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.

Loaction 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 complicities 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.

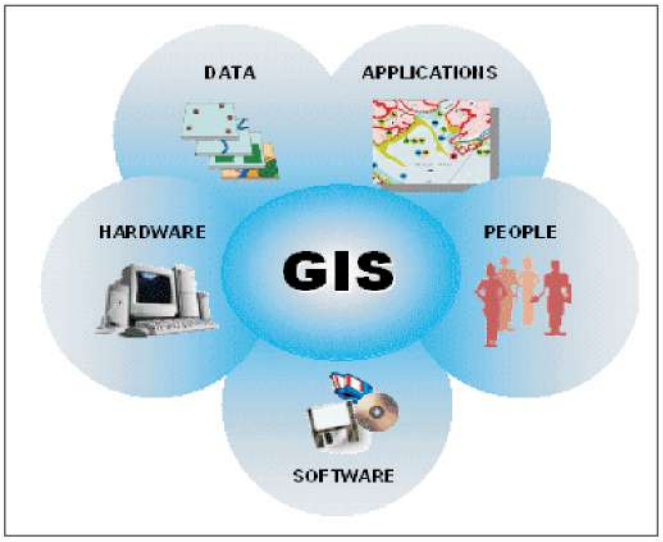


Fig. 62

(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

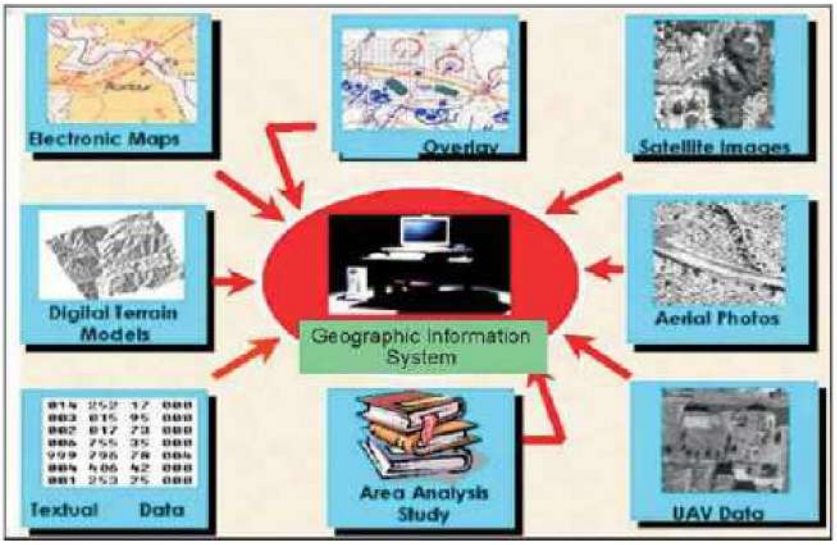


Fig. 65

(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:

Fig. 66

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.

