Intro to Spatial Science & Technology

Lecture 11: Spatial Analysis and Modelling - Map based approaches

Dr. K. S. Rajan
Lab for Spatial Informatics, IIIT Hyderabad
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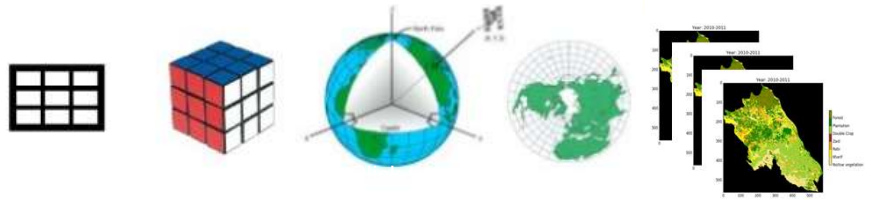
Geo-Spatial Data

((geo)spatial) data



Tabular	Spatial	Geospatial	Geospatial Projected	Spatiotemporal
	xyz	Xyz lat/long/H	xy(H) EN(H)	xy(H)t

Image Modified based on Talk by Thierry Gregorius Delivered to the BCS Data Management forum, an overview of GIS/Geospatial

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What to do with the Spatial Data?

- Primarily to V**isualize (Depict or Draw)** the data

Location of a Spatial Object
- Points like IIITH
- Linear Objects like River Ganges
- District of Hyderabad

- How to **locate or identify** the interested Spatial Object/Objects ?

Query the data to highlight
Extract the data (for use here or elsewhere)

- What about **Analysis** ?

Spatial relationships ?
Cause-effect relations; Co-occurence; mathematical

- Spatial **Modelling** – what and how?

Map analysis and modelling

"What distinguishes a GIS from other types of information systems are its spatial analysis functions. These functions use the spatial and non-spatial attribute data in the GIS database to answer questions about the real world".

— Aronoff, 1989, pp 189.

Analysis or modelling?

- The advantage a GIS is in providing the capability for transforming the original spatial data to answer user's questions.
- Such transformations are often referred to as "data analysis" capabilities in GIS.
- However, most so-called "analysis" capabilities of today's GIS are in fact data manipulation and maintenance functions, very rarely it actually tells us something by "analysing" spatial data.

What is a Model?

A model is an idealized and simplified representation of reality and/or its processes

Additionally, In GeoSpatial or Geoinformation sciences,

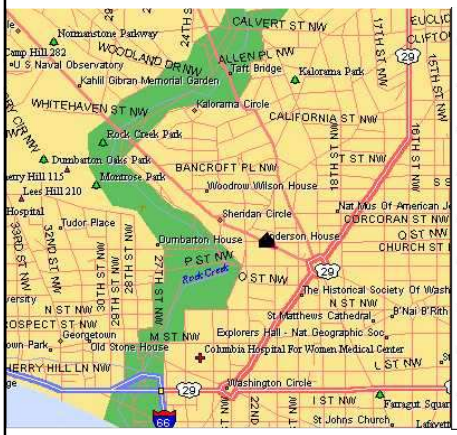
Model also refers to replicate something.

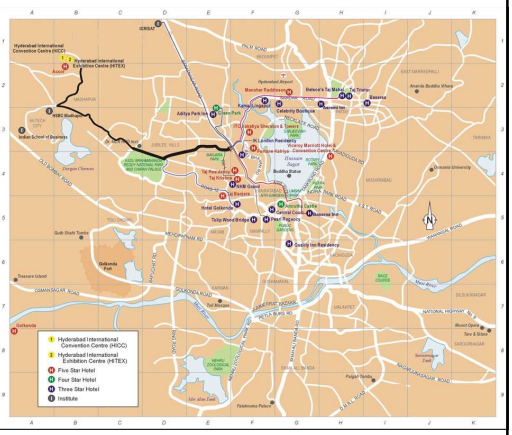
So, can be comparable to "mould, or form", and has the meaning of design, plan, or scheme.

