“Introduction to Geographic Information System(GIS)”

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What is GIS?

Geographic Information System

Geographic: Location-specific data(Spatial Data) latitude and longitude.

Information System: It is a system used for collecting, storing, manipulating, and retrieving Spatial Data.

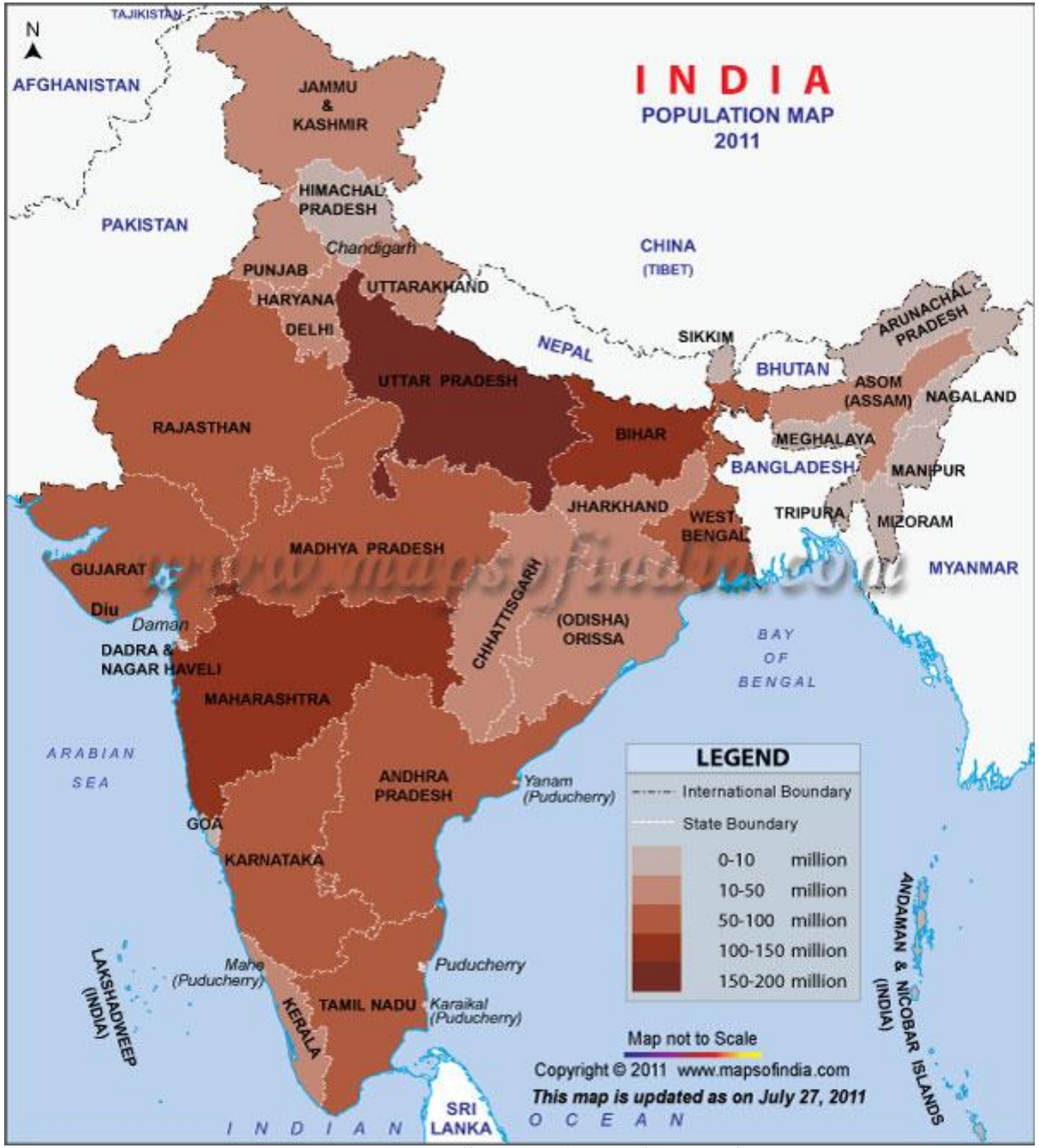
https://previews.123rf.com/images/naschy/naschy1611/naschy161100007/67318621

Definition:

GIS is defined as an information system that is used to **input, store, retrieve, manipulate, analyze and output** geographically reference data or geospatial data, in order to support decision making for planning and management of land use, natural resources, environment, transportation, urban facilities and other administrative records.

State/ UT Code	India/ State/ Union Territory#	Population 2011			Percentage decadal change 2001-2011		
		Total	Rural	Urban	Total	Rural	Urban
1	2	3	4	5	6	7	8
	INDIA	**1,21,05,69,573**	**83,34,63,448**	**37,71,06,125**	**17.7**	**12.3**	**31.8**
01	Jammu & Kashmir	1,25,41,302	91,08,060	34,33,242	23.6	19.4	36.4
02	Himachal Pradesh	68,64,602	61,76,050	6,88,552	12.9	12.7	15.6
03	Punjab	2,77,43,338	1,73,44,192	1,03,99,146	13.9	7.8	25.9
04	Chandigarh #	10,55,450	28,991	10,26,459	17.2	-68.5	27.0
05	Uttarakhand	1,00,86,292	70,36,954	30,49,338	18.8	11.5	39.9
06	Haryana	2,53,51,462	1,65,09,359	88,42,103	19.9	9.8	44.6
07	NCT of Delhi #	1,67,87,941	4,19,042	1,63,68,899	21.2	-55.6	26.8
08	Rajasthan	6,85,48,437	5,15,00,352	1,70,48,085	21.3	19.0	29.0
09	Uttar Pradesh	19,98,12,341	15,53,17,278	4,44,95,063	20.2	18.0	28.8
10	Bihar	10,40,99,452	9,23,41,436	1,17,58,016	25.4	24.3	35.4
11	Sikkim	6,10,577	4,56,999	1,53,578	12.9	-5.0	156.5
12	Arunachal Pradesh	13,83,727	10,66,358	3,17,369	26.0	22.6	39.3
13	Nagaland	19,78,502	14,07,536	5,70,966	-0.6	-14.6	66.6
14	Manipur	25,70,390	17,36,236	8,34,154	18.6	9.1	44.8
15	Mizoram	10,97,206	5,25,435	5,71,771	23.5	17.4	29.7
16	Tripura	36,73,917	27,12,464	9,61,453	14.8	2.2	76.2
17	Meghalaya	29,66,889	23,71,439	5,95,450	27.9	27.2	31.1
18	Assam	3,12,05,576	2,68,07,034	43,98,542	17.1	15.5	27.9
19	West Bengal	9,12,76,115	6,21,83,113	2,90,93,002	13.8	7.7	29.7
20	Jharkhand	3,29,88,134	2,50,55,073	79,33,061	22.4	19.6	32.4
21	Odisha	4,19,74,218	3,49,70,562	70,03,656	14.0	11.8	26.9
22	Chhattisgarh	2,55,45,198	1,96,07,961	59,37,237	22.6	17.8	41.8
23	Madhya Pradesh	7,26,26,809	5,25,57,404	2,00,69,405	20.3	18.4	25.7
24	Gujarat	6,04,39,692	3,46,94,609	2,57,45,083	19.3	9.3	36.0
25	Daman & Diu #	2,43,247	60,396	1,82,851	53.8	-40.1	218.8
26	D & N Haveli #	3,43,709	1,83,114	1,60,595	55.9	7.7	218.2
27	Maharashtra	11,23,74,333	6,15,56,074	5,08,18,259	16.0	10.4	23.6
28	Andhra Pradesh	8,45,80,777	5,63,61,702	2,82,19,075	11.0	1.7	35.6
29	Karnataka	6,10,95,297	3,74,69,335	2,36,25,962	15.6	7.4	31.5
30	Goa	14,58,545	5,51,731	9,06,814	8.2	-18.5	35.2
31	Lakshadweep #	64,473	14,141	50,332	6.3	-58.0	86.6
32	Kerala	3,34,06,061	1,74,71,135	1,59,34,926	4.9	-25.9	92.8
33	Tamil Nadu	7,21,47,030	3,72,29,590	3,49,17,440	15.6	6.6	27.0
34	Puducherry #	12,47,953	3,95,200	8,52,753	28.1	21.3	31.5
35	A & N Islands #	3,80,581	2,37,093	1,43,488	6.9	-1.2	23.5

https://cdn1.byjus.com/wp-content/uploads/2019/11/census-2011.jpg



https://www.mapsofindia.com/census2011/population.html

London Cholera Epidemic 1854

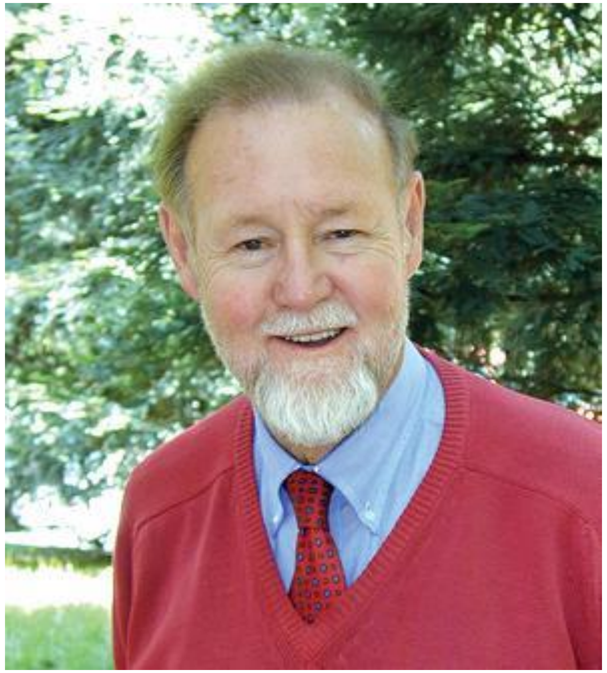
https://blog.rtwilson.com/wp-content/uploads/2012/01/SnowMap_Points-1024x724.png

History of GIS

The field of geographic information systems (GIS) started in the 1960s as computers and early concepts of quantitative and computational geography emerged.

The First GIS

Roger Tomlinson's pioneering work to initiate, plan, and develop the Canada Geographic Information System resulted in the first computerized GIS in the world in 1963. **The Canadian government had commissioned Tomlinson to create a manageable inventory of its natural resources**. Tomlinson created the design for automated computing to store and process large amounts of data, which enabled Canada to begin its national land-use management program. He also gave GIS its name.



