Spatial Modelling and Analysis

Lecture 9

Introduction to Vector Data Model and Analysis

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PNG University of Technology - 2022

Lecture Outline

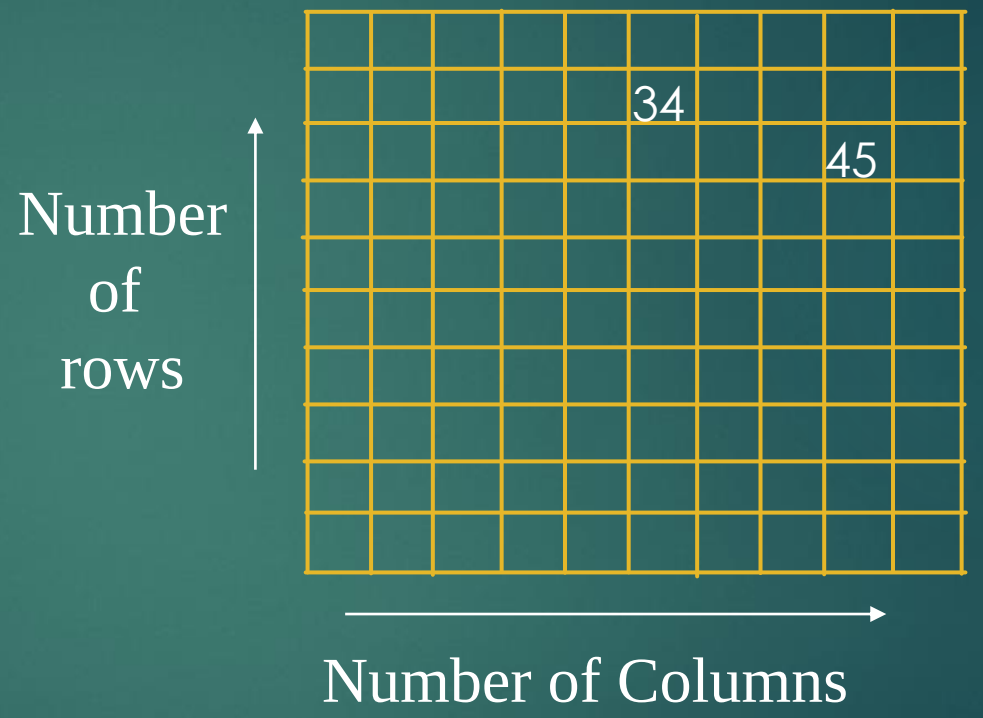
1. GIS Data Model Concepts
2. Vector Data Model Concepts
3. Vector feature and Attribute Table
4. Vector Data structure
5. Vector Data Formats
6. GIS Software
7. DWG Files
8. Tab Files
9. Introduction to Vector Data Analysis
10. References

1. GIS Data Model Concepts

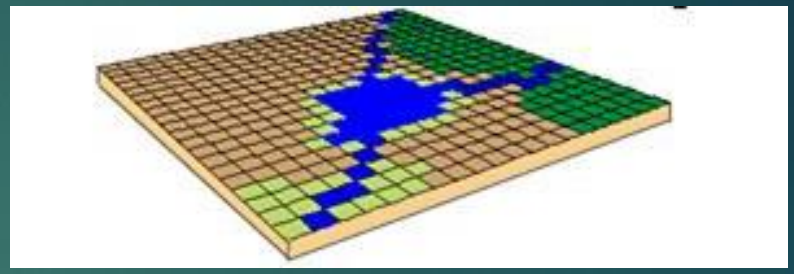
There are two main data models or conceptualizations used for spatial data:

- Vector data model
- Raster data model

"raster is faster but vector is corrector" Joseph Berry

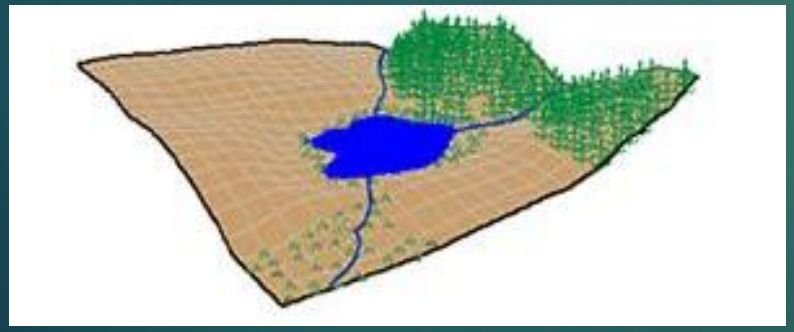


1.1. Vector Data Model and Raster Data Model Concepts



Raster

Vector



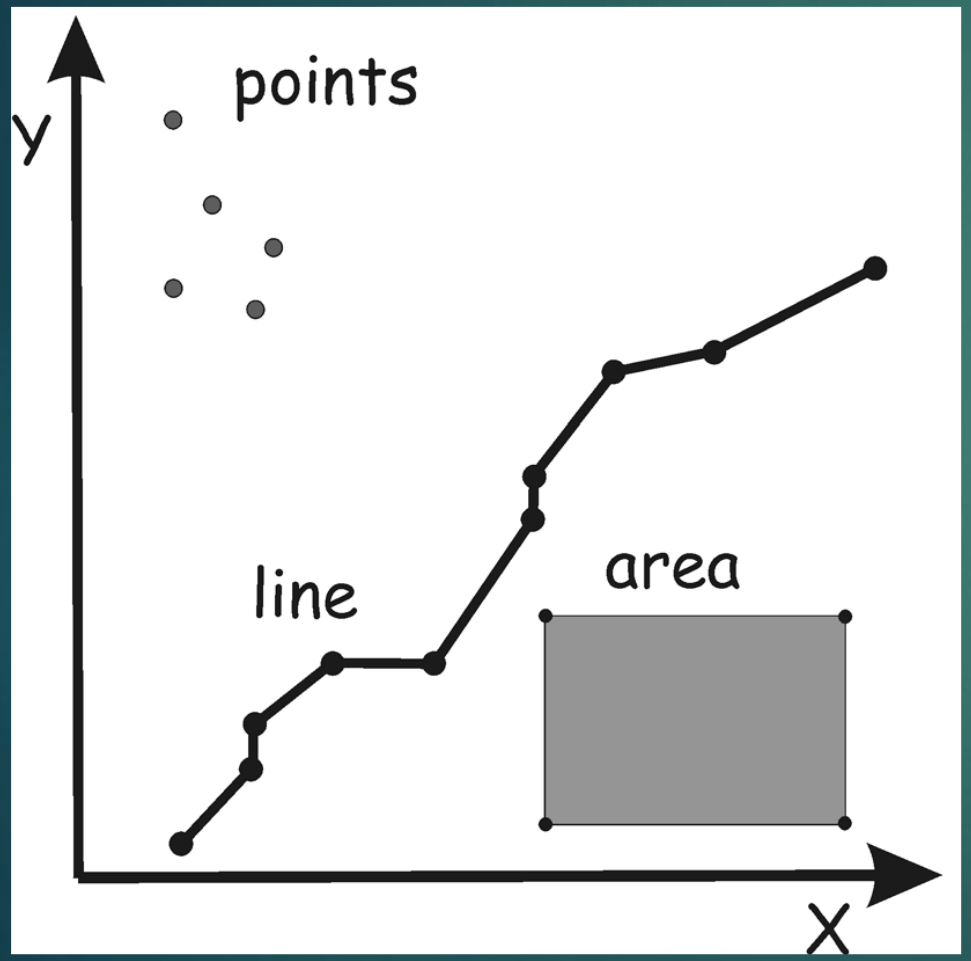
Real World

Raster vs. Vector Data Model

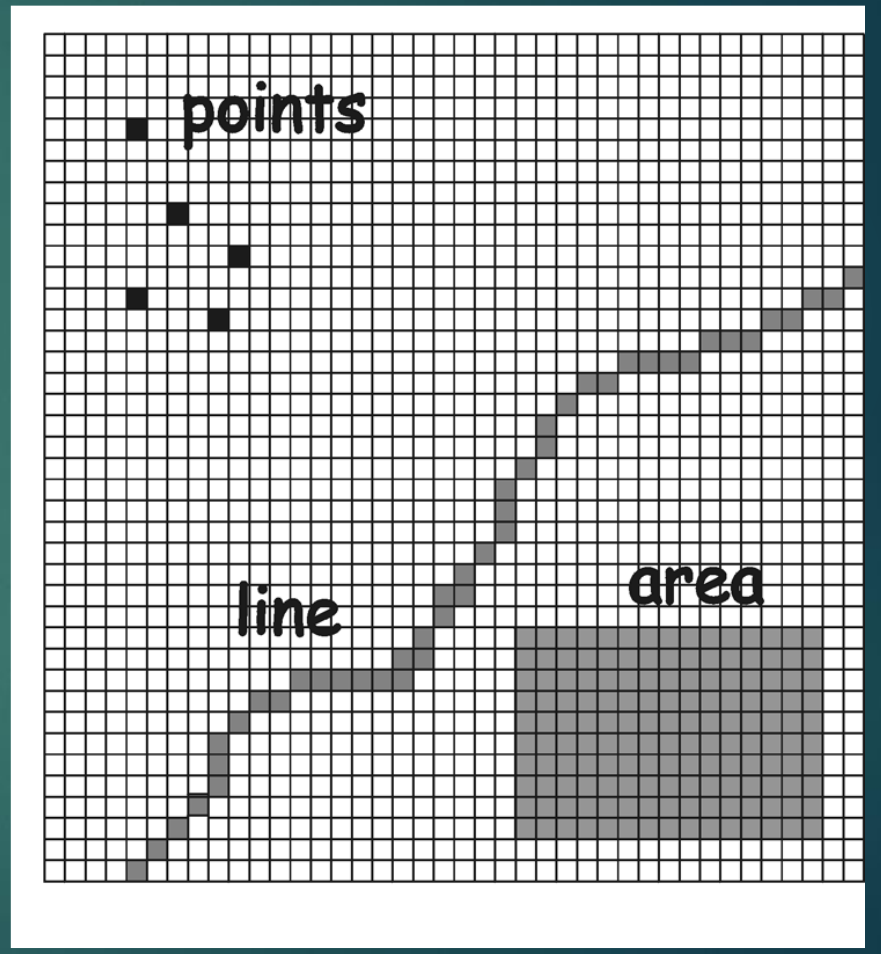
Source: United Nations Economic commission for Africa, 2018

2. Vector Data Model Concepts

Vector



Raster



Source: United Nations Economic commission for Africa, 2018

2.1. Vector Data Model

* **Vector data model**

Defines discrete objects:

For example: Building foot print, roads, lakes, fire hydrants, river network, etc..

3 basic type of vector data model:
- point,
- Lines
- polygons

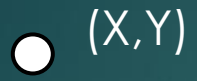
They represent the geometry of the real-world entities, discrete entities.

