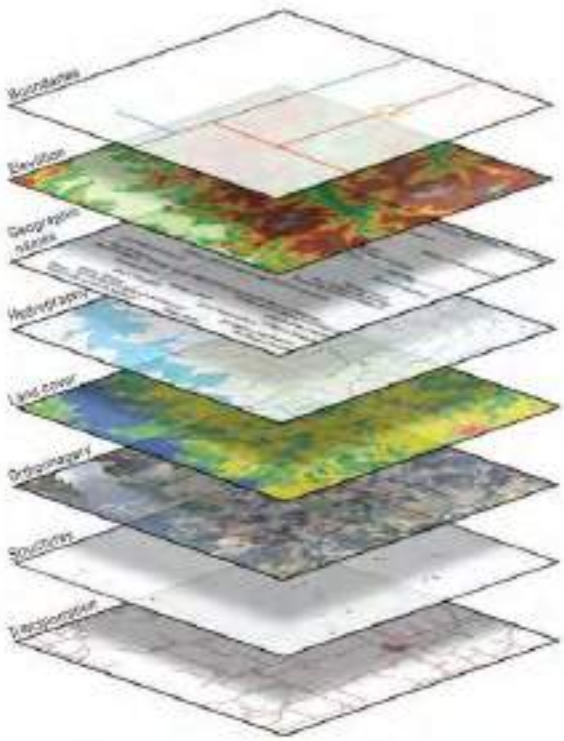

INTRODUCTION TO GIS

ABSTRACT

A Geographic Information System (GIS) is a computer-based information system for input, management, analysis, and output of geographic data and information. GIS systems are important tools for managing natural and other resources at all scales ranging from local to global

Consumer Education Research Center

ENVIS Resource Partner

CERC
Since 1978

WORKING TOWARDS A SUSTAINABLE ENVIRONMENT
ENVIS INDIA

CONTENTS

OVERVIEW

DEFINING GIS

A geographic information system is a computer system that includes hardware, software, and data for capturing & preparation, managing with storage & maintenance, manipulation & analyzing, and representing all forms of geographically referenced information.

Basically, a computer based system which develops, store and represent data in different forms.

Geographic information systems have emerged as an essential tool. GIS has the capability to store, retrieve, analyze, model and map vast areas with huge volumes of spatial data which has led to an extraordinary proliferation of applications. Geographic information systems are now used for land use planning, utilities management, ecosystems modelling, landscape assessment and planning, transportation and infrastructure planning, market analysis, visual impact etc.

CONCEPT OF GIS

1. Data capture & preparation
2. Data Management, include storage & maintenance
3. Data manipulation & analysis
4. Data presentation

Data capture & preparation

Data capture refers collection of data such as surface temperature, wind speed etc. These are achieved by using different measurement equipment. All the data along with geographic position obtained by sensors are transmitted by satellite communication. Data are then acquired and prepared using remote sensing equipment.

Data Management, include storage & maintenance

Data management refers to the storage and maintenance of the data transmitted via satellite communication. This stage requires a decision to be made on how to represent our data in terms of spatial properties and attribute values to store. The data is acquired in digital form and will be converted into computer-readable format for further analysis.

Data manipulation & analysis

Data when collected, stored is then analyzed in a computer system. GIS functions like georeferencing, spatial interpolation techniques etc. are done in this section. For example, data like total population of a district, number of population of a city is collected for calculating population density. Using spatial analysis population density is calculated on GIS platform.

Data presentation

After data analysis, it is prepared for producing outputs. This stage deals with putting it all together into a format that communicates the result of data analysis. Here, we need to consider many things like what we want to portray, the medium of presentation, the audience, techniques to be applied/available for the representation, rules of the aesthetics apply etc.

