Project for the Strengthening of Spatial Data Infrastructures in Member States and Territories of the Association of Caribbean States

Capacity Building Program

Geographic Information Systems

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UN-GGIM:Américas
COMITÉ REGIONAL DE LAS NACIONES UNIDAS SOBRE LA GESTIÓN GLOBAL DE INFORMACIÓN GEOESPACIAL PARA LAS AMÉRICAS
ACS AEC
Association of Caribbean States
Asociación de Estados del Caribe
Association des Etats de la Caraïbe
AMEXCID
AGENCIA MEXICANA DE COOPERACIÓN INTERNACIONAL PARA EL DESARROLLO
INEGI
INSTITUTO NACIONAL DE ESTADÍSTICA Y GEOGRAFÍA

Topic 1:
GIS Fundamentals

Topic Outline

- What is a GIS?
- Components of a GIS
- Functions of a GIS
- Data Models used in GIS
- Components of Spatial Data
- GIS Software
- The GIS Process

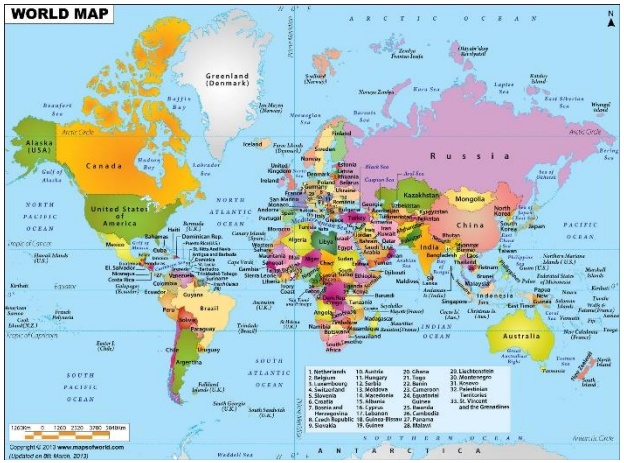
"…..everything that happens, happens somewhere. Knowing 'what' is 'where' and 'why' it is there, can be critically important for decision making. GIS is the technology as well as science to help answer these types of questions and for making intelligent decisions based on space and location…. "

Pinde Fu and Jiulin Sun

What is GIS?

What is GIS?

- Is it mapping???

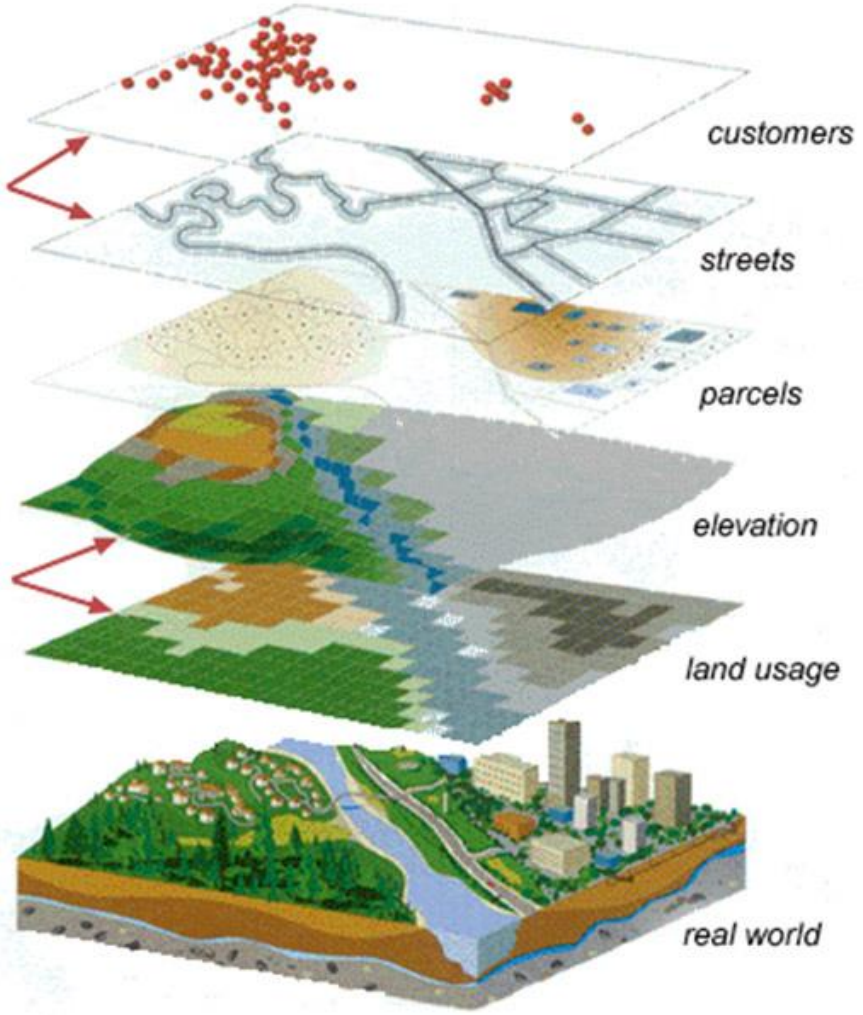


What is GIS?

- What's the GI?

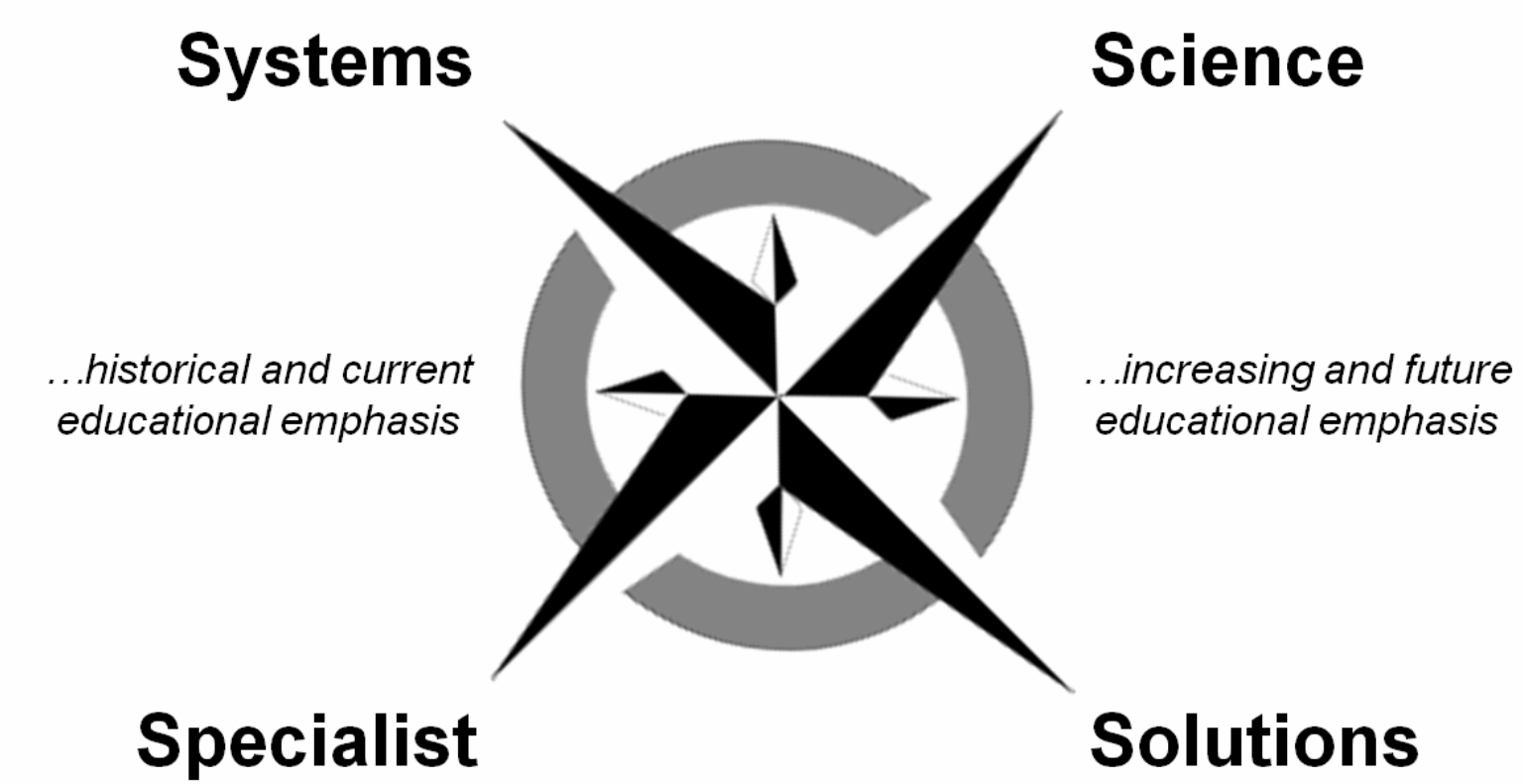
Geographic/Geospatial Information

  - information about places on the earth's surface
  - knowledge about "what is located where"



What is GIS?