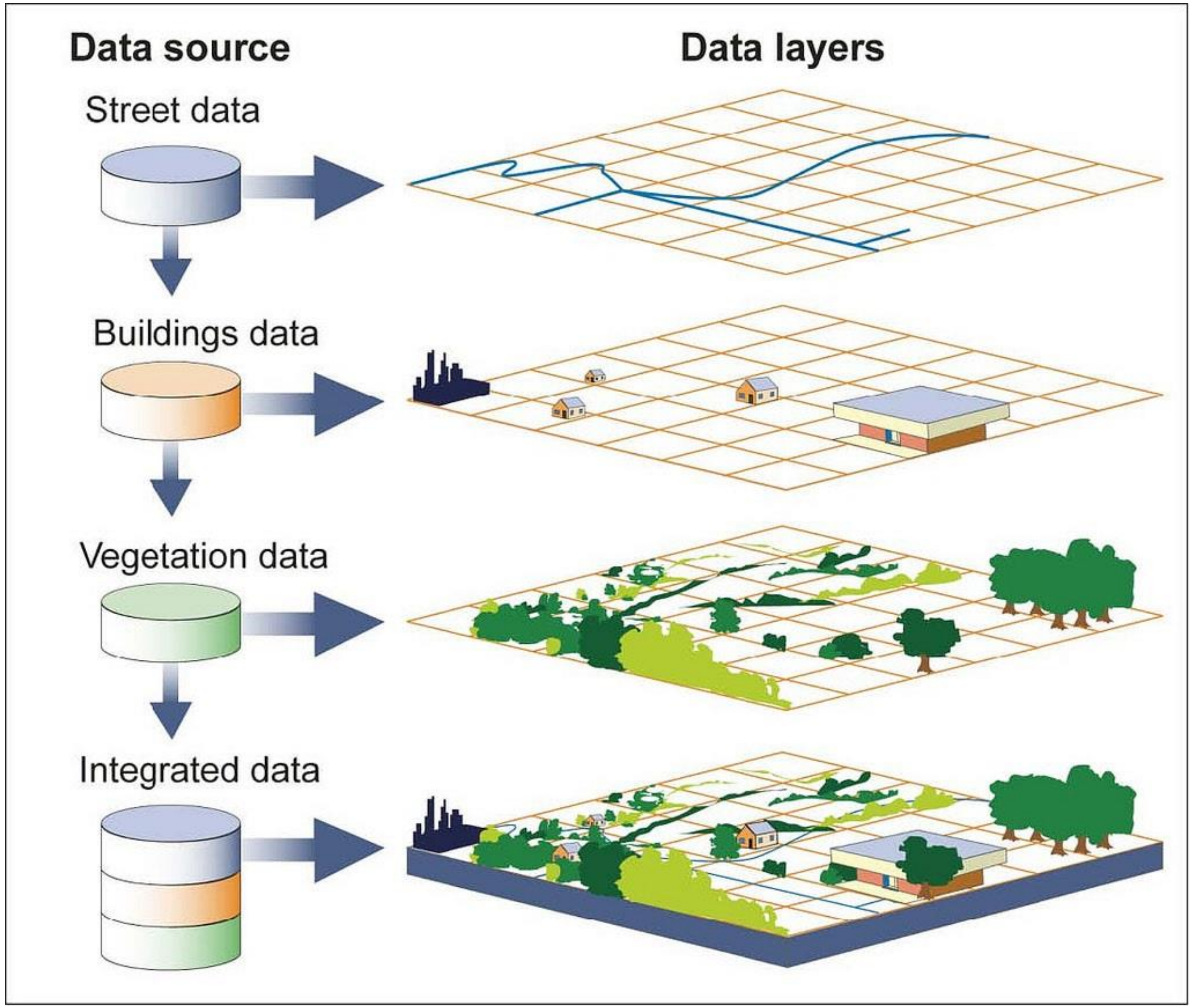
Roger Tomlinson

https://upload.wikimedia.org/wikipedia/en/d/d2/Roger_Tomlinson_-_Father_of_GIS.jpg

How is GIS Used ?

GIS Store information about the World as a **Collection of themed Layers** that can be used together.

A layer can be anything that contains similar features such as Land Cover, Water body, Road Network, Buildings etc.



https://images.nationalgeographic.org/image/upload/v1638886493/EducationHub/photos/gis.jpg

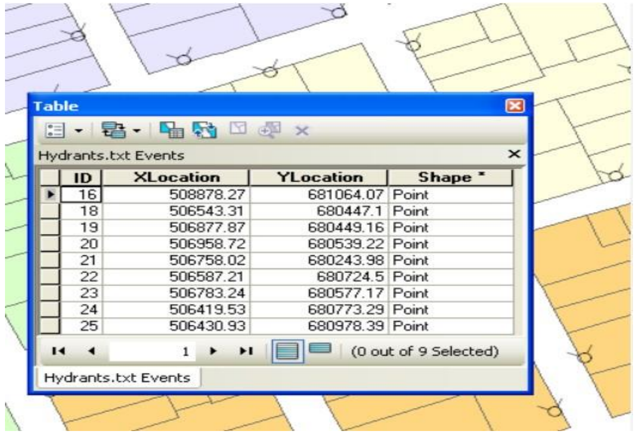
Describing our world

We can describe any element of our world in two ways:

1.Location Information:

Location information describes where a particular geographic feature situated on the earth in spherical coordinate systems i.e. **Degree, minute and seconds**.

This can be converted into cartesian coordinate system to prepare a 2 dimensional map.



Table

Hydrants.txt Events

ID	XLocation	YLocation	Shape *
16	508878.27	681064.07	Point
18	506543.31	680447.1	Point
19	506877.87	680449.16	Point
20	506958.72	680539.22	Point
21	506758.02	680243.98	Point
22	506587.21	680724.5	Point
23	506783.24	680577.17	Point
24	506419.53	680773.29	Point
25	506430.93	680978.39	Point

1 (0 out of 9 Selected)

Hydrants.txt Events

2.Attribute Information:

Attribute information Describes the feature’s details like what it is ,what it contains etc.

Geography began in map making and regional descriptions ,but has been transformed by the advancement of science, the development of computers and global environmental change .

Today geographers combine **natural science, social studies, information technology** to understand our changing world.

https://desktop.arcgis.com/en/arcmap/latest/manage-data/tables/GUID-5A309AD2-B84E-4ECF-A475-7E4B492660EC-web.png

Latitude-17˚25’32’’ N
Longitude-78˚25’55” E

Building Name-Rainbow
Type-Hospital
Address- No-2,
Banjara Hills, Hyderabad
Pin-500034

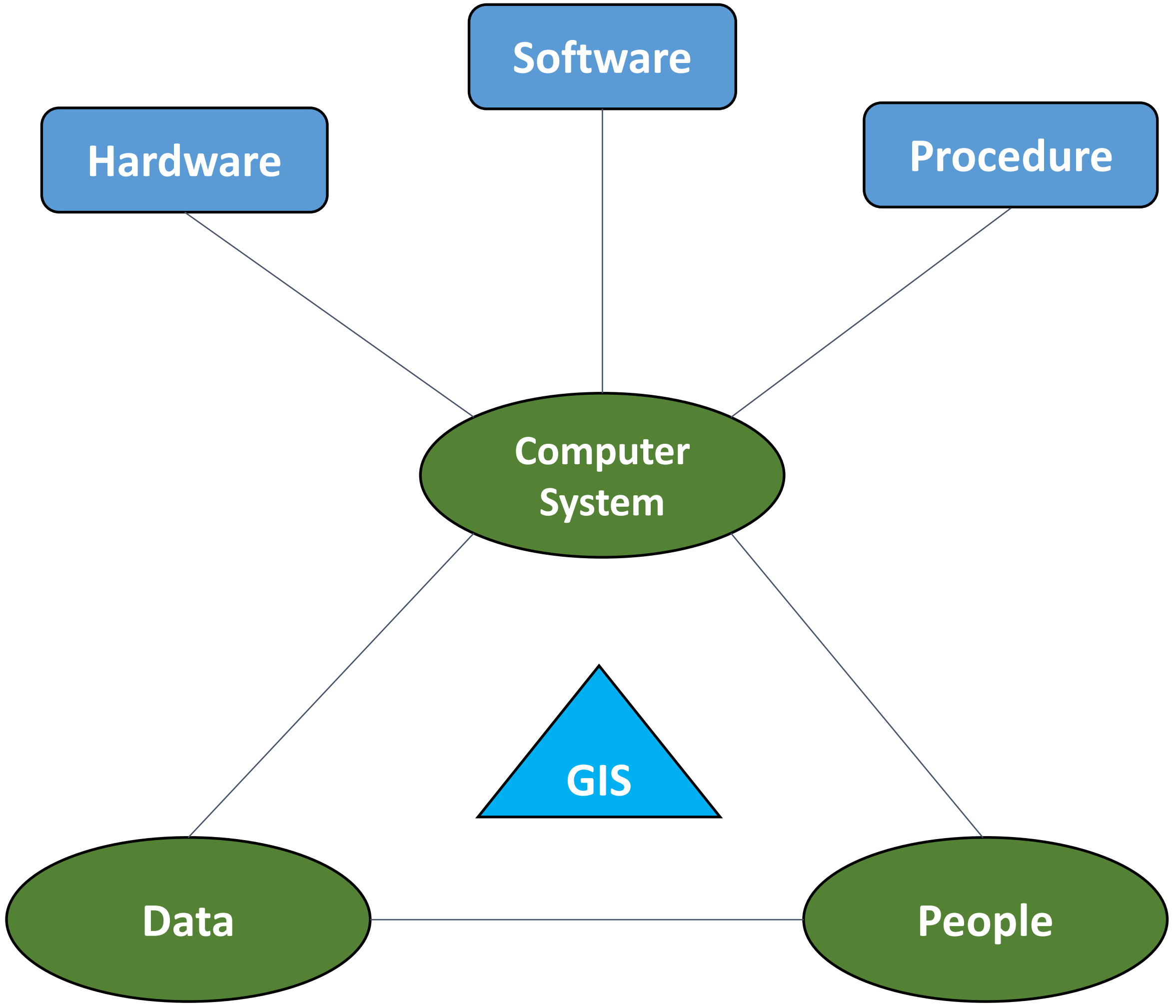
Where it is ?
Location information

What it is ?
Attribute information

https://easydrawingguides.com/wp-content/uploads/2021/03/Hospital-Step-10.png

How does GIS Work ?

