- A map provides information about the location distance between ground features, such as populated places & routes of travel and communication. It also indicates variations in terrain, heights of natural features, and the extent of vegetation cover.
- There are four types of elements used to depict different features i.e. Points, Lines, Polygons and Text.
- Maps are very important for planning, locating, navigating & getting knowledge of what else is there.





- Direction is usually indicated on a map by a North-South line with north represented by an arrowhead.
- Map symbols are used to represent the real world objects.
- Cartography is the art and science of map making, practiced by cartographers.
- The scale of a map is defined as the ratio of a distance between two points on the map to the corresponding distance on the ground.
- Scale is represented in three different ways: statement, representative fraction (R.F.) and graphical or linear scale
- Maps are classified into two categories like Large scale maps & Small scale maps
- Large-scale map shows greater details than small scale map of the same area
- Thematic maps are created according to the subject.
- Map elements are legend, scale, north arrow, neat line, projection, source and title.
- Geographic coordinate systems and projected coordinate systems are the two commonly used map coordinate systems
- Latitudes are imaginary Lines drawn from West to East. Equator is a zero degree latitude.
- Longitudes are imaginary Lines drawn from North to South Pole. Greenwich line or Prime Meridian is zero degree longitude line.
- A topographic map is a representation of both Natural and Manmade features on the ground.
- Contour is an imaginary line drawn on maps joining the places that have same heights.
- Contours which are CLOSE indicate STEEP terrain whereas contours which are OPEN indicate FLAT terrain.
- Eight parameters are used in the interpretation of remote sensing images such as location, size, shape, shadow, tone/color, texture, pattern, height/depth and site/situation/association

Review

Very Short Answer Questions

1. What is a globe?
2. What is cartography?
3. Why are directions used in a map?
4. A line of convenient length is divided into regular interval & graduated in terms of distances on the ground. True or False?
5. Small scale shows greater details. True or False?
6. Name types of maps used in planning and navigation?
7. Maps are classified into two scale maps. Name them.
8. Which latitude represents the zero degree latitude?
9. Where is the prime meridian?
10. Maps represent the earth three-dimensionally. True or false?
11. How are topographic maps prepared?
12. Indian toposheets are created by Survey of India. True or False?
13. As denominator of the representative fraction gets larger and ratio gets smaller the scale of the map decreases. True or False?
14. Cadastral maps represent both Natural and Manmade features. True or False?
15. By which map can you find the elevation of the terrain?
16. Name eight parameters used in the interpretation of satellite Images.

Short Answer Questions:

1. What is a Map?
2. What are the differences between globe and map?
3. What are the differences between point, line and Polygon?
4. What symbols would you use to represent a river, road, building and tree in a map?
5. Define Map scale.
6. Differentiate between large scale map and Small scale map.
7. What are contour lines?





8. How can you identify steep and flat terrain?
9. What is a cadastral map?
10. Name the elements of Maps
11. Which map shows climatic parameters like rainfall, wind direction etc
12. Define in two lines
 - a) Latitude c) Prime meridian
 - b) Longitude d) Equator

Long Questions:

1. Explain the importance of maps
2. How do you locate yourself on the map?
3. The map scale is 1:25000. If distance between 2 points is 5cm then calculate actual distance on the ground. Explain the procedure.
4. Scale is represented in three different ways. Explain in detail
5. Explain the map features in detail
6. Explain the topographic map
7. What are the benefits of a topographic map?
8. What type of information can you collect from a topographic map?
9. What is a map legend?
10. Explain briefly about the thematic map
11. Describe the map elements
12. What is geographic coordinate system?

CHAPTER 3

Remote Sensing (RS)

Learning Objectives

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

- 3.1 Understand the Remote Sensing Technology (RS)
- 3.2 Know the Fundamentals of Remote Sensing
- 3.3 Understand the Physics of Electro Magnetic Radiation (EMR)
- 3.4 Understand about Remote sensing platforms sensors and data products
- 3.5 Understand the Indian Remote sensing Satellite System
- 3.6 Understand about Remote sensing applications

3.1 Overview of Remote Sensing Technology (RS)

We perceive the surrounding world through our five senses. We acquire information about our surroundings through the senses of sight and hearing which do not require close contact between the sensing organs and the external objects. In another words, we are performing Remote Sensing all the time. ` Of our five senses (sight, hearing, taste, smell, touch), three may be considered forms of "remote sensing", where the source of information is at some distance for example Telephone conversation, smelling of the object etc. The other two senses (taste & touch) rely on direct contact with the source of information.



Fig. 33

Eating Ice Cream is an example for Direct Sensing

Telephone conversation an example for Indirect Sensing





Remote Sensing refers to the activities of recording / observing / perceiving (sensing) objects or events at far away. In remote sensing, the sensors are not in direct contact with the objects or events being observed. The information needs a physical carrier to travel from the objects/events to the sensors through a medium. The electromagnetic radiation is normally used as an information carrier in remote sensing. The human visual system is an example of a remote sensing system.

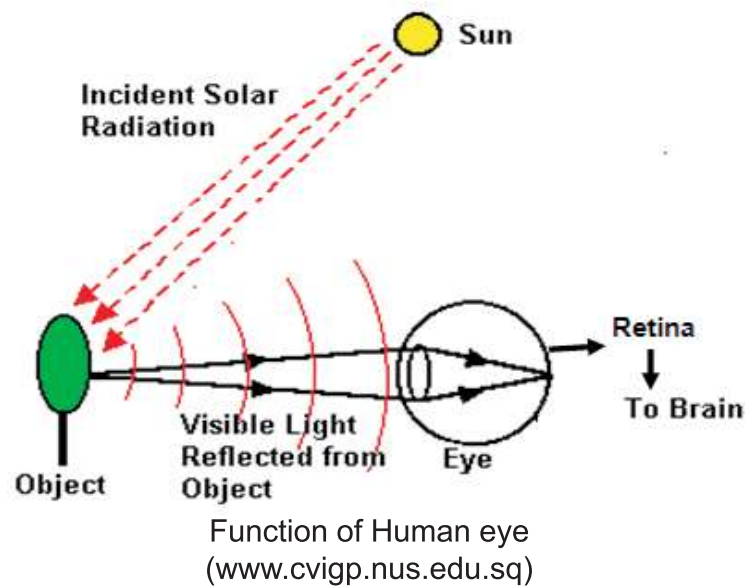


Fig. 34

Light emanates from the source of radiation. The radiated light passes over a distance, and is captured by a sensor (your eyes). Each eye sends a signal to a processor (your brain), which records the data and interprets this into information.

Remote sensing is a technology which is used to create maps, without having physical touch of the territory being described. These remote sensing technologies are often deployed from a plane or satellite

Remote Sensing is the science and art of acquiring information about material objects, area or phenomenon, without coming into physical contact with the objects or area or phenomenon under investigation.

(a) Definition of remote sensing:

Remote sensing is the technology used to gather/analyze the information of the earth surface from a far end. This can be done by a few meters from the Earth's surface, from an aircraft flying hundreds or thousands of meters above the surface, or by a satellite orbiting hundreds of kilometers above the Earth.

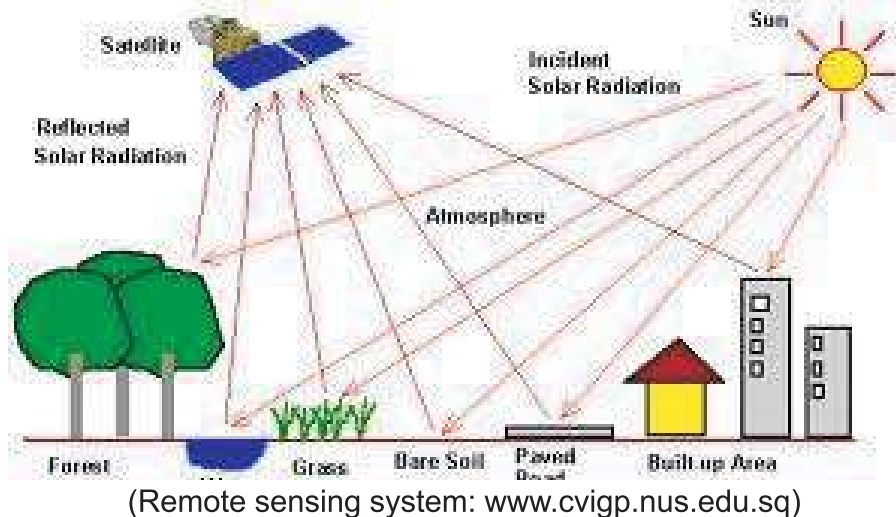


Fig. 35

Remote sensing is a technique used to collect data about the earth without taking a physical sample of the earth's surface. Such examination can occur with devices (e.g. cameras) based on the ground, and/or sensors or cameras based on ships, aircrafts, satellites, or other spacecraft.

3.2 Fundamentals of Remote Sensing

The light originates from the sun or any other source of energy. It hits the earth, bounces and then comes back to the earth into our eyes. The sun provides a source of energy for remote sensing. Radiation can reach and interact with the Earth's surface. There are three forms of interaction that can take place when energy strikes, or is incident (I) upon the surface. These are: absorption (A), transmission (T); and reflection (R). The total incident energy will interact with the surface in one or more of these three ways. The proportions of each will depend on the wavelength of the energy and the material and condition of the

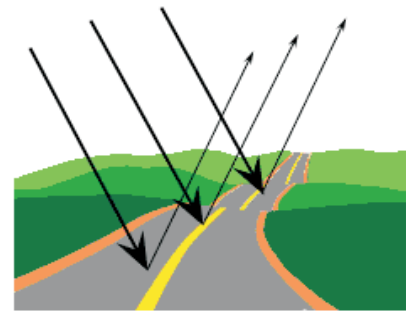




feature. Absorption (A) occurs when radiation (energy) is absorbed into the target while transmission (T) occurs when radiation passes through the target. Reflection (R) occurs when radiation "bounces" off the target and is redirected. Remote sensing measures the radiation reflected from targets.

Why in this picture does the rose look red and leaves look green? The color of an object is determined by the energy which it reflects. Sun is the source of energy which emits the electromagnetic radiations. These radiations strike the earth objects and reflect back. The reflected energy decides the color of the

object. This reflectance' in that fraction of the radiation falling upon a surface which is reflected back by the surface. This reflectance depends upon the chemical composition and physical properties of the object. Different type of objects different patterns of reflectance. Because of this phenomenon we can distinguish the colors of objects. The objects which reflect the green color look green and the objects reflecting red color, look red. If all the energy is reflected back to atmosphere then the object looks white.



CCRS



CCRS



Fig. 36

Why black board looks black?

What happens to absorbed energy ?

3.3 Physics of Electro Magnetic energy (EMR)

Generally in remote sensing we use Sun as source of energy. The energy emitted by the sun has both magnetic and electric fields. These two fields are propagating perpendicular to each other. This energy is called Electromagnetic energy. As it propagates in the forms of waves we call it Electromagnetic waves.

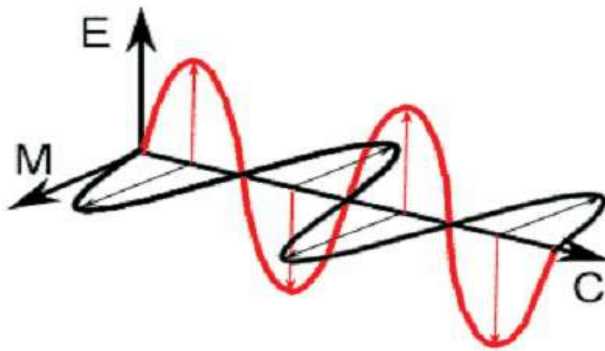


Fig. 37

Electric and magnetic fields are propagating perpendicular to each other.



Sun is the source of Energy. The energy emitted by the sun is travels at the speed of light, that is, 3×10^8 m/s.

Electromagnetic Waves have different wavelengths. When we listen to the radio, watch TV, or cook in a microwave oven, we are using electromagnetic waves. Radio waves, television waves, and microwaves are different types of electromagnetic waves. They differ from each other in wavelength

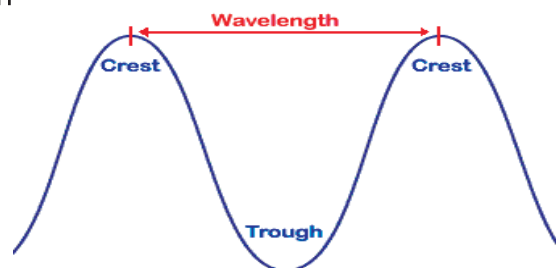


Fig. 38





(a) Wavelength: The distance between successive crests of waves is called wavelength

(b) Frequency: The number of crests per second is called frequency. The larger the distance between two crests the longer is the wavelength, but shorter is the frequency.

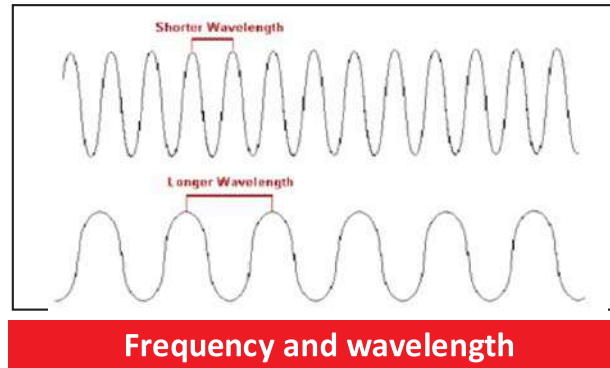


Fig. 39

(c) Electro Magnetic Spectrum:

Electromagnetic radiation is classified into several types according to the frequency of its wave. These types include radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, X-rays and gamma rays. A small variable window of frequencies is sensed by the eyes of various organisms; this is called visible spectrum.