- …four main perspectives of the trailing "**S**"



GIS

Geographic Information System

Maps + Database = GIS

What is a GIS ?

A **G**eographic **I**nformation **S**ystem (**GIS**) is an organized collection of computer hardware, software, people, data and workflows designed to efficiently capture, store, query, analyze and display of all forms of spatially referenced data.

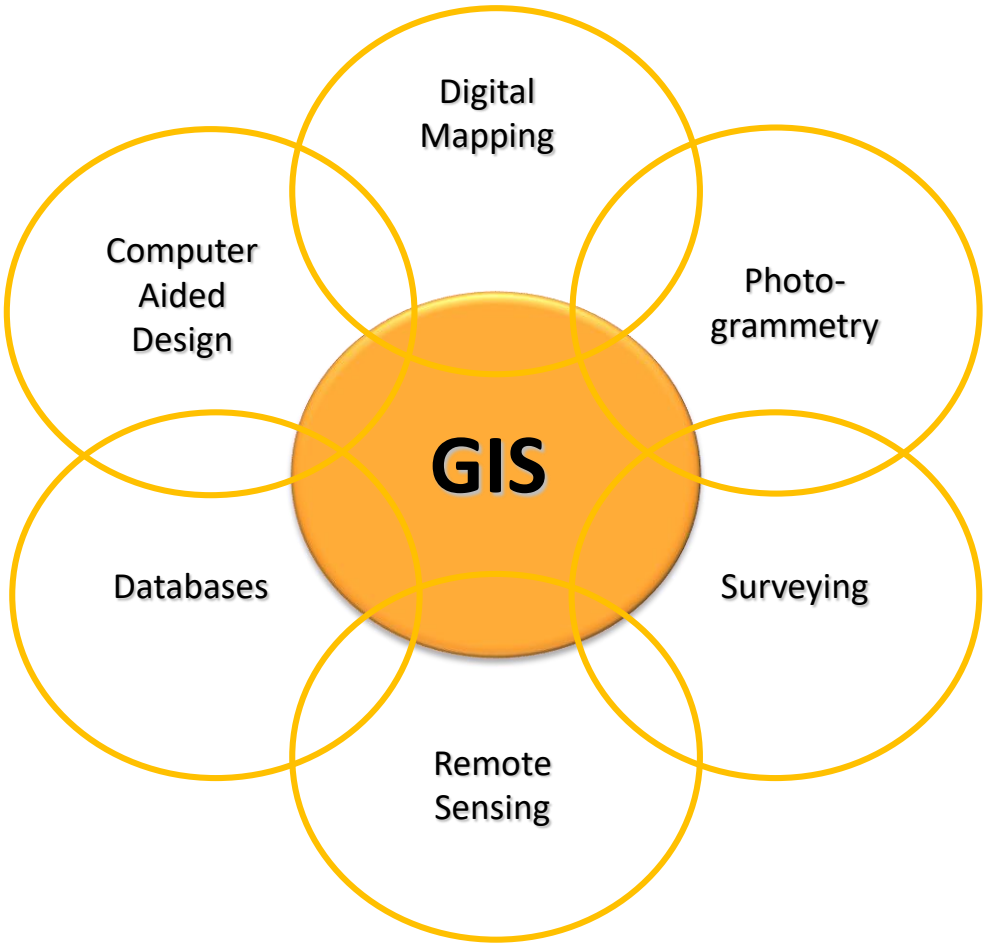
What is GIS?

Geographic **I**nformation **S**ystems (**GIS**) is a set of tools that integrate and link various components: hardware, software, human capital, data and processes; that capture, store, manage, analyse and model large amounts of geographically referenced information in order to meet the needs related to planning and management

UNGGIM: Americas

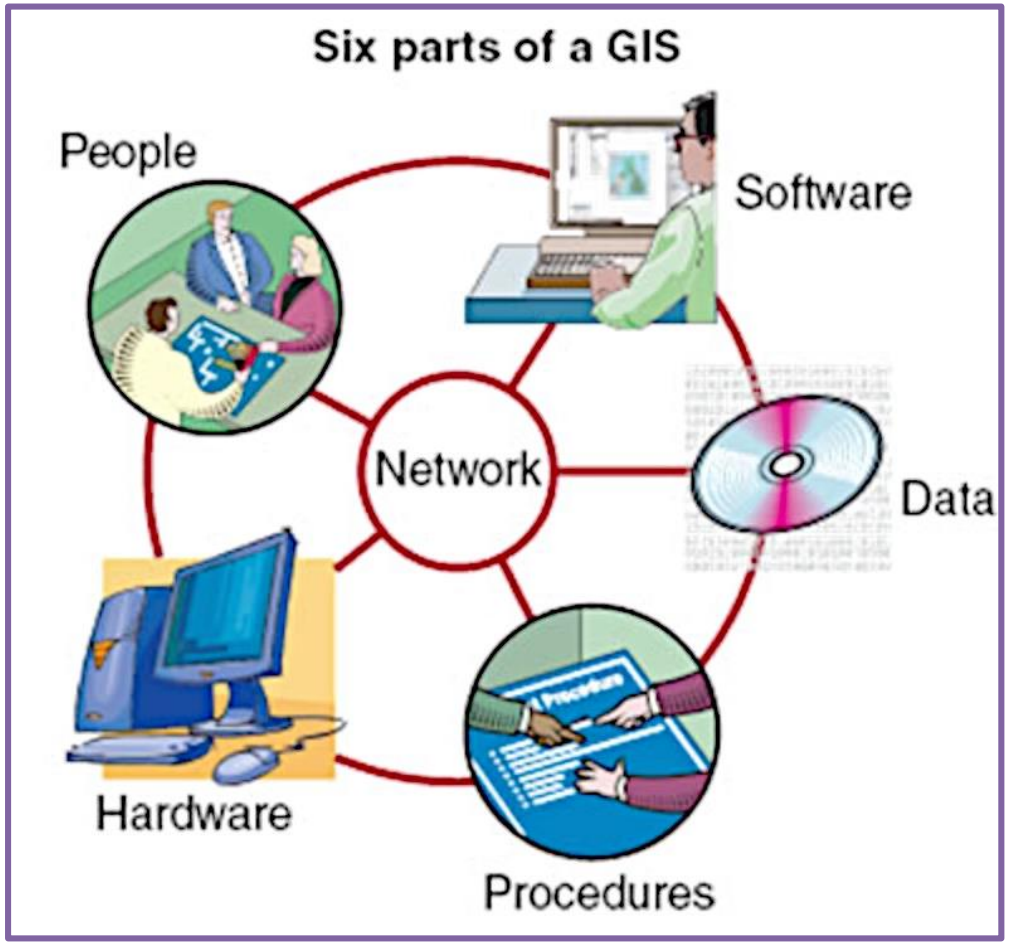
What is GIS?


GIS
INFORMATION
PRESENT
GEOGRAPHIC
MANIPULATE
DIGITAL
ANALYZE
SYSTEM
INFORMATION
CAPTURE
SPATIAL
STORE
DATA
SOFTWARE
ACCURACY
MANAGE
MODELING
MAPPING
TECHNOLOGY
CARTOGRAPHY
LOCATION



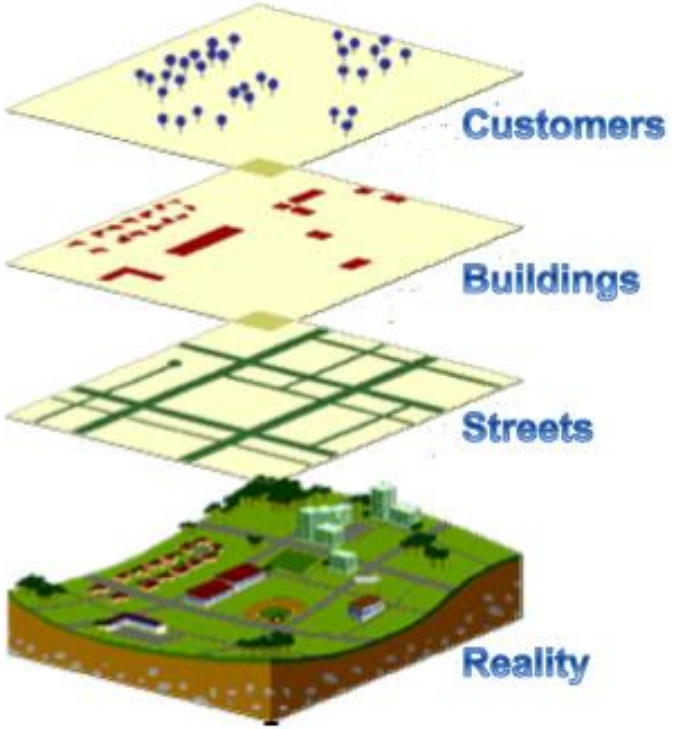
Cross-disciplinary nature of GIS

Components of a GIS



- **People**: *users*
- **Software**: *desktop clients, web browsers*
- **Data**: *spatial features*
- **Procedures**: *workflows*
- **Hardware**: servers, *workstations, plotters*
- **Network**: *intranet, internet*

