Spatial Information Technology

Practical Work in Geography (Part II) - Chapter 4

What this chapter is about

- Computers help us process data + draw maps, graphs + diagrams faster than by hand.
- But simple DBMS + computer cartography only process + display data. They cannot decide.
- Real life asks: What is where? Why is it there? What if it shifts? Who gains, who loses?

Three terms to fix first

- Spatial = anything tied to space + location.
- SIT = Spatial Information Technology.
- GIS = Geographical Information System.

What you should be able to do

- Define SIT + GIS in your own words.
- Tell raster from vector data.
- List the 5 components + 5 GIS activities.
- Explain overlay + buffer analysis.

How to use these notes

- Read the diagrams + tables first, then bullets.
- Last pages = quick recall + common slips.

Date : Page : 2

What is Spatial Information Tech?

Meaning of "spatial"

- The word spatial comes from "space".
- It means features + phenomena spread over a geographically definable space.
- So they have real, physically measurable dimensions (length, area, location).

Most data has a location

- Almost all data we use has a spatial part. location
- E.g. address of a municipal facility, or ~~the~~ the boundary of an agricultural holding. key

Definition of SIT

SIT is the use of ~~draw~~ technology to collect to store, retrieve, display, manipulate, manage + analyse spatial information.

SIT is an amalgamation of

- Remote Sensing
- GIS
- GPS (Global Positioning System)
- Digital Cartography
- Database Management Systems (DBMS)

In short: SIT joins 5 tools to work with located data.
Its core + most-used member is GIS.

What is GIS?

(Geographical Information System)

Why GIS came up

- Advanced computing since the mid 1970s let us process georeferenced information.
- It organises spatial + attribute data, locates files, runs computations + builds a decision support system.

Standard definition

- GIS = a system for capturing, storing, checking, integrating, manipulating, analysing + to the displaying data spatially referenced to the Earth.

What GIS is built from

- It joins Computer Assisted Cartography + DBMS.
- It needs a spatially referenced database + the right application software to run on it.

Allied sciences it draws from

Computer Science, Statistics, Cartography, Remote Sensing, Geography, Geology, Hydrology, Agriculture, Resource + Environmental Science, and Public Administration.

So GIS is multidisciplinary: many subjects feed it.

Forms of Geographical Information

Two types of data carry geographical information:

1. Spatial data

- Has a definite location on a map / the Earth.
- Shown in three forms: positional, linear + areal (point, line, area).
- Must be geometrically registered to an agreed coordinate system + coded for the GIS database.

2. Non-spatial (attribute) data

- Data that DESCRIBE the spatial data.
- They have no location of their own.

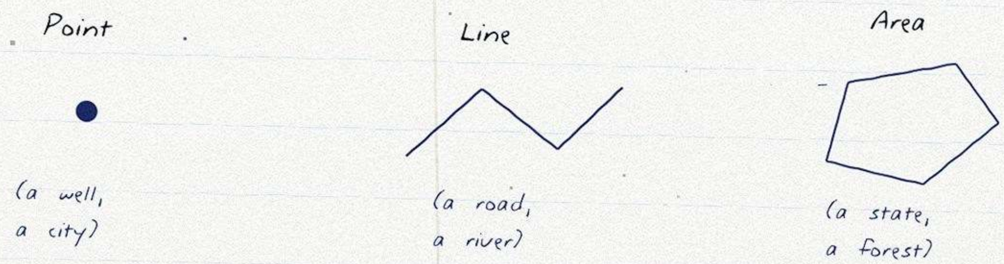
Spatial	Non-spatial
has a location	no fixed place
e.g. state on a map (literacy)	e.g. cycle parts in a register

Example (Box 4.1)

- Cycle shop stock register = non-spatial; the parts can be anywhere.
- Literacy % by state = spatial; each state has a definite place on the map. This one suits GIS.

Point, Line and Area Features

Spatial data appears in three basic shapes (Fig. 4.1). Every map feature is one of these.



How to read them

- Point = one location, no length or area.
- Line = length only (linear feature).
- Area / polygon = encloses a measurable area.

Sources of spatial data

- Most common source = topographical or thematic maps, hard copy (paper) or soft copy (digital).
- Each map has a scale, symbols + colours, and an agreed coordinate system.

Spatial data is the most important input of any GIS.

Building Spatial Data in GIS

Three ways to build the core

- Acquire data already in digital form from buya data supplier.
- Digitise existing analogue (paper) data. digitise,
- Carry out your own survey of geographic survey entities.