The light which our eyes can detect is part of the visible spectrum. The visible wavelengths cover a range from approximately 0.4 to 0.7 μm . This visible part of the electromagnetic spectrum consists of the colors (VIBGYOR) that we see in a rainbow - from reds and oranges, through blues and purples. As shown in the Figure. (40)

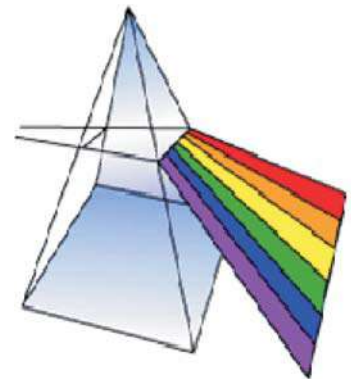


Fig. 40

The longest visible wavelength is red and the shortest is violet. Common wavelengths of what we perceive as particular colors from the visible portion of the spectrum are listed below. It is important to note that this is the only portion of the spectrum we can associate with the concept of colors.

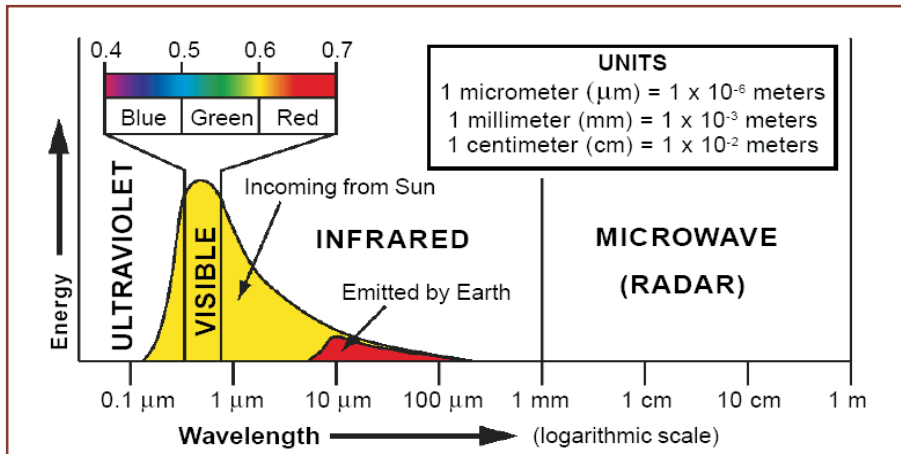


Fig. 41

Electromagnetic Spectrum Source RSE

Visible Wavelength Spectrum Coverage	
Wavelength (μm)	Color
0.4 - 0.446	Violet
0.446 - 0.500	Blue
0.500 - 0.578	Green
0.578 - 0.592	Yellow
0.592 - 0.620	Orange
0.620 - 0.700	Red

Table 1

The next to visible band in EMR spectrum is Infrared band which is not visible to human eye. The reflection by this band is very prominent to identify the features. The remote sensing sensors can recognize this infrared band of electromagnetic spectrum. So in the case of satellite based remote sensing we are using infrared band along with normal visible band.



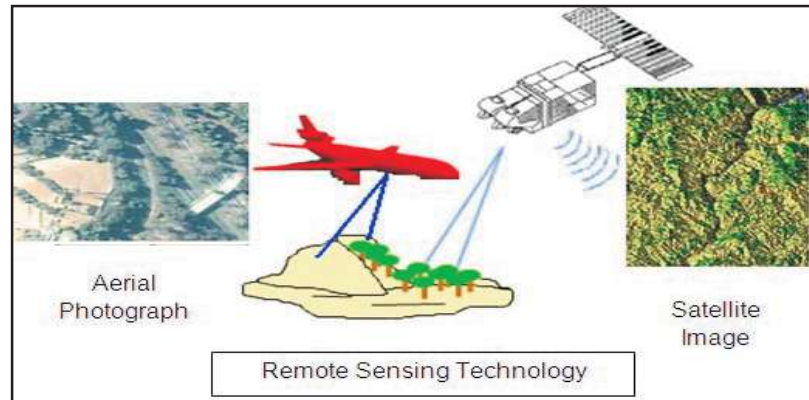


Fig. 42

Photographs acquired by the camera can view only visible range EMR for example Aerial Photographs. Satellite sensors can view beyond the visible band for example satellite imagery.

(a) Spectral Signature

As we discussed earlier each and every object has a unique kind of reflection pattern based on their chemical composition and physical properties. This unique reflectance pattern of individual object is called spectral signature. Spectral reflectance is the portion of incident radiation that is reflected by a non-transparent surface. The reflectance of features varies at different wavelengths.

This is an essential property of matter that allows for different features to be identified and separated by their spectral signatures. The graph shows the different objects which reflect different amounts of energy in various spectral bands. For example longer wavelength visible and near infrared radiation is absorbed more by water than shorter visible wavelengths. Thus water typically looks blue or blue-green due to stronger reflectance at these shorter wavelengths, and darker if viewed at red or near infrared wavelengths. If there is suspended sediment present in the upper layers of the water body, then this will allow better reflectivity and a brighter appearance of water.

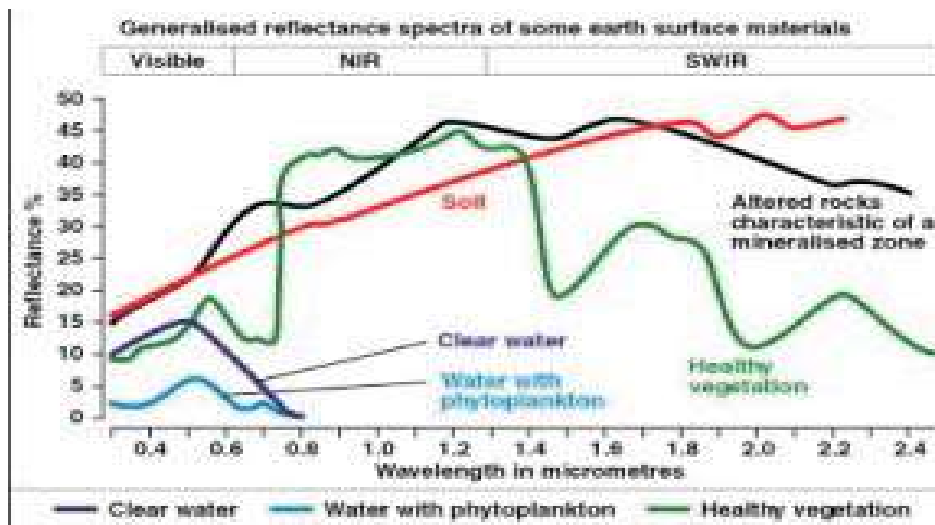


Fig. 43

Spectral signature of different elements

www.vsacl.co.vk

Suspended sediment can be easily confused with shallow (but clear) water, since these two phenomena appear very similar. Chlorophyll in algae absorbs more of the blue wavelengths and reflects the green, making the water appear greener in color when algae are present. The topography of the water surface (rough, smooth, floating materials, etc.) can also lead to complications for water-related interpretation due to potential problems of spectral reflection and other influences on color and brightness. In case of vegetation may reflect somewhat similarly in the visible wavelengths but are almost always separable in the infrared. Spectral response can be quite variable, even for the same target type, and can also vary with time (e.g. "green-ness" of leaves) and location. The barren land looks white in color because it reflects all the energy received by the sun. An object absorbing all visible wavelengths will appear black.

(e) Remote Sensing Process flow: Remote sensing process is completed through some steps using different techniques and equipments as indicated below:



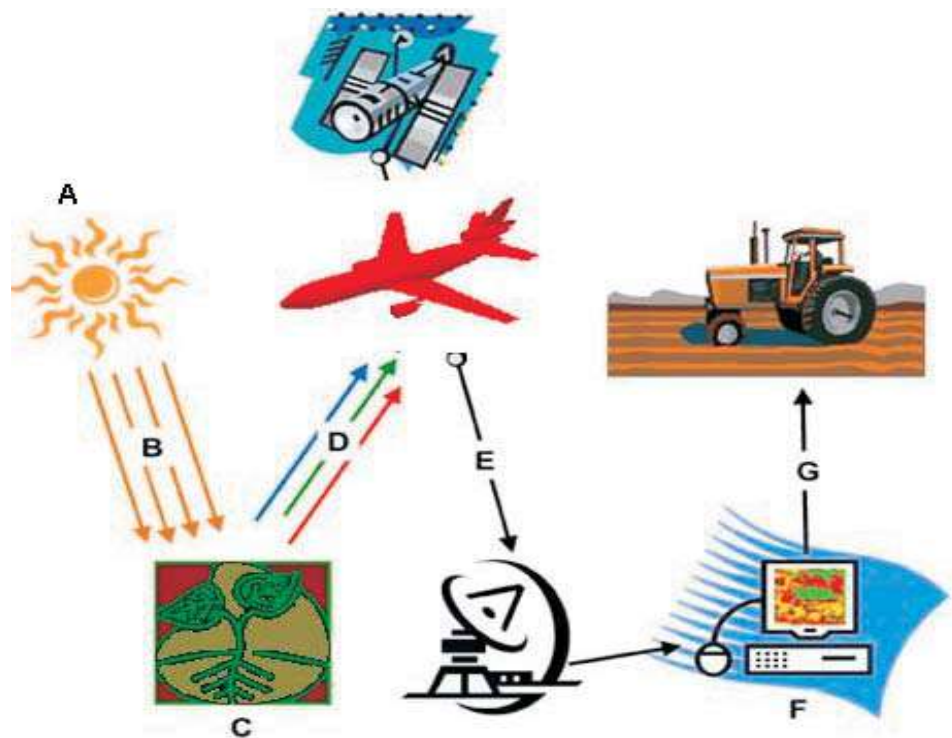


Fig. 44

Remote Sensing Process flow

1. **Energy Source or Illumination (A)** - the first requirement for remote sensing is to have an energy source which illuminates or provides electromagnetic energy to the target of interest.
2. **Radiation and the Atmosphere (B)** - as the energy travels from its source to the target, it will come in contact with and interact with the atmosphere it passes through. This interaction may take place for the second time as the energy travels from the target to the sensor.
3. **Interaction with the Target (C)** - once the energy makes its way to the target through the atmosphere, it interacts with the target depending on the properties of both the target and the radiation.

4. **Recording of Energy by the Sensor (D)** - after the energy has been scattered by, or emitted from the target, we require a sensor (remote - not in contact with the target) to collect and record the electromagnetic radiation.
5. **Transmission, Reception, and Processing (E)** - the energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data are processed into an image (hardcopy and/or digital). Examples for Remote Sensing products are shown below.



Fig. 45

Satellite Imagery



Fig. 46

Aerial Photography

6. **Interpretation and Analysis (F)** - the processed image is interpreted, visually and/or digitally or electronically, to extract information about the target which was illuminated.
7. **Application (G)** - the final element of the remote sensing process is achieved when we apply the knowledge we have been able to extract information from the imagery about the target in order to better understand it, reveal some new information, or assist in solving a particular problem

Aerial Photographs can be captured by using the Analog camera or by Digital Camera.





3.4 Remote Sensing Platforms Sensors and Data Products

(a) Remote Sensing Platforms

Platform is a stage to mount the camera or sensor to acquire the information about a target under investigation. The sensor needs to be placed on suitable observation platforms. They can be stationary or mobile depending upon the needs of observation and constraints. The resolution becomes poorer as the platforms height increases, and the area coverage also increases. Platforms for remote sensors may be situated on the ground, on an aircraft or balloon (or some other platform within the Earth's atmosphere), or on a spacecraft or satellite outside of the Earth's atmosphere. In broad sense we can classify the Platforms in three groups

1. Ground based Platforms
2. Airborne Platforms
3. Space borne Platforms

(i) Ground based Platforms

Ground-based platforms are mainly used for collecting the detailed information of the earth surface. In these cases the sensors or cameras are placed on a ladder, tall building, crane etc. The images or photographs collected by these platforms are very clear compared to the rest of the platforms. But its viewing area is very limited so Ground based platforms cannot be used for large area mapping



Ground Based Platform

Fig. 47

Activity – 1 Capture the two photographs of your school building

By standing next to your school building

By standing 500 m away from the school building

Compare both the photographs for resolution and area coverage

(ii) Airborne Platforms

Airborne Platforms are basically used to collect detailed photographs of the target area. The sensors are mounted on the balloons or aircrafts etc. Compared to ground based platform these platforms collect the information from a larger area because the general altitude of these platforms is around 2000-3000 meters.



Fig. 48

Airborne Platform

Analog Aerial Photography, Videography and Digital Photography commonly use airborne platforms

(iii) Space borne Platforms

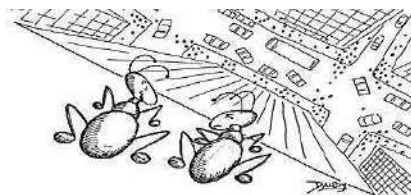
Here mainly satellites are used to carry the sensors. These satellites are revolving round the earth's surface at an altitude of around 800 Km. The data obtained from the satellites are in the form of Images and they cover more area. The resolution of the satellite Images is comparatively less than that of aerial photographs. Nowadays we have advanced sensors which provide the Images at a resolution of 0.6m.