Functions of a GIS



Storing Data

SINGLE-USER GDB

- File GDB
- Personal GDB

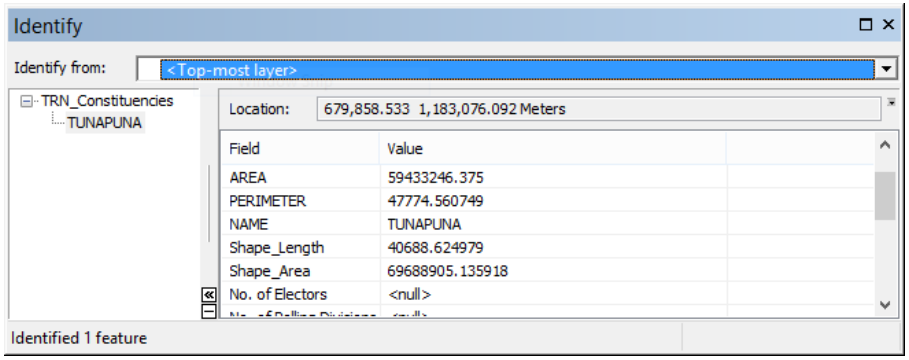
MULTI-USER GDB

- Enterprise GDB
- Workgroup GDB
- Desktop GDB

GEODATABASE (GDB)

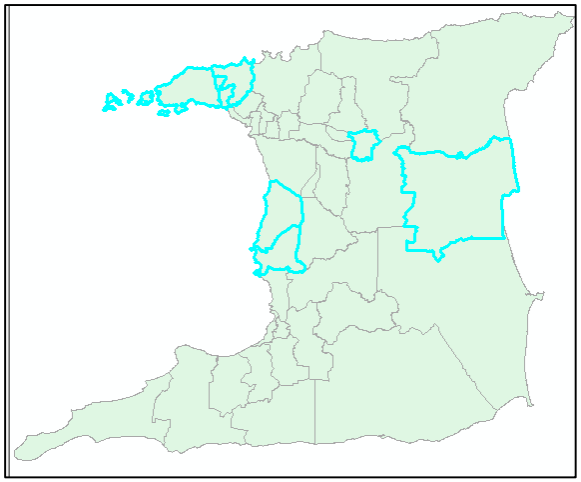
Query

- Identifying specific features



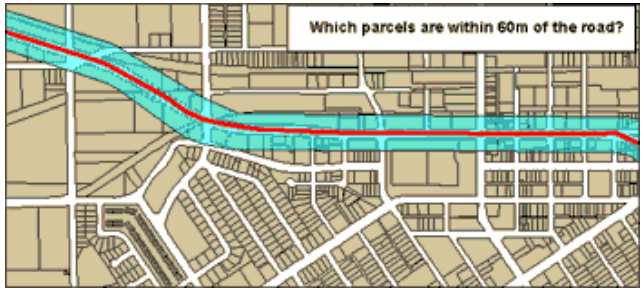
- Identifying features based on conditions

Trinidad Constituencies with an electorate greater than 28,000



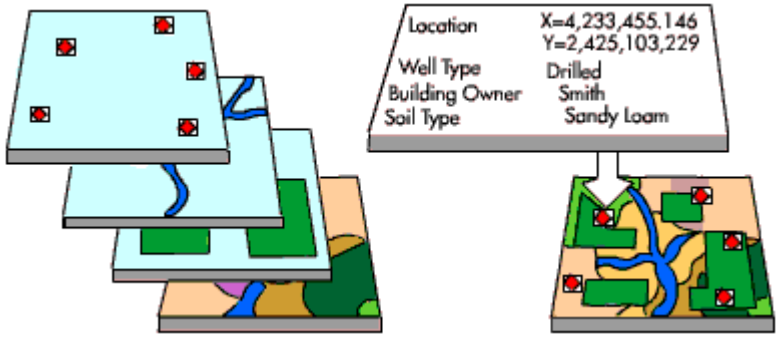
Analysis

Proximity



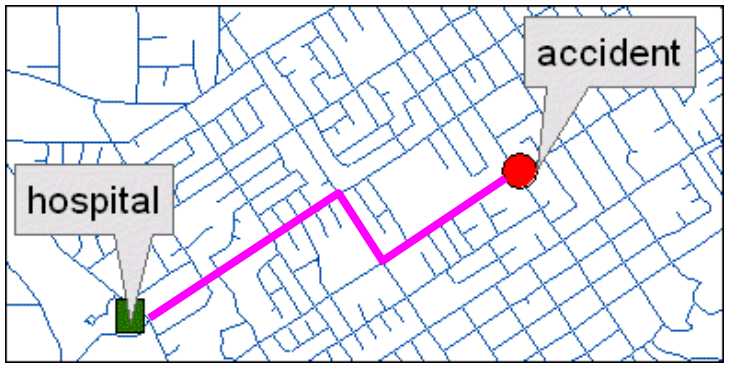
Which parcels are within 50 feet of the road?