Composed of coordinates and attributes

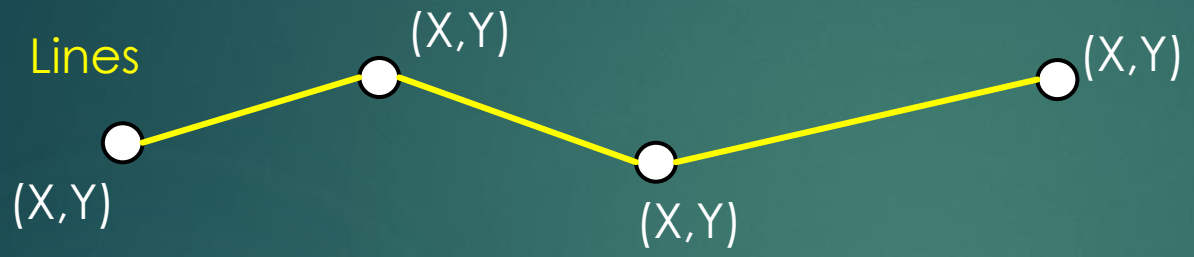
Source: Bradley A. Shellito, 2020

2.2. Simplified Vector Data Model

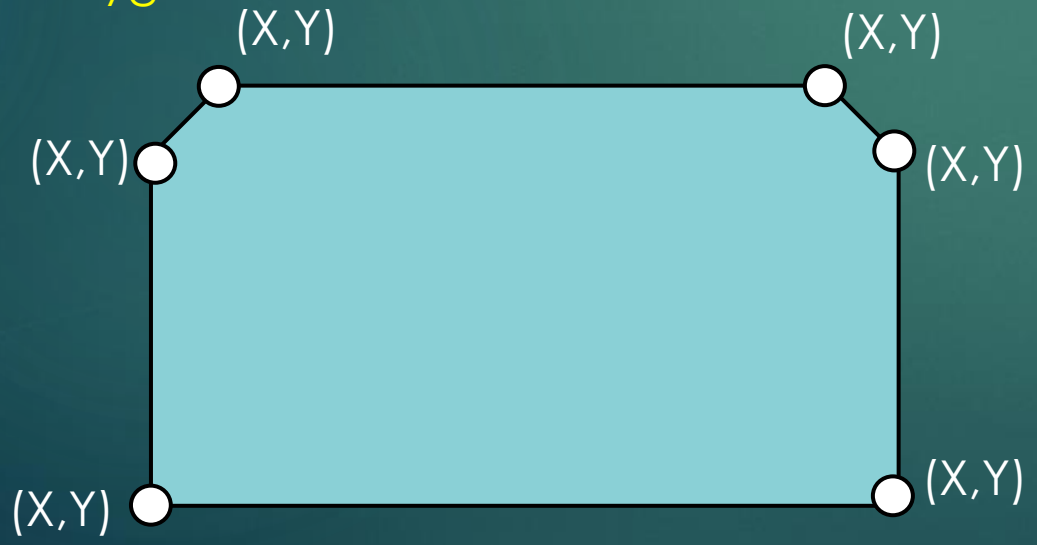
Points



Lines



Polygons



Source: T.Sekac, 2022

2.3. Reality to Model

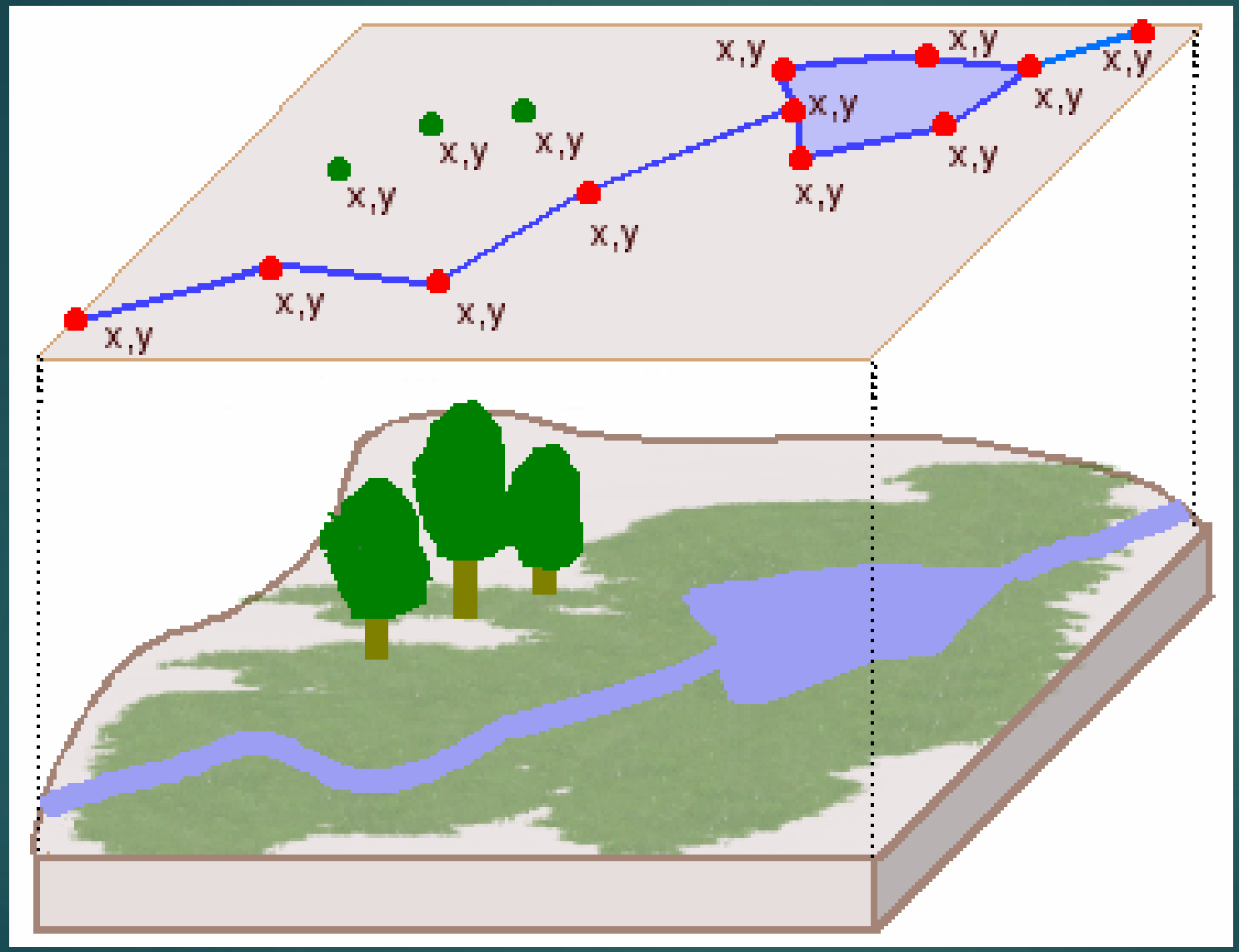


Image Source: http://www.geography.hunter.cuny.edu/~jochen/gtech361/lectures/lecture05/concepts/03%20-%20Geographic%20data%20models.html#:~:text=The%20vector%20data%20model%20is,features%20with%20well%2Ddefined%20boundaries.

2.4. Vector Data Model - Points

* Vector data model uses sets of coordinates and associated attribute data to define discrete objects

* Point objects in spatial database represent location of entities considered to have no dimension.

  Simplest type of point spatial objects

  E.g:
  wells,
  sampling points,
  poles,
  Telephone towers,
  Schools
  Heath Center etc.

2.5. Vector Data Model - Line

Line objects are used to represent linear features using ordered set of coordinate pairs

E.g.