Fig. 49

Space born Platform

Resolution defines the clarity of the picture. When height is more the picture clarity will be less but we can view more data as in satellite Images. Aerial Photographs are taken at a Low altitude than the satellite Images so we can get better pictures but area coverage is less.



"From up here they look like us."

Fig. 50





(b) Remote Sensing Sensors

Sensors are electronic devices which collect and record electromagnetic energy which is reflected/emitted from the target or surface.

There are two basic types of sensors:

- Passive Sensors
- Active Sensors

(i) Passive Sensors

Passive sensors record radiation reflected from the earth's surface. The source of this radiation must come from outside the sensor; in most cases, this is solar energy. Because of this energy requirement, passive solar sensors can only capture data during daylight hours.

(ii) Active Sensors

Active sensors are different from passive sensors. Unlike passive sensors, active sensors require the energy source to come from within the sensor. For example, a laser-beam remote sensing system is an active sensor that sends out a beam of light with a known wavelength and frequency. This beam of light hits the earth and is reflected back, recording the time it took for the beam of light to return.

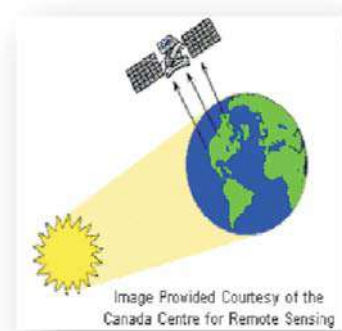


Fig. 51



Fig. 52

Example: Camera without Flash light is the Passive Sensor. Camera with flashlight is the active sensor.

(c) Remote Sensing data Products

The data captured by the Remote Sensing Technology are classified as:

- Analog Data
- Digital Data

These are captured by using ground based Platforms or airborne platforms. The platform like balloons and aircraft carry the Analog camera to capture the images of earth surface. The analog camera uses thin films to record and store the reflected light energy.



Fig. 53

These films are made by the light sensitive material. When EMR strikes this material it causes chemical change in the material. These variations are then developed to produce a photograph. Analog photography is capable of providing high resolution. These photographs need to be scanned while feeding to the system.

(a) Digital Images

(i) Digital Camera Imagery

These images are captured by the digital camera which is mounted on the ground based or airborne platforms. The reflected energy from the features is stored in the digital Format and can be transmitted directly to the system for further analysis.



Fig. 54





(b) Satellite Imagery

The sensors which are mounted on Remote sensing satellites are the source for Satellite Imagery. The sensor records the reflected EMR and converts it into digital numbers. These digital numbers are collected by the ground receiving station. Receiving station processes these data and converts each digital number into picture element. These are called pixels. The pixels arranged into a matrix format give the complete image of a particular location. The digital number of each pixel is determined by the brightness associated with it.



Fig. 55

**Overview of Ground Station Complex,
Shadnagar Near Hyderabad**

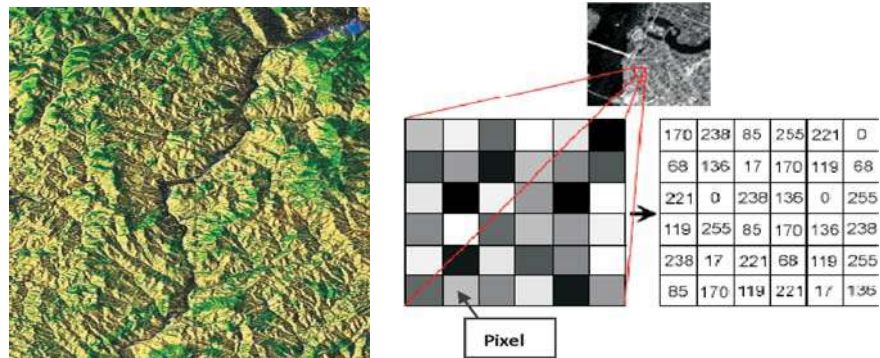


Fig. 56

Pixels (Picture Element) Pixel is the smallest possible feature that the sensor or digital camera can detect. Pixel determines the resolution of the data.

(c) Spatial Resolution

Spatial Resolution refers to the size of smallest object that can be identified on the ground. In a digital image, the resolution is limited by the pixel size, i.e. the smallest object identified by sensor cannot be smaller than the pixel size. For example, IRS LISS have resolution of 72.5 m; it means sensors can identify the object of size 72.5 m on the ground. Similarly satellite sensor for example Cartosat-1 – 2.5 m resolution can identify the object of size 2.5 m

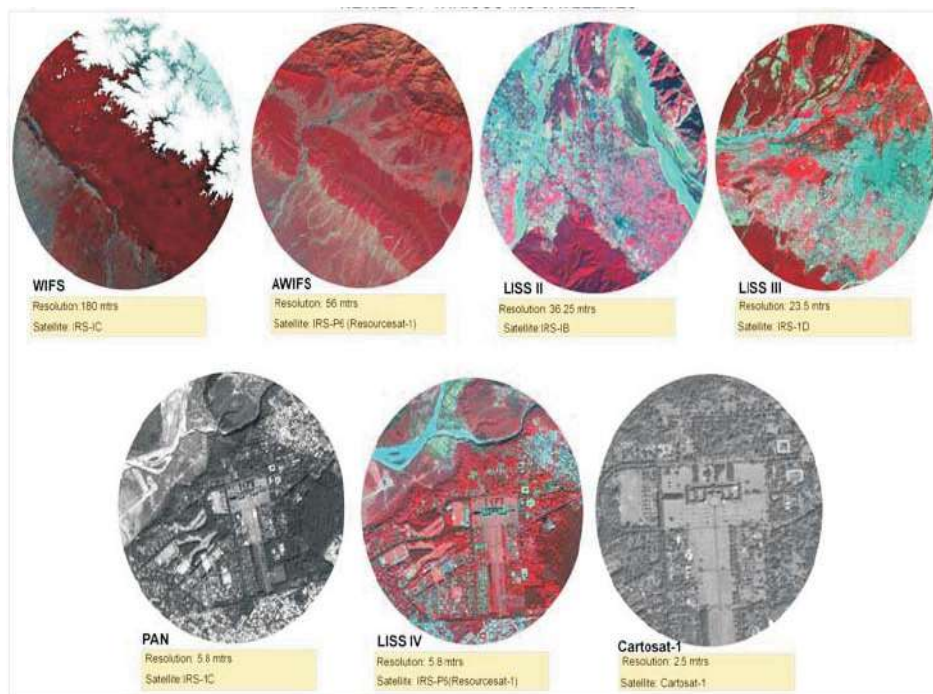


Fig. 57

High resolution has more clarity than low resolution

(Source : RRSC - North)





Remote Sensing Satellites

The remote sensing satellites are placed in Sun synchronous orbits. A sun synchronous orbit means that a satellite passes over each area of the Earth's surface at a constant local time of day called local solar time. These satellites follow the path of North to South

Direction (pole-pole direction) as earth revolves in direction of West to East. The altitudes of these satellites are around 700 - 800 km. The sensors mounted on the satellite 'sees' a certain portion of the earth surface, this is called Swath. Swaths for space borne sensors generally vary between tens and hundreds of kilometers wide.

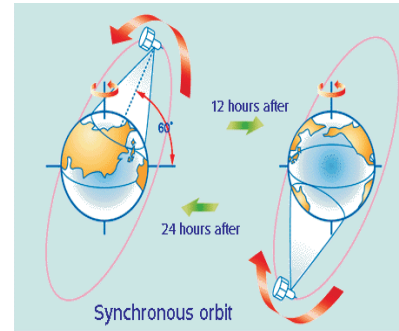


Fig. 58

Remote Sensing Satellite Orbits

Satellite Orbits

The path followed by a satellite in space is referred to as its orbit. Every satellite has to maintain its own orbit. Basically there are two types of orbits.

Sun synchronous
Geostationary

All the remote sensing satellites follow sun synchronous orbits. (Eg-IRS series The Communication satellites follow the geostationary orbit (Inset Series) In Geostationary orbits satellites always view a particular portion of the earth.

3.5 Indian Remote Sensing Satellite Systems (IRS)

Indian Remote sensing systems (IRS) commission was established in 1988. It has the world's largest constellation of five remote sensing satellites IRS - 1C, IRS - 1D, IRS-P3, IRS - P4 (OCEANSAT1) offering space base data in a range of spectral band spatial resolution and swaths. The data is used to several applications covering agriculture, water resource, urban development, Forestry, Drought and Flood forecasting and Ocean resources. National Remote Sensing Centre (NRSC) is one of the centers of Indian Space Research Organization under the Department

of Space, Govt. of India, engaged in operational remote sensing activities. NRSC has its own ground station at Shadnagar, 60 Km south of Hyderabad to acquire remote sensing satellite data from the Indian Remote Sensing satellites. India's first civilian remote sensing satellite IRS - 1A was launched in March 1988. Subsequently, IRS - 1B, having similar sensors, was launched in August 1991, and they provided better receptivity. The LISS - III, PAN and WiFS sensors on IRS - 1C (December 1995) and IRS - 1D (September 1997) further strengthened the scope of remote sensing. The launch of IRS - P6 (Resourcesat - 1) in October 2003, provided an excellent opportunity to obtain high resolution multi-spectral data. IRS - P5 (Cartosat - 1), launched on May 5, 2005, catapulted the Indian Remote Sensing program into the world of large scale mapping and terrain modeling applications. Subsequently in Jan 2008 CARTOSAT- 2 was launched, which led Indian Remote Sensing to the class of high resolution satellites. It has a PAN camera with 0.8 m resolution. Ocean sat - 2 was launched on September 23, 2009

3.6 Remote Sensing Applications

Remote sensing technology collects the earth surface features in the form of imagery. The collected imagery from this technology helps to monitor and map the natural resources and manage them properly. In recent years the high resolution data integrated with GIS tools play a major role in the mapping of natural resources like agriculture, forestry, geology, water, ocean etc It also allows monitoring the environment and thereby helping in conservation. Some of the major applications of Remote sensing data are discussed below:





(a) Coastal Zone Studies

Under the Coastal Zone Studies project are included mapping & monitoring of coastal zone, mangroves and coral reefs and development of Coastal Zone Information System. The mapping includes monitoring of vital / critical habitats, marine protected areas, shore line changes and impact of sea level rise and integrated coastal zone management.

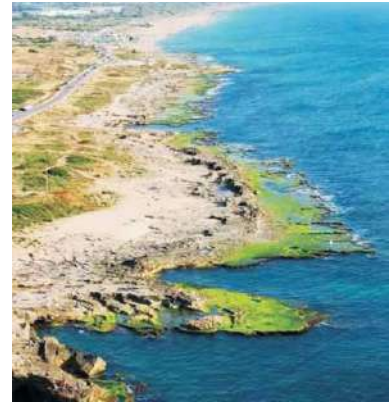


Fig. 59

Image Shows Coastal Zone

(b) Flood Mapping and Monitoring

Remote sensing techniques are used to measure and monitor flooded areas to efficiently target rescue efforts and to provide quantifiable estimates of the amount of land and infrastructure affected. A constant watch is kept on the flood situation in the country through hydrological and meteorological information from remote sensing sources. Major floods/cyclones are mapped and monitored with the high resolution satellite data. Remotely sensed data integrated with GIS allows for quick calculations and assessments of water levels, damage, and areas facing potential flood danger.



Fig. 60

Flooded area by Yamuna River

(c) Land Cover & Land Use

With multi-temporal analyses, remote sensing gives an overview of the city. The remote sensing helps in mapping rural to urban land use changes. By this we can discriminate between rural usage (farming, pasture, forests) and urban usage (residential, commercial, and recreational). Remote sensing methods can be employed to classify types of land use over large areas.

(d) Other Remote Sensing Satellites

Apart from the Indian Remote Sensing Satellites, NRSA acquires and distributes data from a number of foreign satellites. During the 1970's and 80's, India's remote sensing data needs were being addressed by foreign satellites like LANDSAT, NOAA, SPOT etc. With the setting up of an Earth Station at Hyderabad in 1979, data reception started from LANDSAT satellite. NRSA continues to acquire or distribute data from foreign satellites to supplement the data requirements of its users. Currently, NRSA is acquiring data from NOAA - 17, NOAA-18, TERRA, AQUA and ERS. Apart from acquiring, NRSA also distributes data collected by RADARSAT, IKONOS, QUICKBIRD, ORBIMAGE and ENVISAT.

Let's us wrap up what we covered in this chapter:

- Remote sensing is the technology to collect the information about the earth features without any direct contact.
- Remote sensing can be done by a few meters from the Earth's surface, from an aircraft flying hundreds or thousands of meters above the surface, or by a satellite orbiting hundreds of kilometers above the Earth.
- The sun provides a source of energy for remote sensing.
- When sun light hits on the target elements, it process three types of actions viz. absorption, transmission and reflection.





- Absorption (A) occurs when radiation (energy) is absorbed into the target while transmission (T) occurs when radiation passes through a target. Reflection (R) occurs when radiation "bounces" off the target and is redirected.
- Remote sensing measures the radiation reflected from targets.
- Sun radiation is composed of electric and magnetic fields, so it is called electromagnetic radiation
- Electromagnetic radiation is classified into several types according to the frequency of its wave; these types include (in order of increasing frequency and decreasing wavelength): radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, X-rays and gamma rays.
- A small and somewhat variable window of frequencies sensed by the human eyes is called the visible spectrum.
- Satellite based remote sensing uses infrared band along with normal visible band.
- Spectral reflectance is the portion of incident radiation that is reflected by a non-transparent surface. The reflectance of features varies at different wavelengths.
- Processes involved in Remote Sensing are Energy Source or Illumination, Radiation and the Atmosphere, Interaction with the Target, Recording of Energy by the Sensor, Transmission-Reception- Processing, Interpretation and Analysis, Application.
- Platform is a stage to mount the camera or sensor to acquire the information about a target under investigation.
- Platforms are categorized in three groups like, Ground based, Airborne, and Space borne
- Sensors are electronic devices which collect and record electromagnetic energy which is reflected/emitted from the target or surface.
- Passive sensors use sun as energy source.