A Globe is a model of the Earth

Source: Wikipedia https://en.wikipedia.org

A Map is a graphical model of the earth surface





A Photo is a pictorial model of surface features

Models are of many different types

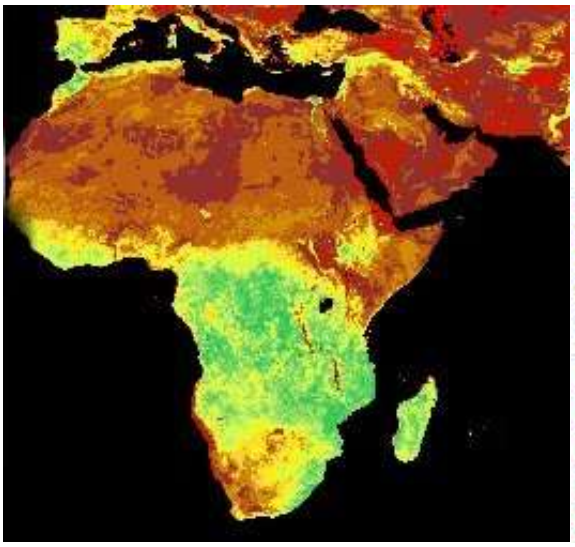
A model could be a theory, a law, a hypothesis, an equation, or even a structured idea

From Haggett and Chorley, 1967

Model can also be used to simulate, visualize, test and evaluate tasks, activities and their impacts or outcomes

- End product is a Replica of a portion of the Earth
  - Maps, etc
- For information science to utilize this geo-spatial model,
  - It should be in a digital / computer readable form
  - Can be manipulated, exploited and used to perform different tasks
- Such digital Models then help in tasks -
  - Making it easier than in reality
  - Too difficult or expensive or impossible to do in reality

Vegetation Index Map – based on NDVI as a Model



Low NDVI

$$NDVI = \frac{IR-R}{IR+R}$$

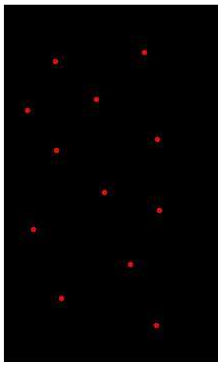
Models the abundance of living plant material from satellite data

High NDVI

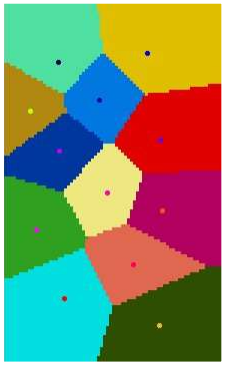
Digital Elevation Model

Weather Modelling for a location

Thiessen Polygon:



Weather Station



Predicted Model

GeoSpatial Modelling of Flood visualization

Vishal Tiwari and KS Rajan, 2017

Modelling of Reality

- All aspects of Reality cannot be modelled in one model
- Only some aspects at a Manageble level is included in the model
- Quality of the model is in its purpose, performance of the tasks or operations with acceptable results

- Single-purpose Model
- Integrated Models

Levels of Abstraction in GIS Data Models

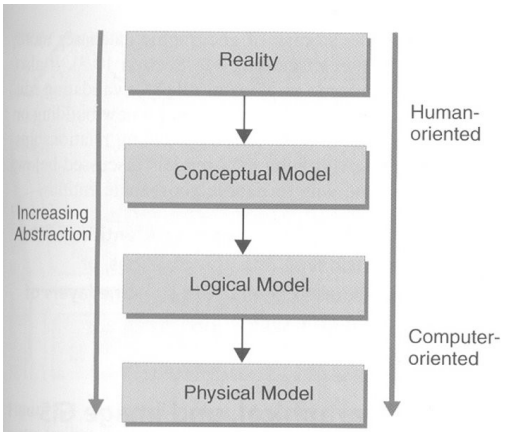


Figure 8.2 Levels of abstraction relevant to GIS data models

Levels of GeoSpatial Modelling

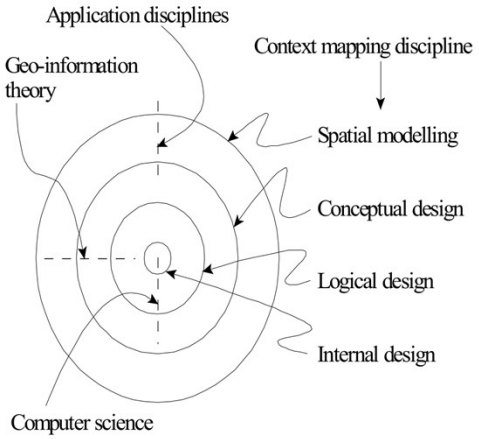


Fig. 4.3 Levels of geo-spatial modelling (after Molenaar 1994b).

