RS_GIS_01

Introduction to Geographic Information System

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1 Introduction to Geographic Information System

Every decision that we take today is largely driven by location and has spatial connotation directly or indirectly. In this unit we will learn about Geographic Information System (GIS) –a modern day spatial decision making system. GIS has come a long way from digital mapping to decision making , invoking simulations , creating networks, evolving models based on big geo- data analytics and all gearing for real time decision making with prediction capability. That is where lies the power of geospatial domain and of which Geographic Information System is an important part. The users of this technology have multiplied manifold from few specialists in Universities, space research centres , government departments, and industry to a lay man. The usefulness of GIS is driven today by many pull and push factors and the rapid changes taking place around natural ecosystem. To meet the ever increasing demand created by huge population on infrastructure development, rural and urban planning, safe neighbourhood, multiple transportation facilities, disaster readiness of the community, conservation of nature require a holistic approach with careful understanding of space , created geography and /or varied dimensions of geographical aspect of the earth. Availability of multiple datasets collected from ground platform, aerial platform and space platform have given a new meaning and understanding of the existing locations. Use of GIS capturing various layers of these data sets have definitely added value to the usefulness of the decisions taken by the respective experts of the varied fields. We will study the basics of GIS in this lecture and empower ourselves in understanding the various dimensions of Geographic Information System as noted in the learning outcomes below.

Learning Objectives*: After studying this unit you should be able to:*

1. **Define Geographic Information System (GIS) and develop a basic concept of its diverse applications;**
2. **Understand that What Answers GIS can Give?**

3. **Identify the various datasets, elements and components of GIS;**

4. **Visualise the relevance of GIS ; and**

5. **List some GIS software.**

2. What is Geographic Information System?

GIS is a discipline generating massive interest worldwide. It is an interdisciplinary area used by heterogeneous groups What you find is that since mid-1950's GIS as a subject has evolved changes taking place in "theoretical framework , technological improvements and institutional involvement in organizational improvement and inclusive nature" in the GIS field. It has a capability of using large data sets , performing multiple geo-analytics and at the same time geo-visualizing it as per the requirement. But all this begins with georeferencing –tagging different locations.

To begin with, let us try to understand different definitions of GIS given by different authors. This will help us in giving a meaning to Geographic information System and understand various capabilities that this technology has a scope to offer.Marble (1983) define Geographic information System simply as a "*A Spatial Data Collecting System"*. Clarke (1986) and Burrough (1987) expands the meaning by stating it as a"*Computer Assisted System to Capture, Store, Retrieve, Analyse and Display the Spatial Data in a particular Organization'"* and as "*Powerful Spatial Tool for Collecting, Storing, Retrieving, Transforming and Displaying Spatial data from a real world"* respectively and *"A Computer based System that provides four sets of capabilities to handle geo-referenced data : data input ; data management; manipulation & analysis; and data output" by Arnoff(1989), and with Parker (1988) defining it as "An information technology which stores, analyses, and displays both spatial and non-spatial data" . ESRI (2017) explains the capability of "*Geographic information System (GIS) as a system that let us visualize, question, analyse and interpret data to understand relationships, patterns and trends"

GIS brings together the ideas developed in various fields such as Geography, Computer Science, Mathematics, Civil Engineering, Surveying, Economics, Town planner and Agriculture to name a few. Some related names of GIS with similar characteristics are: *"Multipurpose geographical data system"; "Computerised GIS"; "Image-based information system"; "Land resource information system"; "Natural resource management information system"; "Spatial data handling system"; "Spatial information system"; "Environmental information system" ; "Automated GIS and Knowledge based GIS".*

3. What Answers GIS can Give?

Geographic information System (GIS) as a system answers through visualization and data analytics. It help us to understand spatial relationships, different patterns and changing trends. GIS therefore answers questions related to Location –'*What is at …* ?'; Condition *Where is it … ?* ; What type is it …?;Trends:What has changed since ...? Patterns:What spatial Patterns exist? and questions related to Modelling-What if …? The detailed examples of all the raised questions would be undertaken in subsequent lesson.

Task 1: LOCATION

GIS is location based. It starts with geo-referencing- tagging different locations.