- infrastructure networks (transport networks: highways, railroads, etc.) ;
- utility networks: (gas, electric, telephone, water, etc.);
- airline networks: hubs and routes, etc.);

natural networks such as river channels

2.6. Vector Data Model - Polygon

* **Polygon** objects in spatial database represent entities which covers an area

  E.g.

  lakes,

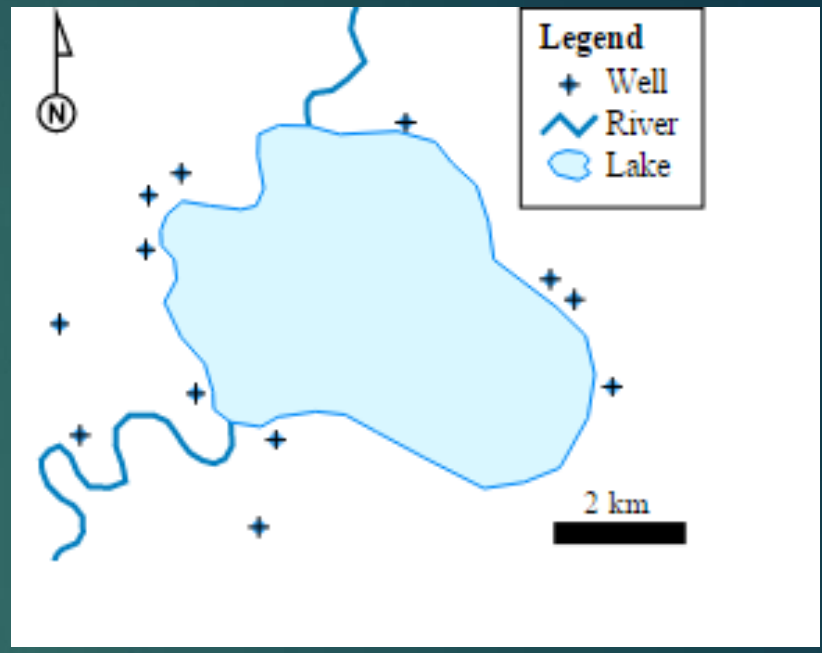
  Buildings,

  parcels,

  Land cover data: forested lands, urban areas, etc.

  Soil data – soil types/soil texture

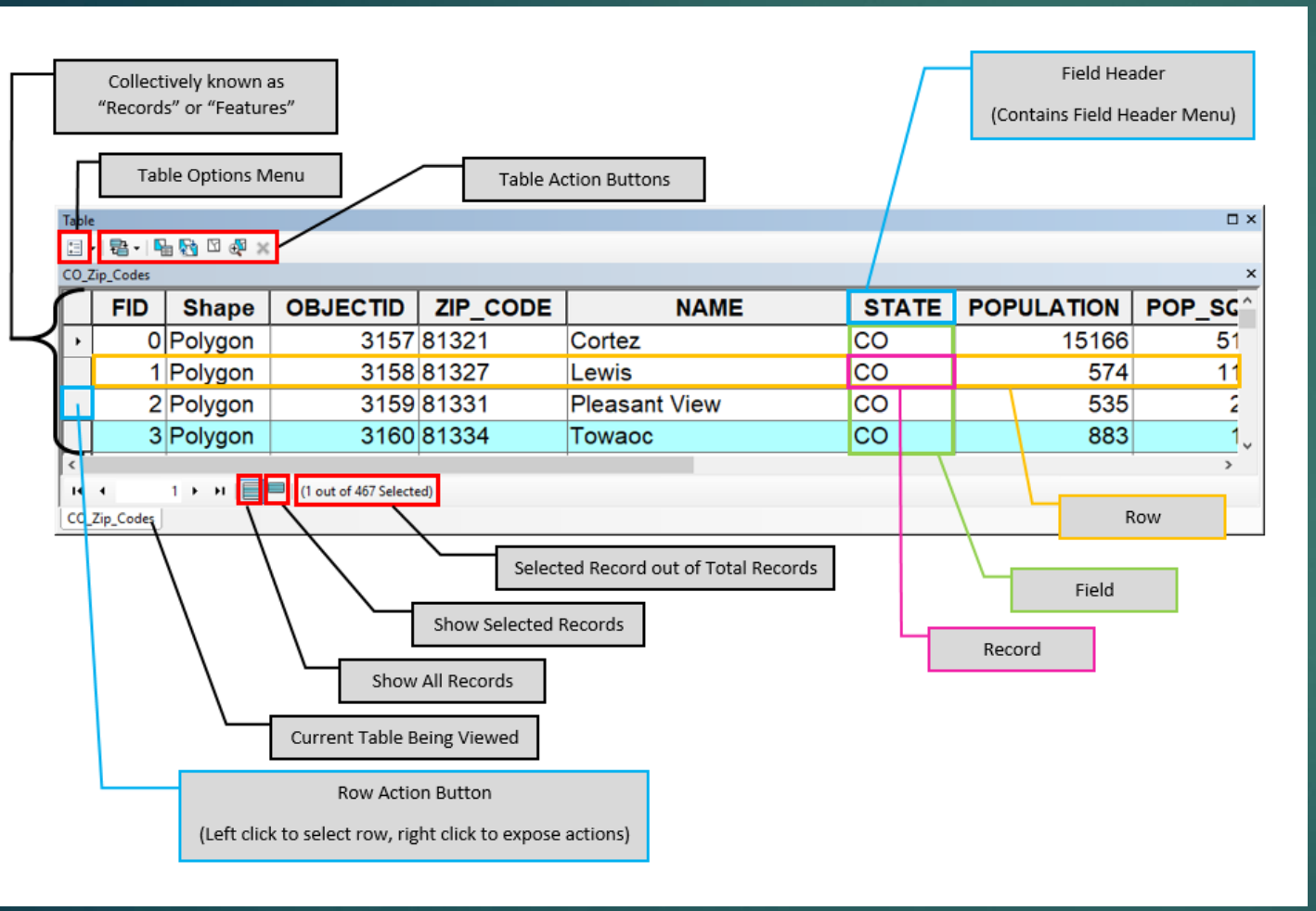
  etc.



* Boundaries may be defined by natural phenomena (e.g. lake), or by man made features (neighborhoods, building foot print)

Source: United Nations Economic commission for Africa, 2018

3. Vector feature and Attribute Table



1.Attribute tables are available for viewing and editing for each layer in ArcMap.