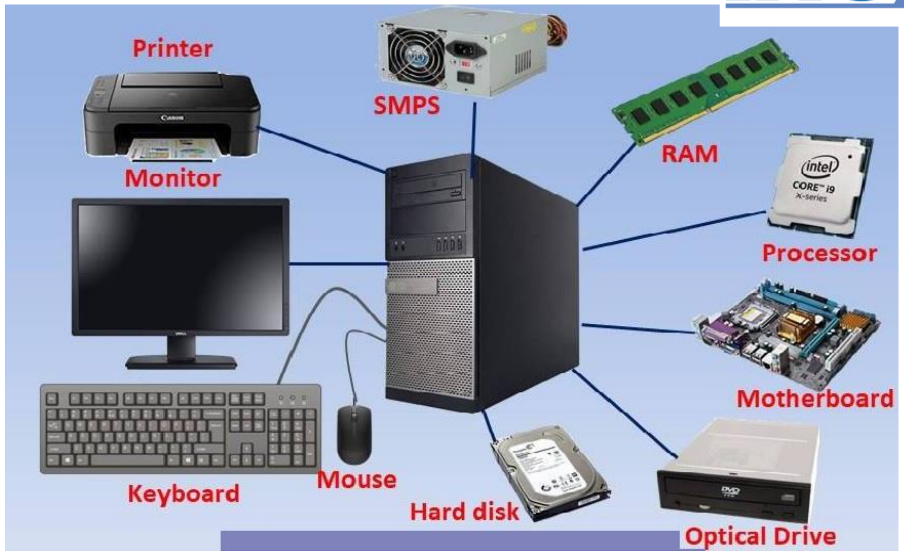
Components of GIS:-



Computer System:-

Hardware:

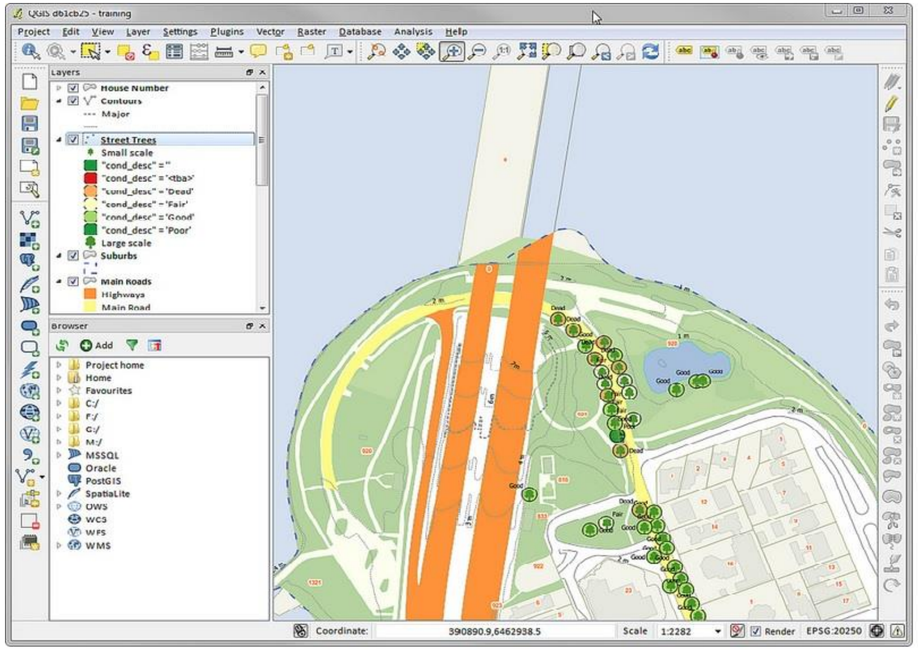
It consists of the computer on which the GIS software runs. Hardware should be robust and should have the future potential to deal with heavy software patches and updates.



Software:

GIS software provides the **functions and tools** needed to store, analyze, and display geographic information. Key software components are:

- ❑ A database management system (DBMS)
- ❑ Tools for the input and manipulation of geographic information
- ❑ Tools that support geographic query, analysis, and visualization
- ❑ A graphical user interface (GUI) for easy access to tools



Some examples of GIS Related Software are-Arc View, Arc GIS, Arc SDE,MAP Info, QGIS

https://mycomputernotes.com/wp-content/uploads/2019/01/computer_hardware.jpg
https://www.qgis.org/en/_images/qgisdesktopscreenshot.jpg

Procedure:

A successful GIS operates according to a well-designed plan and business rules, which are the models and operating practices unique to each organization.

Data:-

Data are named as geospatial data in GIS. The sources of spatial data are digitized maps, aerial photographs, satellite images, statistical table and other related documents.

These are some technology are used to collect the geospatial data: Field survey, Aerial photography, Satellites and SONAR – LIDAR Technology.

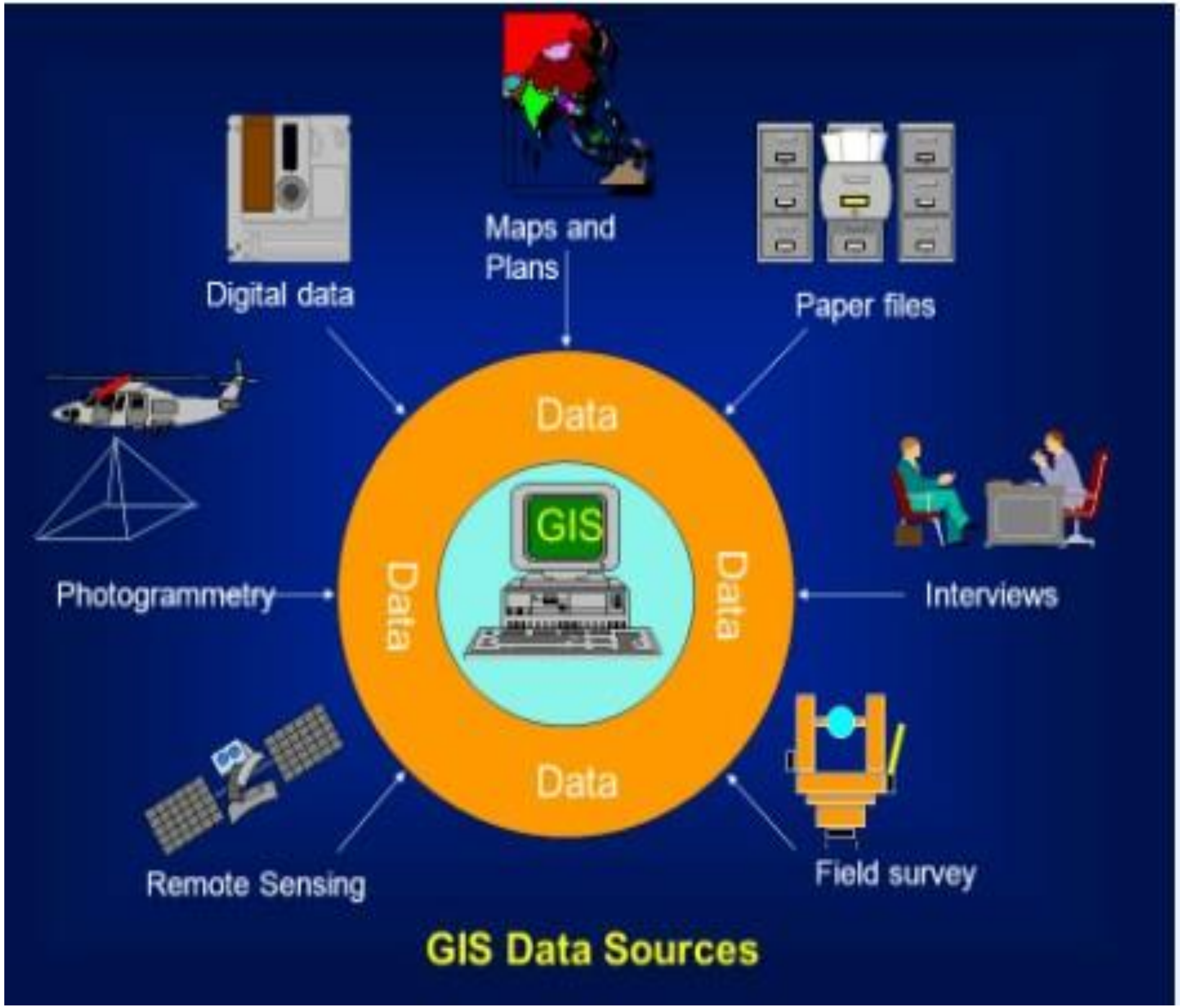
People:-

People are an important catalyst in doing a GIS Components setup. **GIS Analysts and Technicians** play along with the GIS data to analyze and monitor various forms of data sets. **GIS developers** and **database administrators** look after the frontend and the backend part of the setup.

https://img.freepik.com/free-vector/character-illustration-diverse-people-world_53876-66233.jpg?q=10&h=200

https://www.shutterstock.com/image-vector/vector-illustration-gis-spatial-data-260nw-514839721.jpg

GIS Data


Maps and Plans
Digital data
Paper files
Data
Data
Data
Data
GIS
Photogrammetry
Interviews
Remote Sensing
Field survey
GIS Data Sources

GIS Data majorly two types:

1. Spatial Data

2. Non-Spatial Data

1. **Spatial Data** is that which has physical dimensions and geographic locations on the surface of Earth.

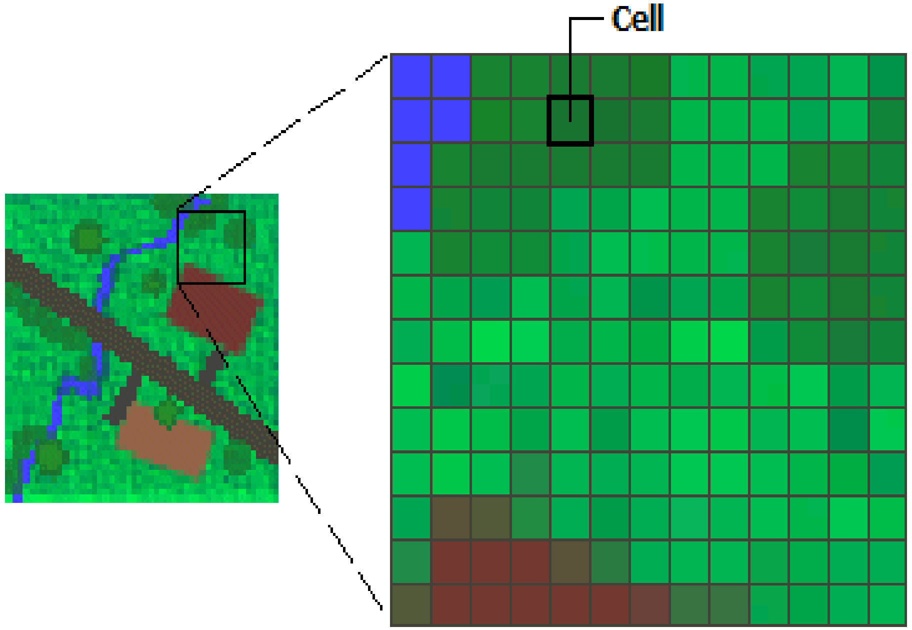
Example:-River, State Boundary, Lake, State Capital, etc.

Spatial Data is mainly classified into two types:-

Raster data and Vector data

1.1 Raster Data-

The data stored is in **cell-based and color-pixel format with a digital value/number (DN)**for each cell. These are pixels that are arranged in columns and rows format. Units are usually represented as square grid cells that are uniform in size. The data is in .jpg, .png, and .tiff. The Raster Data in GIS is very efficient for visualization and analysis, which is barely possible in vector-based data.

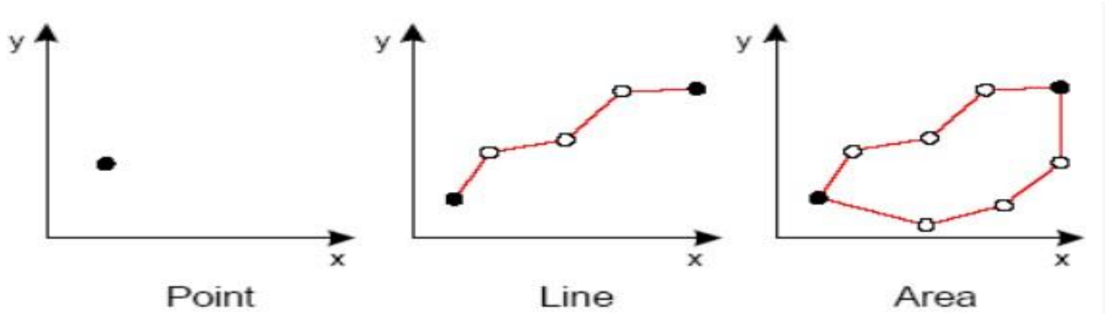


https://desktop.arcgis.com/en/arcmap/latest/manage-data/raster-and-images/GUID-6754AF39-CDE9-4F9D-8C3A-D59D93059BDD-web.png

1.2 Vector data-

Vector data is a geographic data type where data is stored as a collection of points, lines, or polygons along with attribute data.