Choice depends on

- The application area itself.
- The available budget.
- The data structure needed (vector / raster).

What every map gives you

- A definite SCALE: links map to real surface.
- SYMBOLS + COLOURS: define the attributes of the entities mapped.
- A COORDINATE SYSTEM: fixes location on Earth.

Watch out

Using ready data is ~~colour~~ autorapeak-ibility: projection, scale + attributes may differ between suppliers.

Rule: never mix data of different scales or projections blindly.

GIS vs Manual Map Methods

Limits of a paper map

- Information is fixed in one set way.
- It shows only one or a few preset themes.
- To change anything you must draw a NEW map.

paper = rigid + fixed

Why GIS is better

- It STORES data + PRESENTS it separately, so one dataset gives many views.

Four key advantages

1. Click a feature to retrieve its attribute data for analysis.
2. Maps can be drawn by querying / analysing the attribute data.
3. Spatial operations (overlay, buffering) make brand new sets of information.
4. Different attribute items link through a shared location code.

One-line memory

- Manual = draw once, fixed forever.
- GIS = store once, query + remap endlessly.

This flexibility is exactly why GIS replaced hand methods.

Components of GIS

A GIS has five components (Fig. 4.2). Easy memory: H, S, D, P, P.

(a) Hardware

- The machine: processing, storage, display + input / output sub-systems.

(b) Software

- Modules for data entry + editing, analysis / transformation, and data display + output.

(c) Data

- The backbone: spatial data + linked tabular data. The digital map is the basic input.

data = backbone

(d) People

- From hardware / software engineers to scientists, policy-makers + monitoring agencies.

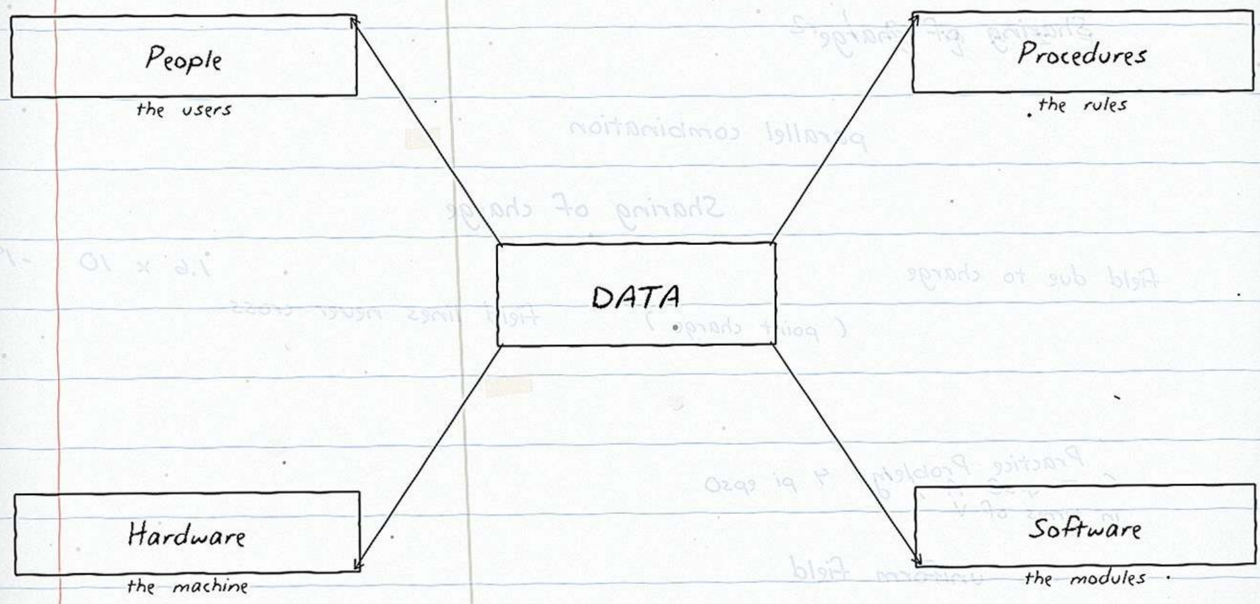
(e) Procedures

- The set rules: how data is input, stored, managed, transformed, analysed + finally presented.

Miss any one component + the GIS cannot work properly.

GIS Components: Diagram

All five components work around the DATA at the centre. (a memory map of Fig. 4.2)



Reading the map

- Hardware runs the software; people follow procedures to act on the data.
- Data sits at the heart; everything else exists to capture, manage + analyse it.

