

Introduction to Geographical Information Systems (GIS)

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Key concepts, components, and applications

1. What Is GIS?

- **Definition:** A GIS is a computer-based system that captures, stores, manipulates, analyzes, manages, and visualizes spatial or geographic data.
- **Purpose:** Turns raw location-based data into useful information for decision-making, planning, and problem-solving.
- **Core Idea:** “What’s happening **where?**” – linking attributes (what) to locations (where).

2. Core Components

Component	Function	Typical Tools / Examples
Hardware	Processing power, storage, display, GPS receivers, mobile devices	Servers, workstations, tablets, drones
Software	GIS platforms for data handling & analysis	ArcGIS, QGIS, GRASS, MapInfo
Data	Spatial (coordinates, geometry) + attribute (descriptive)	Raster images, vector layers, tables
People	GIS analysts, cartographers, domain experts, end users	Urban planners, environmental scientists
Methods	Procedures and workflows for data collection, analysis, and presentation	Data cleaning, spatial queries, model building

3. Types of Spatial Data

Data Model	Geometry	Typical Use Cases
Vector	Points, lines, polygons	Roads, parcels, utility networks
Raster	Grid of cells (pixels) with values	Satellite imagery, elevation models, land cover maps

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Data Model	Geometry	Typical Use Cases
Tabular (Non-spatial)	Linked by a key (e.g., ID)	Census tables, survey results
Temporal	Time-stamped layers	Traffic flow over the day, land use change

Systems (GIS)

4. GIS Data Sources

- **Remote sensing** – satellites, aerial photography, LiDAR.
 - **Surveying & GPS** – field measurements, GNSS receivers.
 - **Existing databases** – cadastral records, utility maps, open data portals (e.g., OpenStreetMap).
 - **Crowdsourcing** – citizen science apps, social media geotags.
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5. Fundamental GIS Operations

1. Data Capture

- Digitizing maps, importing GPS tracks, scanning raster images.

2. Data Storage & Management

- File-based (Shapefile, GeoTIFF) vs. database (PostGIS, Oracle Spatial).

3. Data Editing & Cleaning

- Topology checks, attribute validation, projection conversion.

4. Spatial Analysis

- **Overlay** – intersect, union, clip.
- **Proximity** – buffer, nearest neighbor.
- **Network** – shortest path, service area.
- **Surface** – slope, aspect, interpolation.
- **Statistical** – hotspot detection, regression with spatial autocorrelation.

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5. Visualization & Cartography

Systems (GIS)

- Symbolization, labeling, scale selection, layout design.

6. Output & Sharing

- Maps (PDF, PNG), interactive web maps (Leaflet, ArcGIS Online), reports, APIs.
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6. GIS Workflow Example (Urban Planning)

1. **Define problem** – Identify suitable sites for new schools.
2. **Gather data** – Parcel boundaries, population density, road network, existing schools.
3. **Prepare data** – Project all layers to a common coordinate system, clean topology.
4. **Analyze**
 - Create buffers (e.g., 2?km) around