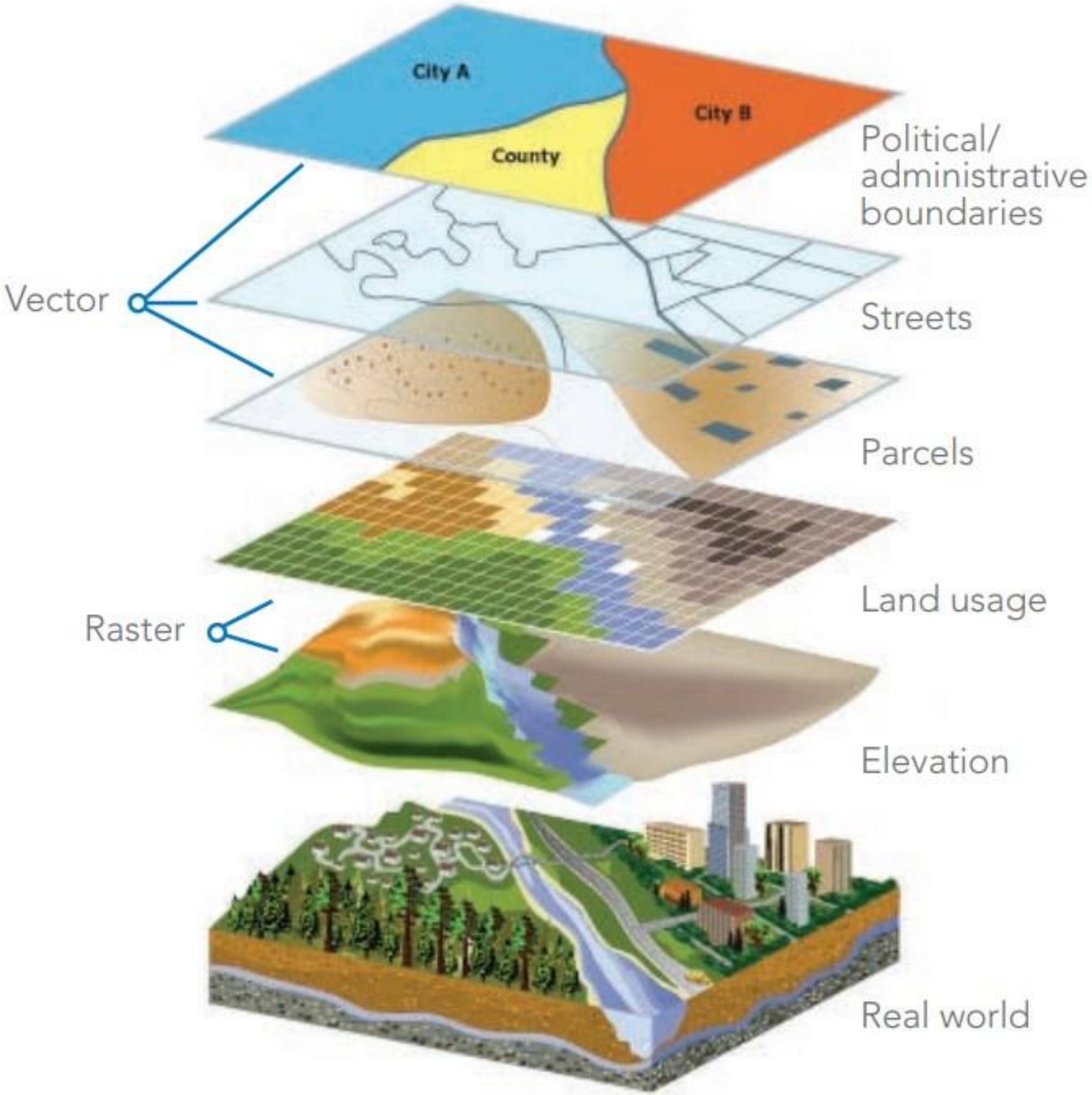
Vector data specified in 3 types **Point, Line, Polygon**



- **Point-** Point data represents non-adjacent features and has zero dimensions. We can't measure area or length with point data but we can measure density(Number of points in certain area)
  Point Data can be used to show the location of certain features.
  Example– Cities Name

- **Line-** Line data is used to represent linear features. Line have one dimension and can be used to measure the length of the feature.(how long)
  Example-- Road Network, River, Railway line etc..

- **Polygon-** Polygon are used to represent areas. Polygon have two dimensions and can be used to measure area. An area is fully encompassed by a series of connected lines.
  Example-- Lake, forest, Urban areas, Political boundary etc..



https://www.cvrd.ca/ImageRepository/Document?documentID=78986

	Advantages	Disadvantages
Raster	❑ Simple data Structure. ❑ High spatial variability efficiently represented. ❑ Efficient representation of continuous features. ❑ Compatible with remote sensing imagery.	❑ Hard to represent objects less than cell size. ❑ Finer resolution generates huge data. ❑ Loss of information when using large cells. ❑ Difficult to edit.
Vector	❑ Simple discrete geometry that means less data. ❑ Easy to edit. ❑ Attribute are combined with objects. ❑ Accurate map output ❑ Many types of geographical analysis techniques supported	❑ Complex data structure. ❑ Continuous data is difficult to represent. ❑ Lots of manual editing may be necessary. ❑ High spatial variability inefficiently represented. ❑ Not compatible with remote sensing imagery.

2. **Non- Spatial Data** describes the characteristics of a geographical feature. Non spatial data is also known as attribute or characteristics data. This data represented in table formats.

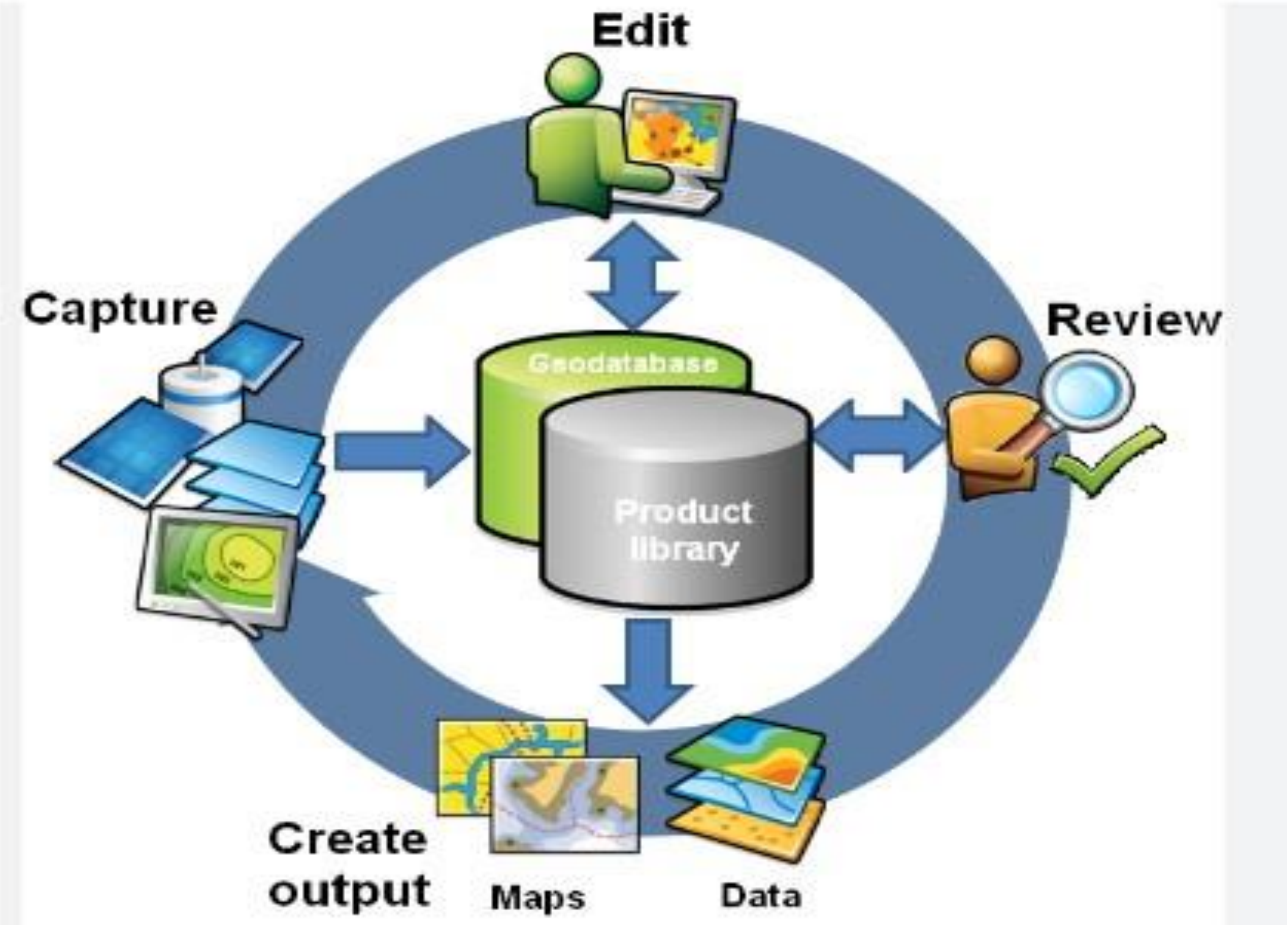
Example– Administrative boundary table has population information, districts name, provinces, Sex ratio etc..

Data Capturing

When working on a GIS project, the first issue or decision that cartographers have to face is how to incorporate data into the system. This is the process called “data capture”. There are different methodologies to capture data.

Scanning: All of map converted into raster data

Digitizing: Individual features selected from map as point, line and polygons



https://desktop.arcgis.com/en/arcmap/latest/extensions/production-mapping/GUID-56E2BC12-601E-4E39-AC54-472D7EDC7B2C-web.png

Digitizing is the process of capturing knowledge of a feature's geometry and attributes into a digital format stored on the computer's disk.

- GIS Data can be stored in a database or as files.
- One commonly used file format is the shapefile which is actually a group of three or more files (.shp, .dbf and .shx).
- Before creating a new vector layer one need to plan both what geometry type and attribute fields it will contain.
- Geometry can be point, polyline or polygon.
- Attributes can be integers (whole numbers), floating points (decimal numbers), strings (words) or dates.
- The digitizing process consists of drawing the geometry in the map view and then entering its attributes. This is repeated for each feature.

Topology

Topology expresses the spatial relationships between connecting or adjacent vector features (points, polylines and polygons) in a GIS. Topological or topology-based data are useful for detecting and correcting digitizing errors (e.g. two lines in a roads vector layer that do not meet perfectly at an intersection). Topology is necessary for carrying out some types of spatial analysis, such as network analysis.