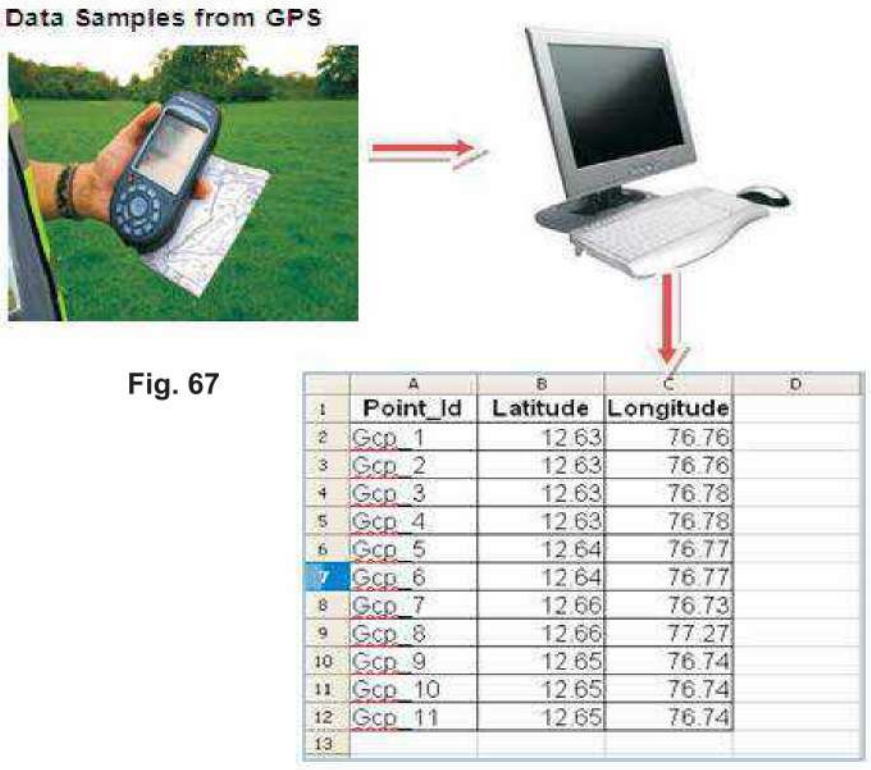


Fig. 67

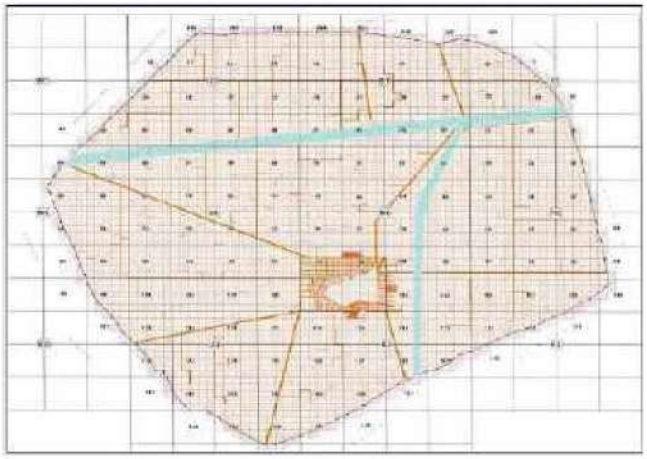
	A	B	C	D
1	Point_Id	Latitude	Longitude	
2	Gcp_1	12.63	76.76	
3	Gcp_2	12.63	76.76	
4	Gcp_3	12.63	76.78	
5	Gcp_4	12.63	76.78	
6	Gcp_5	12.64	76.77	
7	Gcp_6	12.64	76.77	
8	Gcp_7	12.66	76.73	
9	Gcp_8	12.66	77.27	
10	Gcp_9	12.65	76.74	
11	Gcp_10	12.65	76.74	
12	Gcp_11	12.65	76.74	
13				

(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.