ELEMENTS OF GIS

The elements of geographic information system are:

1. Hardware
2. Software
3. Data
4. Methodology
5. User

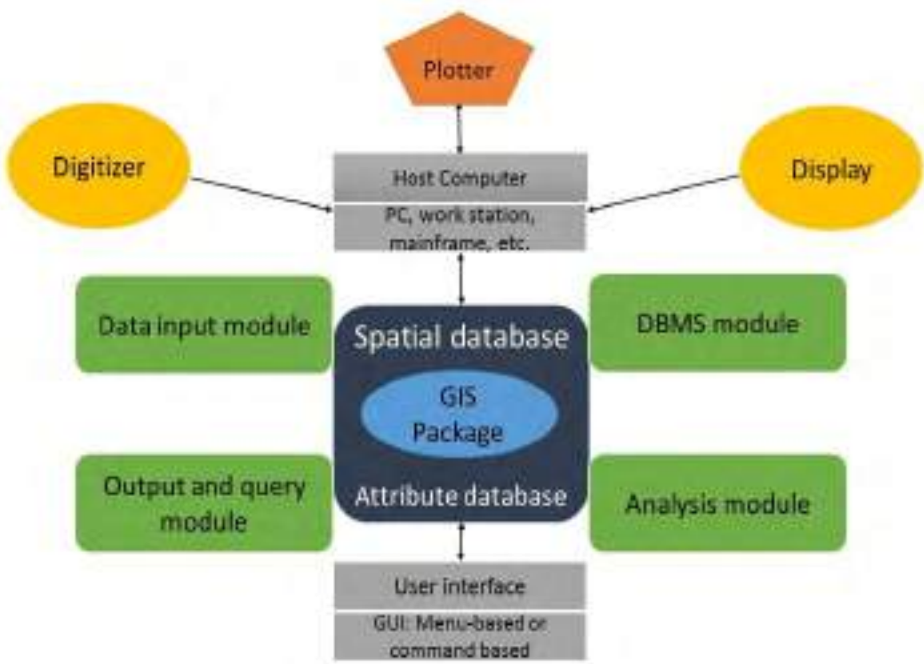

Figure 1 Components of a GIS

Hardware: To run GIS efficiently technical equipment (Mother board, Hard drive, processor, RAM, Printer, External disk, Monitor) is required. A good configured, standalone and networked computer system. The system having capability to run GIS software, enough hard disk space to store spatial data, and input & output devices such as scanners, printers, etc. to store hardcopy of the maps/data.

Software: Software (GIS tools, DBMS, Query tools, GUI, Layout) used for GIS helps to store, analyze and display geographic information. It provides a Graphical User Interface (GUI) which is a visual way of interacting with a computer system. GUI provides easy display and access to tools for input, visualizing, processing, editing, analyzing and querying geographic data. Data is accessed and managed through Data Base Management System (DBMS).

Data: The most important and expensive component of GIS is the data. Data is stored as graphic data (spatial data) and related tabular data (non-spatial data). Graphic data can either be vector or raster. Data comes in various formats, and GIS integrates such spatial data and non-spatial data by using DBMS. It is the key functionality of GIS that helps in organizing, managing and accessing data. Both type of data can be created in house using GIS software or can be purchased. The process of creating the GIS data from the analog data is called digitization. The Digitization process involves registering of raster image using few GCP (ground control point) or known coordinates is called Georeferencing.

Methods: With investments in hardware, software & data, knowledge is required to utilize GIS technology. Methods to access, store, managed, processed, analyzed and present may vary with different applications. An organization needs to document their process plan & GIS methods for GIS operation. A well-designed plan and business operation rules are important for GIS operations.

User: Technical persons (GIS managers, database administrators, specialists, analysts, and programmers) design and maintain the GIS operations. People in GIS can be categorized as viewer: the one who use GIS for reference, general users: who use GIS for business, services, and making decisions such as planners, scientists, engineers, etc. GIS specialists: who maintain, process and analyze geographic data. They provide technical support to the users.

TYPES OF GIS DATA

There are two categories of GIS data –Spatial data which describes location and attribute data which specifies the characteristics at that location. GIS primarily deals with spatial data and attribute data in an organized manner using computer hardware & associated software. Within the spatial referenced data group, the GIS data can be further classified into two different types: vector and raster. Most GIS software applications mainly focus on the usage and manipulation of vector geodatabases with added components to work with raster-based geodatabases.

SPATIAL DATA

Spatial data tells *where is it?* that specifies location; while attribute data tells *what (how much) is it?* that shows characteristics at that location. Spatial data has to be referenced, generally in forms of longitude and latitude or respect to a grid of which origin is known. Spatial locational data is represented in three ways viz., points, lines and areas (polygons).