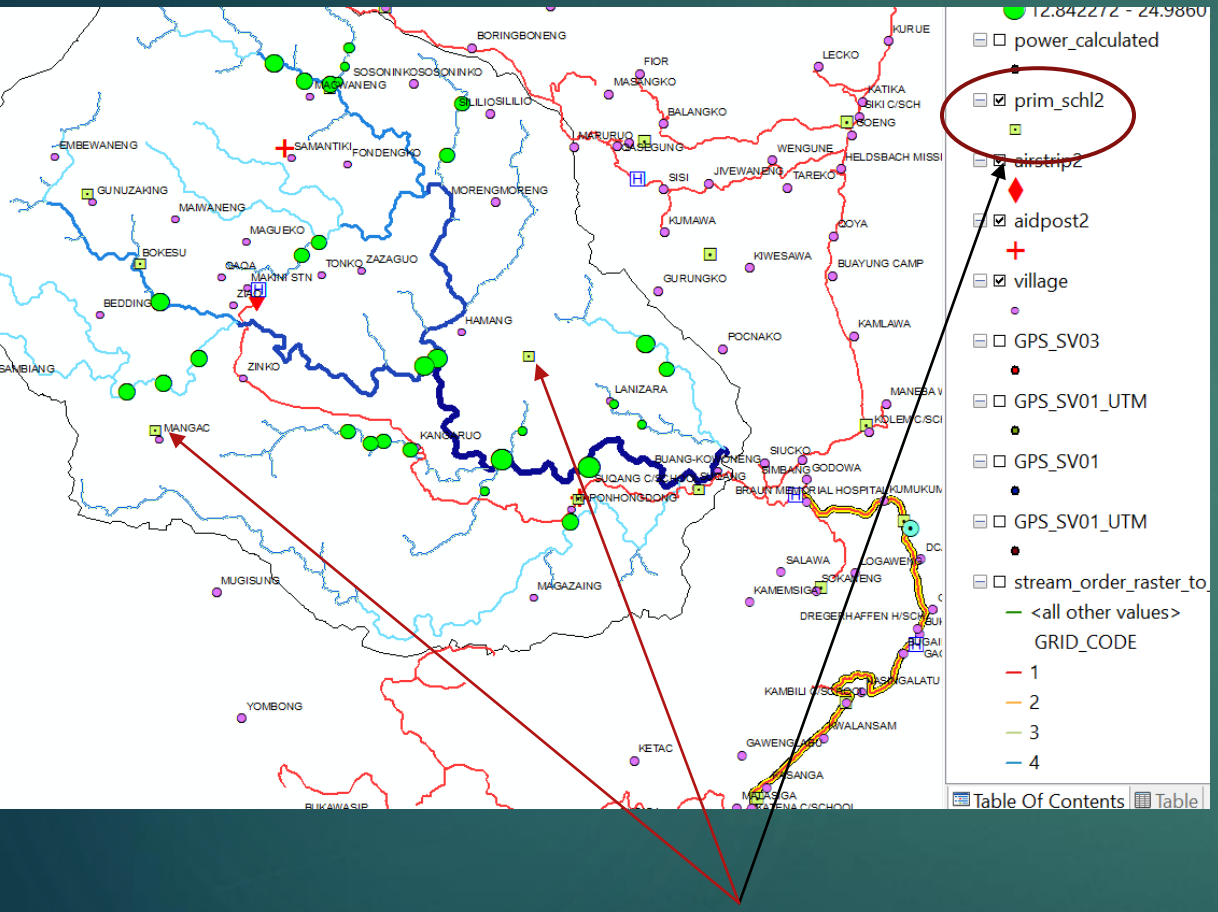
2.All attribute tables are made up of rows, and columns,

3.Vector data is a combination of the object (polygon, polyline, or point) seen in the map - known as the feature, and a corresponding row in the attribute table, which contains the non-spatial information about it.

Source: https://vector.geospatial.science/textbook/section-two-attribute-tables-more-depth-look-operations