- Active sensors use their own energy source
- The data captured by the remote sensing Technology can be classified as: Analog Data and Digital Data
- Remote sensing satellites move in sun synchronous orbit
- Pixel represents the smallest element that the sensor can view at an instant
- Resolution defines the clarity of the Image
- National Remote Sensing Centre (NRSC) is one of the centers of Indian Space Research Organization under the Department of Space, Govt. of India, engaged in operational remote sensing activities.

Review

Very Short Answer Questions

1. Name any one example of direct sensing
2. Which is the source of energy for remote sensing
3. What is wavelength?
4. What is frequency?
5. What is the range of visible spectrum?
6. Can human eye recognize beyond visible band?
7. Why green leaves look green?
8. How can you see seven colors in a rainbow?
9. What is the altitude of remote sensing satellite?
10. Every object has a unique pattern of reflection. Yes or no.
11. Name types of remote sensing platforms.
12. In ground based platform where are camera/sensors placed?
13. Name types of sensors.
14. Name any five types of application of remote sensing.
15. Active sensors use sun as an energy source. True or False.
16. Name the remote sensing data products.
17. What is the source of satellite imagery?





Short Answer Questions

1. Define Remote Sensing?
2. Explain Electromagnetic radiation?
3. Name the various bands in EMR
4. What is Spectral Signature?
5. Why does water look blue, green and black?
6. What is the difference between active and passive sensors?
7. What is Analog data?
8. What is the difference between Analog Photo & digital Image?
9. What is a satellite image?
10. What is (i) a pixel and (ii) resolution?
11. What is the relationship between height and resolution?
12. What is sun synchronous Orbit?
13. Name some of Indian Remote sensing satellites

Long Answer Questions

1. Give an example of remote sensing system and explain.
2. Explain the fundamentals of remote sensing.
3. Explain with diagram the spectral signature of following features, vegetation, soil, barren land water body.
4. Explain the processes involved in Remote sensing
5. Explain types of platforms.
6. Write a brief note on sensors.
7. What is difference between 10 m , 20 m , 30m resolution?
8. Write a brief note on Indian remote sensing system.
9. Explain any one of the Remote sensing applications.

CHAPTER – 4

Geographic Information System (GIS)

Learning Objectives

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

- 4.1 Understand the Geographic information System (GIS)
- 4.2 Learn about Various Components of GIS
- 4.3 Study GIS Data Acquisition
- 4.4 Know types of GIS Data
- 4.5 Understand application of GIS

4.1 Fundamentals of GIS

A map represents geographic features or other spatial phenomena by graphically conveying information about locations and attributes. Locational information describes the position of particular geographic features on the Earth's surface, as well as the spatial relationship between features. For example, find the shortest path from a fire station to a library. Attribute information describes attributes of the geographic features represented, such as type of feature, its name or number and quantitative information such as its area or length.

GIS is a tool which represents useful & interactive geospatial data as per user requirements in different types of maps such as Road & River maps etc. It creates and updates the map data intelligently, regularly and manages them efficiently.

Definition of GIS:

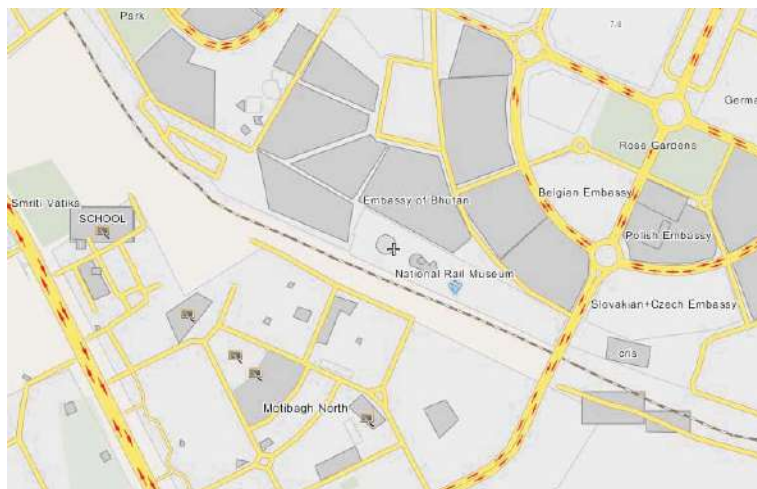
Geographic Information System is computer based system used to digitally represent and analyze the geographic features present on the earth surface along with information about attributes of the geographic feature.





(a) What is Geographic Information System?

Have you ever visited a Museum? Museums are used for seeing interesting things to see than you can possible examine in half a day. How do you decide what to see? How do you find out what to do? At the entrance of every museum you see a row of computer stations. At each station, a screen displays a map of the museum. As you move the computer mouse over the map, a window appears and displays a map indicating how to get there from the museum. GIS is used here. Computer retrieves the Information faster and presents it in a way to understand faster.



Location Map of Museum

Fig. 61

Earlier to GIS era, traditional map techniques were used to check the location of museum on the location map. Here first we search for the location where we are standing currently and check how to reach the place. GIS helps us to find the location within a few seconds. GIS is important because of its ability to analyze maps.

GIS is a way of representing information about the world in the computer in the same way as a map shows the world on paper. GIS can help us in our everyday life. For example, if you wish to know telephone booths in a particular area you need to type telephone booth in GIS software in the computer and it will show the location of all the telephone booths. So GIS would help us to take the decision faster.

GIS is being used widely for natural resource management, environmental monitoring and planning, socio-economic and demographic research. GIS technology enables us to integrate social, economic, demographic and environment database to understand the complexities and inter-connections between different features of natural and human environments.

(b) Why do we need GIS?

Traditional paper maps exist in different map scales and projections. If we want to put together different types of maps laid one over the other, and prepare an integrated single map, we need to get maps of the same scale covering the same area. In GIS at a glance you can get detailed information about each feature. GIS has the facility to convert the map of any scale. Into that of another. In a more generic sense, GIS applications are tools that allow users to create interactive Queries (user-created searches), analyze spatial information, edit data, including maps and present the results of all these operations.

4.2 Components of GIS

A geographic information system (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information.

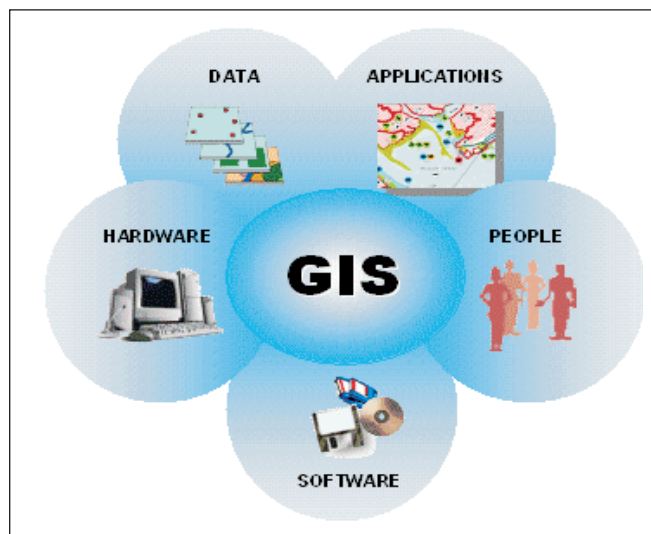


Fig. 62





(a) Hardware

Hardware is the computer system where GIS operates. Today, GIS software runs on a wide range of hardware types, from desktop computers to centralized computer servers.



Fig. 63



Fig. 64

(b) Software

GIS software provides the functions and tools needed to store, analyze, and display geographic information.

Example - Rolta Geomatica

(c) Data

This is the most important component of GIS system. This includes Geographic data and related tabular data which are called as Spatial and Non spatial data respectively in GIS.

(d) People

GIS technology is of limited value without the people who manage the system and develop plans for applying it to real world problems. GIS users range from technical specialists to those who use it for their daily work.

(e) Methods

A successful GIS operates according to a well-designed implementation plan and business rules, which are the models and operating practices unique to each organization.

4.3 GIS Data Acquisition

Data is a major element of Geographic Information System. GIS uses various types of data which comes from various sources, and in different formats. GIS software helps the system to handle any type of data. The major data sources for GIS are listed and discussed in details below:

- a. Remote Sensing Data
- b. Global Positioning System (GPS) Data
- c. Paper Maps
- d. Scanned Drawings
- e. (Existing) Digital Data
- f. Statistical Data

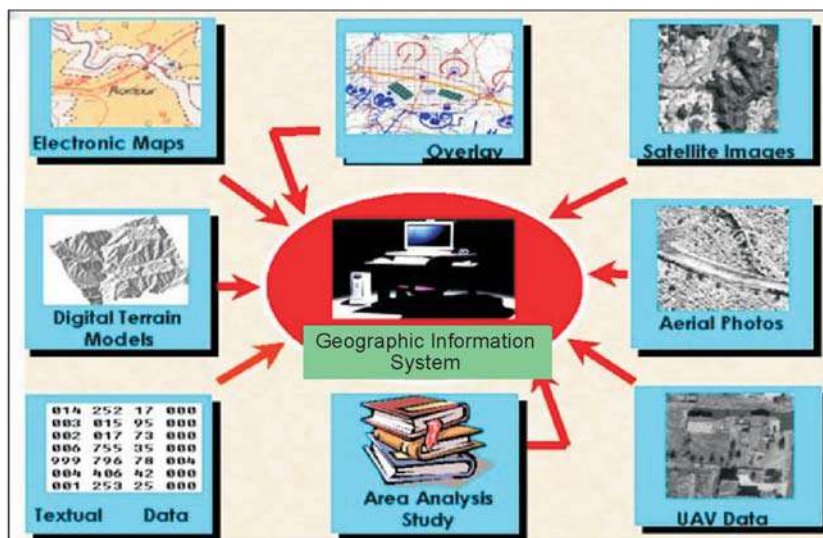


Fig. 65

(a) Remote Sensing Data

Remote sensing is the technology which is used to gather, analyze the information of the earth surface from a far end. By this technology we can get the picture of earth surfaces in the forms Aerial Photographs or Satellite Images. GIS uses these data for further analysis and helps better management of resources. (Details of Remote Sensing are Discussed in Chapter-3)





(b) Global Positioning System Data:

GPS stands for Global Positioning System and it allows users to determine their location on land, sea and in the air around the earth. GPS uses satellites information of the features. This collected location information in the form of latitude and longitude can be fed to the GIS to help users analyze the information.



Fig. 66

Data Samples from GPS



Fig. 67

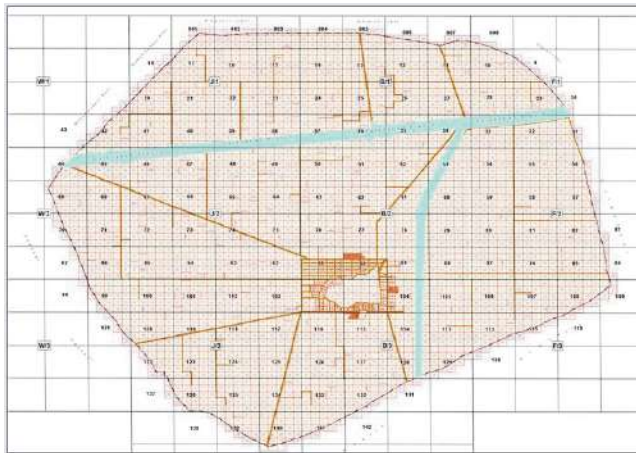
	A	B	C	D
1	Point_Id	Latitude	Longitude	
2	Gcp_1	12.63	76.76	
3	Gcp_2	12.63	76.76	
4	Gcp_3	12.63	76.78	
5	Gcp_4	12.63	76.78	
6	Gcp_5	12.64	76.77	
7	Gcp_6	12.64	76.77	
8	Gcp_7	12.66	76.73	
9	Gcp_8	12.66	77.27	
10	Gcp_9	12.65	76.74	
11	Gcp_10	12.65	76.74	
12	Gcp_11	12.65	76.74	
13				

(c) Paper Maps:

This is one of the inputs to GIS. These maps essentially contain information about an area like buildings, urban development, boundaries, railways, power transmission lines, electric poles, canals, lakes, rivers, parcel boundary, streams, etc. The data is extracted from these maps and analyzed by GIS. For example Toposheets, Cadastral Maps etc.

(d) Scanned Drawings

These also act like an input for GIS. For example most of the Utility companies store their records in hard copy. Now a days all the utility companies are converting their hard copy into softcopy data to computerize their daily routine work using GIS. All those hard copy maps are scanned and fed to the system for further process like Capturing the feature, adding the attributes, building the relationship between the elements, and finally to get proper decision making system.



Data Samples from Scanned Drawing

Fig. 68

(e) Existing Digital Data

The data which are in vector format can be the source for GIS system. The data which are created by using any of the GIS software or any CADD system can be fed to the GIS systems for further process. This data already in vector format can be directly used it to build the relation between the elements and data analysis.