Points is a zero dimensional abstraction of an object represented by a single coordinate (x, y), therefore it can measure neither length nor area. Point data is used to represent discrete data points and nonadjacent features like schools, point of interest, bridges, hotels, city locations or place names etc.

Lines are spatial objects whose width is too narrow to be displayed as an area in a given scale of map. There are one-dimensional objects represented by a set of ordered co-ordinates. Example being railway tracks, roads, streams etc.

Polygon represent areas and are defined by the lines that make up the boundary. It is a two-dimensional spatial object, such as lakes, forest area, agriculture etc.

The type of representation also depends on the scale of mapping. For example on a small scale map, say 1:250,000, a playground will be represented as a point, while in a city map, it could be represented as a polygon.

ATTRIBUTE DATA

Attribute data are descriptions, measurements and/or classification of geographic features. The attributes can be both qualitative (soil type) and quantitative (moisture content, pH, etc.). Attribute data stored in the database can be related to the spatial data. The location of a hospital at Ahmedabad is a spatial data. It can have attributes, such as number of patients, number of doctors, number of beds, etc. The attributes can be both numeric and textual.

	EHANDLE	LAYER	vill_name
1	3A0A	PDF_Dangvill	Borkhal
2	3A09	PDF_Dangvill	Linga
3	3A08	PDF_Dangvill	Kosambia
4	3A07	PDF_Dangvill	Anjankhud
5	3A06	PDF_Dangvill	Don
6	3A05	PDF_Dangvill	Chinchli

Figure 2 Example of the attribute table of a layer

DATA MODEL

The data has to be organized to be compatible for computer processing. The database so crated can be considered as computed representation of real world information. The way in which the spatial data are structured for storing the data will determine how the user can retrieve, analyze and do modelling. The often-used data models for spatial data are raster and vector.

VECTOR DATA

The fundamental theory of a vector model is that all geographic features in a real world can be represents as points, lines or polygons. In this model, the spatial location of features are defined on the basis of coordinate pairs. Vector data is stored as a series of X, Y coordinate pairs inside the computer's memory. Vector data is used to represent points, lines and areas. A point is represented by a single coordinate pair (x,y) having no dimension. Line data have a starting and ending point and is used to represent linear features like rivers, trails, and streets. It requires a minimum of two (x,y) coordinates to define a line. Polygons are represented by listing coordinated of points. The coordinate pairs at the beginning and end are the same, making it a closed area.

RASTER DATA

A raster model divides the entire study area into regular grid of cells, organized into rows and columns. The grid has a defined origin and the location of each cell is calculated from the origin. These cells are basic unit for which information is explicitly recorded in a raster model. Each cell is assigned a single attribute value for example land use, soil type, moisture content etc. In this type of model, a point is represented by a single cell. A line is represented by multiple cells usually with only 1 or 2 neighbors. A polygon is represented by a group of contiguous cells joined at edges or corners. One important difference between raster and vector data is that if you zoom in too much on a raster image, it will start to appear 'blocky'. In fact these blocks are the individual cells of the data grid that makes up the raster image.

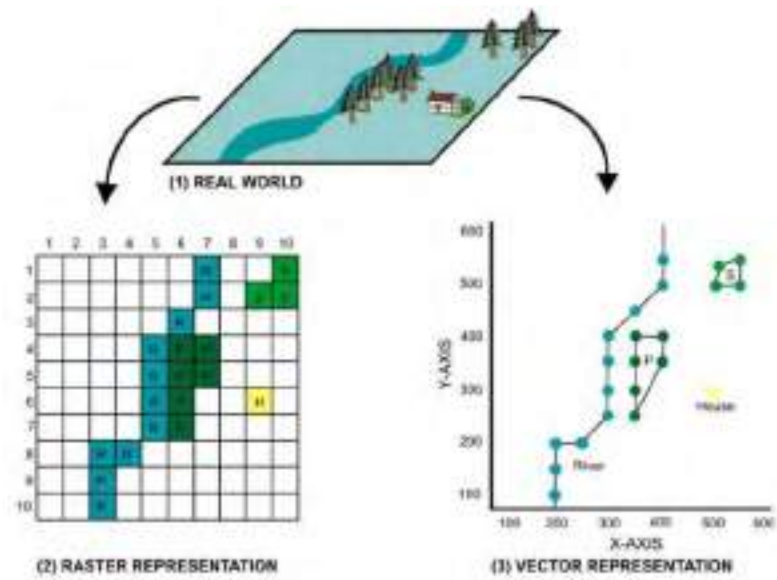

Figure 3 A representation of difference between real image, raster and vector image