3.1. Point Representation

Represent discrete point features



Every Point location has a record in the Attribute Table

Table

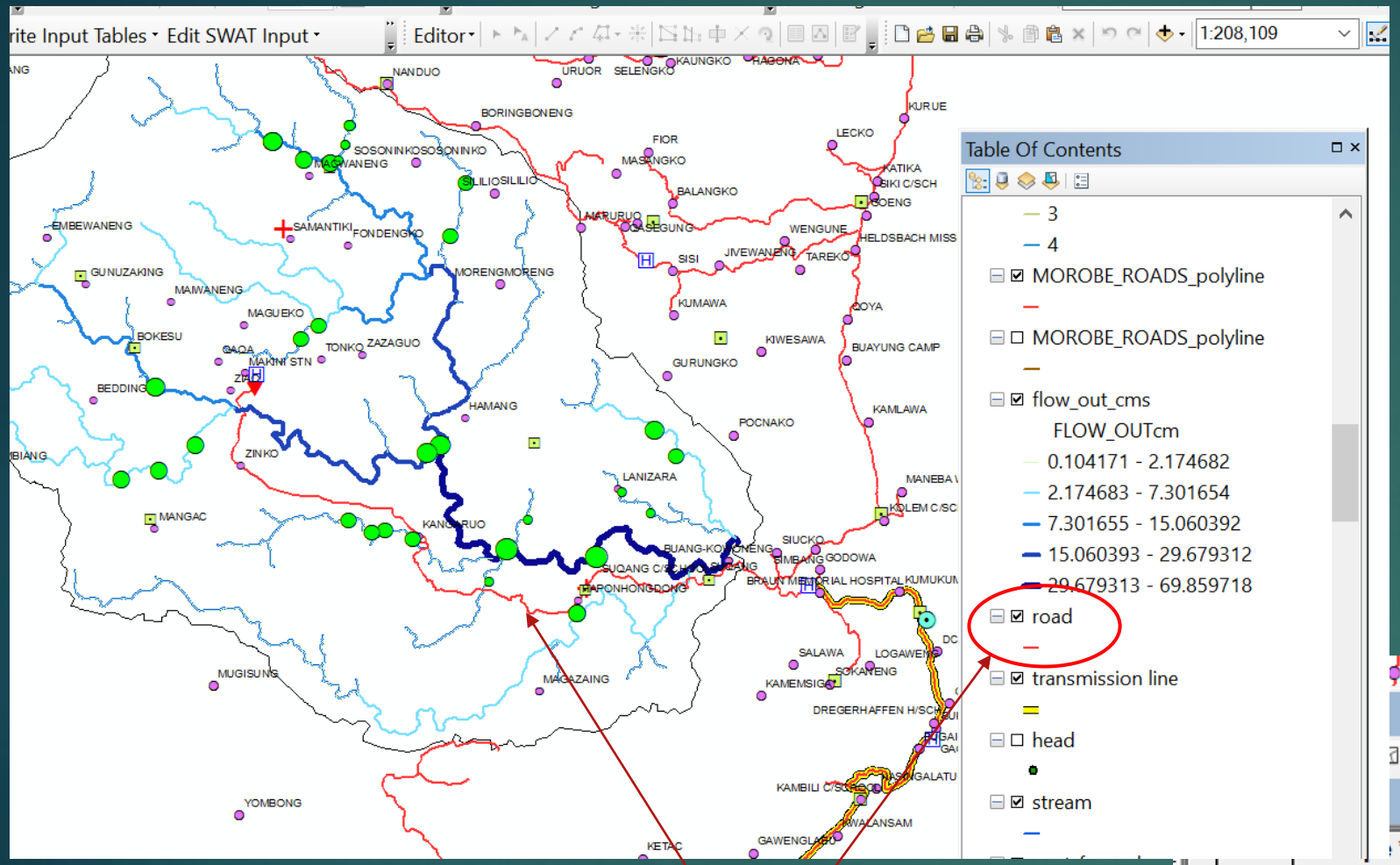
prim_schl2

FID	Shape *	NAME	CODE	GEOCODE	DISTRICT	LLG	AGEN
0	Point	Suquang	63289		Finschaffen	Yabim Mape Rural	Lutheran
1	Point	Hapo - Hondong	63310		Finschaffen	Yabim Mape Rural	Lutheran
2	Point	Gunuo	63146		Finschaffen	Yabim Mape Rural	Governm
3	Point	Samantiki	63096		Finschaffen	Yabim Mape Rural	Governm
4	Point	Kenong	63111		Finschaffen	Yabim Mape Rural	Governm
5	Point	Gunazaking	63013		Finschaffen	Yabim Mape Rural	Governm
6	Point	qembung			Finschaffen	Yabim Mape Rural	Lutheran

Primary Schools are point features
Each stored as a coordinate pair

Image Source: T.Sekac, 2022

3.2. Line Representation



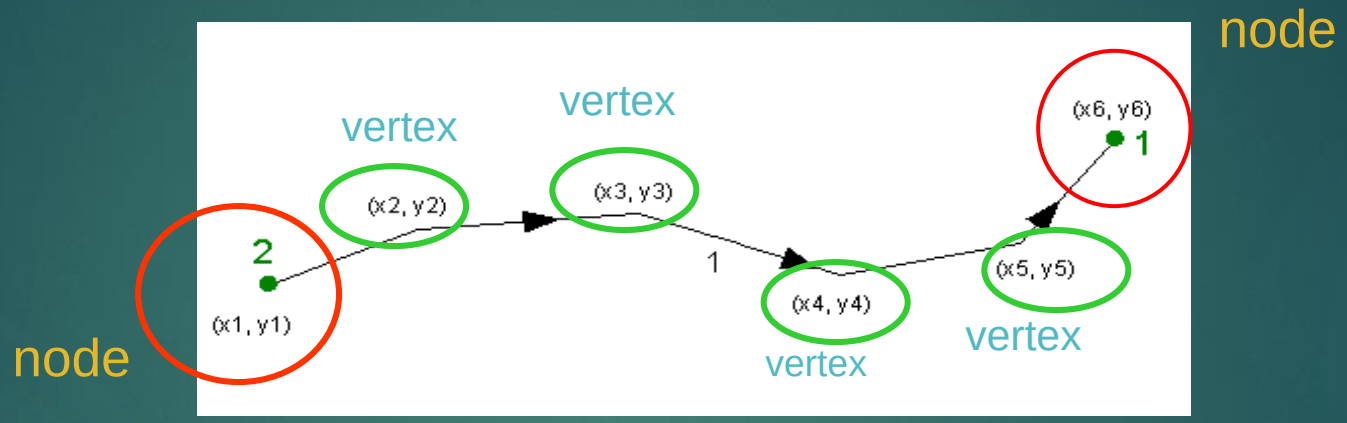
Each road segment has a record in the attribute table

		NAME	TYPE	SURFACE	CONDITION
0	Polyline	HELDSBACH-PINDIU	Provincial Road	Gravel	Poor
1	Polyline	HELDSBACH-PINDIU	Provincial Road	Gravel	Poor
2	Polyline	Suqang-Hapo	National Road	Dirt	Fair
3	Polyline	Hapo-Kanengko	Provincial Road	Dirt	Fair
4	Polyline	Kanengko-Makini	Provincial Road	Dirt	Poor