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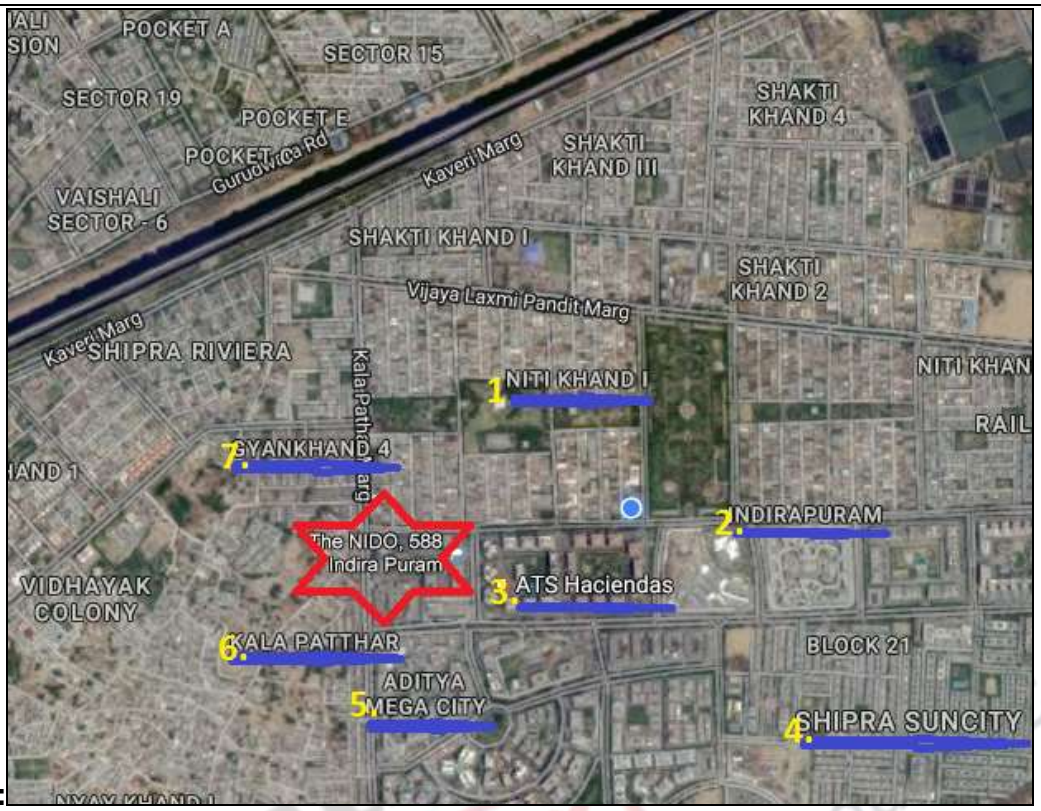

Figure 1: A section of the Google map showing THE NIDO , dated 11 June ,2017

Q1: Locate the House Number of The NIDO in Figure 1:

Options: a)588 b) 488 c) 688

A1: _____

Q2: Name any 7 locations placed near The NIDO in Figure 1:

A2:_____

_____

_____

The strength of GIS is its ability to integrate multiple data options considering both spatial data with non-spatial data (descriptive information about the spatial data). It has advantages over other similar system which are listed down below:

- GIS visualises where, when, what and why possibilities which is just not feasible with any other software system.

- GIS enables to create a comprehensive framework to a concern in hand. It supports the policy and decision makers to arrive at the right ground reality.

- GIS enable cost saving from greater efficiency; better decision making through improved communication and record keeping.

- GIS predict events/outcomes derived based on multi-criteria analyses carried out using the appropriate thematic layers in GIS.

- GIS assists in planning strategies, especially useful in case where disastrous events demands quick decision making.

- GIS is also becoming essential in designing and prescribing actions in different regions after understanding what is happening and what will happen in geographical space.

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- Moreover, through different combination of data sets and geo-analytics GIS generates new ideas never before thought of using earlier studies.

- Above all, GIS geo-visualizes the scenarios given the current situation, how the simulation would look like and its consequences. Such scenarios greatly assist disaster managers to plan for future and safe human lives.