Five parts, one purpose: turn raw data into decisions.

Spatial Data Formats

Spatial data is stored in two formats:

RASTER and VECTOR.

Raster data format

- Shows a feature as a grid of small squares raster (cells or pixels), like a sheet of graph paper. = cells
- Each cell has a row + column position + a value based on the attribute there.
- Resolution = link between cell size + number of cells. Smaller cells = finer detail.

Vector data format

- Records only the coordinates of points. vector
- A point = X, Y (2D) or X, Y, Z (3D). X points from left, Y = from bottom, Z = elevation.
- Lines join points in order (lines have direction); polygons are built from points or lines.
- Vectors can store TOPOLOGY (how features connect).

Best input methods

- Raster: scanning / satellite + scanned images.
- Vector: manual digitising is the best way in.

Same diagonal line: raster fills cells, vector stores 2 points.

Raster vs Vector (Box 4.2)

Point	Raster	Vector
Structure	simple	compact
Overlay	easy + efficient	difficult
Network	difficult	efficient
Sat. imagery	compatible	not compatible
Map output	less accurate	accurate
Storage	inefficient	efficient
Variability	handled well	handled poorly

Use raster when

- Aerial photos, satellite images, scanned maps.
- Cost must be kept low; backdrop maps; no analysis of individual features needed.

Use vector when

- High precision is needed; file size matters.

Individual ~~display~~ feature analysis,

+ descriptive info must be stored.

Trick: raster wins on overlay; vector wins on networks + accuracy. Pick the format that fits the job.

Sequence of GIS Activities

GIS work follows a fixed 5-step order. Learn it as a chain; each step feeds the next.

1. Spatial data input
2. Entering the attribute data
3. Data verification + editing
4. Spatial + attribute data linkages
5. Spatial analysis

Why the order matters

- You cannot link (step 4) before both spatial + attribute data exist (steps 1 + 2).
- You must verify + edit (step 3) before you trust the analysis (step 5).
- Analysis is the LAST + most powerful step.

Memory line: Input, Attributes, Check, Link, Analyse.

Same as: I-A-C-L-A.

Spatial Data Input

Two categories

- (a) Acquire digital data sets from a supplier.
- (b) Create digital data sets by manual input.

(a) Buying digital data

- Fast + saves time; frees small offices from digitising their own data.
- But watch data compatibility: scale, geo-referencing, quality + record length.

(b) Manual input: 4 stages

1. Enter the spatial data.
2. Enter the attribute data.
3. Verify + edit both sets.
4. Link the spatial to the attribute data.

spatial
then
attribute

Two main input methods

- Digitisation: trace features into points, lines + polygons using their coordinates.
- Scanning: convert a paper map to a digital raster image.

Digitisers + scanners save a lot of time + labour over writing coordinates by hand.

Scanners + Attribute Data

What scanners do

- Devices that turn analogue maps into digital, grid-based (raster) images.
- Output can be used directly or processed into vector topology.

Two basic types

- Step-for-step scanners (record bit by bit).
- Whole-document scanners (scan in one go).

CCD: the sensor

- CCD = Charged Coupled Device.

  It turns photons of ligh~~protons~~unts of electrons, recorded as a digital value.
- Maps mount on a flat bed or a rotating drum.
- Even the best scan keeps the smudges + defects of the original; excess data must be removed.

Attribute data

- Define properties of a feature that are NOT spatial. E.g. a road: width, surface type, traffic count, regulations.
- Sources: records, censuses, surveys, spreadsheets.

Spatial data = where; attribute data = what + how much.

Data Verification + Editing

Why check the data

- Captured data may have errors; we verify it to ensure accuracy before analysis.
- Best check: plot the data on a translucent sheet at the same scale + overlay it on the original on a light table; compare left to right, top down.

Three common error types

- 1. Incomplete / double: omissions of points, gaps, lines or polygons; gaps in scanned lines.
- 2. Wrong scale: digitised or geo-referenced scale, an incorrect scale.
- 3. Distorted: from lens distortion, relief, or warp paper warped by rain, sun + folding.

How errors are fixed

- View the faulty part on screen + edit with the keyboard, mouse cursor or a digitiser tablet.
- Move, rotate, erase, insert, stretch or truncate entities. Extra points removed by "weeding".
- Raster errors fixed by changing faulty cell values.

Editing can take longer than the data input itself; it is slow + interactive but vital for accuracy.

Data Conversion

One format at a time

- While analysing, all layers must be in the SAME format: all raster, or all vector.
- Mixed formats cannot be analysed together.