Components of a Geo-Spatial Model

1. Object types
   - Eg. River, road, city, etc
2. Relationships
   - Eg. NH44 passes through Hyderabad
3. Attributes or Characteristics or Description
   - Eg. Name, size etc and how it affects its use
4. Conventions
   - Eg. Each feature has only one geometry
5. Operations

"Modelling"?

- Modelling specifies data transformations which involve the synthesis of information.
- The "synthesis" is the process to put together expressions of general principles with representations of parts of the reference system so as to form a replica that exhibits behaviour similar to that of the reference system.

Analysis versus modelling

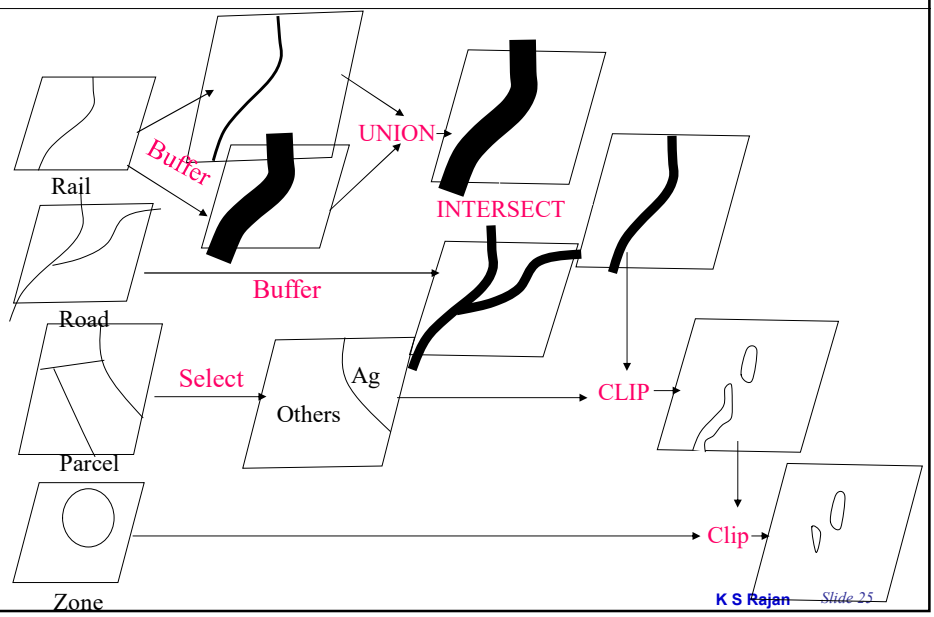
- A theory is the product of analysis.
- A model is the product of syntheses, using theory.

Solving Spatial Problem with GIS

Find a suitable site that meets the following criteria:

1. Can't be located on existing Agricultural Land
2. Should be within 2000m of roads
3. Should be located beyond 500m but within 3500m of existing railroads
4. Should be within industrial zone
5. The proposed site should be at least 45 acres