4. Types of Data used in GIS

Data is the most important component of any computer based decision making system and so is the case of Geographic Information System. There are two types of datas used in GIS and they include Spatial data and Aspatial data

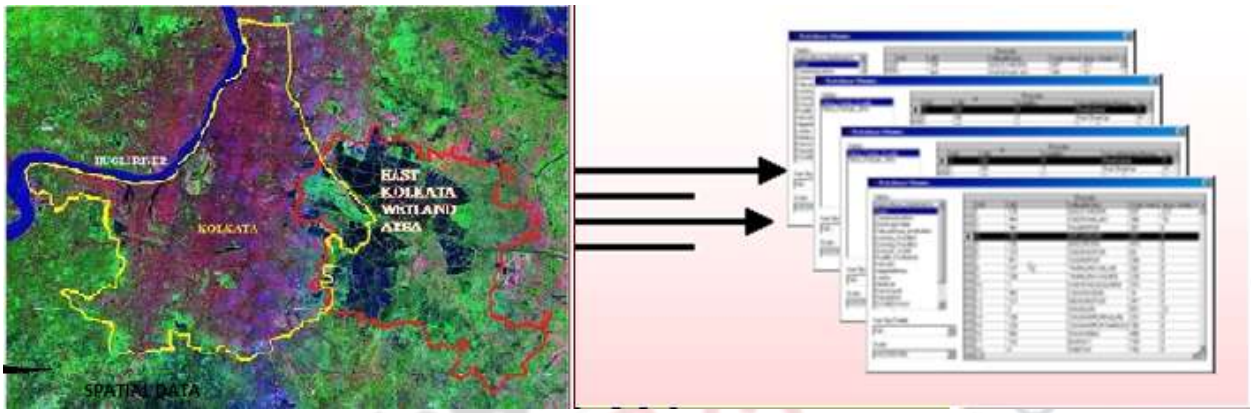


Figure 2: illustrating the spatial and Aspatial data sets ready to be used in GIS environment

Spatial Data gives information about the features geometrical orientation, shape, size and relative position with respect to other features. These are described by x, y coordinates. Spatial /coordinate data as we understand by now is with accurate geo-referencing and correct cardinal locations. Whereas, Vector data are represented by three elements of GIS referred as PLA:

P-P oints,
L-Llines, and
P/A- Polygons/Area

Raster are represented through an array of grid with rows arranged in a mesh consisting of cpluman and and column matrix. Look at the following map of India where points in the states constitute spatial data.

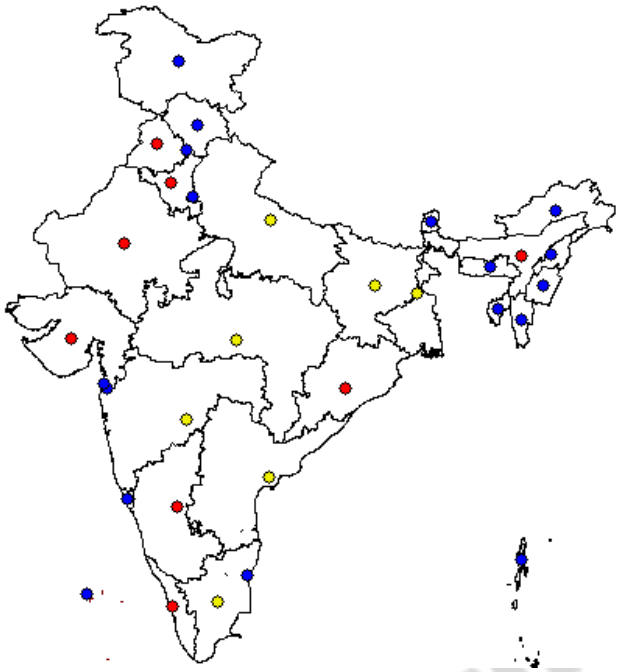


Figure 3: Spatial Data distribution

Spatial data of course have an attribute information that describes a particular data base and this is called an "*attribute data".* This data type is also called an aspatial or descriptive data through which one understands and/or Qualifies information about various attributes like area, length, number, etc. These are best organised in alphanumeric fields and are mostly tabulated. Spatial data can be understood from a detailed framework of :