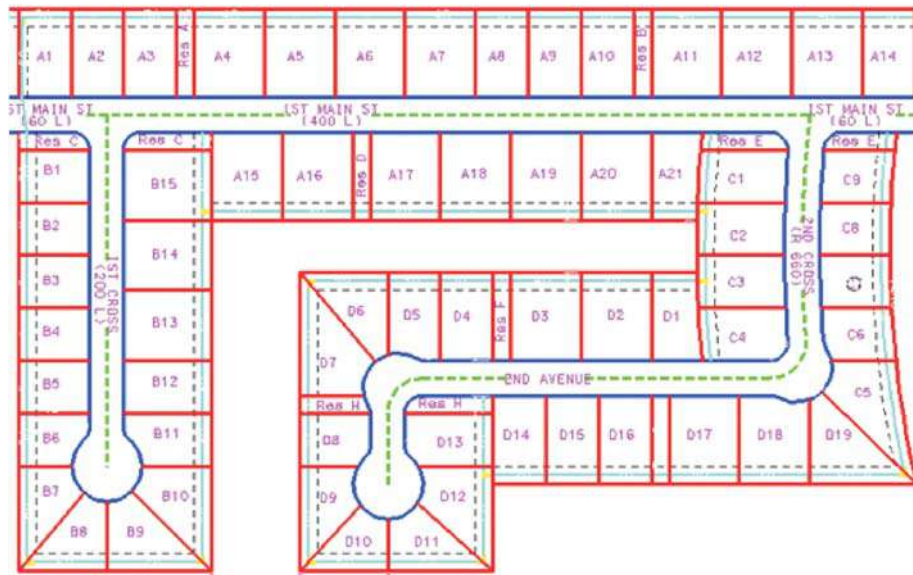


Fig. 69

Data Samples from CADD Data

(f) Statistical Data

These are tabular data or we can say attribute data, which can be attached to the Geographic features. The report or tabular data shows the information of geographic or spatial data. It is also called Non spatial information.

Table-2

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)			Sex ratio (females per 1000 males)	Density (per Sq.km.)	Decadal growth rate
			Persons	Males	Females			
1	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

Data Sample for Non Spatial Information

4.4 Data Types of GIS

The map communicates to us through its symbols and text. We can easily see the map features and their spatial relationships. GIS does not store a map in any conventional sense, nor stores a particular image or view of geographical area. Instead, a GIS stores geographic data with its size, shape, location and related attribute information.

Based on this the GIS data is categorized as

- Spatial Data
- Non-Spatial Data.

(a) Spatial Data

Spatial data also known as graphic data. Spatial data refers to information related to a location anywhere on the earth's surface. Spatial Data describes the location of a geographic feature which is usually stored as coordinates and its relation with other features. Spatial Data are available in many forms including digital maps, paper maps, photograph prints and digital satellite images. These data can be manipulated in desktop mapping or GIS programs.

The basic properties of spatial data are given below:

- Location
- Size & shape
- Relation between the features

GIS stores the spatial data in two formats which are known as:

- Raster Data
- Vector Data

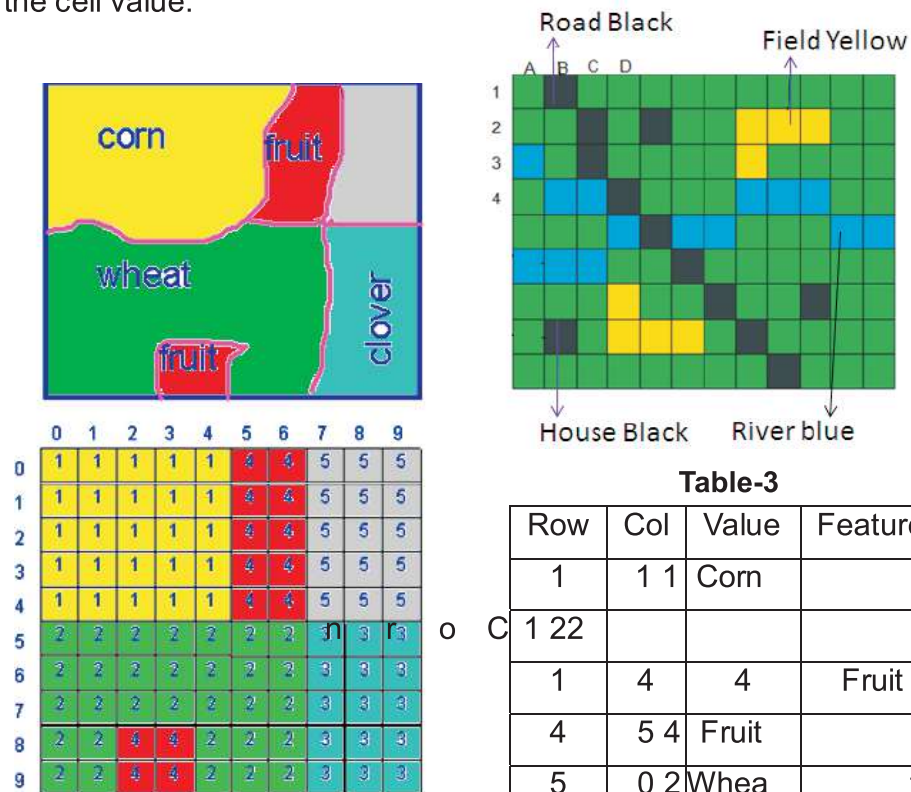
(i) Raster Data

The raster data uses a regular grid to cover the space based on the satellite resolution. For example if the resolution is 10 m then all the grids are 10 m size. In raster data each area is divided into rows and columns, which form a regular grid structure. Each cell within this matrix contains pixel location co-ordinates as well as attribute values.





The variation of the spatial phenomenon is reflected by the changes in the cell value.



The Cell value indicates value of the pixel, by which we can differentiate the features.

Fig. 70

Table-3

Row	Col	Value	Feature
1	1 1	Corn	
1 2 2			
1	4	4	Fruit
4	5 4	Fruit	
5	0 2	Whea	t
6	2 2	Whea	t
7	1 2	Whea	t
9	8 4	Fruit	
8	7	3	Clover
8	8 3	Clover	

A wide variety of data used in GIS are encoded in raster format. They include digital elevation data, satellite images and scanned maps. Most GIS packages can display raster and vector data simultaneously and convert from raster to vector data or vector to raster data.

(ii) Vector data

Vector is a data structure, used to store spatial data. Vector data is comprised of lines or arcs, defined by beginning and end points, which meet at nodes. Vector data represents the features more accurately. They are preferred in urban applications where legal boundaries and the analysis of networks are important.

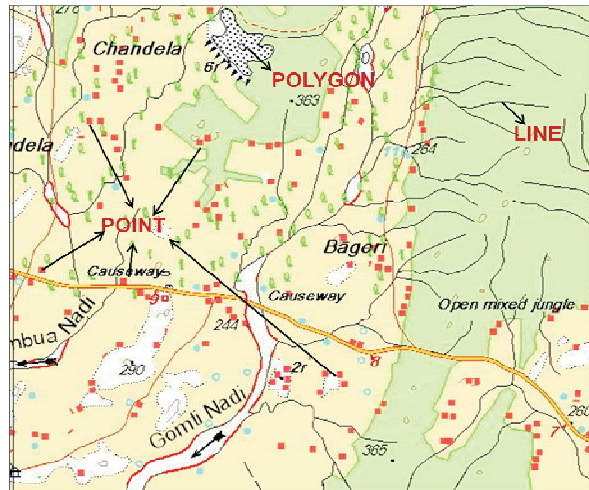


Fig. 71

GIS stores the data in vector format in three basic elements which are

- (i) Point Features
- (ii) Line Features
- (iii) Polygon Features

Vector data are good at accurately representing true shape and size; of non-continuous data for example Rivers, political boundaries, road lines, mountain peaks.

(b) Non Spatial Data

The Non Spatial data refer to the properties of spatial entities. They are often referred to as Attribute data. These data do not represent location information but describe characteristics of the spatial features. These characteristics can be quantitative or qualitative in nature.

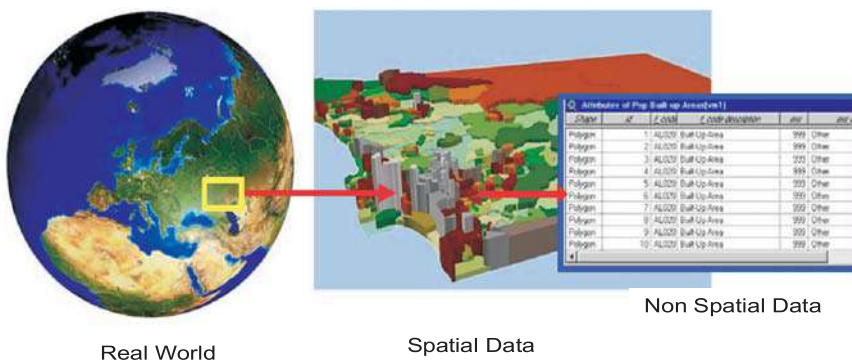


Fig. 72





For example if a map shows the road. The Spatial information shows the location & size of the object. The non spatial information provides the related data like what type of road it is? What is the width of the road?

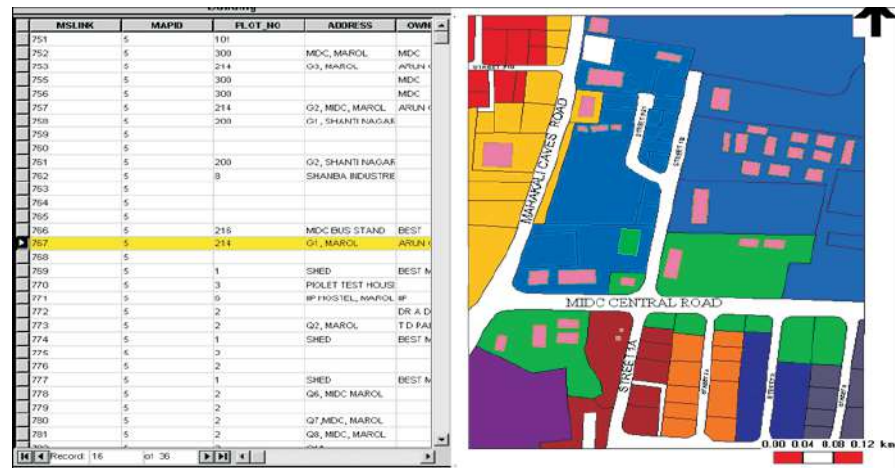


Fig. 73

Road Network is shown in Graphic format -Spatial Data information about the road – Non - Spatial data Linkage between Spatial and Non - Spatial data through unique ID.

Attribute data stores in tables. Each row of a table represents a map feature, and each column represents a characteristic. The intersection of a column and row shows the value of particular characteristics for a particular map feature.

4.5 Applications of GIS

(a) Town Planning

Government / Administrative people using this technology for the town planning, Infrastructure management, and also for the property tax collection.

Example

GIS technology used for Municipal Planning which contains information of all the holdings including tax, house structure, land use, availability of urban facilities and all infrastructure details was put into digital format both in spatial & non spatial form. It is being used for day to day work of

Tax demand notice & collection, preparation of ward level annual plan, identification of deficit area, evaluation of health indicators & Monitoring etc.



Town/City planning By Geospatial Technology

Fig. 74

(b) Public Safety and Defense

Geospatial Technology also plays a major role for disaster management, Public safety, and also provides valuable inputs for the defense department like where the enemy bunkers are located, which are the area easily accessed by the enemies etc



Fig. 75

Public safety & Defense Technology





We cannot predict natural disaster. But by using proper decision making tool we can minimize the damages caused by the natural disasters. Like while cyclone hits the coastal area we can predict the affected location by this technology and plan for the evacuation.

(c) Utility Service

The utility service providers are using this technology to manage their utility network. This tool provides the valuable information like where the new service is required? What is the shortest path to provide the service? Where the regular service is disturbed? How to collect the service charges etc. All of these are better answered by this technology.

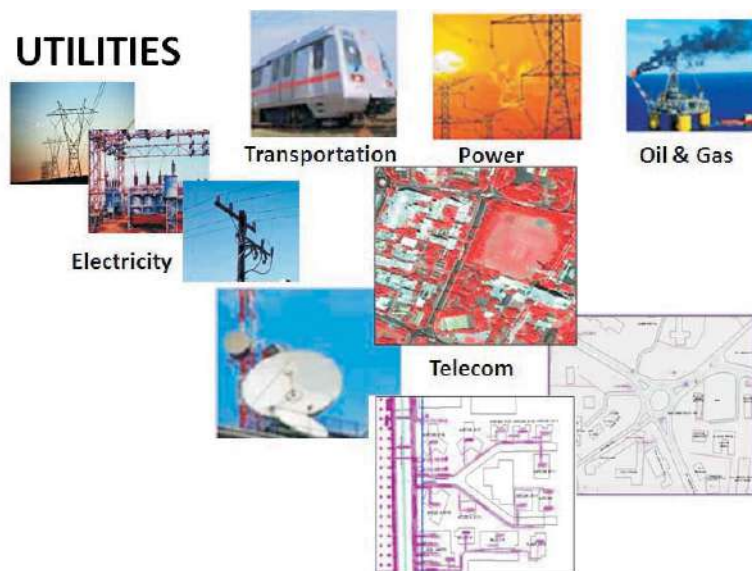


Fig. 76

Utility Services

(d) Infrastructure Planning

Integration of inherently geographical and non-geographical information is the first task for the planning of infrastructural services. For this the Information required is:

- Village location
- Transport and irrigation network
- Topographical information

Let us wrap up what we covered in this chapter:

1. GIS as a mapping tool creates different types of maps as per user requirement.
2. Geographic Information System is computer based system used to digitally represent and analyze the geographic features present on the earth surface along with its attribute information.
3. GIS creates and updates the map data intelligently, regularly and manages them efficiently.
4. GIS application tools allow users to create interactive queries, analyze spatial information, edit data, maps, and present the results of all these operations.
5. GIS integrates five components like hardware, software, data, methods, and people
6. Source data for GIS can be by Remote Sensing, GPS, Topomaps, Scanned Digital data, Statistical Report etc..
7. GIS data is categorized as Spatial data and Non spatial data
8. Spatial data also called graphic data, describes the location shape of geographic features, and their spatial relationship to other features.
9. GIS stores the spatial data in vector or raster format
10. In vector format geospatial data is stored like point, line and polygon features
11. In Raster format geospatial data is stored in regular grid format
12. GIS stores the non spatial data in tabular format
13. Some of the major applications of GIS are listed like Local government, Public safety and defense, Utility service, etc.