Contiguity(Adjacency)

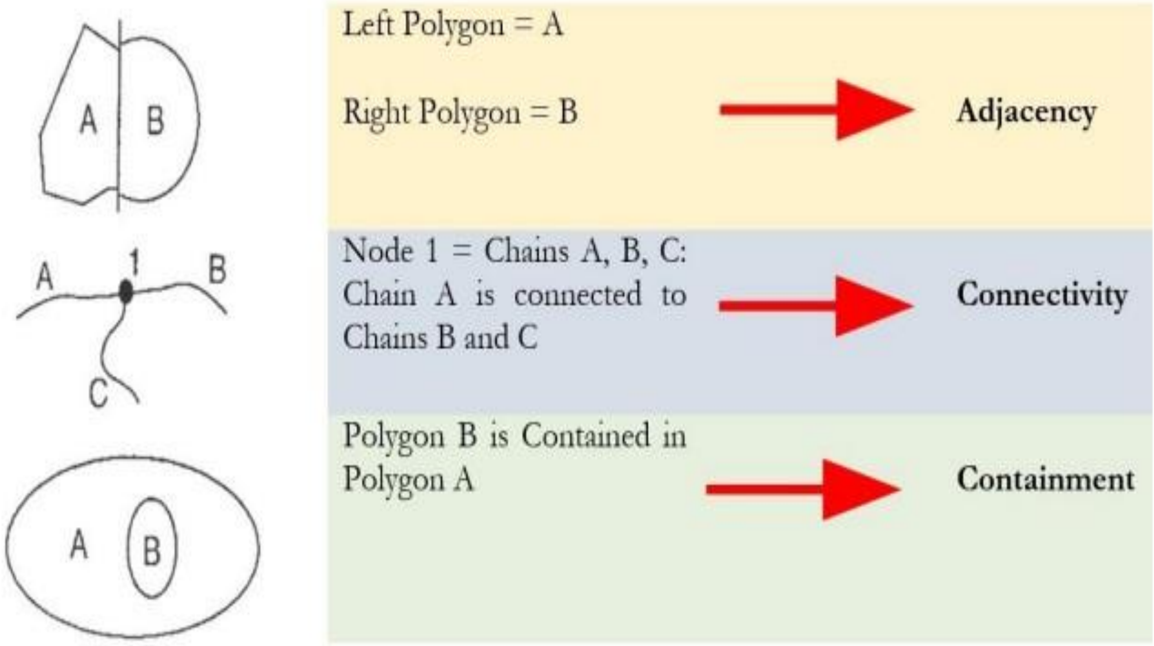
- Every arc has a direction
- A GIS maintain a list of polygons on the left and right side of each arc
- The computer then uses this information to determine which features are next to one another

Connectivity(Node topology):

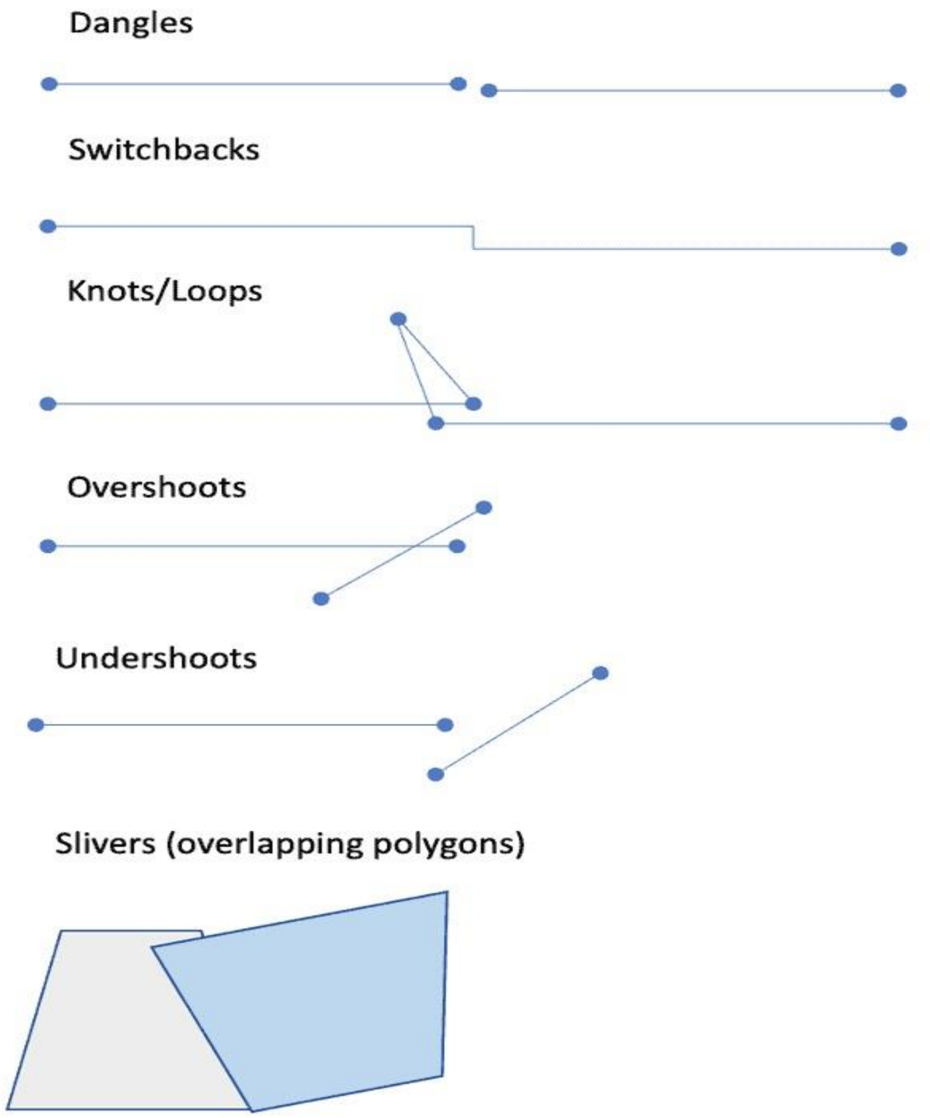
- Points along an arc that define its shape are called vertices.
- End point of an arc called nodes.
- Arcs join only at the nodes.

Containment(Polygon -Arc topology):

- An enclosed polygon has a measurable area.
- Lists of arcs define boundaries and closed areas are maintained.
- Polygons are represented as a series of (XY) coordinates that connect to define an area.



Topology errors:



https://i1.wp.com/www.gislounge.com/wp-content/uploads/2011/11/types-digitizing-GIS-errors.png?resize=620%2C900&ssl=1

Topology Rules:

Many common errors that can occur when digitising vector features can be prevented by topology rules that are implemented in many GIS applications.

The following list shows some examples of where topology rules can be defined for real world features in a vector map:

- ✓ Area edges of a municipality map must not overlap.
- ✓ Area edges of a municipality map must not have gaps (slivers).
- ✓ Polygons showing property boundaries must be closed.
- ✓ Undershoots or overshoots of the border lines are not allowed.
- ✓ Contour lines in a vector line layer must not intersect (cross each other).

Summary

- Topology shows the spatial relation of neighbouring vector features.
- Topology in GIS is provided by topological tools.
- Topology can be used to detect and correct digitizing errors.
- For some tools, such as network analysis, topological data is essential.
- Snapping distance and search radius help us to digitize topologically correct vector data.

Spatial Analysis

Spatial analysis is a set of techniques and methods used to **examine and understand patterns, relationships, and trends** in geographic data. It involves the study of the spatial distribution of various features, objects, and phenomena on the Earth's surface or in other geographic spaces. Spatial analysis leverages geographic information systems (GIS) and other tools to gain insights into how location, proximity, and spatial relationships impact various processes and phenomena.

Geospatial Data Analysis Methods:

A wide range of functions for data analysis are available in most GIS packages, including data Query, Geospatial Measurement, Overlay Operations, Network Analysis.

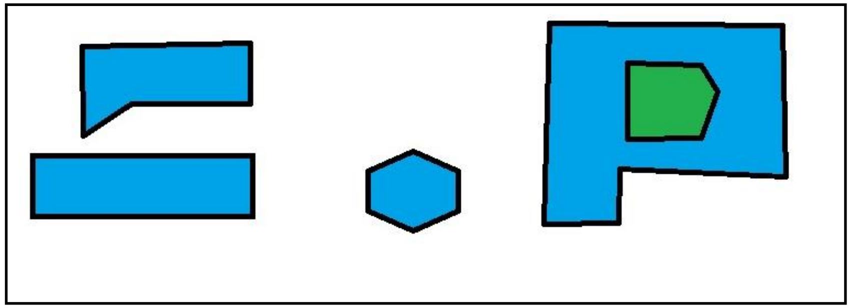
1. Database Query:

GIS database can be retrieved by simple browsing (display) and querying on the database.

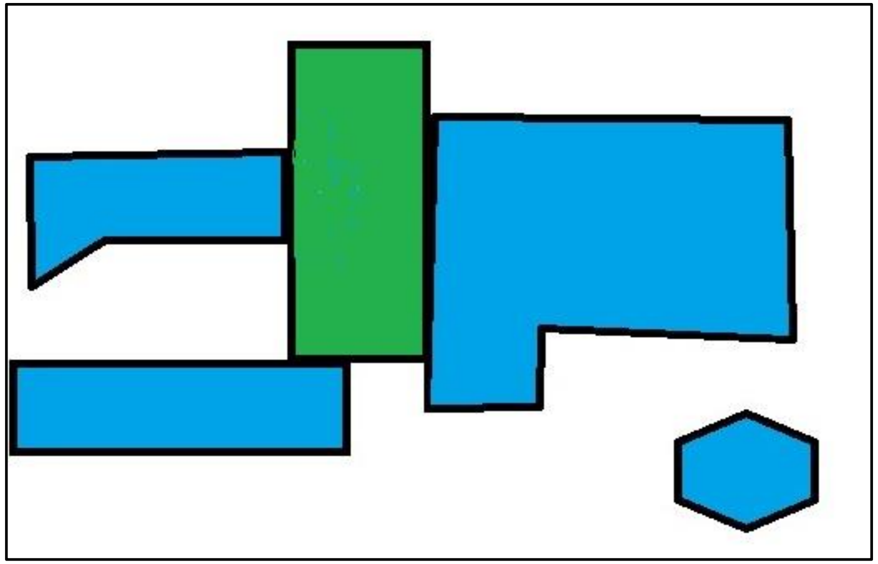
There are two types of queries that a GIS generally allows on Vector data.

Spatial query:

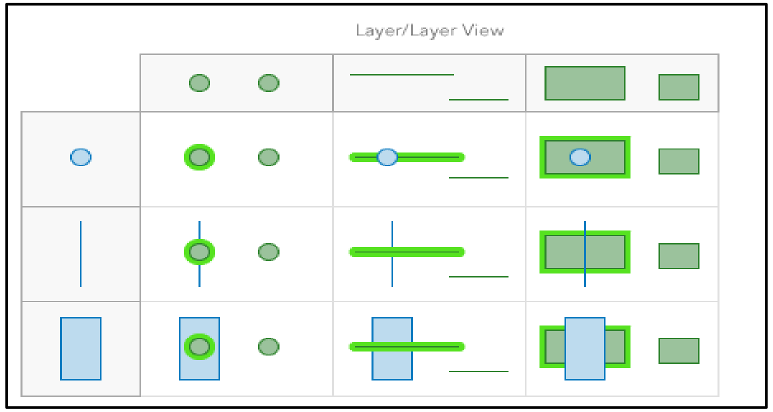
- **Containment** Selects features that fall completely within features used for selection, e.g., selecting all cities within the selected districts.