- Tabular data , eg. CSV, Excel;
- Database for example generated from Access, PostgreSQL or Oracle,)

these can be transformed into spatial data and mapped. Generally what happens is that visual image consisting of spatial data file is having a backend common attribute image that may have been arranged with Unique ID in the form of country id- name-code-population-etc. For usefulness and a requirement maps are joined through locations marked with cardinal point information may be with

latitudinal values and longitudinal values recorded by any GNSS device like NAVIK along with the related attribute information including road network or spot dots information.

Normally Spatial & Aspatial data are stored separately in a GIS and links are established between the two types of Data. This section would be done in detail later.

Figure 4: GIS Database is a combination of Spatial Data, Aspatial Data and Linkages

5. LEARN ABOUT THREE BASIC ELEMENTS

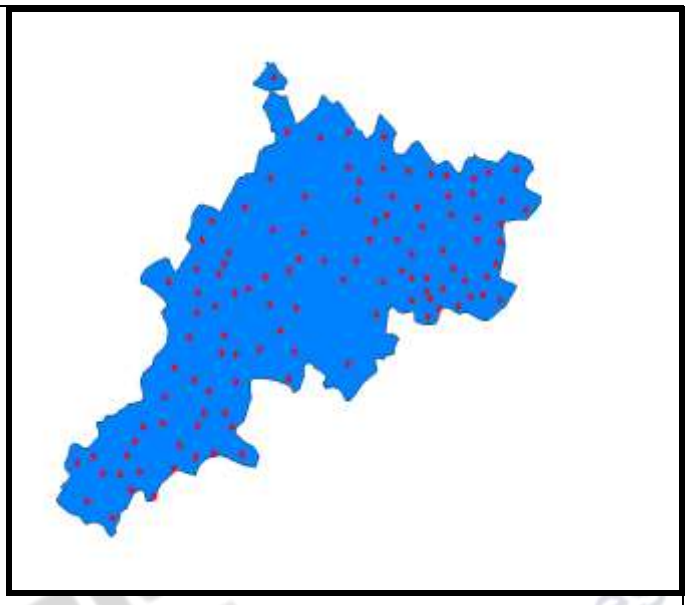
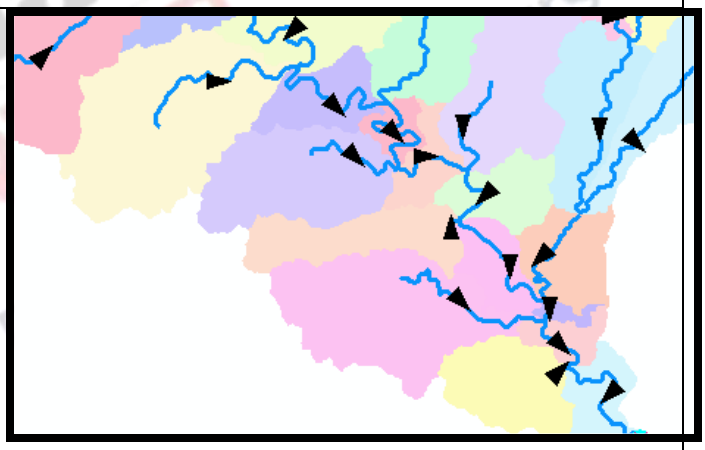
GIS software is a versatile tool where as we have learned capturing, retrieval, transformation and big time analysis can be completed. All this will be in different layers and with variety of shapes, sizes overlaid over one another to create a composite map. In addition geo-analytics an be performed on each other. We need to understand that these are created by three elements: one depicted as Point; second made up of points called Lines and third represented as Polygons or Areas.

There are three elements of GIS : Point, Line and Area or Polygon. The queries can be performed on them and through them.. All noted elements along with their descriptive information called attributes can be visualized in the form of maps. This is represented and presented present in the following maps of East Kolkata Wetland region (Figure 5)

Figure 5: Point, line and polygons depicted in wetland space of EKW, West Bengal

Points are generally objects /features which is correctly geo-referenced but is noted without any dimension including any direction like Head quarters, temples, etc. Whereas, what we have recognized by now is that Linear features are noted with discrete beginnings and ending points. Rivers (Figure 6) , roads, canals are some examples of linear features. Polygons/Areas are enclosed features with well defined arrangement of sequential lines all enclosed in an area.