Vector to raster

- Most common conversion.
- Done because most analysis runs in the raster domain.

vector
raster

- Method: overlay a grid of a chosen cell size on the vector data.

Raster to vector

- Done mainly to REDUCE data storage.
- Raster files need much more storage than vector files for the same area.

Quick contrast

Con~~tort saveasspace~~ to

analyse; convert to vector to save space.

So conversion direction depends on your goal: analysis (use raster) or storage (use vector).

Linkages + Matching

Linkages

- A GIS links different data sets together.
- E.g. to find child mortality from malnutrition, link the "number of children" file with the "mortality rate" file, then divide.

Three kinds of matching

1. Exact matching

- Two files about the same features (e.g. towns) joined by a common key, like the town name.

2. Hierarchical matching

- Small areas added up until grouped areas match the bigger ones, then matched exactly.
- Used when smaller areas nest inside larger ones.

3. Fuzzy matching

- Used when boundaries do NOT match neatly.
- Common with environmental data, e.g. crop edges vs soil-type boundaries: overlay both + compute the combinations.

Sets link only when they ~~name~~ the same geographical area.

Spatial Analysis

The strength of GIS

- Spatial analysis is what makes GIS different from any other information system.
- Aim: turn data into useful information for decision-makers; even predict future trends.
- Always define the problem + purpose first, then work step by step.

Four analysis operations

– (i) Overlay analysis
– (ii) Buffer analysis
– (iii) Network analysis
– (iv) Digital Terrain Model

syllabus:

overlay +

Note for exams

- The chapter studies only OVERLAY + BUFFER in detail (next two pages).

Why it matters

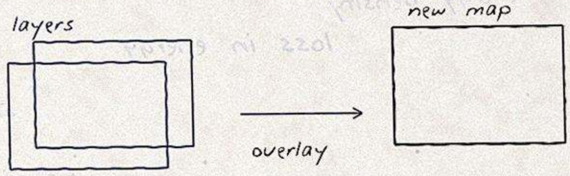
- Analysis answers real questions about the world: what is where, why, + what if it changes.
- Models built in GIS reveal trends + new options.
- This is how GIS becomes a decision support system.

Remember: overlay + buffer are the two you must explain fully in the board exam.

Overlay Analysis

What it does

- The hallmark of GIS.
- Stacks two or more thematic map layers of the SAME area to make a new map layer.
- Like sieve mapping: tracing maps laid over each other on a light table to compare.



Where it is used

- Study land use / land cover change over two different time periods.
- Suitability analysis: is this land fit for a proposed new use?

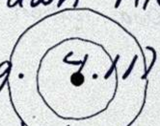
Case study (Figs 4.8 to 4.10)

- Aligarh city, Uttar Pradesh: urban land use of 1974 + 2001 overlaid.
- Result maps the urban TRANSFORMATION + the urban SPRAWL during 1974 to 2001.

Buffer Analysis

What a buffer is

- A zone of a fixed distance drawn AROUND a point, line or area feature (Fig. 4.11).



- It always makes a polygon, whatever the feature.
- This is also called PROXIMITY analysis.

What it is used for

- Find areas / people served OR denied a facility: hospitals, post offices, roads, parks.
- Study impact of point pollution (air, noise, water) on the population around it.

Case study (Figs 4.12 to 4.13)

- Western UP cities: Saharanpur, Muzaffarnagar, Meerut, Ghaziabad, Gautam Budh Nagar + Aligarh.
- Buffers of 2, 4, 6, 8 + 10 km drawn around cities with a major hospital.
- Finding: areas close to cities are well served; distant areas are least benefitted.

Free GIS software (FYI)

- Arc View / ArcGIS, Geomedia, Quantum GIS (QGIS) all provide buffer + overlay modules.

Overlay = stack layers; buffer = ring of nearness.

Key Terms + Quick Facts

Spatial	Tied to space + a definite location
SIT	Tech to handle spatial information
GIS	System for spatially referenced data
Attribute data	Non-spatial data describing a feature
Raster	Grid of cells / pixels
Vector	Points stored as X, Y (2) coordinates
Topology	How features connect, stored by vectors
Resolution	Cell size vs number of cells (raster)
Digitisation	Tracing features into coordinates
CCD	Sensor: photons to electron counts
Overlay	Stacking map layers to a new layer
Buffer	Fixed-distance zone (proximity)