roads are linear features

Image Source: T.Sekac, 2022

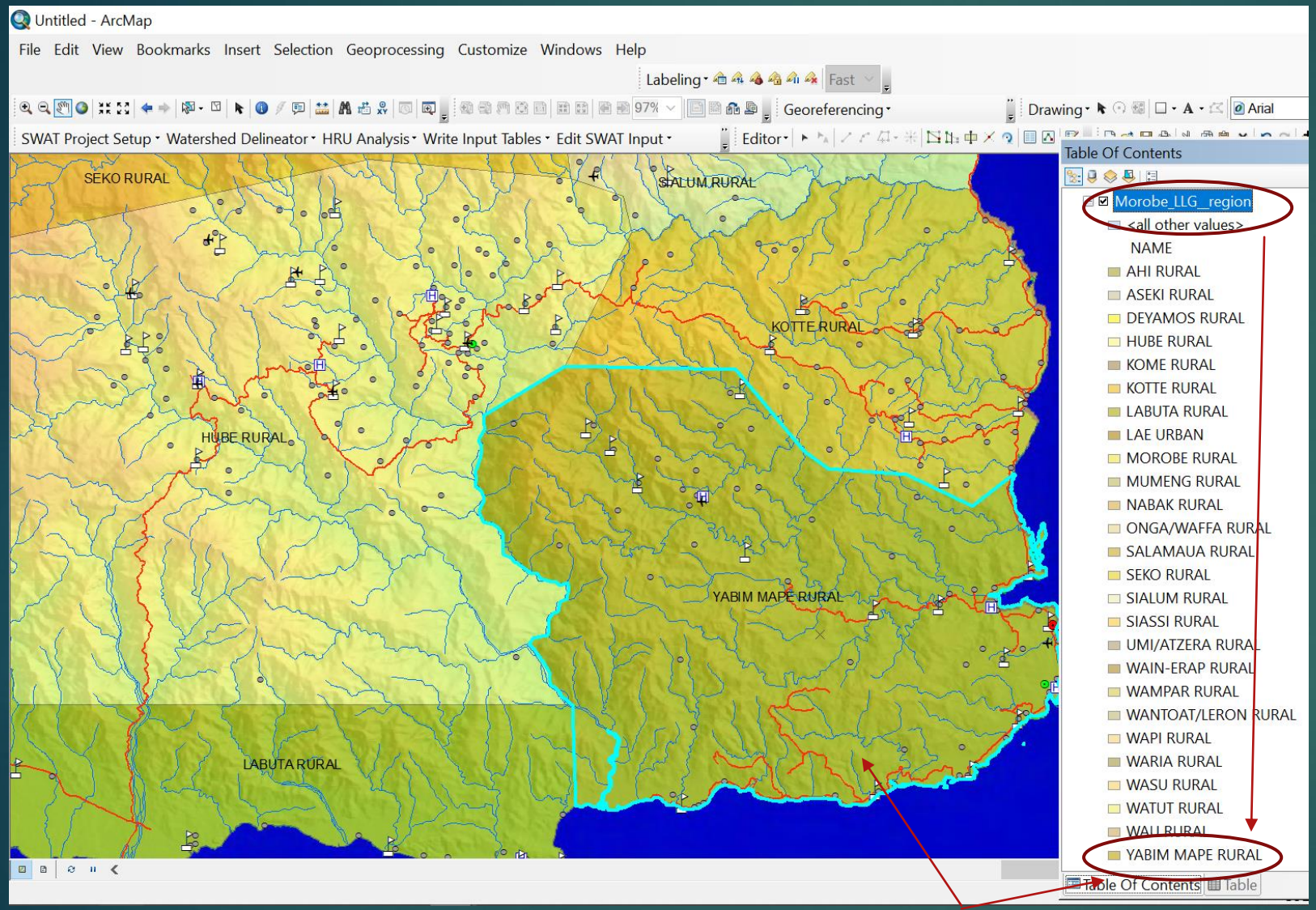
3.2.1. Linear Vector Data Structure



- Lines start *and* end at nodes
  - line #1 goes from node #2 to node #1
- Vertices determine shape of line
- Nodes and vertices are stored as coordinate pairs

Source: Bradley A. Shellito, 2020

3.3. Polygon Representation



LLG boundaries are polygonal features

Each LLG bounded polygon has a record in the Attribute Table

lable

Morobe_LLG_region

FID	Shape *	NAME	UNIQUE_ID	AREA
0	Polygon	MUMENG RURAL	120101	
1	Polygon	NABAK RURAL	120824	
2	Polygon	DEYAMOS RURAL	120412	
3	Polygon	WAIN-ERAP RURAL	120825	
4	Polygon	SEKO RURAL	120413	
5	Polygon	HUBE RURAL	120206	
6	Polygon	WATUT RURAL	120103	
7	Polygon	WARIA RURAL	120102	
8	Polygon	MOROBE RURAL	120309	
9	Polygon	SALAMAUA RURAL	120310	
10	Polygon	WAU RURAL	120105	
11	Polygon	ASEKI RURAL	120720	
12	Polygon	WAPI RURAL	120722	
13	Polygon	KOME RURAL	120721	
14	Polygon	ONGA/WAFFA RURAL	120617	
15	Polygon	UMI/ATZERA RURAL	120618	
16	Polygon	WANTOAT/LERON RURA	120619	
17	Polygon	YUS RURAL	120414	
18	Polygon	WASU RURAL	120928	
19	Polygon	SIALUM RURAL	120926	
20	Polygon	KOTTE RURAL	120207	
21	Polygon	YABIM MAPE RURAL	120208	
22	Polygon	LABUTA RURAL	120823	
23	Polygon	SIASSI RURAL	120927	
24	Polygon	AHI RURAL	120515	
25	Polygon	LAE URBAN	120516	
26	Polygon	WAMPAR RURAL	120311	

Image Source: T.Sekac, 2022

4. Vector Data structure

- Points are discreet
  - Nodes
  - Vertices
- Lines
  - Nodes
  - Vertices
  - Arcs
- Polygon
- Lines + points

Source: Bradley A. Shellito, 2020

5. Vector Data Formats

- Vector data formats available in ArcGIS and other GIS software

- ESRI GeoDatabases
- ESRI shapefiles/shapefiles (shp)
- ArcInfo coverages and libraries
- CAD files (AutoCAD DWG, DXF; microstation DGN)
- StreetMap files
- Spatial Database Engine (SDE) data
- ASCII point coordinate data

- Vector data formats available in MapInfor:

- Tab files

5.1. Vector Data Formats - Shape file

The shapefile format is a geospatial vector data format for geographic information system software.

It is developed and regulated by Esri as a mostly open specification for data interoperability among Esri and other GIS software products.

Shape files a created through digitizing processes or converting from raster to vector and other ways.

Once created multiple files are generated

Shape files can be converted to other formats like:

-Tab file
-DWG file
-other

5.2. Shape Files - Multiple

Shape file format files

- .dbf
- .Shp
- .Shx
- .Prj
- .Avi
- .sbn

clip_mape_cont.cpg	4/1/2022 10:36 PM	CPG File	1 KB
clip_mape_cont.dbf	4/1/2022 10:36 PM	DBF File	98 KB
clip_mape_cont.prj	4/1/2022 10:36 PM	PRJ File	1 KB
clip_mape_cont.sbn	4/1/2022 10:36 PM	SBN File	33 KB
clip_mape_cont.sbx	4/1/2022 10:36 PM	SBX File	3 KB
clip_mape_cont	4/1/2022 10:36 PM	AutoCAD Shape Sou...	41,831 KB
clip_mape_cont.shp	4/1/2022 10:36 PM	XML Document	6 KB
clip_mape_cont	4/1/2022 10:36 PM	AutoCAD Compiled ...	26 KB
clip_river_mape.cpg	1/15/2022 10:00 PM	CPG File	1 KB
clip_river_mape.dbf	1/15/2022 10:00 PM	DBF File	2 KB
clip_river_mape.prj	1/15/2022 10:00 PM	PRJ File	1 KB
clip_river_mape.sbn	1/15/2022 10:00 PM	SBN File	1 KB
clip_river_mape.sbx	1/15/2022 10:00 PM	SBX File	1 KB
clip_river_mape	1/15/2022 10:00 PM	AutoCAD Shape Sou...	119 KB