Spatial Model for selecting proposed sites



Data Conversion

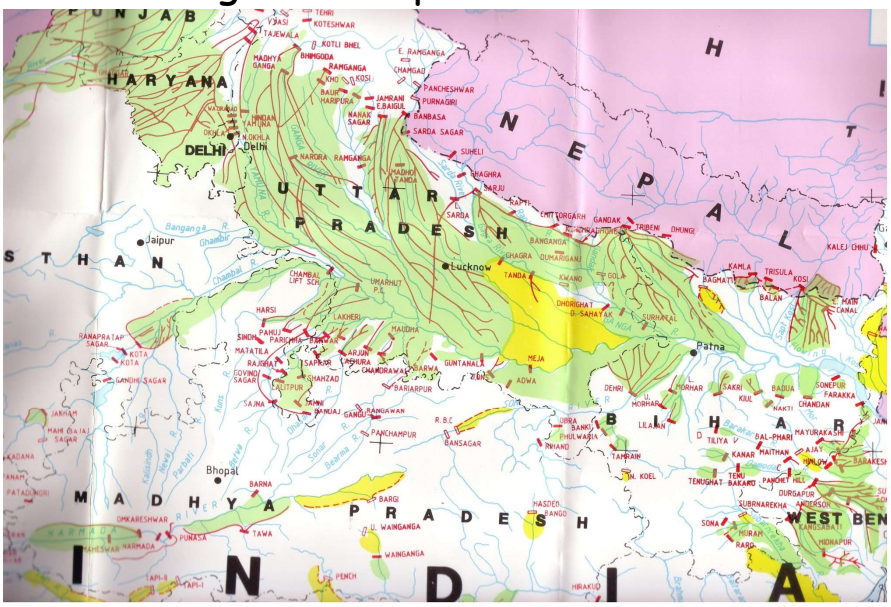
Often necessary to change from one basic data model to another.

Challenges
- Loss of data.
- Reduction in accuracy

✓ **Rasterization (V2R)**
✓ **Vectorization (R2V)**

Rasterization is relatively easy.
Vectorization is much more complicated and difficult.

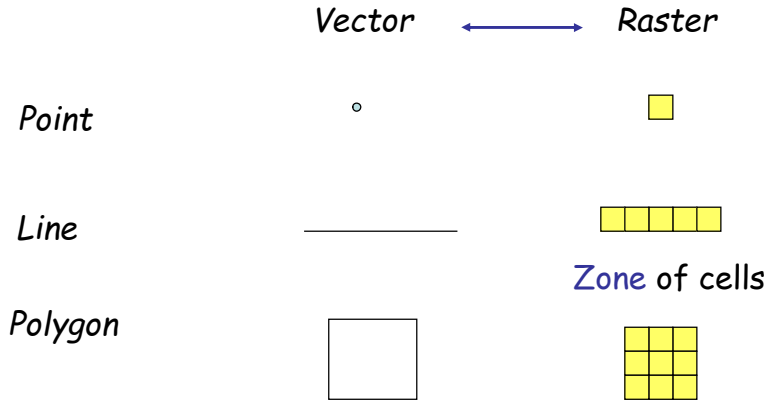
Irrigation Map of North India



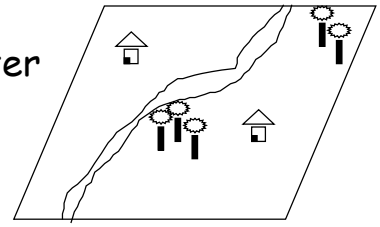
Vector – Raster Comparison and Conversion

Raster and Vector Data

Raster data are described by a cell grid, one value per cell



Concept of Vector and Raster

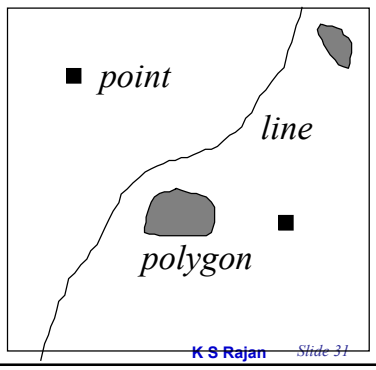


Real World

Raster Representation

	0	1	2	3	4	5	6	7	8
0								R	T
1							R		
2		H					R		
3							R		
4					R	R			
5				R					
6			R		T	T		H	
7			R		T	T			
8		R							