- **Adjacency** Selects features that are adjacent to features used for selection, e.g., selecting all adjacent districts of a selected state.

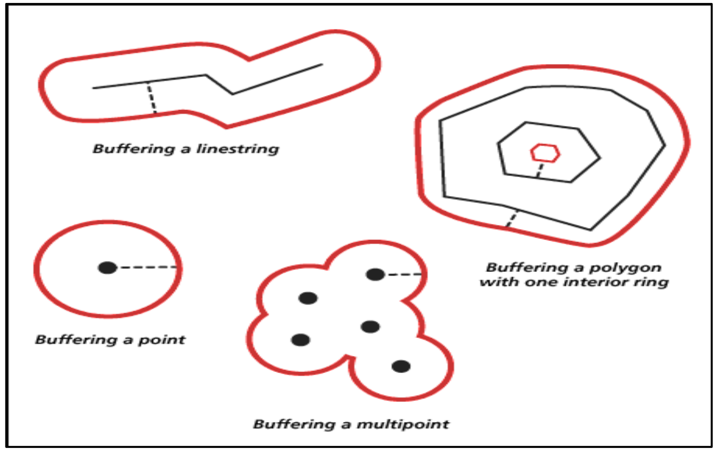


- **Intersect** Selects features that intersect features used for selection, e.g., selecting all districts on which a selected highway passes.



https://developers.arcgis.com/javascript/latest/api-reference/esri-rest-support-Query.html

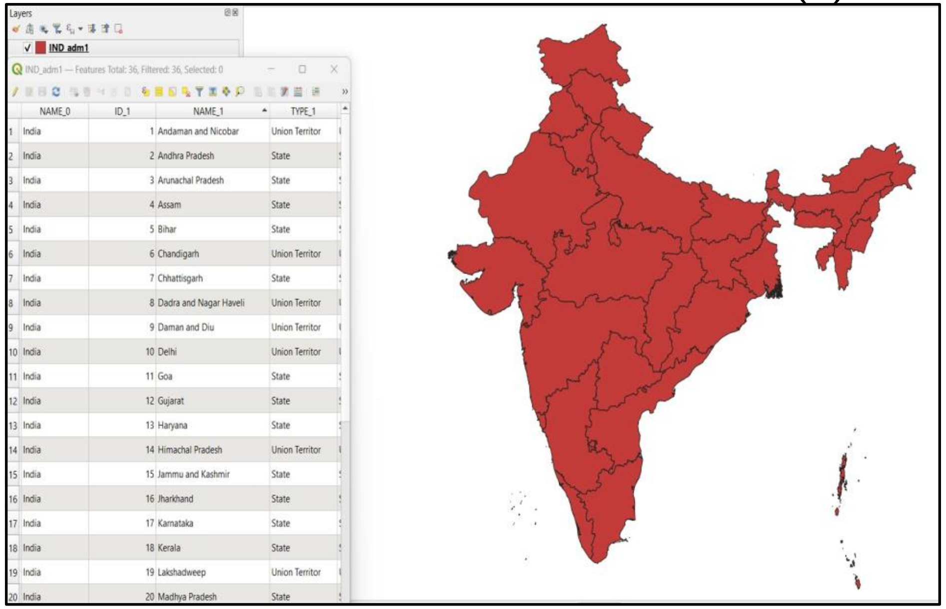
- **Proximity** Selects features that are within a specified distance of features used for selection, e.g., selecting all the shops and households that are situated within 80m from both sides of the selected road. One of the most popular proximity analyses is based on 'buffering'. Buffer can be defined as an influenced area/zone of an object in GIS.



https://www.tamiu.edu/cees/courses/fall2018/geol4460_labs/lecture12.pdf

Attribute query: Attribute querying is the process of identifying a subset of features based on the categories of the attributes. Attribute queries are usually implemented based on logical conditions. Users can ask about the location of the features based on their attribute values. Simple to more complex queries can be made with the help of SQL. The attribute data can be searched with some specifications. The specifications include the following three items, usually given in SQL.

- SELECT <attribute/fieldname>
- FROM <table(s)>
- WHERE<conditions statement(s)>



Geospatial Measurement:

Measurement is also a type of query; however, it does not select any object from the GIS database; instead, it gives some statistical/geometrical results by measuring the map.

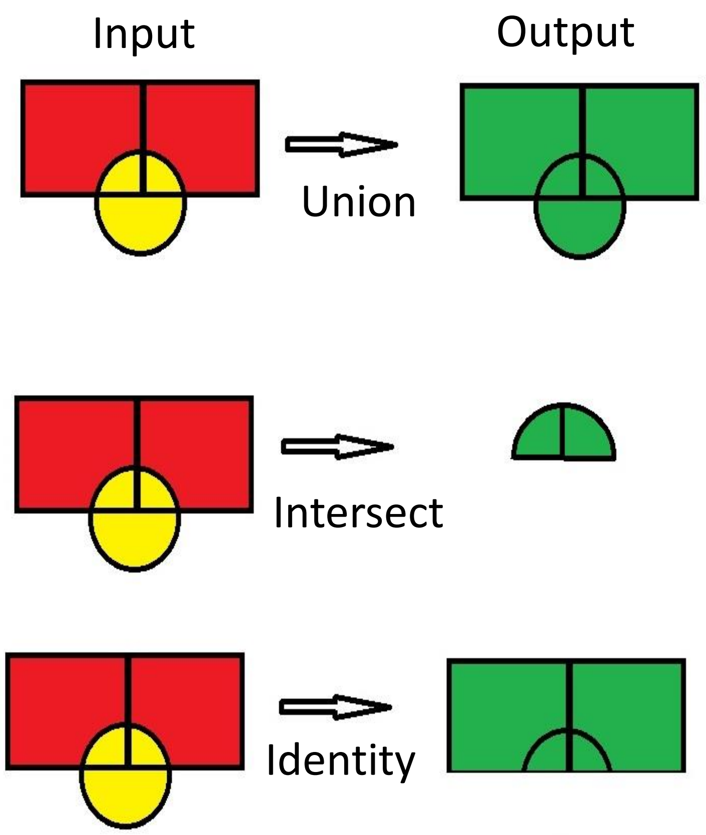
Two types of Geospatial measurements are popular in GIS.

- Measurement Of Density: The density tool distributes a measured quantity of an input point layer throughout a landscape to produce a continuous surface.
- Measurement of Distance: Measures the distance that how far away one thing is from another.

Overlay Operations:

Vector overlay: Integrate more than one layer.

- Union: Keep all the areas from both the coverages.
- Intersect: The output is only those portions of the input coverage feature falling within the overlay coverage features.
- Identity: Creates output layer by combining the features of overlapping areas of input and analysis layers.



Raster Overlay:

- **ADD** performs the arithmetic function of the addition of cell values of two layers. Information from the input layer is added to the corresponding cell value of the other layer. This information is later recorded if required for further analysis.
- **SUBTRACT** is performed by subtracting the values of one layer from the other layer. It is carried out normally to find out the changes through time.
- **MULTIPLICATION** operation is carried out by multiplying the cell values of input layers and the result is written in the output layer. This type of operation is needed to extract a small area from the larger data set layer. For example, extraction of land use information of a district from the state data set. In this operation, the cell values outside the district data set are assigned as '0'.
- **DIVISION** operation is performed by dividing the cell values of one set by the corresponding values of another data set. This operation is used when one needs to calculate densities i.e. calculation of population density from population and area layers.
- **DIFFERENCE** is performed by calculating absolute difference values between two layers.

Network Analysis:

Network analysis is a set of connected lines. These lines represent railways, streams, roads, waterlines, pipelines, telecommunication lines, etc., that generally need to be analyzed as a network.

The three main types of network analyses are network tracing, network routing, and network allocation.

- **Network Tracing** finds a particular path through the network based on the criteria provided by the user, e.g., finding a path that connects the nearest ATM of a specific bank.
- **Network Routing** determines the optimal path along a linear network. Some possible criteria to select the path include the shortest distance, fastest route, or minimum cost from a position on the network to a known location.
- **Network Allocation** deals with the designation of the proportion of the network to 'supply centers' or 'destination points', e.g., a fire station (to determine its service coverage and service distance). This example also shows the amount of overlap between the service areas of the two fire stations.

Spatial Interpolation

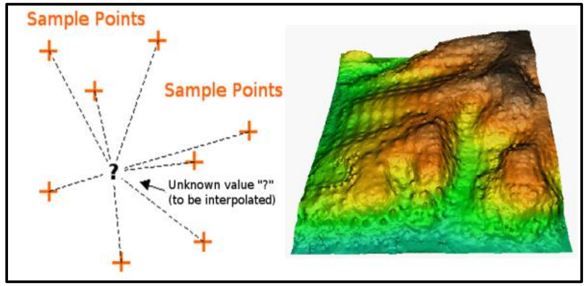
Spatial interpolation is the process of using points with known values to estimate values at other unknown points. Spatial interpolation can estimate the temperatures at locations without recorded data by using known temperature readings at nearby weather stations. This type of interpolated surface is often called a statistical surface.

This is majorly two types:

- **Inverse Distance Weighted Interpolation (IDW)**
- **Triangulated Irregular Network (TIN) Interpolation**

- **Inverse Distance Weighted Interpolation (IDW):**

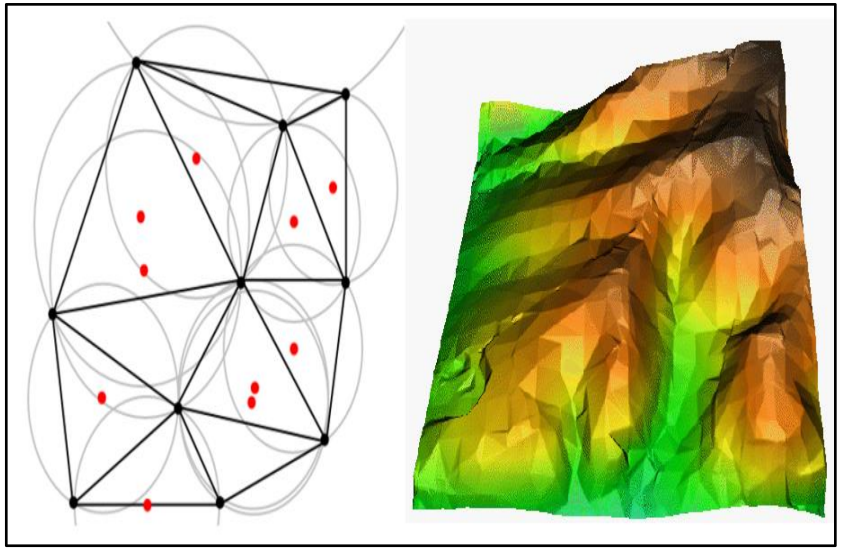
In the IDW interpolation method, the sample points are weighted during interpolation such that the influence of one point relative to another declines with the distance from the unknown point we want to create.