Overlay

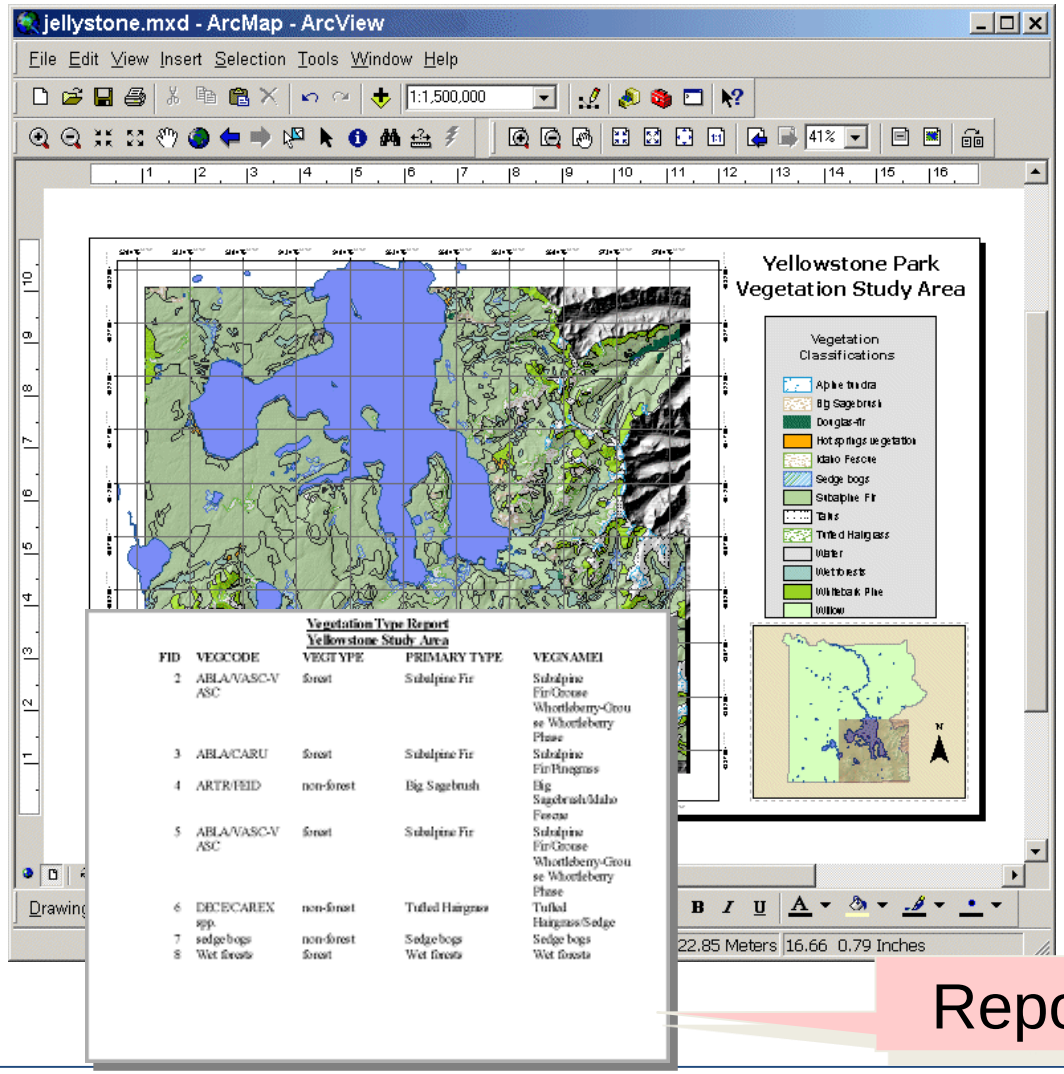


Well type	Drilled
Building owner	Smith
Soil type	Sandy

Network

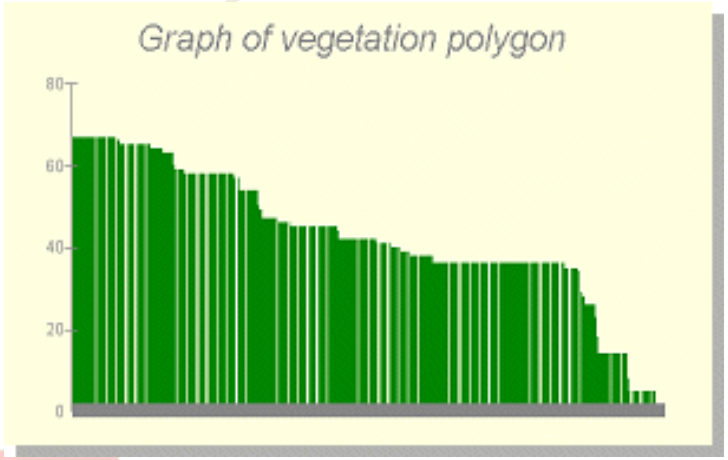


Display



Maps

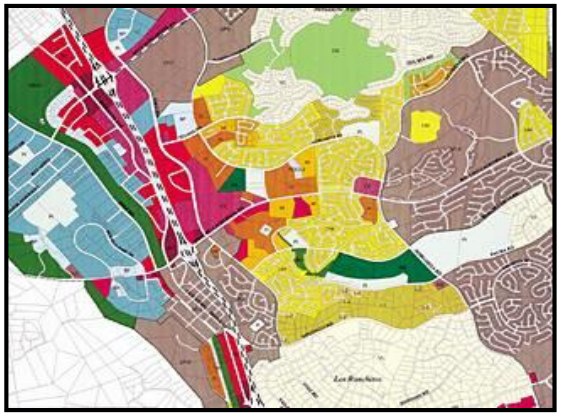
Graphs



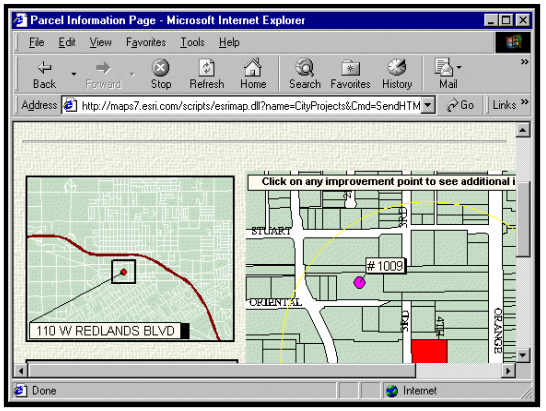
Reports

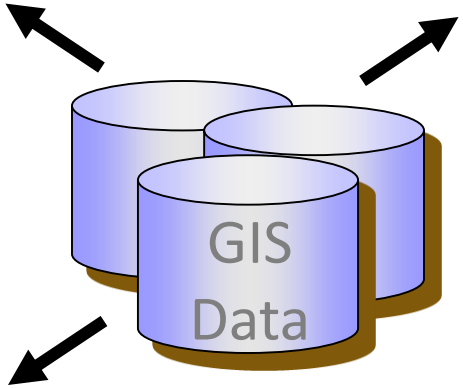
Output

Paper map



Internet





Image

Trinidad.jpg

Document

Trinidad.mxd

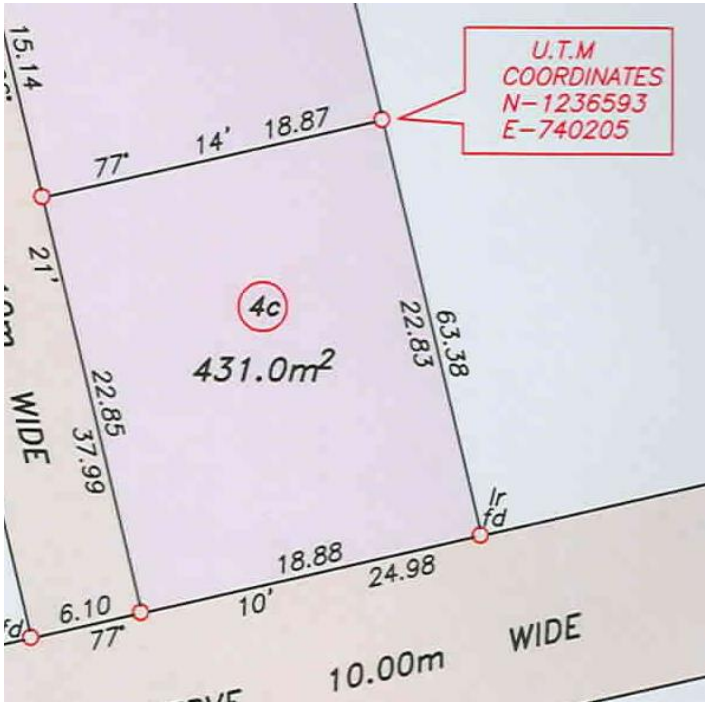
GIS DATA

- A GIS comprises traditional data found on a map and more…
- it utilizes two basic types of data:

- **Spatial data**:
  - describes the ***absolute*** or ***relative*** location of geographic features
- **Attribute data**:
  - describes the ***characteristics*** of the spatial features
  - Quantitative or qualitative
  - Also referred to as ***tabular data (or Aspatial)***

Example

The boundary lines of a parcel would be its spatial data



The characteristics of that parcel: eg. ID, Owner, area, perimeter, address, value, would be attribute data!

Linking Spatial and Attribute Data

Spatial data

- specifies location
- stored in a *geodatabase* or similar *GIS* file

Attribute data

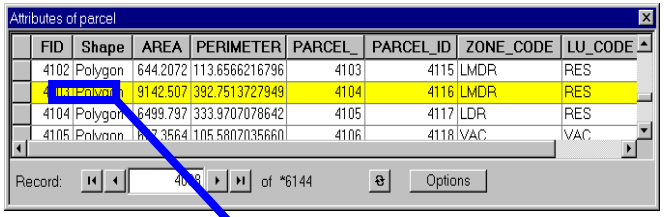
- specifies characteristics *(what, how much, when)*
- stored in a database *table*

The two are 'Linked' using ***relational*** database tables

Linking Geometry (spatial) and Attributes

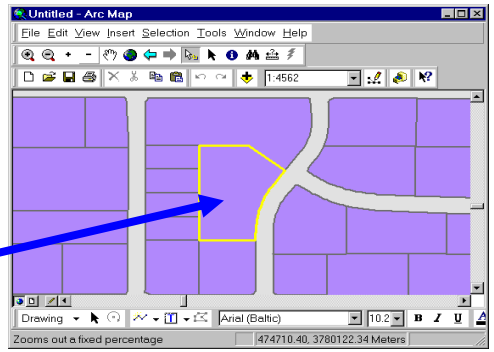
- Geospatial data (features) are stored in tables

- Each feature has a record (row) in the table
  - A unique identifier links feature and attributes



FID = 4103

(Feature IDentifier)



Land Information System

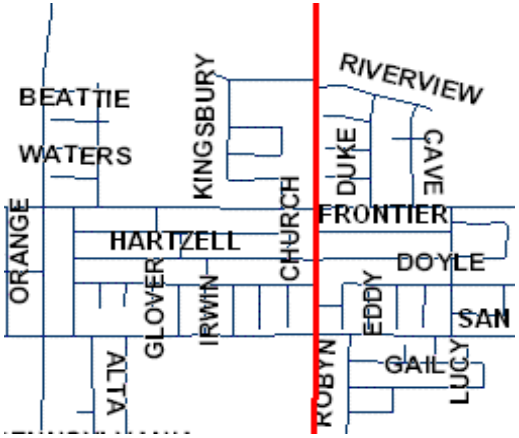
CAMA

Property ID	29140201402500006
Property Address	7355 Catboat Ct
City	Fishers
State	IN
Zip	46038
Year Built	2010
Assessed Value Land	47000
Assessed Value Improvements	222700