From your learning about the three elements answer the following:

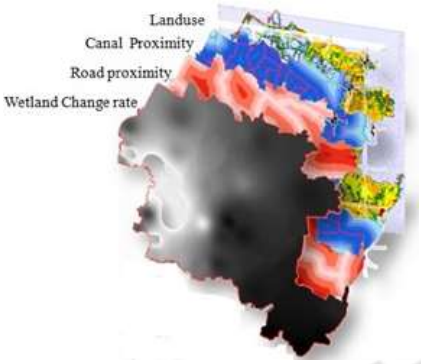
POINTS: Think of examples near your House 1)_____ 2)_____ 3)_____.	
Lines : Think of examples near your House 1)_____ 2)_____ 3)_____.	

Polygons/Area : Think of examples near your House

1)_____

2)_____

3)_____.



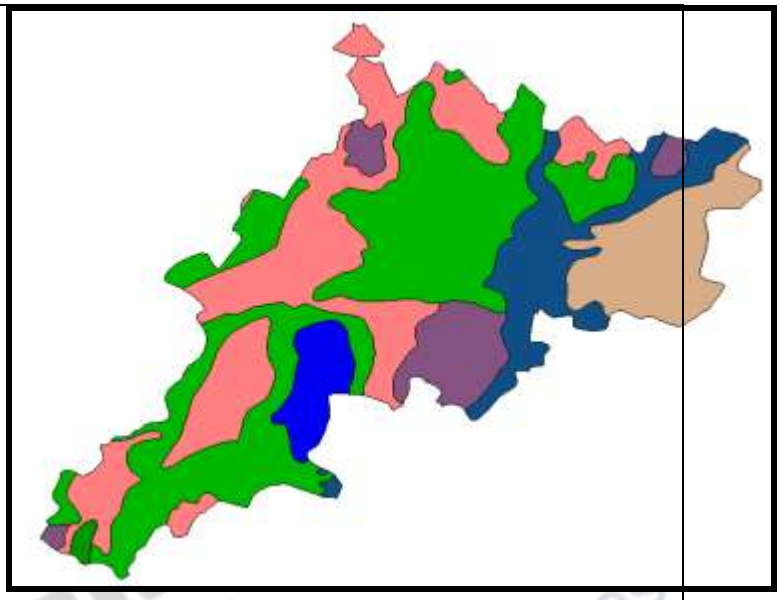


Figure 6: Three Elements of GIS: Point, Line and Area

6. Basic Components of GIS

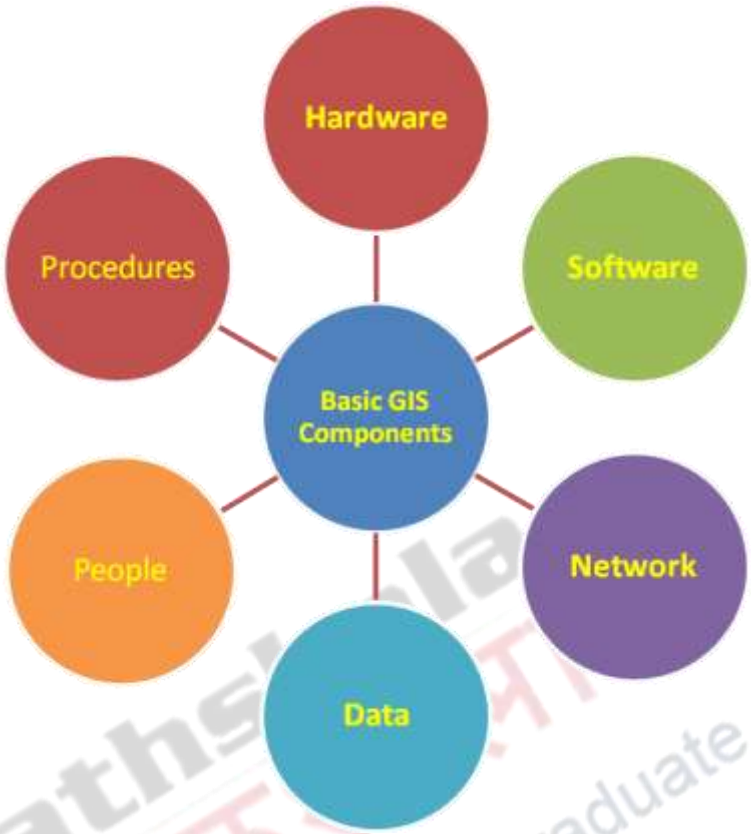


Figure 7: Six components of GIS

There are six components of GIS (figure 7) and each one is incomplete without the other . These include: Hardware, Software, Network, Data, People and Procedures.

Computer Hardware Module: Hardware components include all these tools devices and accessories that can be set-up on the desk, lap or in the palm. In previous times , carry out complex GIS operations, large mainframe computers were required. Today, users have wider choices. Even moderately priced PCs are capable of being used for GIS. A range of latest products includes handheld GIS compatible GPS, a variety of high-end scanners and printers that make the GIS operations worthy of it. Now GIS functions are carried out in PDAs, in-vehicle devices and even in mobile phones.

Computer Software Modules: Software is required for various functions to be carried out in GIS. Software for data entry, data storage, data processing, and analysis and

data output are bundled together as software packages. These ranges from a simple package to work horses. Table 2 illustrates varied kry tasks of the 5 GIS software modules. Moreover each product comes with different requirements and applications. Now freeware are also available which can be easily downloaded from the web. The consumers can use these freeware not only free of cost but also change the source codes of the programmes. On the other hand, the ones available in the market are property right products whose source codes are protected by the copyright act and are not available for the users. Most of the software packages available commercially come as menu driven which are more user- friendly. Open GIS and interoperability are the recent keywords in the GIS world. Open GIS stands for open source coding. Interoperability aims to increase interaction between different software packages for easy data transfer and processing from one package to another and vice versa.

TABLE 2: GIS SOFTWARE MODULES

MODULE	KEY TASKS
MODULE 1 : Data Input & Verification	Software to transform various data to digital form. Devices - To read data sets from different input devices