Review

Very short Answer Questions

1. What are two types of data in GIS ?
2. What information is available in Spatial Data ?
3. What information is available in Non spatial data?
4. GIS stores the Non-spatial data in tabular form - true or false
5. Name the components of GIS
6. Name the data sources used for GIS
7. In which format does GIS store data? Name it.
8. In Raster data each area is divided in rows and columns. True or False?
9. Vectors are used to store Non-Spatial Data. True or False?
10. Name the elements of Vector data?

Short Answer Questions

1. What is GIS?
2. What do you understand by attribute information and how is it used in GIS?
3. How is GIS used to locate Place of Interest?
4. How are scanned drawings used in GIS?
5. Define in two line:
 - a) Spatial Data
 - b) Non-Spatial Data
6. What is vector data?
7. What is raster data?
8. How is Non- spatial data stored?

Long Answer Questions

1. Explain the components of GIS
2. Why is GIS required?
3. Explain any two applications of GIS

CHAPTER – 5

Global positioning System (GPS)

Learning Objectives

- 5.1 Overview of GPS
- 5.2 Understanding functions of GPS
- 5.3 Knowing the various segments of GPS
- 5.4 Understanding the various factors affecting the GPS Data
- 5.5 Understanding the applications of GPS

5.1 Overview Global Positioning System (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. There are currently 24 satellites in orbit operated by the US Department of Defense (DoD) that provide worldwide coverage 24 hours a day, 7 days a week in all weathers.



Fig. 77

GPS Satellites

Nmt. Edu.

The GPS technology has tremendous amount of applications in GIS data collection, surveying, and mapping in utilities.

The technology can benefit GPS user community in terms of obtaining accurate data upto 100 meters for navigatoion, mapping up to meter level and down to millimeter level for geodetic positioning.





5.2 Functions of GPS

GPS satellite sends time and position information to the receiver. Receiver picks up this information using the signals from at least four satellites. Information user can get latitude, longitude, and elevation information.

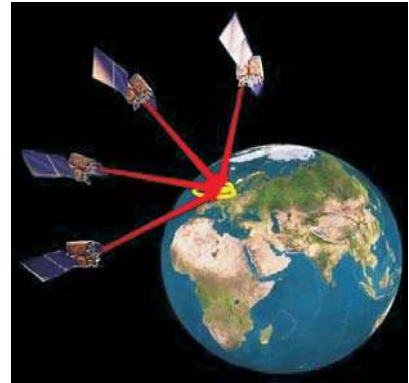


Fig. 78

Functioning of GPS Network

pevisonalgps.wordpress.com.

The Global Positioning System consists of 24 earth-orbiting satellites so that it can guarantee that there are at least 4 of them above the horizon for any point on earth at any time. Each satellite contains an atomic clock. The satellites send radio signals to GPS receivers so that the receivers can find out how far away each satellite is sometimes with millimeters precision at a given time.

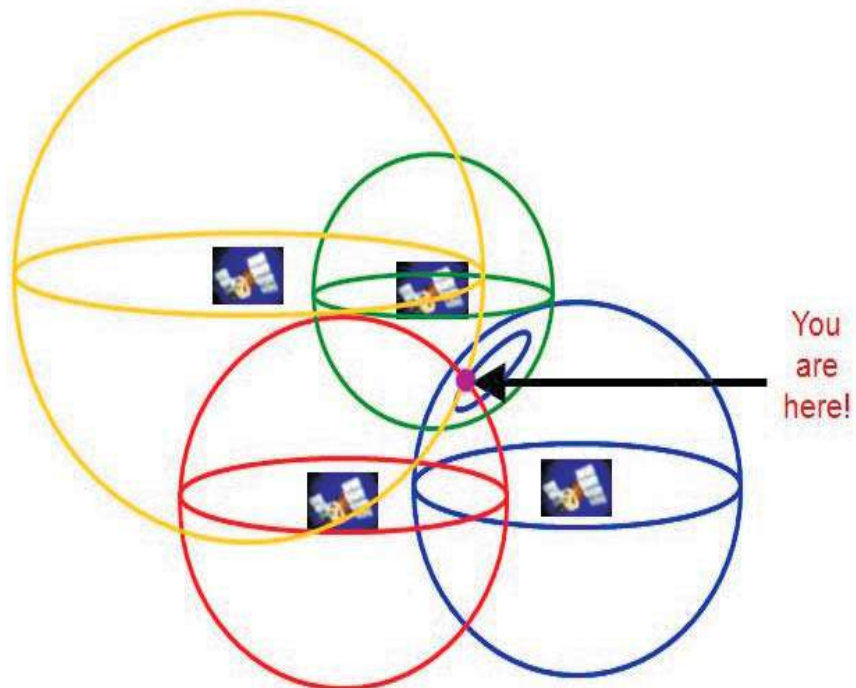


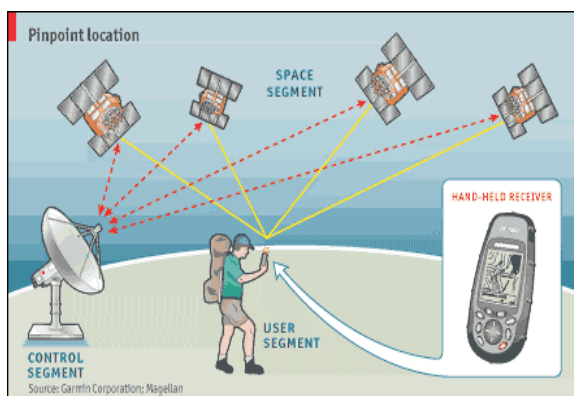
Fig. 79

Trilateration is a basic geometric principle that allows us to find the location of an unknown point by knowing the location of other points. The GPS receiver has the ability to find the receiver's distance from 4 (or more) GPS satellites. Once it determines its distance from the four satellites, the receiver can calculate its exact location and altitude on Earth. If the receiver can only find three satellites, then it can use an imaginary sphere to represent the earth and can give you location information but no altitude information.

5.3 Segments of GPS

The GPS is divided into three major components:

1. The Space Segment
2. The Control Segments
3. The User Segment



Segments of GPS

Fig. 80

(a) The Space Segment

Global Positioning System consists of 24 earth-orbiting satellites. The satellites are arrayed in 6 orbital planes. They orbit at altitude of about 12000 miles. Each satellite contains four precise atomic clocks and has a microprocessor on board for limited self-monitoring and data

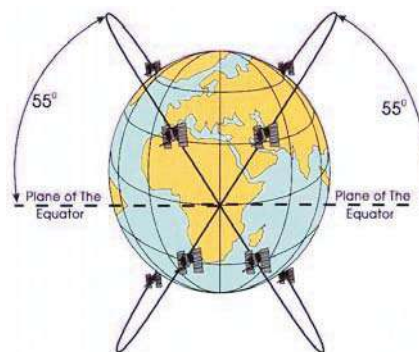


Fig. 81





processing. The satellites are equipped with thrusters, which can be used to maintain or modify their orbits.

(b) The Control Segment

The Control Segment consists of five Monitoring stations (Colorado Springs, Ascension Island, Diego Garcia, Hawaii, and Kwajalein Island). Three of the stations (Ascension, Diego Garcia, and Kwajalein) serve as uplink installations capable of transmitting data to the satellites including new ephemerides (satellite positions as a function of time), clock corrections, and other broadcast message data, while Colorado Springs serve as the master control station.



Fig. 82

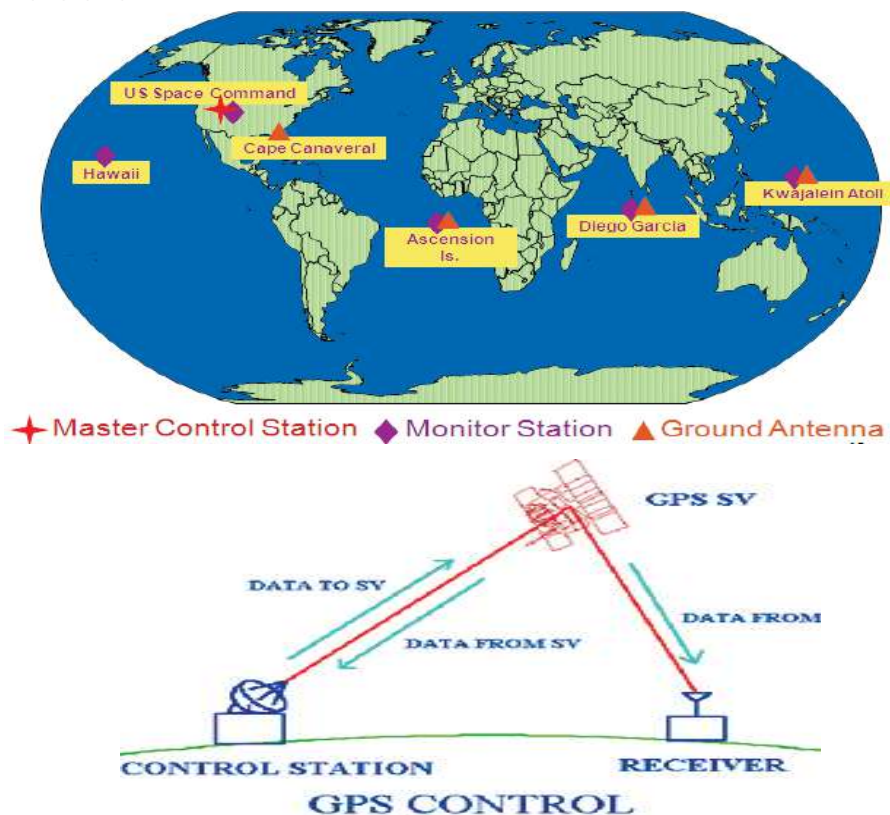


Fig. 83

The Control Segment is the sole responsibility of the DoD who undertakes construction, launching, maintenance, and virtually constant performance monitoring of all GPS satellites.

(c) The User Segment

The GPS receiver is the user segment in GPS system. Entire spectrum of applications equipment and computational techniques that is available to the users.



Fig. 84

5.4 Factors Affecting GPS Data

(a) Accuracy of GPS

The accuracy of GPS depends on several factors such as the receiver and the surroundings in which it is being used in. Factors which affect the accuracy of the GPS readings are explained below

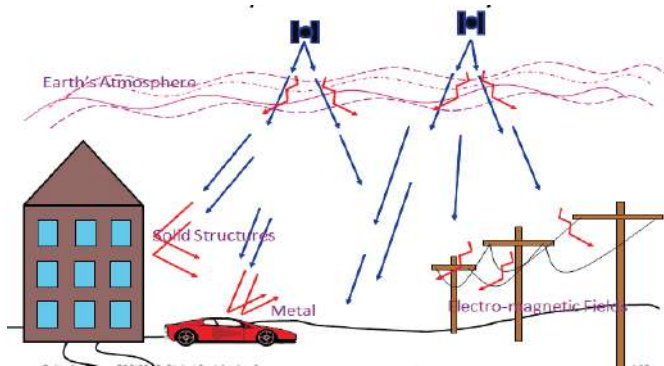


Fig. 85

(b) Atmospheric Conditions

The ionosphere and troposphere both refract the GPS signals. This causes the speed of the GPS signal in the ionosphere and troposphere to be different from the speed of the GPS signal in space. Therefore, the distance calculated from "Signal Speed x Time" will be different for the portion of the GPS signal path that passes through the ionosphere and troposphere and for the portion that passes through space.

(c) Orbital position Error/Clock Drift/Measurement Noise

GPS signals contain information about orbital position (ephemeris) errors, and about the rate of clock drift for the broadcasting satellite. Distortion of the signal by measurement noise can further increase positional error. The disparity in orbital position data can introduce 1-5 meters of positional error, clock drift disparity can introduce 0-1.5 meters of positional error and measurement noise can introduce 0-10





(d) Selective Availability

Orbital position error should not be confused with Selective Availability (SA), which is the intentional alteration of the time and Orbital position signal by the Department of Defense. SA can introduce 0-70 meters of positional error. Fortunately, positional errors caused by SA can be removed by differential correction.

(e) Multipath

A GPS signal bouncing off a reflective surface prior to reaching the GPS receiver antenna is referred to as multipath. Because it is difficult to completely correct multipath error, even in high precision GPS units, multipath error is a serious concern to the GPS user.