Components of spatial data

- Spatial data can be described in terms of:
  - geometry, location, and topology OR shape, place and relationship to other spatial data

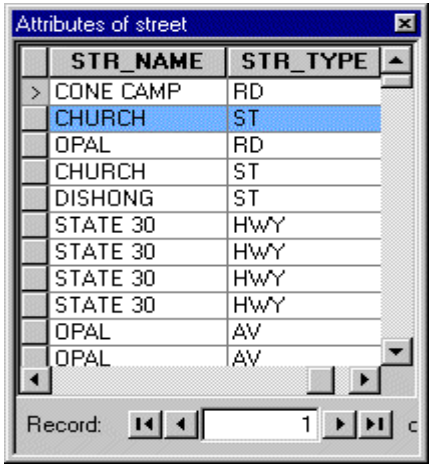
Geometry



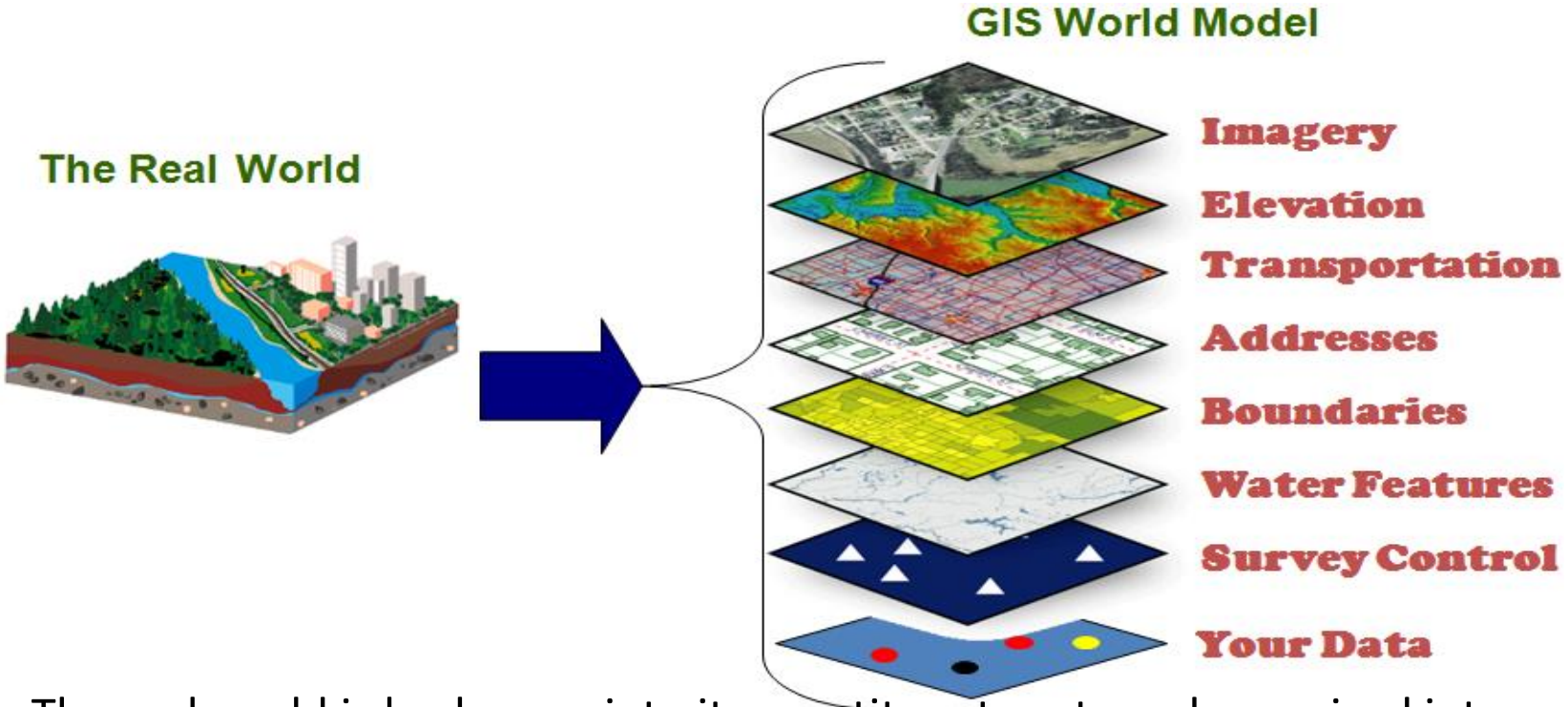
Behavior

Connectivity
Relationships

Attributes



Representing Reality: The GIS Data Model

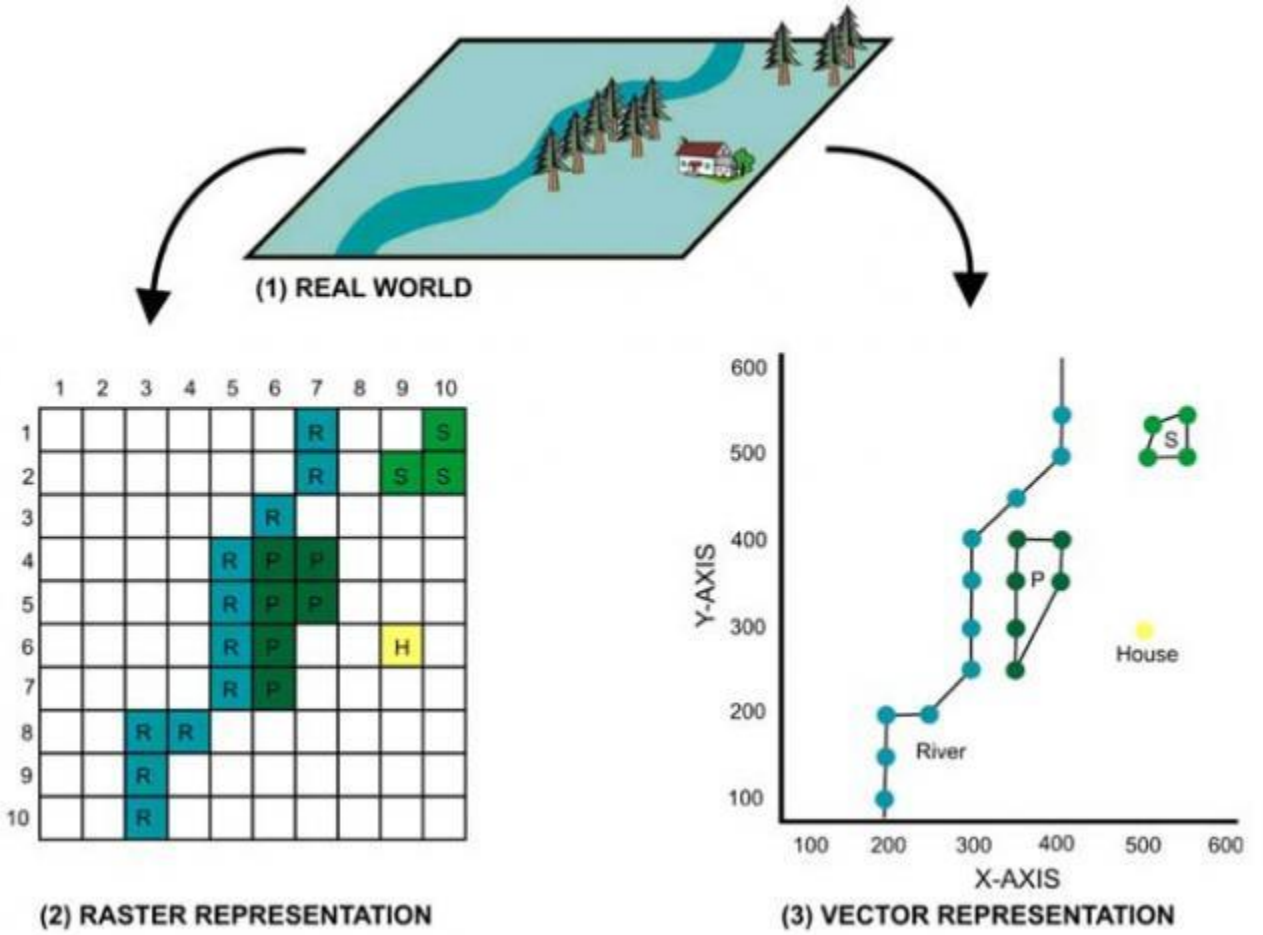


- The real world is broken up into its constituent parts and organized into spatially referenced layers or themes*, with each layer representing a common feature.*
- A spatial reference system becomes critical for ensuring accurate feature overlaying