Inverse Distance Weighted interpolation based on weighted sample point distance (left). Interpolated IDW surface from elevation vector points (right)

- ## Triangulated Irregular Network (TIN) Interpolation

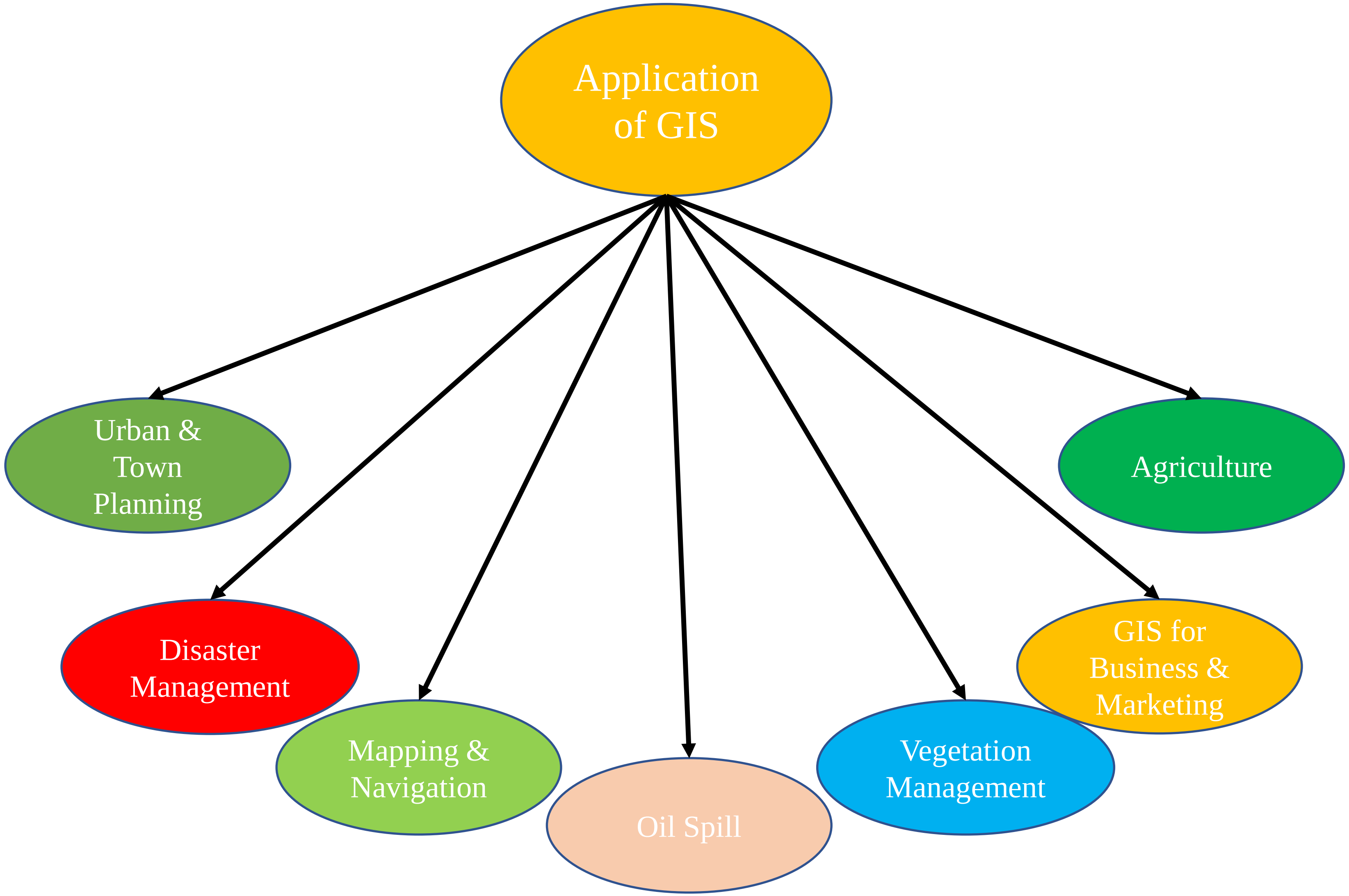
TIN interpolation technique uses the algorithm called Delaunay triangulation. It tries to create a surface formed by triangles of nearest neighbour points. This method aims at creating non-overlapping triangles (as equilateral as possible) whose circumscribed circle contains only the three points that gave birth to the triangle. To do this, circumcircles around selected sample points are created and their intersections are connected to a network of non-overlapping and as compact as possible triangles.



Delaunay triangulation with circumcircles around the red sample data. The resulting interpolated TIN surface is created from elevation vector points

Applications of GIS

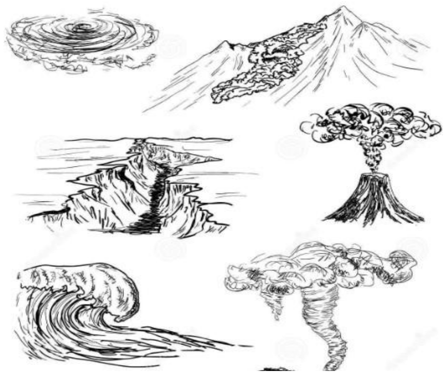
Geographic Information Systems are applied in various domains. The count of its applications is only growing day by day. Below are some of the well-known applications concerning GIS.



Urban & Town Planning

Developers, Builders, Architects, and Engineers are now using spatial data sets to plan on the futuristic township. With the help of granular information, it becomes easier for engineers and architects to hardly miss out on any of the parts. The data is also useful to tackle water clogging during the time of flood and cloud burst in monsoons. It has also helped in redesigning the drainage models.

Disaster Management



GIS is used to monitor disaster and natural calamity prone areas. The geospatial data sets and databases allow organizations to store data of all levels. The database can contain all the information related to risk-prone areas like hospitals and isolation centres near the risk-prone zones, quick habitation centers, history of the calamities in that area, and the effect of the past disaster to plan for further contingency plans.

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Mapping & Navigation

The best example of today’s world mapping and navigation is Google Maps. Humans around the world use it while travelling to a new place and also to review any place. It has also become a popular tool within Cab and carpool service providers. GPS, with the help of GIS, adds crisper and edge to the experience of navigation. Other Mapping applications are-Here Maps, Apple Maps

Oil Spill

Oil Spill can be intentional or accidental, depending on the conditions. The price is always paid by the Marine life and the humans who have frequent access to that particular sea route. GIS and geospatial data sets are used to curb such havoc spreading spills. It is cost-effective than the hazardous oil spill, which is also harmful to marine life.

https://cdni.autocarindia.com/ExtraImages/20210608054804_Apple_Maps_new.jpg

https://www.greenpeace.org/static/planet4-international-stateless/2020/09/5a4f7d68-gp1su9nb-1024x576.jpg

Vegetation Management

Using GIS and geospatial data of forest lands allows organizations and governments to keep track of the rate of deforestation. The past information of different periods is used for analysis to plan for reforestation and vegetation. The datasets are used for the further analytical purpose of reforestation. With the help of heat maps and imagery sources, the data can be classified and visualized to take further actions.

GIS for Business & Marketing

Apart from all the above applications, GIS also has unusual usage in making business and marketing sales. Geospatial databases store data of target customers, marketing campaigns and sales territories. This application enables companies and organizations to become strategically more competitive and strong in the market.

Agriculture

Agriculture is one of the important tasks of human civilization. It is not only done for feeding the bellies but also to run the global business. GIS has spearheaded into this field with many of the applications.

Uses in Drought, Pest Control, Land & Soil Analysis, Planning of future food demand

https://digitalhubaustralia.com.au/wp-content/uploads/2020/06/45_omnivsdm.jpg

https://www.integratesustainability.com.au/wp-content/uploads/2018/11/Insight-Thumbnails-GIS.png

Summary

- ✓ What is at? :- location(lat, long)
- ✓ Where is it? :- condition(find the location having certain characteristics)
- ✓ Where has changes since? :- Trend (How things changed over times)
- ✓ Which is the best way? :- Routing
- ✓ What spatial pattern exist? :- Pattern(Describe and compare the distribution)
- ✓ What if? :- Modelling(Determine what will happen)

Geographic Coordinate Systems

To understand how maps are created by projecting the 3-D earth's surface into a 2-D plane of an analog map, we need to understand the georeferencing concepts. Georeferencing involves two stages: specifying the 3-dimensional coordinate system that is used for locating points on the earth's surface that is, the Geographic Coordinate System (GCS), and the Projected Coordinate System that is used for projecting into two dimensions for creating analog maps.
The traditional way of representing locations on the surface of the earth is in the 3- dimensional coordinate system is by its latitude and longitude.

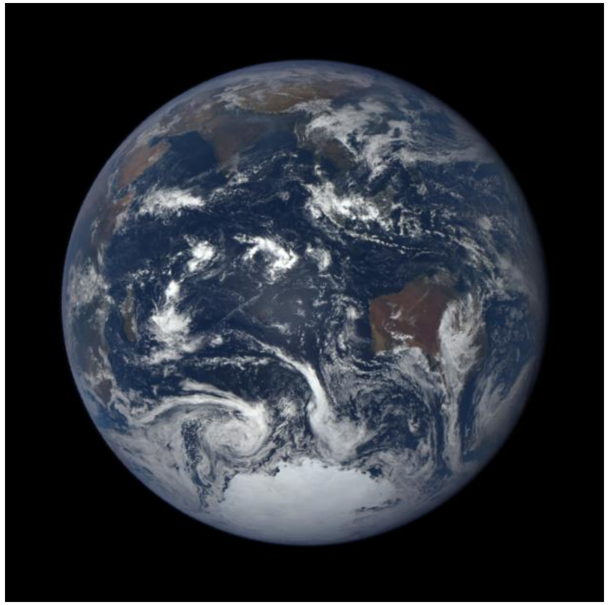
The true surface of the Earth is not the smooth ellipsoid shown in the figure but is quite uneven and rugged. The GCS is the surface used for specifying the latitude and longitude of a point on the earth's surface, is also an approximation and a 3-D model of the earth. Several standard models of the ellipsoid are available to define the GCS (WGS 84, Everest ellipsoid) etc.

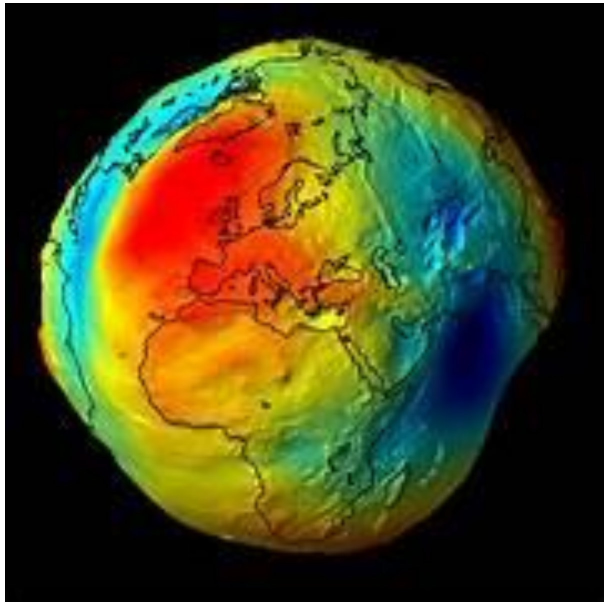
A GCS is defined by **geoid**, **ellipsoid,** and **datum**.

Geoid: Representing the earth's true shape, the geoid, as a mathematical model is crucial for a GIS environment.

Ellipsoid: Assuming that the earth is a perfect sphere greatly simplifies mathematical calculations and works well for small-scale maps (maps that show a large area of the earth). However, when working at larger scales, an ellipsoid representation of the earth may be desired if accurate measurements are needed. An ellipsoid is defined by two radii: the semi-major axis (the equatorial radius) and the semi-minor axis (the polar radius).