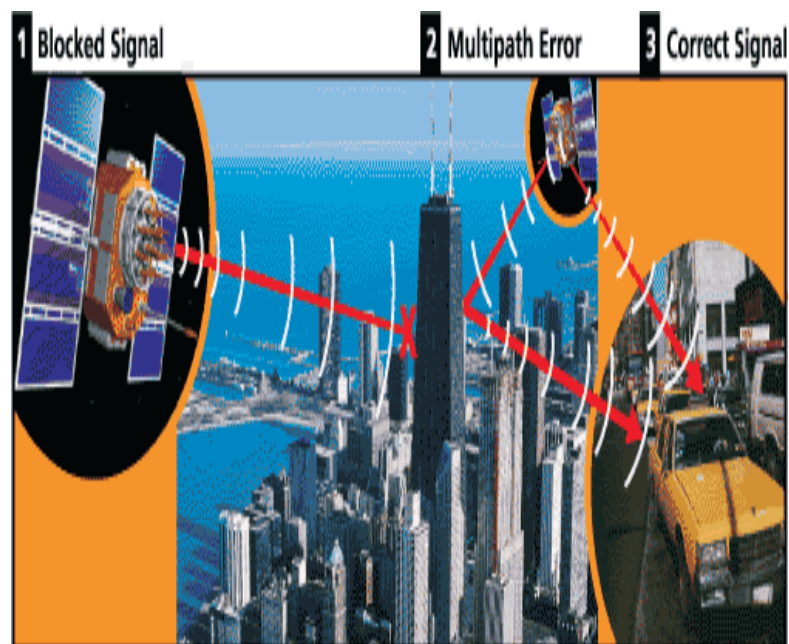


Fig. 86

Multipath error in
GPS Signal
www.aysva.com.my.

5.5 GPS Applications

One of the most significant and unique features of the Global Positioning Systems is the fact that the positioning signal is available to users in any position worldwide at any time. With a fully operational GPS system, it can be generated to a large community which is likely to grow continuously as there are multiple applications, ranging from surveying, mapping and navigation to GIS data capture.



Fig. 87





Let us wrap up what we covered in this chapter:

1. GPS stands for Global Positioning System
2. It allows users to determine their location on land, sea and in the air around the earth.
3. There are currently 24 satellites in orbit operated by the US Department of Defense
4. GPS is divided into 3 Segments
5. The Space Segment consists of the Constellation of 24 earth orbiting satellites.
6. Master control station is in Colorado Springs. Control segment is the sole responsibility of DOD
7. GPS receivers are called User Segment.
8. Atmospheric condition, Orbital position error, selective availability, multipath are some of the factors which affect the GPS readings
9. GPS are used in surveying, navigation, to track the vehicles etc

Review

Very Short Answer Questions

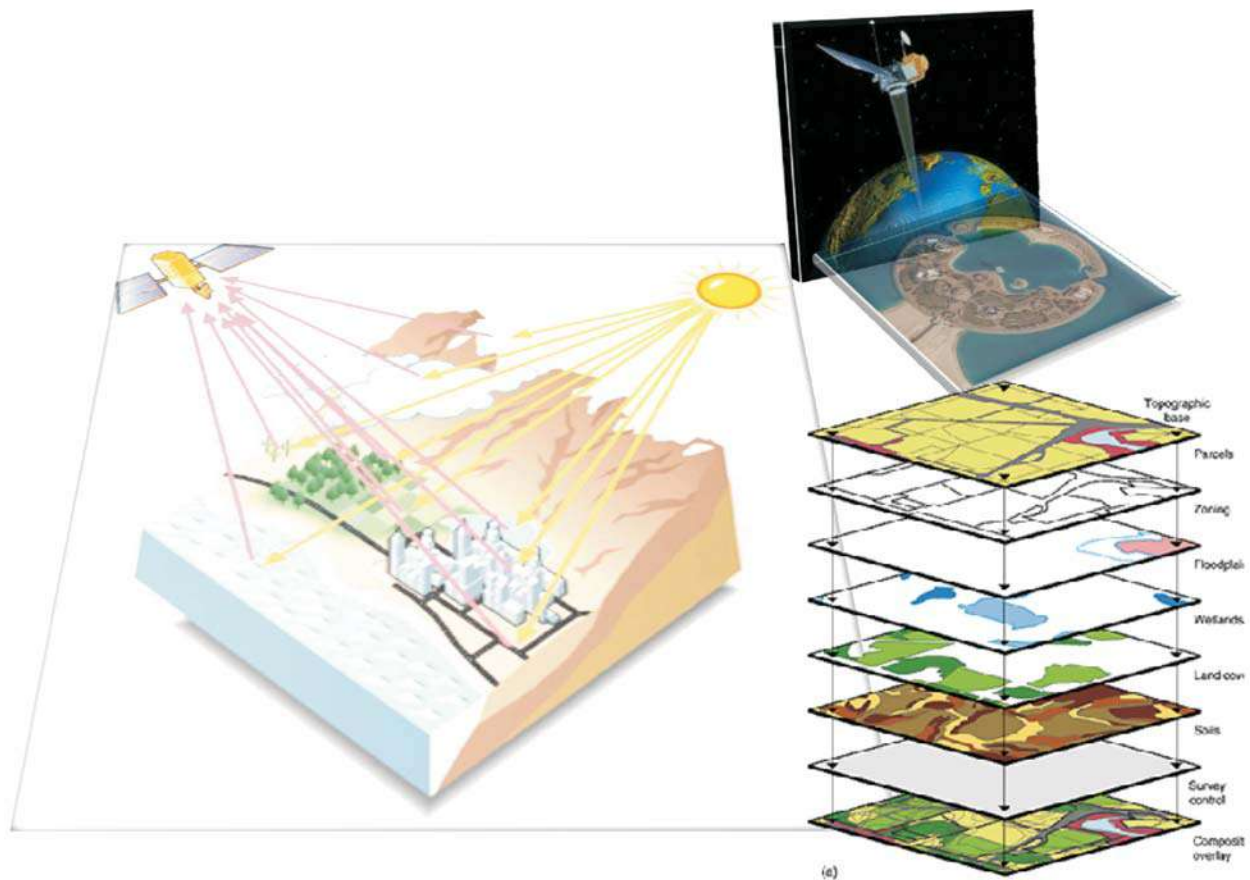
1. How many satellites are there in GPS System?
2. What information can we get from GPS?
3. Where is the Master Control Station?
4. Who is sole responsible for Control Segment?
5. Which component is the user Segment of GPS?

Short Answer Question

1. What is GPS?
2. Explain the function of GPS? Briefly explain the Control Segment of GPS
3. Briefly explain the Space Segment

Long Answer Questions

1. Name some of the applications of GPS?
2. Explain the factors affecting the readings of GPS?



Geospatial Technology

Class-XI

Practicals



Exercise - 1

Aim:

1. To map school building and surrounding environment.

Procedure:

2. Take a blank sheet and draw the map borders.
3. Show school building and other building with proper shape.
4. Show associated features of school building with respective location.

Example - Parking Area, Playground, Access Road, Class Rooms, Principal's Room, Tree Lines etc.

Exercise - 2

Aim:

1. To display various types of maps.
2. To read the maps and identify map features.
3. To learn usage of maps.

Required Data sets:

1. Geo Physical Map
2. Geological Map
3. Political Map
4. Meteorological Map
5. Air Road Route Map
6. Literacy Map

Software Used:

Rolta Geomatica Software

Procedure:

1. Open the Rolta Geomatica Software
2. Add the map to display window
3. Identify the map features

Results needs to be provided for all datasets

Table-1

S. No.	Question	Answer
1	Name of the map	
2	Scale of the map	
3	Features identified in the map	
4	Usage of the maps	

Question:

1. What is a map?
2. What do you mean by map scale?
3. Name different types of maps.
4. Describe the uses of maps.



Solution: 1

Map name: Geo Physical Map of India

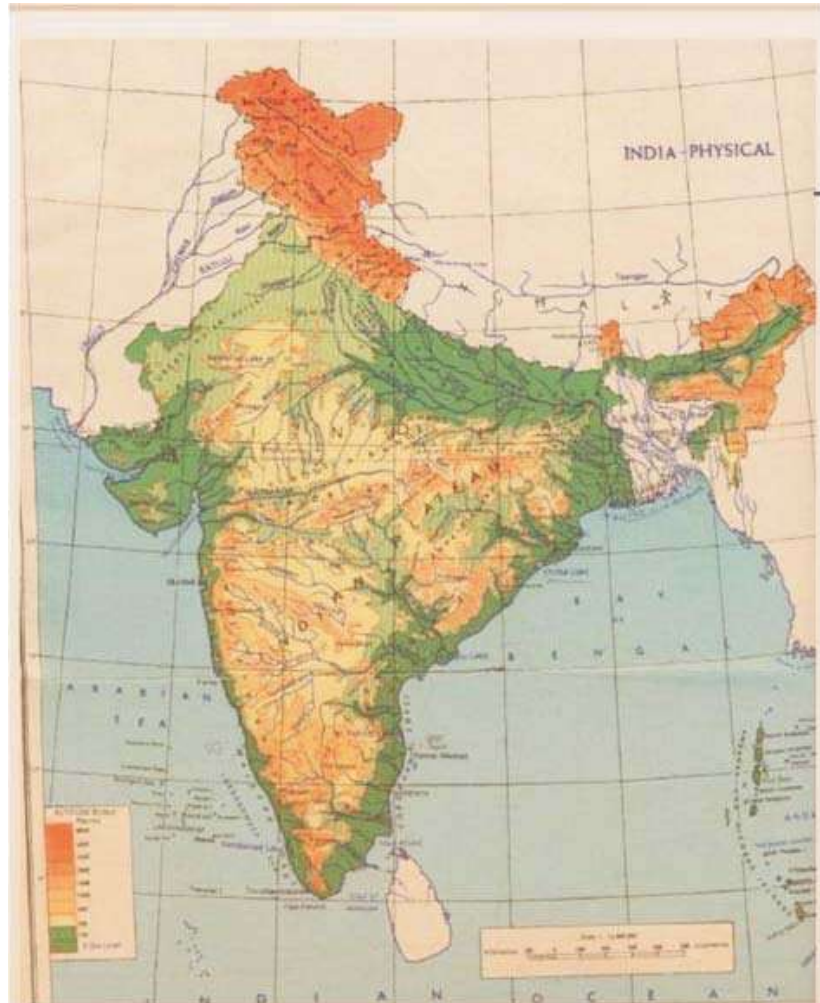


Fig. 1

Solution: 2

Map name: Political map of India



Fig. 2





Solution: 3

Map name: Meteorological map of India

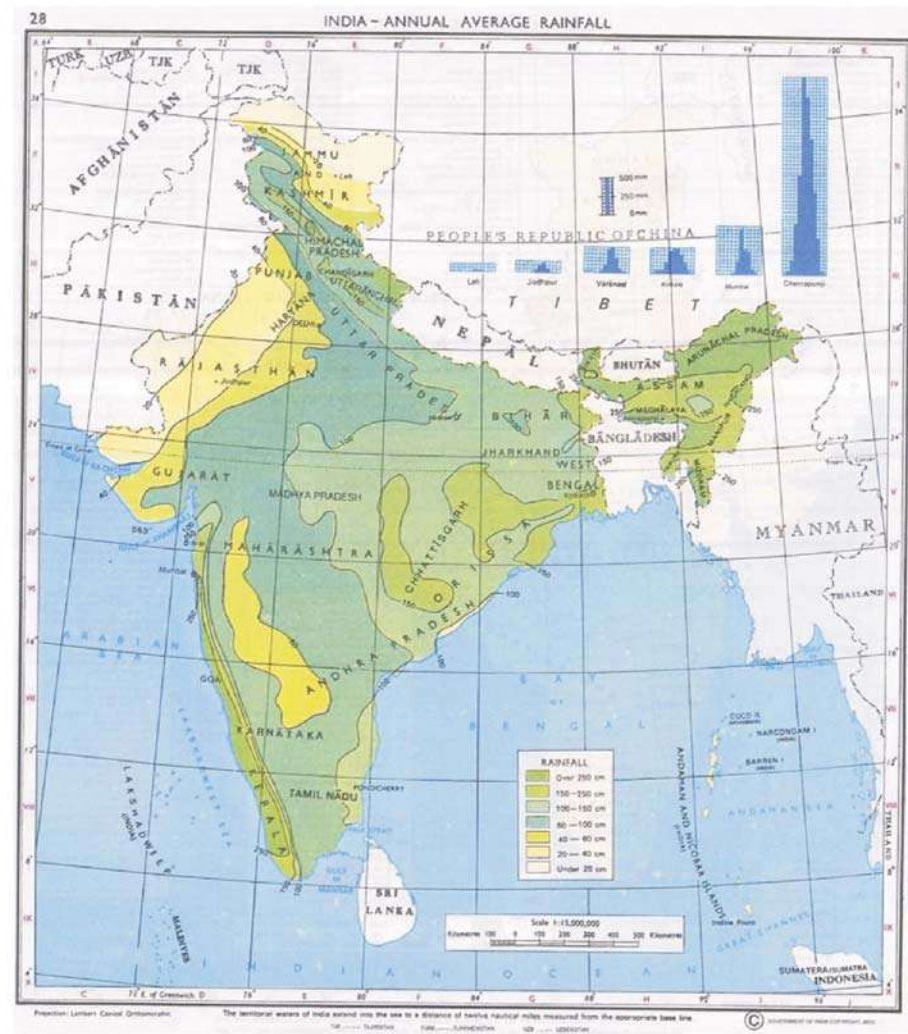


Fig. 3

Exercise - 3

Aim:

1. To display two different scales of Toposheets (1:50,000 and 1:250,000) of the Mt. Abu area
2. To read Toposheet index and identify the adjacent toposheets.
3. To understand the small and large scale map concepts.
4. To compare the area coverage by two different scaled toposheets.
5. To identify the features like Roads, Water Body, River, Contour Lines, Railway Lines, Forest Areas, Settlements etc.
6. To identify the map elements.
7. To know the coordinates of the Toposheets.
8. To find the location of any point.