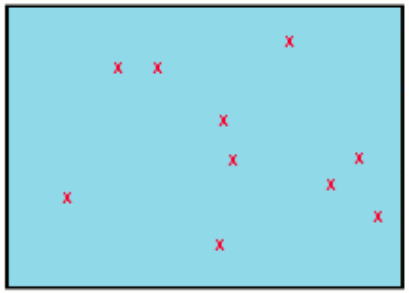
The GIS Data Model: Purpose

Allows the **geospatial features** in **real world locations** to be digitally represented and stored in a database so that they can be abstractly presented in **map** form, and can also be worked with and **manipulated** to address some **problem.**

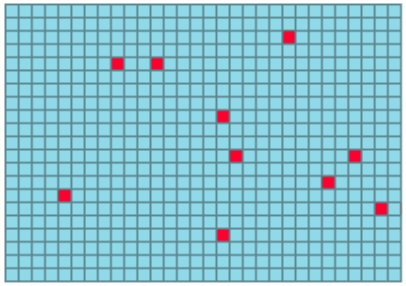
Raster vs. Vector Representation



Raster vs. Vector Representation

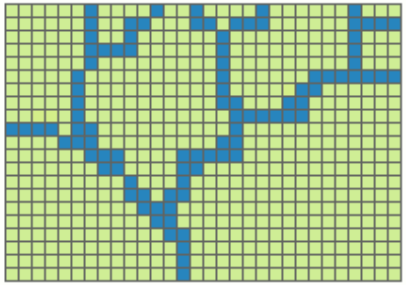


Vector Point Features

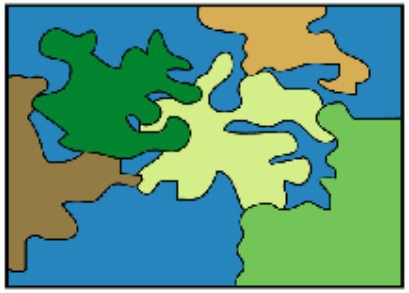


Raster Point Features

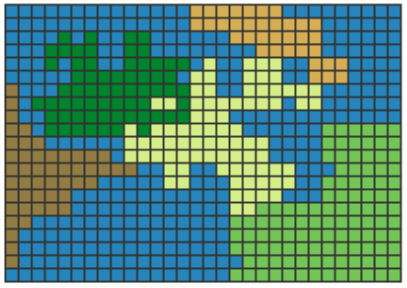
Vector Line Features



Raster Line Features



Vector Polygon Features



Raster Polygon Features

VECTOR MODEL

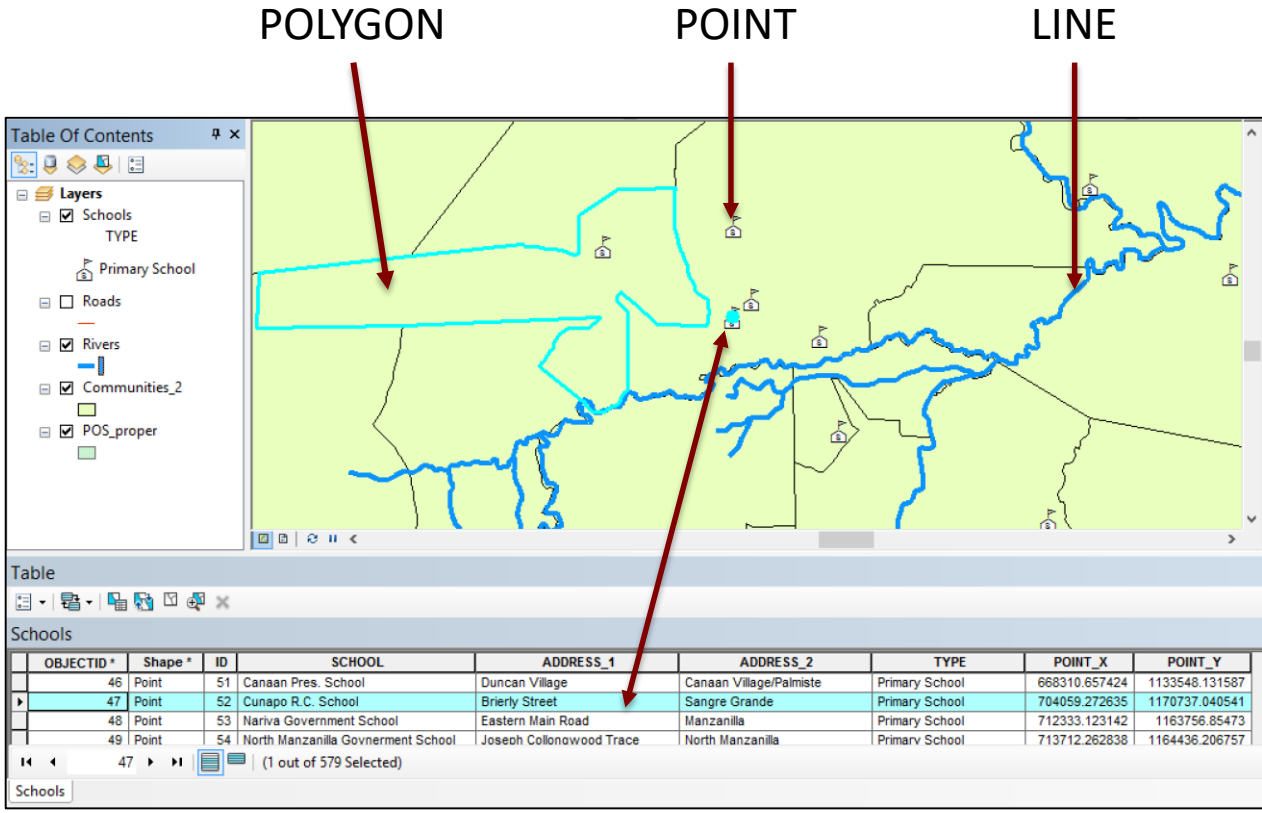
- The fundamental concept of vector GIS is that all geospatial features in the real world can be represented either as:
  - **Points (*nodes)***: trees, poles, fire plugs, airports, cities
  - **lines (*arcs)*:** streams, streets, sewers,
  - **polygons *(areas)*:** land parcels, cities, counties, forest, rock type

- Vector model is best used to represent features with discrete boundaries (roads, buildings, lakes, rivers, administrative boundaries)

- This model tells "where everything occurs", i.e., it gives location to every object.

Representing features in vector data

- Real-world entities are abstracted into three geometric shapes:
  - Point
  - Line
  - Polygon



- Each feature type is stored in a separate *shapefile* or *feature class*.
- Each feature class contains a table in which each row is a record representing one of the spatial features in the file.
- (an exception to the above exists where one row represents multiple features, referred to as *multipart features*.)