Module 2 : Data Storage & Data Base Management	How data is to be structured & organized? DBMS - Data Base Management System.
Module 3 : Data Output & Presentation	Concerns the way data are displayed & Reported.

	Maps, Tables, Figures,etc. Visual Display Terminal, Printer, Plotter & Others.
Module 4 : Data Transformation	<u>General Transformation</u> scale changing fitting data to new projection logical retrieval of data calculations of area and perimeters <u>Application Oriented</u> User dependent, free from data errors
Module 5 : Maintenance	Removal of errors Bringing them update To match them to other data sets

Data: The third component of GIS is data. Data forms the major component. With recent developments in remote sensing and GPS technologies, large volume of high resolution data is widely available at affordable cost. This is also one of the reasons for the increased awareness and development of GIS. To store and maintain large volumes of data the use of database management systems is required. Till recently, relational data base management (RDBMS) was widely used in GIS packages RDBMS was not exclusively created to handle spatial data. As a result, object oriented data

base is increasingly used in recent years for its ability to handle spatial data more efficiently.

People and Procedure: GIS is of no use if people and the organizations in which they work are not properly oriented towards GIS. In many organizations, GIS is not optimally used in spite of costly hardware and sophisticated software packages are available since the organizational aspects are not properly looked into. Longley (2001) define it as “An organization must establish procedures, lines of reporting, control points and other mechanisms for ensuring that its GIS activities stay within budgets, maintain high quality and generally meet the needs of the organization, Longley et.al.2001” The people working in an organization are also important. They possess various skills to handle geographic data. They design, programme and maintain GIS. They also supply data, do suitable analysis and interpret them.

Network: Earlier information generated in GIS is communicated among a handful of people sitting around a monitor. Today, a sheer volume of digital information shared among people who are located across the world. Internet plays a vital role to exchange and establish connection between them. Internet is not only used for personal exchange of information but also for the exchange of corporate data.