Required Data sets:

In the example we have used sample toposheet of Mt. Abu area. It is suggested that regional maps be used depending on the availability.

- ✓ Toposheets of 1:50,000
- ✓ Toposheets of 1:250,000

Software Used:

Rolta Geomatica Software

Example for Toposheet:



Fig. 5



Procedure:

1. Open the Rolta Geomatica software
2. Open Toposheet (1:50,000 scale) of same area
3. Read the Index and scale of the map
4. Read the Toposheet Coordinates
5. Identify features
6. Open Toposheet of 1:250,000 scale at same map window.
7. Compare the amount of area coverage and details in both maps.

Results need to be provided for both toposheets:

Table-2

Index Number of Toposheet of	
Scale of the Toposheet	
Coordinates of the Toposheet Top Left Corner Top Right Corner Bottom Right Corner Bottom Left Corner	
Name the adjacent toposheet No. of following: Top, Right, left and bottom	

Question:

1. What features do you find in Toposheet? Name them.
2. How can you make use of toposheet?
3. What is a difference between large and small scale map? Discuss with example.
4. Longitude varies along with _____ axis
5. Explain how can you calculate location information at any point on the Toposheet?
6. What map element do you use to get the information about adjacent toposheet?





Solution: 1

Toposheet Scale 1:50,000

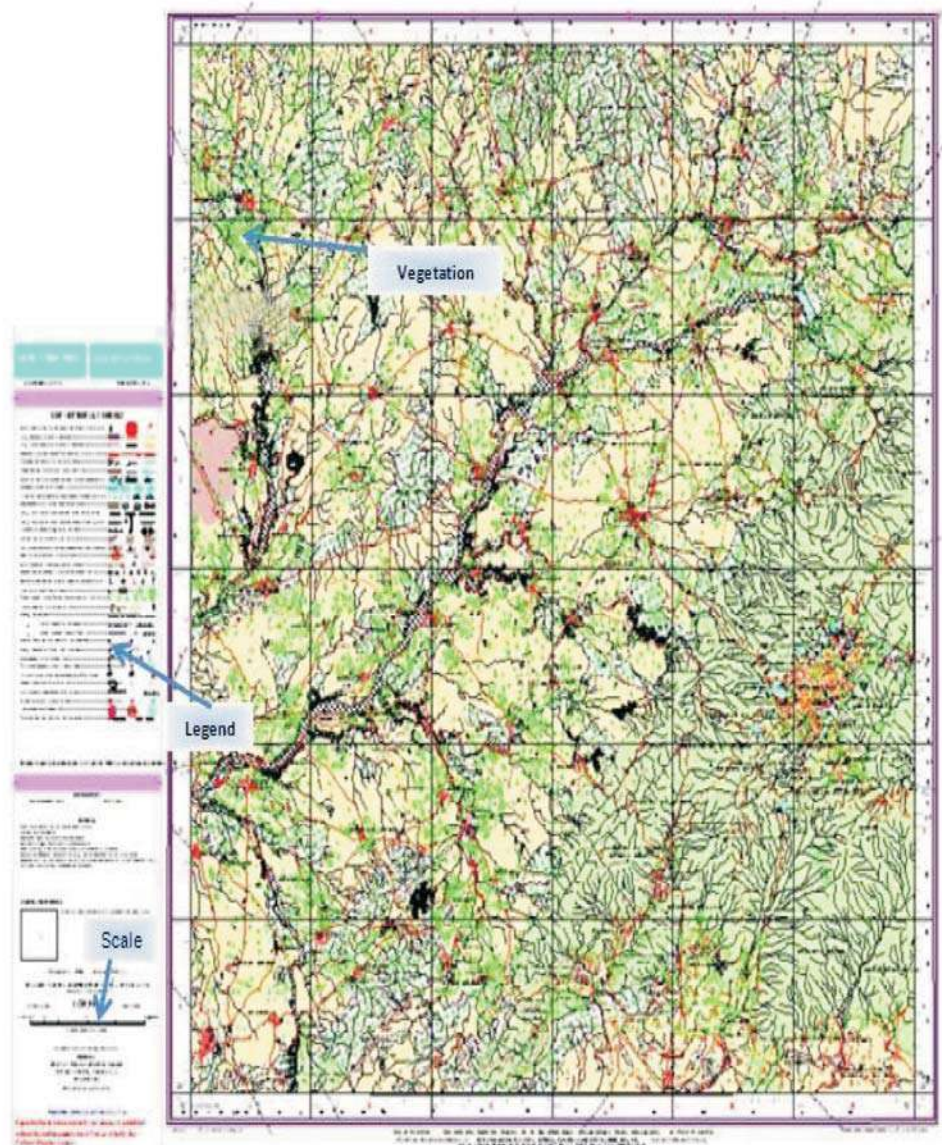


Fig. 6

Exercise - 4

Aim:

1. To display the satellite Imagery and Toposheet of same area
2. To identify the features such as Roads, Railway line, Shadows, Buildings, Water body, River, Forest area, Open space, Play grounds, Airports etc. from Toposheet as well as Satellite image

Required Data sets:

We have provided Sample toposheets and Images but depending on the availability, it is suggested to use regional Indian satellite images and Toposheets. For comparison and better understanding, satellite Images with different resolution & toposheet of same area with different scale can be used.

Software Used:

Rolta Geomatica Software.

Procedure:

1. Open Rolta Geomatica software
2. Add satellite image to display window
3. Identify the image features
4. Add Toposheet to display window
5. Identify the features in toposheet
6. Compare the features from both the data sets and discuss

Result

Table-3

Name of the satellite image	
Identify resolution of image	
Identify same objects in image as well as in Toposheet	





Question:

1. What is the altitude of remote sensing satellite?
2. What is spatial resolution?
3. What is the spatial resolution of Quick Bird and IKONOS pan Image?
4. What do you mean by Pixels?
5. What technique would you use to identify the features in an Image and toposheet?
6. Name the features you identified in the satellite Image as well as in Toposheet. Compare the objects identified and explain in brief.
7. Compare the objects identified in different resolution. Did you find any change in objects please discuss?

Solution: 1

IKONOS Data Set



Fig. 7

Solution: 2

Landsat Data Set



Fig. 8



Exercise - 5

Aim:

To understand the GIS environment

Software Used:

QGIS Geomatica Software

Procedure:

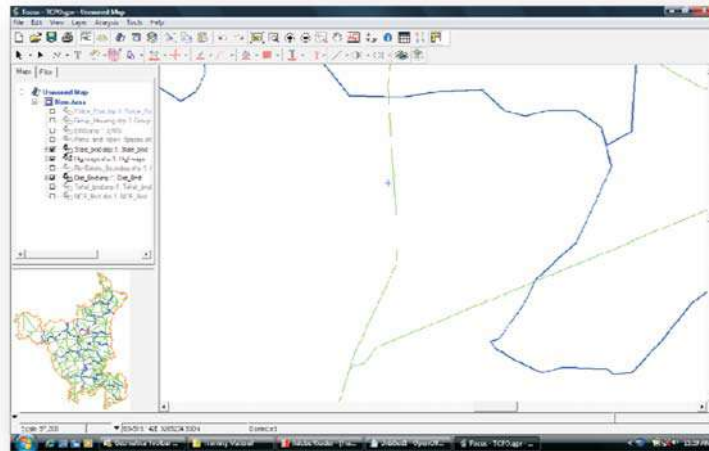
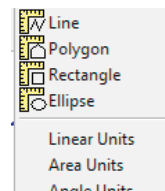


Fig. 9

1. Open any vector layer for where distance is to be measured
2. Click on the drop down arrow on the Distance tool
3. Linear Distance from one point to another rectangular, Polygon and ellipsoidal area can be measured.
4. Select Line from the tool and set the distance units as Meter
5. Now click on the map. Distance along with azimuth from one point to another will be displayed.
6. Coordinates of the map will also be displayed on the bottom
7. If you have 2 vector layers you can overlay them and check the result.



Result:

1. By using GIS you can measure distance, area.



Solution: 1

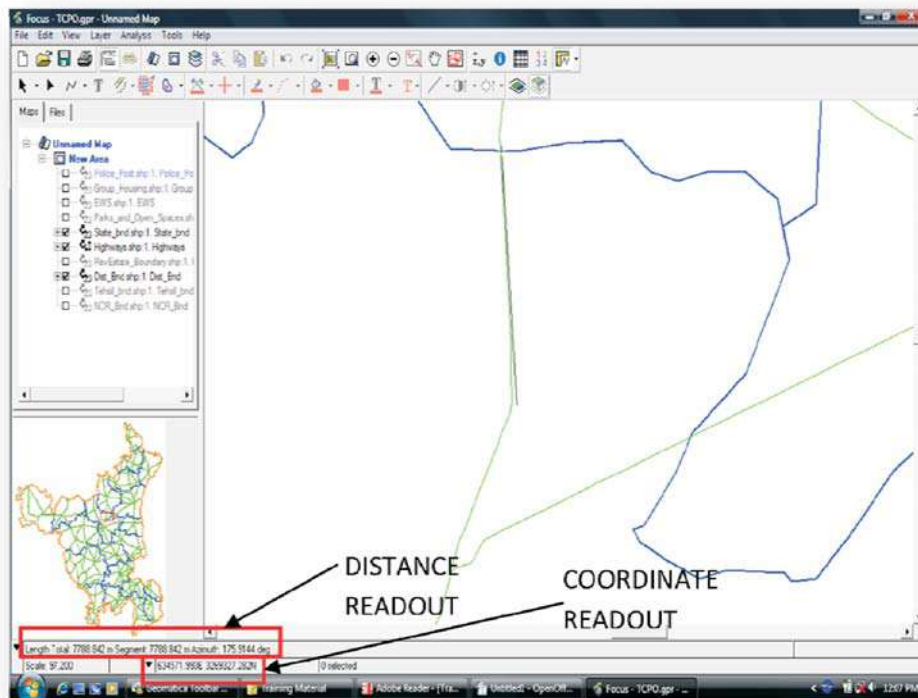


Fig. 10





Exercise - 6

Aim:

To understand the GPS data collection

Device Required:

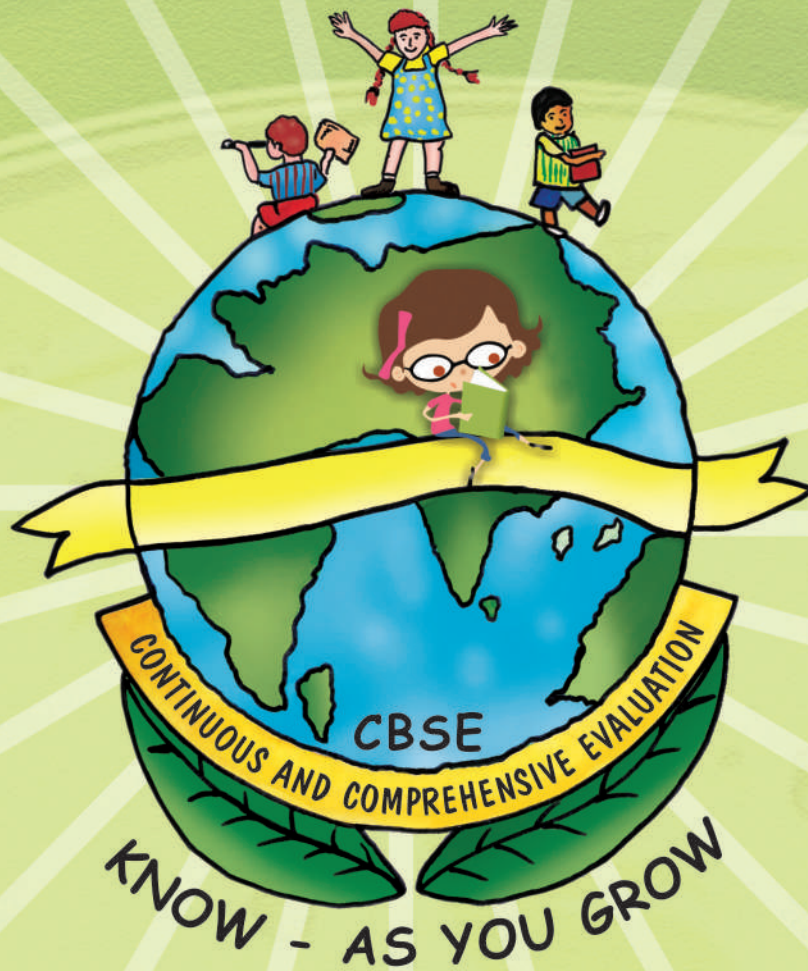
1. GPS Receiver, if GPS is not available user can use any GPS activated mobile.

Procedure:

1. Select an Open Area
2. Activate the GPS
3. Collect The GPS coordinates
4. Find the Coordinates of your school building with GPS receiver
5. View the GPS textual data in GIS format

Result:

By using GPS you can locate your location in the earth. Take the points of school building and inserted that in the Google Earth and check.





CENTRAL BOARD OF SECONDARY EDUCATION

Shiksha Kendra, 2, Community Centre, Preet Vihar, Delhi - 110092, India

Tel.: 91-11-22509252-59 Fax : 91-11-22515826

E-mail : [www.cbse.nic.in](mailto:cbsenda.vsnl.net.in website : <a href=)