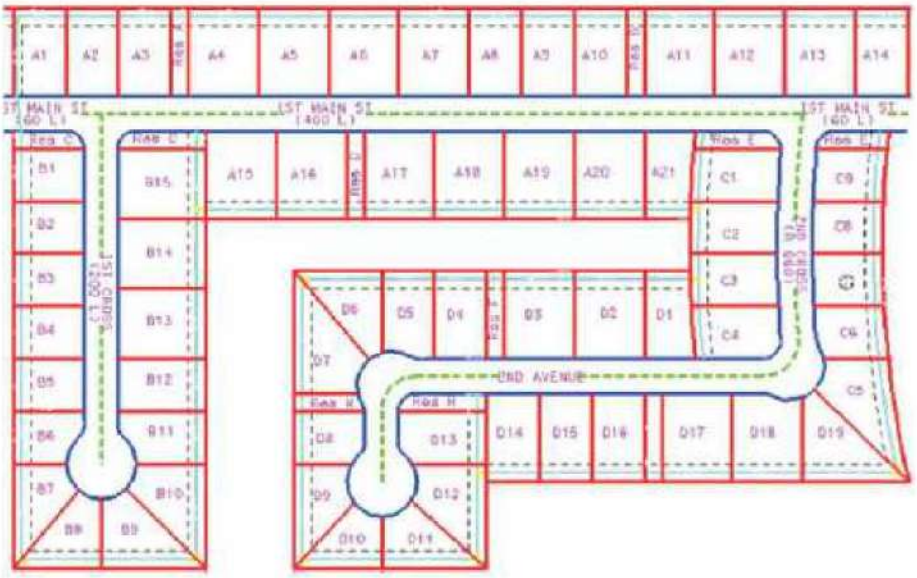


Fig. 69

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) Persons	Males	Females	Sex ratio (females per 1000 males	Density (per Sq km.)	Decadal growth rate
1	2	3	4	5	6	7	8	9
	INDIA	**593**	**1027015**	**531277**	**495738**	**933**	**324**	**21.34**
	States							
1	Jammu & Kashmir	14	10070	5301	4769	900	99	29.04
2	Himachal Pradesh	12	6077	3085	2992	970	109	17.53
3	Punjab	17	24289	12963	11326	874	482	19.76
4	Uttaranchal	13	8479	4316	4163	964	159	19.20
5	Haryana	19	21083	11328	9755	861	477	28.06
6	Rajasthan	32	56473	29382	27091	922	165	28.33
7	Uttar Pradesh	70	166053	87466	78587	898	689	25.80
8	Bihar	37	82879	43154	39725	921	880	28.43
9	Sikkim	4	540	288	252	875	76	32.98
10	Arunachal Pradesh	13	1091	574	517	901	13	26.21
11	Nagaland	8	1989	1042	947	909	120	64.41
12	Manipur	9	2389	1207	1182	978	107	30.02
13	Mizoram	8	891	460	431	938	42	29.18
14	Tripura	4	3191	1636	1555	950	304	15.74
15	Meghalaya	7	2306	1168	1138	975	103	29.94

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

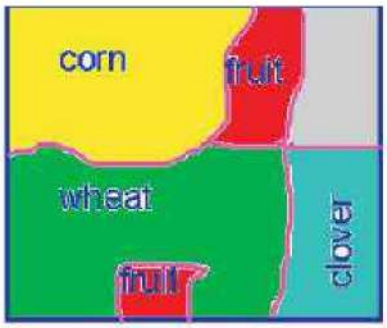
GIS stores the spatial data in two formats which are known as:

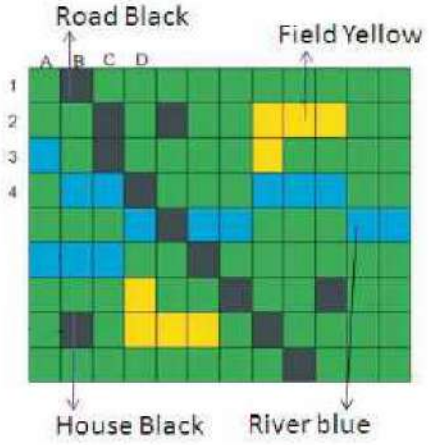
- Raster Data
- Vector Data

(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 22			
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.