Impact of Scale on Vector Models

Map scale determines the size and shape of features

1:500

Large scale

Smaller area

More detail

1:25000

1:25000

Small scale

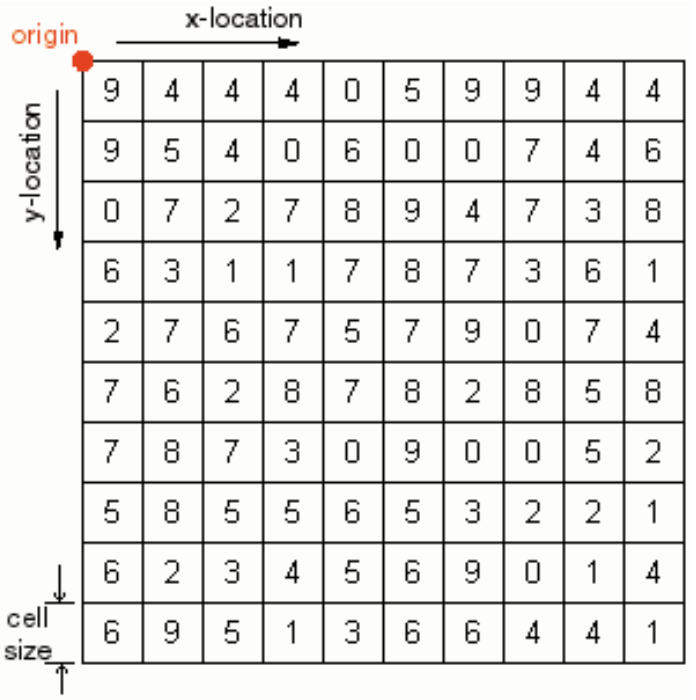
Larger area

Less detail

1:250000

Raster Data Model

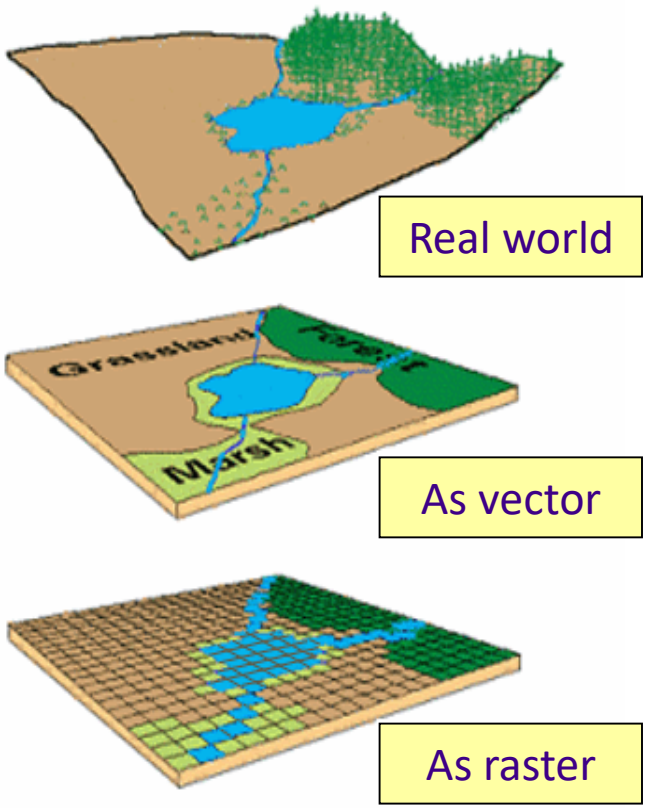
- Area is covered by grid with (usually) equal-sized cells;
  - Cells often called pixels (picture elements).
  - Origin is set explicitly.
  - Cell size is always known.
  - Cell references (row/column) are known.
  - Cell values are referenced to row/column location.
- Values represent numerical phenomena or index codes for non-numerical phenomena.



Raster Data Model

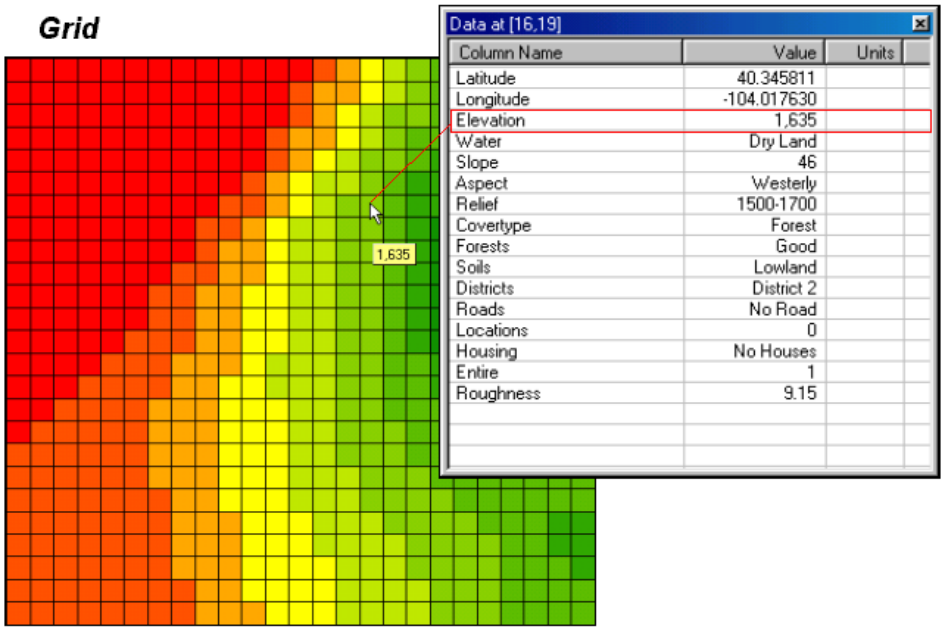
- Advantages of raster over vector
  - Simpler data model
  - Faster processing and display
  - Additional analytic tools
  - Better for unbounded phenomena (like soil pH and elevation)

- Disadvantages of raster
  - Generalization
  - Loss of feature uniqueness



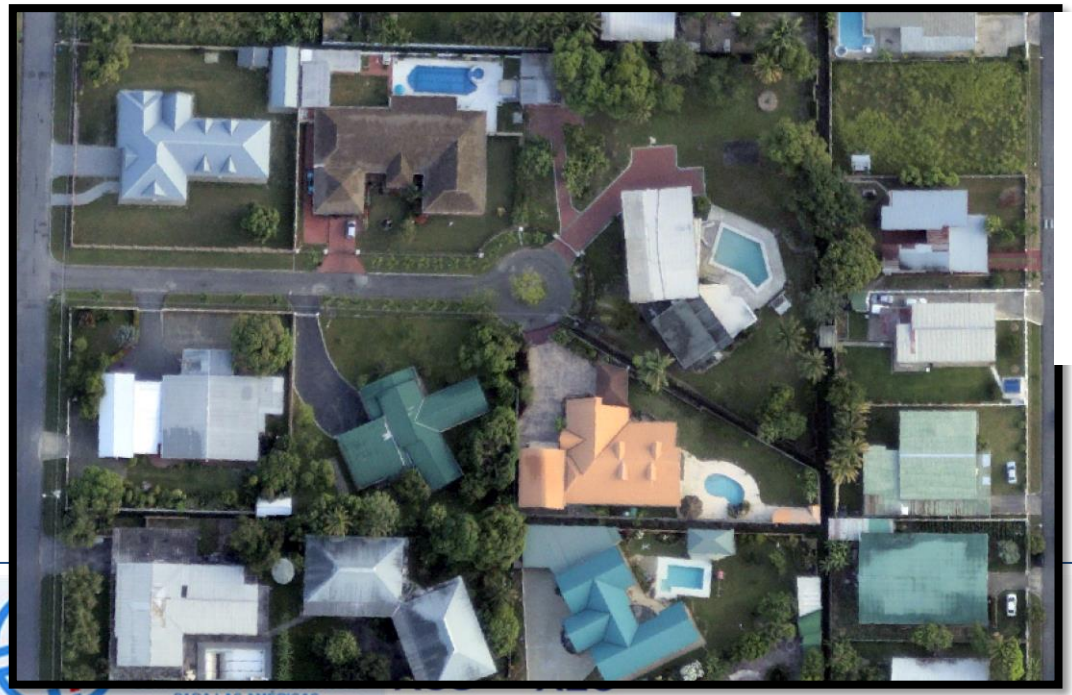
Raster Data Model

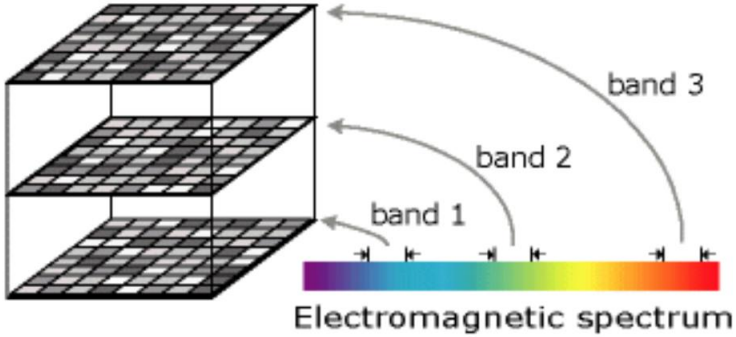
- Attributes are recorded by assigning each cell a single value
- Raster data are good at representing continuous phenomena, e.g.,
  - Wind speed
  - Elevation, slope, aspect
  - Chemical concentration
  - Likelihood of existence of a certain species



Raster types based on cell values

- In terms of the cell values, rasters can be divided into three types:
  - Image
  - Interpolated and,
  - Thematic
- **Image rasters** have values (Digital Number, DN) that represent measurements of energy (electromagnetic reflections) as captured by a sensor (camera)
- These image raster cell values are usually whole numbers (integers).