Datum: The ellipsoid model that is used to calculate latitude and longitude is called the datum.





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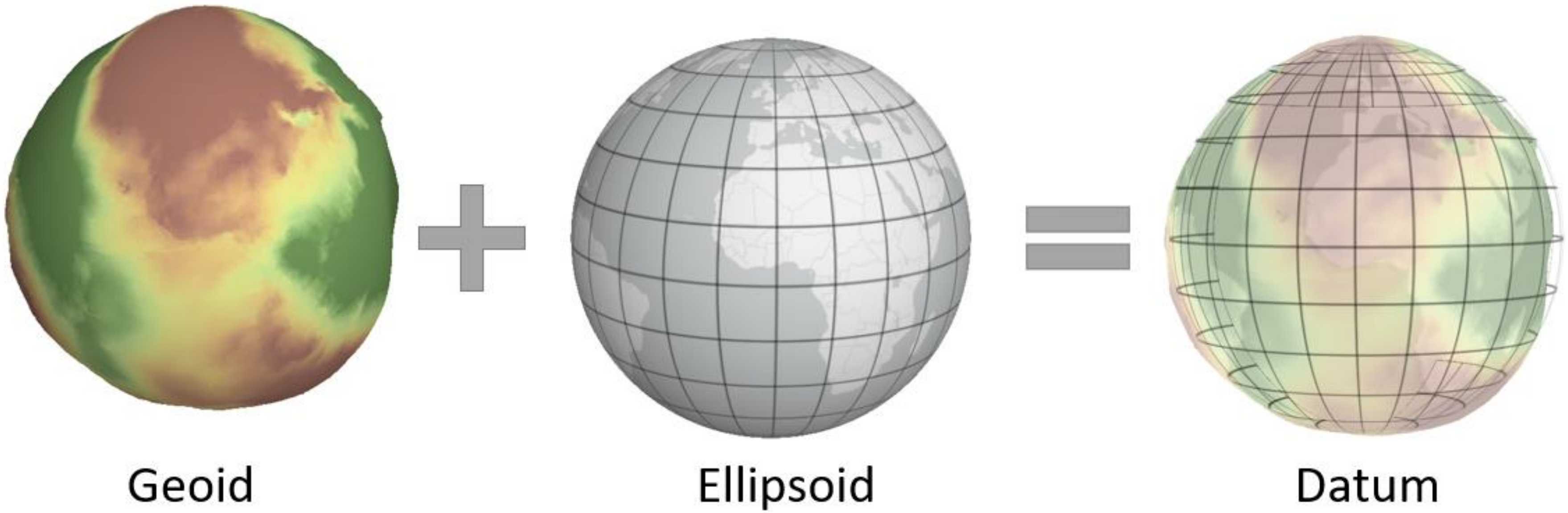
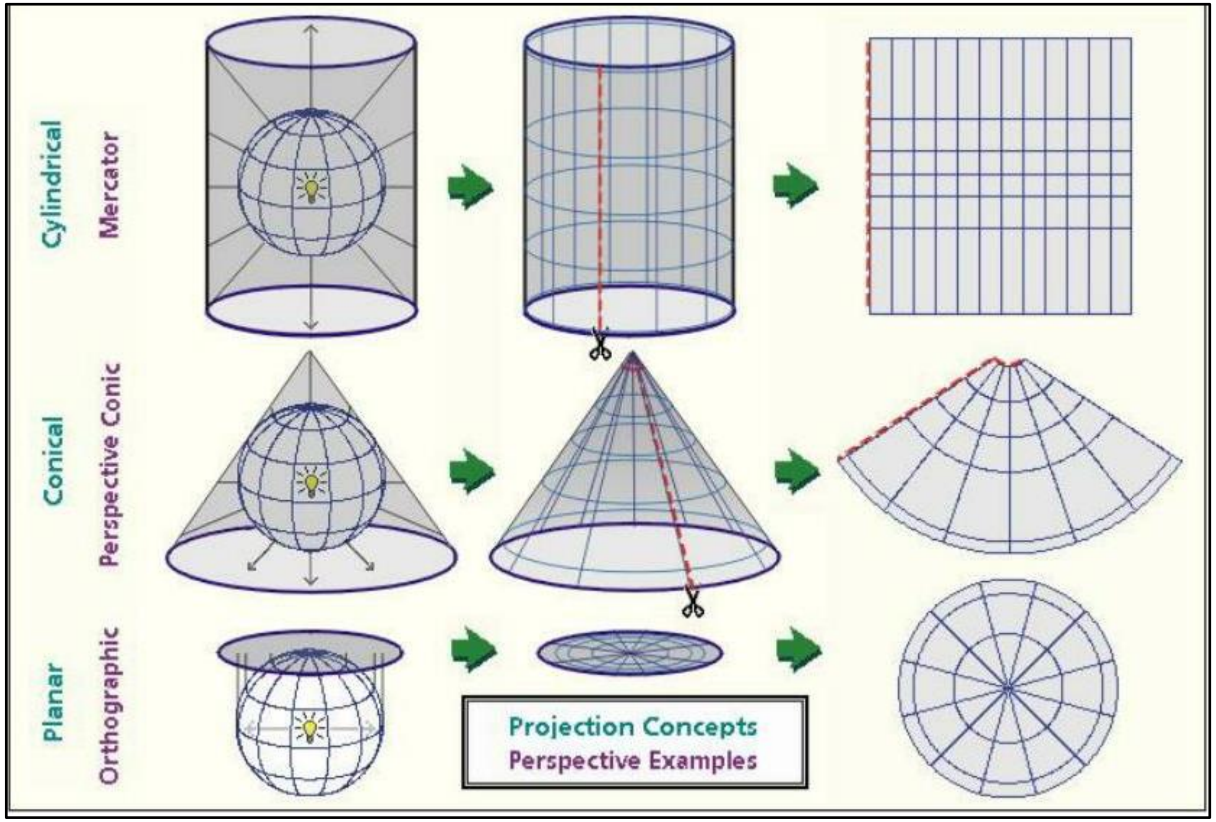

Geoid
Ellipsoid
Datum

Projected Coordinate Systems

The surface of the earth is curved, but maps are flat. A projected coordinate system (PCS) is a reference system for identifying locations and measuring features on a flat (map) surface. It consists of lines that intersect at right angles, forming a grid. Projected coordinate systems (which are based on Cartesian coordinates) have an origin, an *x-axis*, a *y-axis*, and a linear unit of measure. Going from a GCS to a PCS requires mathematical transformations called a projection system. Projection is a mathematical transformation used to project the real 3-dimensional spherical surface of the earth in 2 dimensions on a plane sheet of paper.

The 3-D to 2-D projections can be done to a plane or to the surface of a cone or cylinder, leading to **azimuthal, conic, or cylindrical** projections, respectively, with many variations.



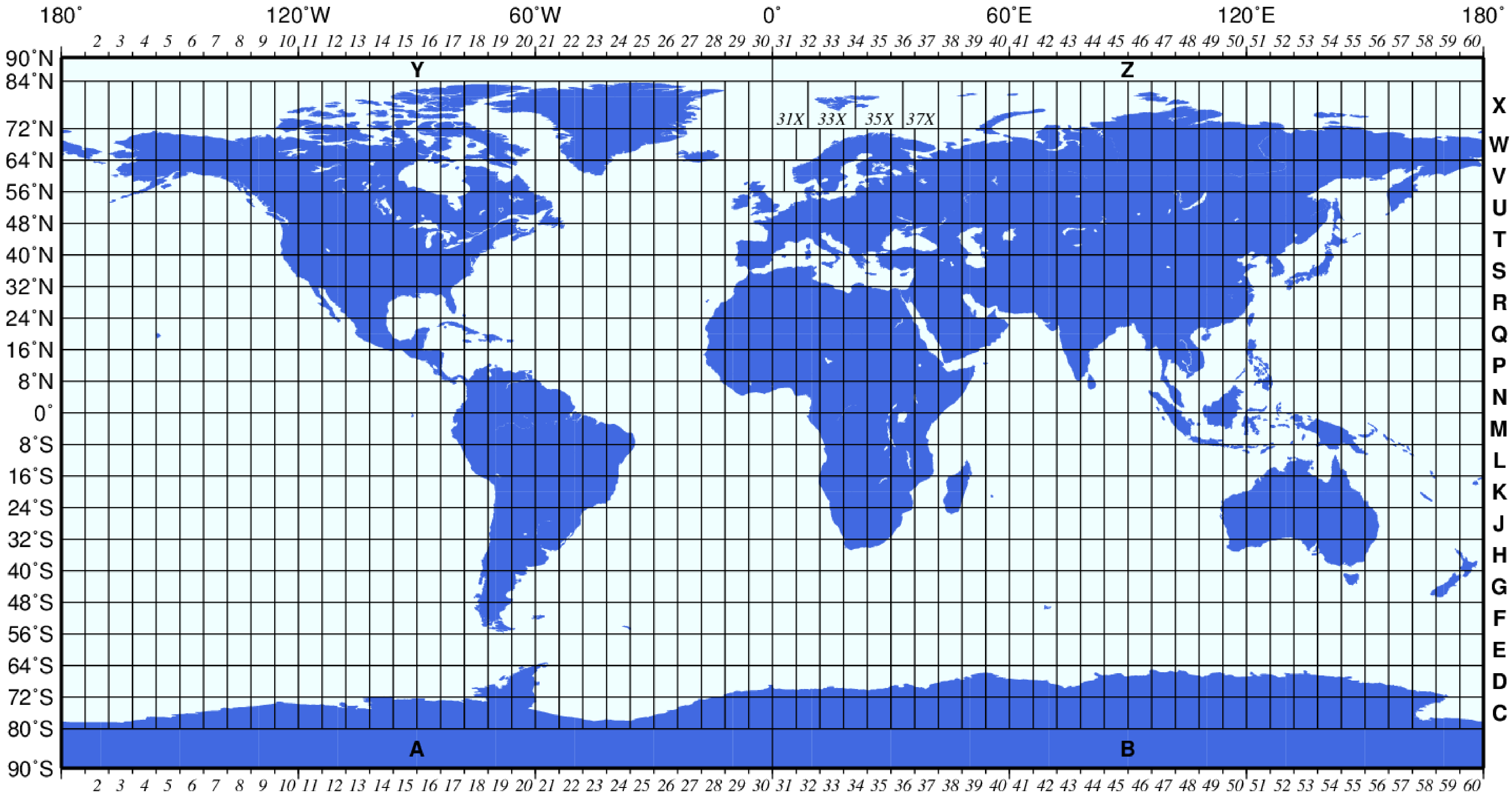
https://www.nwcg.gov/publications/pms437/mapping/using-gis

Universal Transverse Mercator (UTM)

The **Universal Transverse Mercator (UTM)** is a map projection system for assigning coordinates to locations on the surface of the Earth. Like the traditional method of latitude and longitude, it is a horizontal position representation, which means it ignores altitude and treats the earth surface as a perfect ellipsoid.

The UTM system divides the Earth into 60 zones, each 6° of longitude in width. Zone 1 covers longitude 180° to 174° W; zone numbering increases eastward to zone 60, which covers longitude 174°E to 180°. The polar regions south of 80°S and north of 84°N are excluded.

Universal Transverse Mercator



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Thank You