

UNIT 1

Introduction to GIS

Geographical Information System (CACS454) — BCA IV/VIII

Geographical Information System (GIS) is a computer-based system that captures, stores, checks, integrates, manipulates, analyzes and displays data that is spatially referenced to the Earth. This unit introduces the fundamental definition, functions and applications of GIS, its core components, its identity as an information system, the nature and sources of the data it works with, and the emerging trends shaping its future.

1. Definition, Functions and Applications of GIS

A Geographic Information System (GIS) is an integrated system of computer hardware, software, data and trained personnel, designed to capture, store, retrieve, manipulate, analyze and display all forms of geographically referenced (spatial) information. Unlike a simple digital map, a GIS links attribute data (facts and figures) to spatial data (location on the Earth's surface), allowing users to ask “where” and “why” questions together, rather than in isolation.

Core Functions of GIS

- **Data Capture** — acquiring spatial and attribute data through surveys, GPS, remote sensing, scanned maps and existing digital sources.
- **Data Storage & Management** — organizing spatial and attribute data in a structured database for efficient retrieval.
- **Data Manipulation** — converting, editing, projecting and transforming data into a usable and consistent form.
- **Spatial Analysis** — performing operations such as overlay, buffering, proximity analysis and network analysis to derive new information.
- **Data Output & Visualization** — presenting results as maps, charts, reports and 3-D visualizations for decision-making.

Applications of GIS

GIS is applied across almost every discipline that deals with location. Some of the most common application areas are summarized below.

Sector	Typical GIS Application
Urban & Regional Planning	Land-use mapping, zoning, infrastructure planning

Sector	Typical GIS Application
Disaster Management	Flood/landslide hazard mapping, evacuation route planning
Agriculture	Soil mapping, crop monitoring, precision farming
Transportation	Route optimization, traffic analysis, vehicle tracking
Natural Resource Management	Forest inventory, watershed management, wildlife habitat mapping
Public Health	Disease outbreak mapping, hospital accessibility analysis
Utilities	Water supply, electricity and telecom network management
Defence & Security	Terrain analysis, surveillance and strategic planning

Example: GIS in Disaster Management

During the monsoon season, a district disaster management office overlays a digital elevation model (DEM), historical rainfall data and settlement location layers in a GIS. The system automatically highlights low-lying settlements at highest flood risk, allowing authorities to prioritize early-warning broadcasts and pre-position relief supplies before the flood occurs.

2. Components of GIS

A fully functioning GIS is built from five interdependent components. Weakness in any one component limits the effectiveness of the entire system.

Component	Description
Hardware	Computers, GPS receivers, scanners, digitizers, plotters and servers used to run GIS software and store data.
Software	Programs that provide the tools for data capture, storage, analysis and display (e.g. ArcGIS, QGIS, GRASS GIS).
Data	Spatial (locational) and attribute (descriptive) data — the single most valuable and costly component of a GIS.
People	Trained GIS analysts, technicians and end-users who design, operate and interpret the system.
Methods	The plans, models and operating procedures unique to each organization that govern how GIS is used.

Note: Data is often cited as the most expensive component of a GIS, typically accounting for well over half of total project cost.

3. GIS as Information System

A GIS is fundamentally a special type of information system. Like any information system, it takes raw data as input and produces useful information as output, but it is distinguished by its ability to handle data that is explicitly tied to geographic location. This identity can be understood through four interacting subsystems.

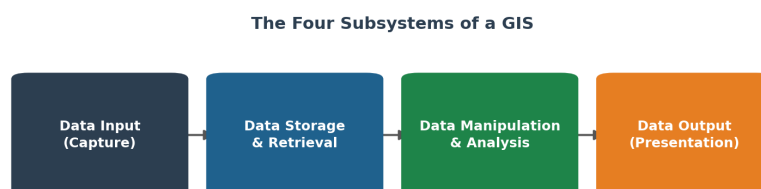


Figure 1.1 — The four subsystems that make GIS an information system.

- **Data Input Subsystem** — collects and processes spatial and attribute data from maps, field surveys, GPS and remote sensing.
- **Data Storage & Retrieval Subsystem** — organizes data into a structured database (usually a spatial database) so it can be updated and retrieved quickly.
- **Data Manipulation & Analysis Subsystem** — determines the additional information that can be generated using techniques such as overlay, buffer and network analysis.
- **Data Output Subsystem** — displays or produces all or part of the database in the form of maps, tables, charts and reports.

This subsystem view highlights that GIS is not merely a mapping tool; it is a complete information system for spatial decision-making, sharing the same input-storage-process-output logic as any other information system, but specialized for geographic data.

4. Nature & Sources of GIS Data

Nature of GIS Data

GIS data has two closely linked components. Spatial data describes the location, shape and relationships of geographic features (stored as vector data — points, lines and polygons — or as raster data, a grid of cells such as satellite imagery). Attribute data (also called non-spatial or descriptive data) provides facts about those features, such as a road's name, width or surface type, stored in linked tables.

Data Type	Representation	Example
Spatial (Vector)	Points, lines, polygons	Village location, river course, district boundary

Data Type	Representation	Example
Spatial (Raster)	Grid of cells (pixels)	Satellite image, elevation model (DEM)
Attribute (Non-spatial)	Tables / databases	Population, land-use type, road width

Sources of GIS Data

GIS data sources are broadly divided into primary sources, where data is collected directly from the field or from sensors, and secondary sources, where existing data is compiled, digitized or converted from another format.

Category	Sources
Primary Sources	Ground/field surveys, GPS (Global Positioning System), total station surveys, remote sensing (satellite and aerial imagery)
Secondary Sources	Existing topographic and thematic maps, census reports, government records, scanned/digitized documents, published statistical data

5. Recent Trends and Future of GIS

GIS continues to evolve rapidly alongside advances in computing, networking and data collection technology. Key trends shaping its future include:

- Web GIS & Cloud GIS — spatial data and analysis delivered through browsers and cloud platforms, removing the need for local installation.
- Mobile GIS — field data collection and map access directly from smartphones and tablets equipped with GPS.
- Integration with AI & Machine Learning — automated feature extraction from imagery and predictive spatial analytics.
- Internet of Things (IoT) Integration — real-time sensor networks feeding live location-based data into GIS.
- 3-D GIS & Digital Twins — realistic three-dimensional city and terrain models supporting smart-city planning.
- Open-Source GIS — growing adoption of free tools such as QGIS and GRASS GIS, increasing accessibility.
- Big Data & Crowdsourced Mapping — volunteered geographic information (e.g. OpenStreetMap) supplementing official data sources.

Key Takeaways

- ✓ GIS integrates hardware, software, data, people and methods to capture, store, analyze and display geographically referenced information.
- ✓ Its core functions are data capture, storage, manipulation, analysis and output.
- ✓ GIS applications span planning, disaster management, agriculture, transportation, health and defence.
- ✓ As an information system, GIS follows the input → storage → analysis → output model, specialized for spatial data.
- ✓ GIS data has two linked parts: spatial data (vector or raster) and attribute data, drawn from primary (field/GPS/remote sensing) and secondary (existing maps/records) sources.
- ✓ Emerging trends — Web/Cloud GIS, Mobile GIS, AI, IoT, 3-D GIS and open-source tools — are shaping the future direction of the field.

— *End of Unit 1* —