7. Recent Trends in GIS

From the time of Quantitative revolution that is in 1960s, to early 2000 the “GEOGRAPHIC INFORMATION SYSTEM” became so huge that people and especially the academic community wanted it to be called “GEOGRAPHIC INFORMATION SCIENCE”. As users increased many also wanted it to be called “SPATIAL INFORMATION SYSTEM”. The users expanded and from North America and Canada it spread world wide. Innumerable conceptual, technological and methodological developments have taken place in the field of GIS. Easy Handling of numerical census data through computer based spatial technology to for receiving useful information has helped in number of ways for taking administrative decisions and have also resulted in

data redundancy . Introduction of topological data structures have enabled easier and comparative ways to store and analyze spatial map data and increasing he tpossibilities of data integration. Relational database technology have evolved with the development of SDMS-spatial database management systems Developments in the field of object orientation in system and database design have further added to the quality of the output. Standardization of quality norms and accuracy standards have further enriched the sharing and interoperability concerns. In addition, advent of internet and subsequent developments of GIS tools have expanded with new Internet protocols, new interfaces and browsers and different languages to solve complex geospatial issues and projects. The technology today is trying to fit itself different platforms and there is a new division referred as Web GIS, Cloud GIS and OPEN GIS. Today one need not be dependent totally on proprietary based software but also the open source software are available. You will be studying all this in coming chapters. Therefore, today the geospatial scientists and technocrats are advocating for strengthening of Geographic information System to a GI Science or Spatial Science.

8. Open Source and Proprietary GIS Software

Depending on your preference, availability of the project in the institution, accuracy and complexity of the project in hand you can pick up from the bunch of following open or proprietry GIS software:

Numerous GIS open Source systems are nowadays available which cover all sectors of geospatial data handling capabilities. To name a few they include “GRASS GIS, SAGA GIS ,MapWindow GIS, ILWIS – ILWIS (Integrated Land and Water Information System),JUMP GIS / OpenJUMP – (Open) and Quantum GIS – QGIS”.

Whereas some popular Proprietary software with enhanced capabilities include : “Autodesk – Products include Map 3D, Topobase, MapGuide and other products that interface with its flagship AutoCAD software package;Bentley Systems – Products include Bentley Map, Bentley Map View and other products that interface with its flagship MicroStation software package; ERDAS IMAGINE by ERDAS Inc; products include Leica, ERDAS ER Mapper, andESRI – Products include ArcView 3.x, ArcGIS,

ArcSDE, ArcIMS, ArcWeb and ArcGIS Server; Intergraph – Products include G/Technology, GeoMedia, GeoMedia Professional; and MapInfo by Pitney Bowes – Products include MapInfo Professional and MapXtrem".

9. Summary

There are many developments taking place in the field of GIS. Many scientists are conceiving Geographic information system as an important tool and technology of the contemporary world. Through this lesson we have made a beginning of understanding the basics of GIS. We have learnt that:

- Geographic Information System is a tool , technology and science of capturing, storing, transforming , analyzing and displaying spatial and aspatial data.
- GIS as a system demonstrates high capability of geo-analytics.
- The strength of GIS is its ability to integrate multiple data options considering both spatial data with non-spatial data (descriptive information about the spatial data).
- There are three elements of GIS : Point, Line and Area or Polygon and overlay analysis in layer format is a strength.
- There are six components of GIS and each one is incomplete without the other . These include: Hardware, Software, Network, Data, People and Procedures.
- Today each one of us can try our hand on GIS using any one of the GIS open Source systems readily available around us and what is required is our intention.

10. Activity

i. **All major Telecom companies like Bharti, Reliance, and Tata Teleservices in India have used GIS to lay its cables and locate mobile towers. Try to find this near your neighborhood.**

ii. **Try to download any GIS Open Source Software from the web and note its capabilities.**

iii. **Have you ever ordered food from Food Panda , Swiggy or similar Mobile App or you have travelled through OLA, UBER or similar transport service ? If yes, transcribe the role of GIS in them.**