Source: https://sqlserverrider.files.wordpress.com/

DATABASE AND SOURCES

Databases are the fundamental units over which information analysis can be performed. The main sources of geo-spatial data are: remotely sensed data from aerial photographs or satellite imagery, topographic maps, thematic maps, statistical information, and digital data which may require converting and importing.

A database is a data collection of information about things and their relationships to each other. The four types of data entry systems commonly used in GIS are keyboard, manual digitizing, scanning, and importation of existing digital files with appropriate data exchange standards. To design the database, the important aspects are the boundary of the area, coordinates, number of data layers, features for each layer, attributes for each feature, and coding and organization of attributes. To manage the database, the spatial data must be put into real world coordinates by joining adjacent coverages.

Sources of remote sensing data for GIS applications in various environmental aspects include; LANDSAT, SPOT, NOAA, METEOSAT, and ground-based weather radar. Databases resulting from the joint use of several information maps can support a series of applications in different fields of environmental management and socioeconomics. Users select pertinent information for the different purposes.

APPLICATIONS OF GIS

The use of Geographical Information Systems (GIS) has flooded almost every field in the engineering, natural and social sciences, offering accurate, efficient, reproducible methods for collecting, viewing and analyzing spatial data. Below mentioned are few examples where GIS can be applied.

- Land Management: Around 50% population of India has been totally dependent on agriculture for their livelihood. ISRO (Indian Space Research Organization) and ICAR (Indian Council for Agricultural Research) together did an experiment called ARISE (Agricultural Resource Inventory and Survey Experiment) in a quest to find possibility to analyze changing land use pattern.
- Soil Management: GIS is a powerful tool in management of soil resources of the country. GIS, GPS and RS have much to offer soil fertility maps. Once soil fertility maps are created, it is possible to transform the information from Soil Test Crop Response models into spatial fertilizers recommendation maps.
- Watershed Management: A watershed is a natural hydrological unit and its management involves the holistic linking of upstream and downstream areas. Watershed Management is the best way to conserve rain fed marginal areas enabling a sustainable living. With the help of satellite data and GIS, water bodies such as lakes, reservoirs can be mapped in 3D formats and data can be used in the planning of sustainable management of water bodies.
- Urban land Management: Urbanization is a major problem for a country like India. Rapid increase in rate of inter-state migration and internal displacement has made it essential for better and effective urban planning. Multi layered mapping can be done by using GIS which can be further used by Municipal Corporation and real state planners. This will help effectively in laying down transportation lines and telecommunication network.
- Forest and ecosystem: India being the 10th largest country in terms of forest cover has potential to increase its forest cover along with sustainable use of forest resources. Use of LISS-I sensor, LandSat satellite data and ResourceSat, IRS-1A has helped Forest Survey of India to map canopy cover in a better way.
- Coastal Zone Management: Rapid increase in sea level due to global warming is causing habitat loss to coastal community and loss of biodiversity to a greater extent. GIS will help in monitoring loss of biodiversity in form of coral polyps, mangrove species etc. It also maps mineral resources available of continental shelves.

REFERENCES

1. Joseph G. *Fundamentals of Remote Sensing,* Universities Press 2003
2. Otto Huisman and Rolf A. de *Principles of Geographic Information Systems* ITC, Enschede, The Netherlands, 2009
3. Ondieki C.M. and Murimi S.K. *Environmental Monitoring*, Vol. II, Kenyatta University, Kenya Copyright-Encyclopedia of Life Support Systems (EOLSS)
4. https://docs.qgis.org/3.4/en/docs/index.html
5. https://www.geographyandyou.com/
6. http://www.geogra.uah.es/patxi/gisweb/GISModule
7. https://www.esri.com/library/bestpractices/what-is-gis.pdf
8. https://iasscore.in/current-affairs/prelims/geospatial-technology-for-monitoring-natural-resources