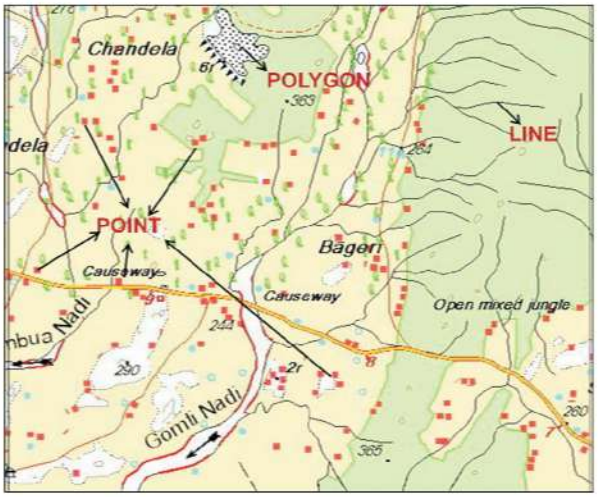


Fig. 71

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

(i) Point Features

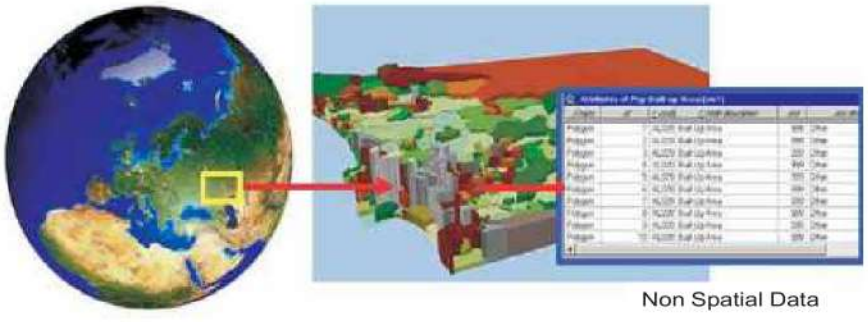
(ii) Line Features

(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.



Real World Spatial Data Non Spatial Data

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?

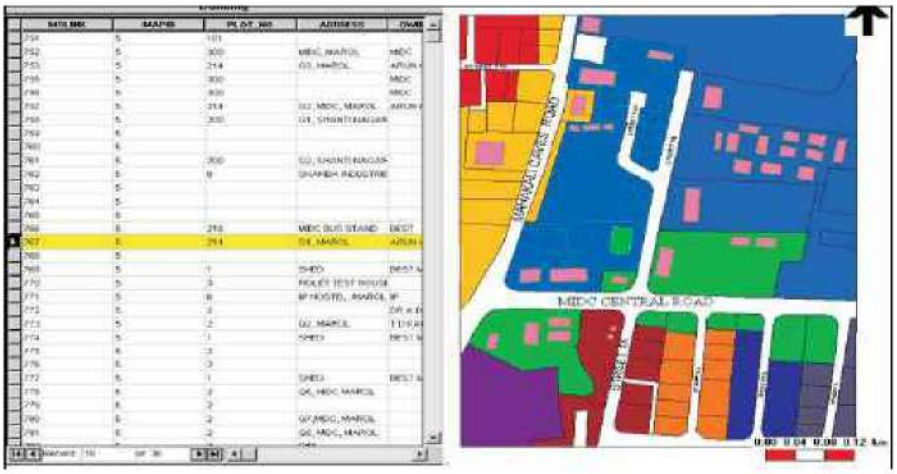


Fig. 73

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.

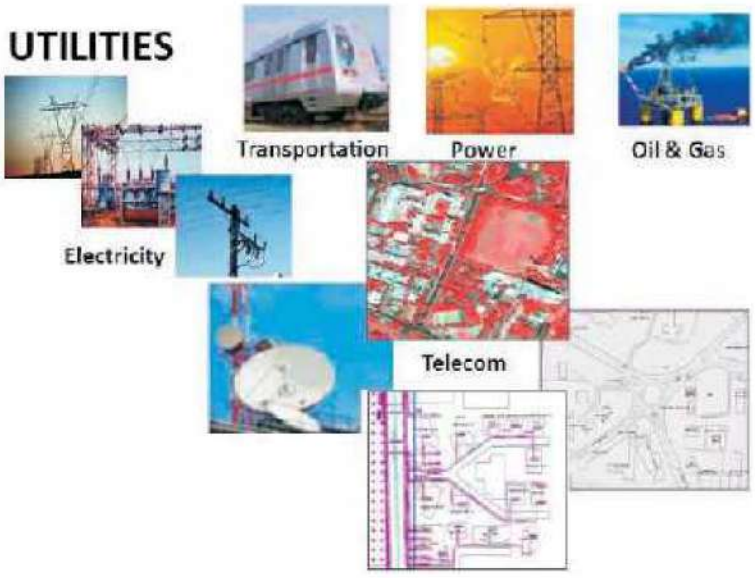


Fig. 76

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