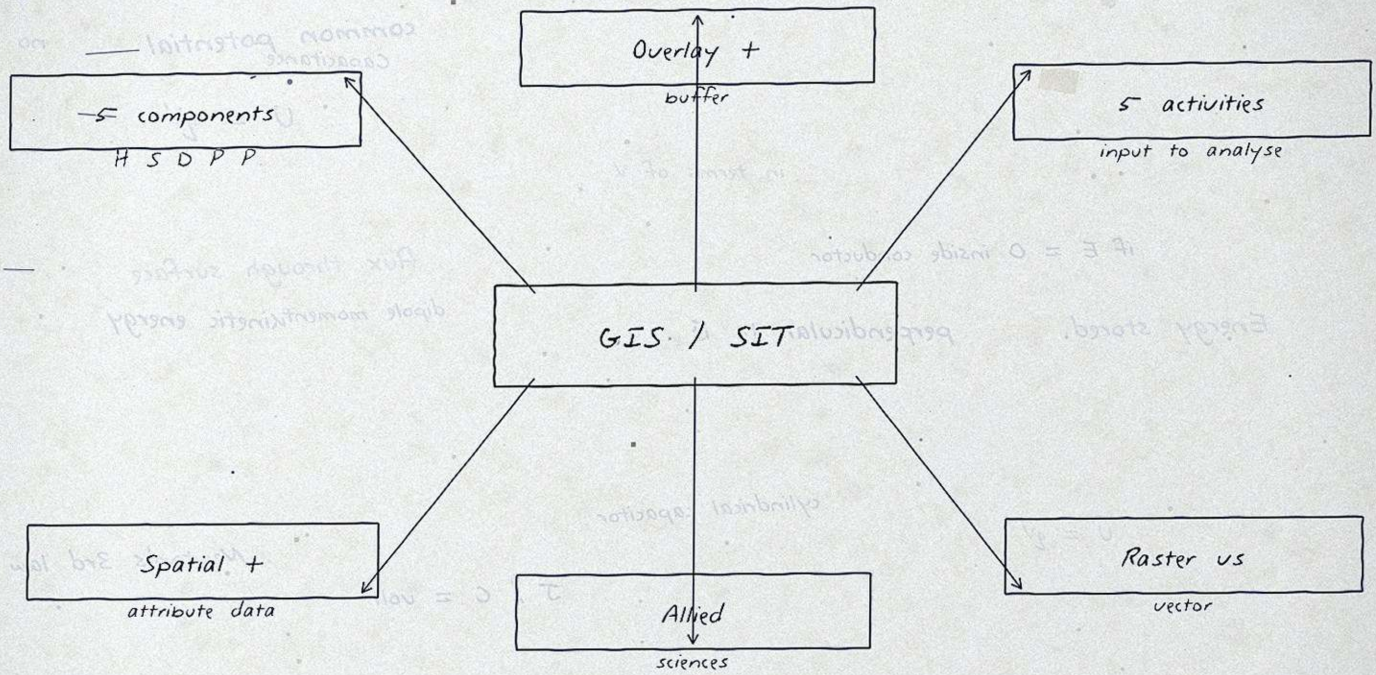
Facts worth quoting

- GIS computing took off since the mid 1970s.
- SIT = Remote Sensing + GPS + GIS + Digital Cartography + DBMS.
- 5 components = Hardware, Software, Data, People, Procedures.
- 5 GIS activities; 4 analysis operations.

~~georefenanced~~ georeferenced, topology, proximity, amalgamation.

Learn definitions word-for-word; examiners reward precision.

Whole Chapter: Mind-Map



Read it as one chain

- SIT joins 5 tools; GIS is its core.
- Data is spatial + attribute, stored as raster or vector.
- Five components run five activities, ending in spatial analysis (overlay + buffer).

Learn this chain; it frames most short + long answers.

Quick Recall + Traps

Five-line answer skeleton

- 1. Spatial = located data; SIT handles it.
- 2. GIS captures, stores, analyses + displays data referenced to the Earth.
- 3. Data = spatial (point/line/area) + attribute; formats = raster (cells) + vector (points).
- 4. 5 components, 5 activities ending in analysis.
- 5. Overlay stacks layers; buffer rings a feature.

Common slips to avoid

~~points~~ ~~cells~~ VECTOR stores

points + coordinates.

~~distances~~ layer change;

BUFFER is for distance / proximity.

- Attribute data is NON-spatial: it describes, it does not locate.
- Vector to raster = for analysis; raster to vector = to save storage.
- Exact / hierarchical / fuzzy = three matchings.

Master these corrections + the format table; that covers

most MCQ + short-answer marks.