Vector Representation



Vector vs Raster Graphics

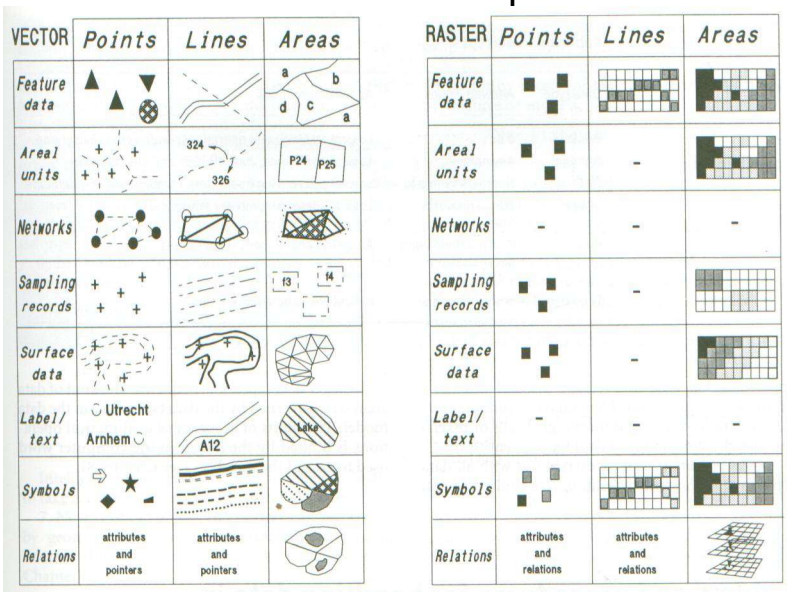


Image Source: Burrough, Peter A. and Rachael A. McDonnell. (1998). *Principles of Geographic Information Systems*. p 27.

Raster Data Model

Advantages

- It is a simple data structure
- Overlay operations are easily and efficiently implemented
- High spatial variability is efficiently represented in a raster format
- The raster model is more or less required for efficient manipulation and enhancement of digital images

Disadvantages

- The raster data structure is less compact data though compression techniques may overcome this problem.
- Topological relationships are more difficult to represent.
- The output of graphics is less aesthetically pleasing depending on the resolution. This can be overcome by using a very large number of cells, but may result in unacceptably large files

Vector Data Model

Advantages

- It provides a more compact data structure than the raster model
- It provides efficient encoding of topology and as a result more efficient implementation of operations that require topological information, such as network analysis
- The vector model is better suited to supporting graphics that closely approximate hand-drawn maps

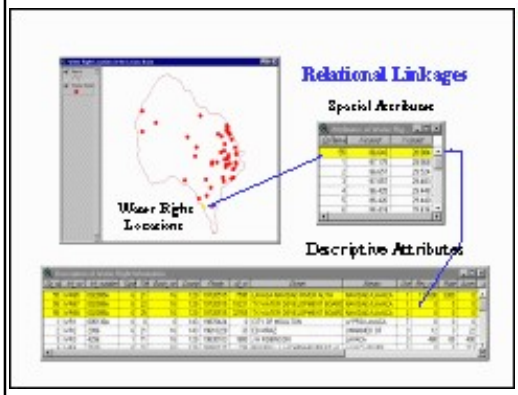
Disadvantages

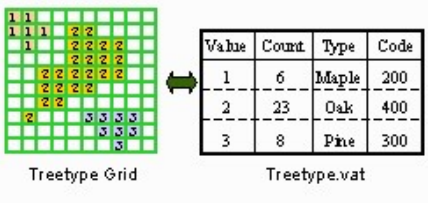
- It is a more complex data structure than a simple raster
- Overlay operations are more difficult to implement
- The representation of high spatial variability is inefficient
- Manipulation and enhancement of digital images cannot be effectively done in the vector domain

Attribute information stored in tables

Feature tables for vector data

Value attribute tables for categorical (integer) grid data (in some software)

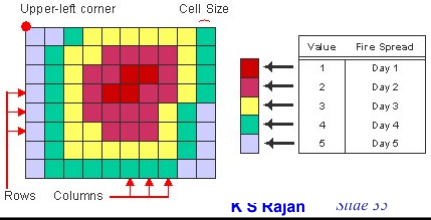




Value	Count	Type	Code
1	6	Maple	200
2	23	Oak	400
3	8	Pine	300

Treetype Grid

Treetype.vat



Additional Reading

Vector models like TIGER, DLG, DNG, DXF, DWG etc

Raster formats like JPEG, TIFF, GEOTIFF, MrSID etc