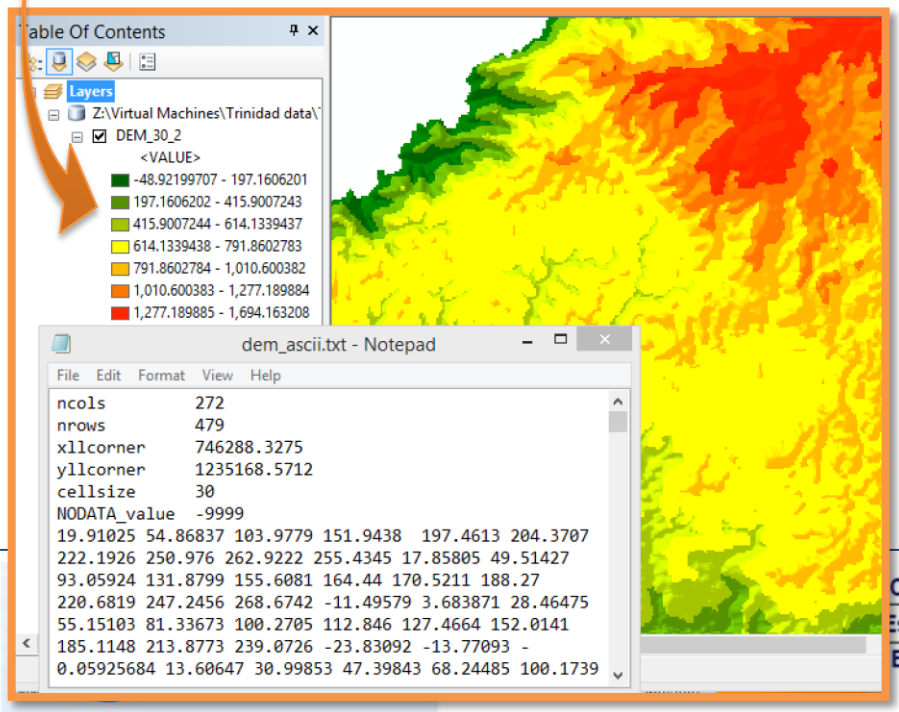


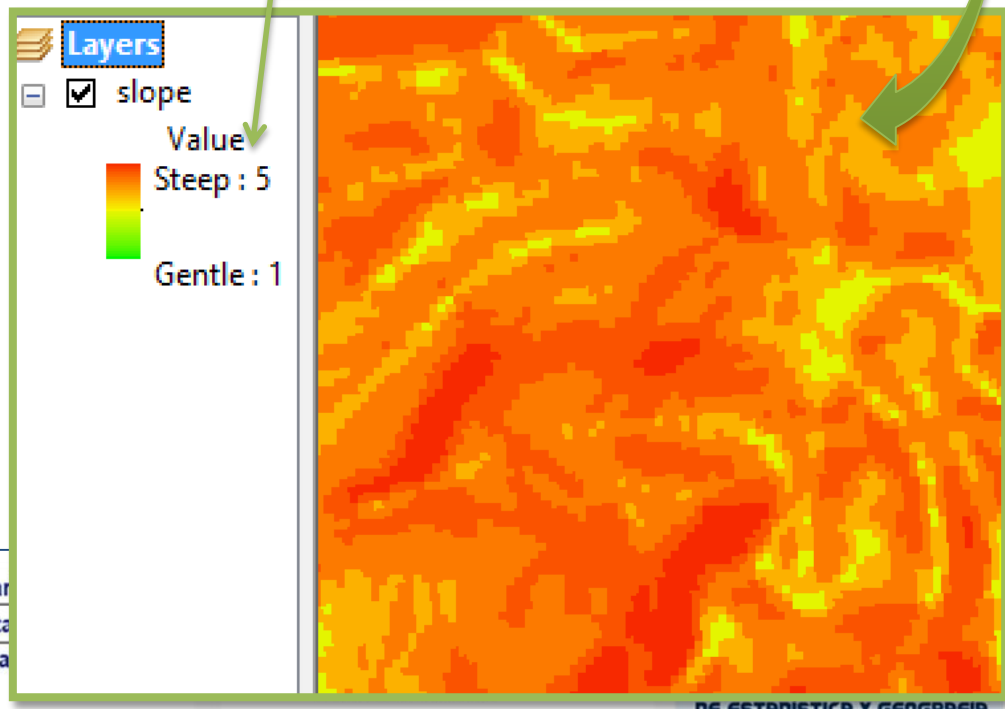


Raster types based on cell values

- **Thematic rasters** have cell values that represent a particular theme, category/code or class (nominal or ordinal data).
- Cell values in **Interpolated rasters** usually represent measurements such as elevation, precipitation, soil pH, etc. These values are usually interval or ratio data.

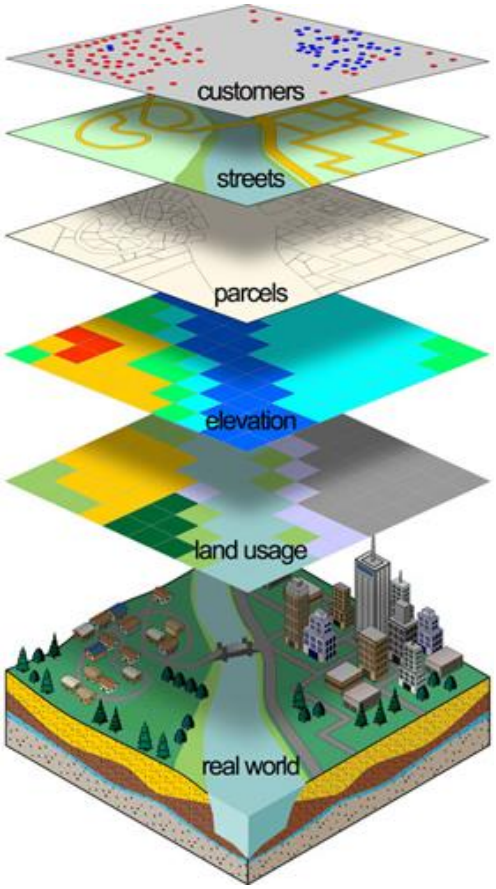
Cell Value 1= Gentle slope
Cell Value 5= Steep slope





Modelling the Real World

- Objects in the real world are digitally represented then stored in a database.
- Either a vector or raster data model can be used.
- It is common to use both data models to represent different features over a selected project area.



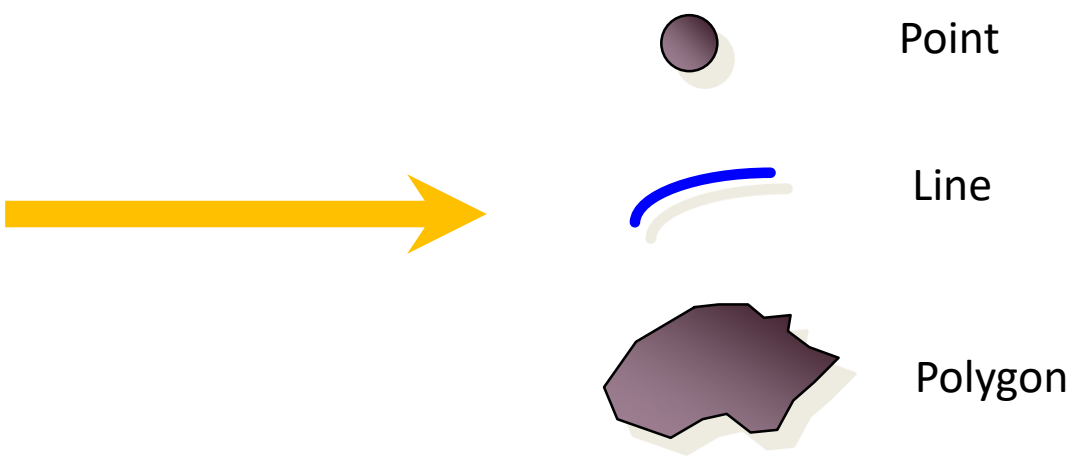
Data Modelling Steps

- **Step 1** - Identify possible features from the real world (this example uses the vector data model)

- Buildings
- Road centrelines
- Utility poles
- Water lines
- Manholes
- Road surfaces

Data Modelling Steps

- **Step 2** - Select a method for representing the feature in the GIS



Data Modelling Steps

- **Step 3** - Use the selected method to represent the feature in the GIS

Feature : Building
Shape: Polygon

Data Modelling Steps

- **Step 4** - Identify appropriate attributes for the feature

ID : 345876
Name : Some Store
Address : 5 Market Place
Town : Some Town
Owner : Ms J Shore
Tel. No : 868 555 1234
Floor space : 1300 sq m

Commercial GIS Software (COTS)

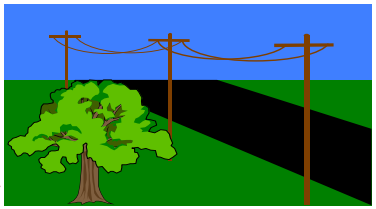
Opensource GIS Software (FOSS)

Factors to Consider

- Budget
- Functionality
- Maintenance
- Technical Support
- Training
- Existing infrastructure
- Community of users
- Datasets
- Customization

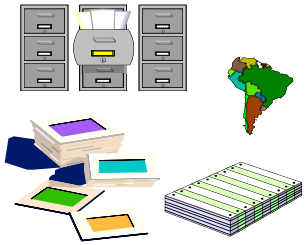
The GIS Process

Geospatial Information processing begins and ends with the real world



Real World

Data Collection



Data Sources

Data Input

Data Management

Data Retrieval & Analysis

Analysis

Information for Decision Making

Users

Implementation

Source: Aronoff (1991)

UP NEXT …..

Activity : Manipulating Geospatial Data in QGIS/ArcGIS