Source: T.Sekac, 2022

5.3. Shape Files Parts – Essential & Important

Shape files has a part/sections that defines it:

The Essential Parts are:

- .shp: Shapefile geometry data
- .dbf: database data
- . Shx: shapefile index

The Important parts is:

- prj: projection file with coordinate reference system info,

Source: Dempsey, C. 2015

5.4. Shape Files Parts – Other

Other shape file parts also exist:

- .avl: Arcview legend file
- .rtf: data dictionary - rich teck document
- .sbn: shapefile – internal
- .sbx: shapefile - internal

Source: Dempsey, C. 2015

6. GIS Software

Common software's that can create and read shape files:

- ArcMap/ArcGIS
- Global Mapper
- QGIS
- ERDAS Imagine
- Grass GIS
- Other

7. DWG Files

DWG is a proprietary binary file format used for storing two- and three- dimensional design data and metadata.

It is the native format for several CAD packages including DraftSight, AutoCAD, BricsCAD, IntelliCAD, Caddie and Open Design Alliance compliant applications.

The DWG files can be converted and open in GIS software like ArcGIS, Global Mapper, MapInfo, etc..

8. Tab Files

A Mapinfo TAB file is a geospatial vector data format for geographic information system (GIS) software developed by Mapinfo.

The TAB file links all other files together and holds the information about the dataset.

The tab file links the
.DAT,
.IND,
.MAP
.ID

files together and turns them into a map.

The TAB format is one of the most used formats in GIS software like Arcgis, QGIS, Mapinfo or Tableau Software.

Source: https://www.spotzi.com/en/about/blog/help-what-is-a-tab-file/#:~:text=A%20Mapinfo%20TAB%20file%20is,the%20information%20about%20the%20dataset.

8.1. Tab Files Specifications

A complete Mapinfo dataset contains files with attribute data (mandatory) and data that draws a vector feature on the map (not mandatory).

The mandatory/essential files are:

- TAB file (.tab) – the file that links all other files together into a dataset;
- Data file (.dat) – the file that stores attribute data. This file can also be a text file (.txt), Excel (.xls), WK file (.wk) or a Microsoft Access Database (.mdb);
- Index file (.ind) – an optional file for tabular data.

Source: https://www.spotzi.com/en/about/blog/help-what-is-a-tab-file/#:~:text=A%20Mapinfo%20TAB%20file%20is,the%20information%20about%20the%20dataset.

8.2. Tab Files

The files that are needed for creating a map from the data:

MAP file (.map) – the file that stores graphic and geographic information that is needed to display each feature on the map;

ID file (.id) – the file that links the graphical data to the database information.

Source: https://www.spotzi.com/en/about/blog/help-what-is-a-tab-file/#:~:text=A%20Mapinfo%20TAB%20file%20is,the%20information%20about%20the%20dataset.

8.3. MapInfo Tab Files

Name	Date modified	Type
existing water pipe.TAB	9/29/2003 6:46 PM	TAB File
Infrastructure (city) (A3) B&W.WOR	12/30/2003 6:38 PM	WOR File
Infrastructure (city) (A3).WOR	10/1/2003 4:55 PM	WOR File
infrastructure cadastral	9/28/2003 9:21 PM	FormatPlayer (dat)
infrastructure cadastral.ID	9/28/2003 9:21 PM	ID File
infrastructure cadastral	9/28/2003 9:21 PM	ERDAS IMAGINE Document
infrastructure cadastral.TAB	9/28/2003 9:21 PM	TAB File
infrastructure roads	9/28/2003 9:22 PM	FormatPlayer (dat)
infrastructure roads.ID	10/1/2003 10:16 PM	ID File
infrastructure roads	10/1/2003 10:16 PM	ERDAS IMAGINE Document
infrastructure roads.TAB	10/1/2003 10:16 PM	TAB File
infrastructure town boundary	9/28/2003 9:54 PM	FormatPlayer (dat)
infrastructure town boundary.ID	9/28/2003 10:12 PM	ID File
infrastructure town boundary	9/28/2003 10:12 PM	ERDAS IMAGINE Document
infrastructure town boundary.TAB	9/28/2003 10:12 PM	TAB File
Powerlines	9/4/2003 10:14 PM	FormatPlayer (dat)
Powerlines.ID	9/29/2003 6:29 PM	ID File
Powerlines	9/29/2003 6:29 PM	ERDAS IMAGINE Document
Powerlines.TAB	9/29/2003 6:29 PM	TAB File
proposed water	6/17/2003 6:57 PM	FormatPlayer (dat)
proposed water.ID	9/29/2003 6:46 PM	ID File
proposed water	9/29/2003 6:46 PM	ERDAS IMAGINE Document
proposed water.TAB	9/29/2003 6:46 PM	TAB File

Source: T.Sekac, 2022

9. Introduction to Vector Data Analysis

- Vector data analysis uses the geometric objects of point, line, and polygon.
- The accuracy of analysis results depends on the accuracy of these objects in terms of location and shape.
- Topology can also be a factor for some vector data analyses such as buffering and overlay

Source: McGraw-Hill Companies, Inc.
https://csm.fresnostate.edu/ees/documents/facstaff/wang/gis200/lecture-notes/gis/chap11.pdf

9.1. Introduction Common Vector Analysis

Most common vector analysis technique/tool

- Overlay Analysis
- Buffer analysis
- Other feature manipulation analysis/tools
    - Dissolve
    - Union
    - Intersection
    - clip
    - Erase
    - other

10. References

ESRI, (2002). Using ArcGIS spatial analysis. Redlands, CA. Pp. 164189.

Shellito, B. A (2020) Introduction to Geospatial Technologies (Book – Fifth Edition).

Dempsey, C., (2015). What is shapefile. Retrieve from https://www.gislounge.com/what-is-a-shapefile/

Siddiqui, M.A and Islamia, J.M (_). GIS-06: Spatial Analysis (1) Overlay Operations & Analysis in GIS. RS/GIS-24 course module. Retrieve from: http://aditi.du.ac.in/uploads/econtent/SPATIALANALYSIS_overlay.pdf

IST, (_). Introduction to GIS Vector Data Analysis. Retrieve from: http://grel.ist.edu.pk/lms/pluginfile.php?file=%2F2168%2Fmod_resource%2Fcontent%2F0%2FLecture_04.pdf