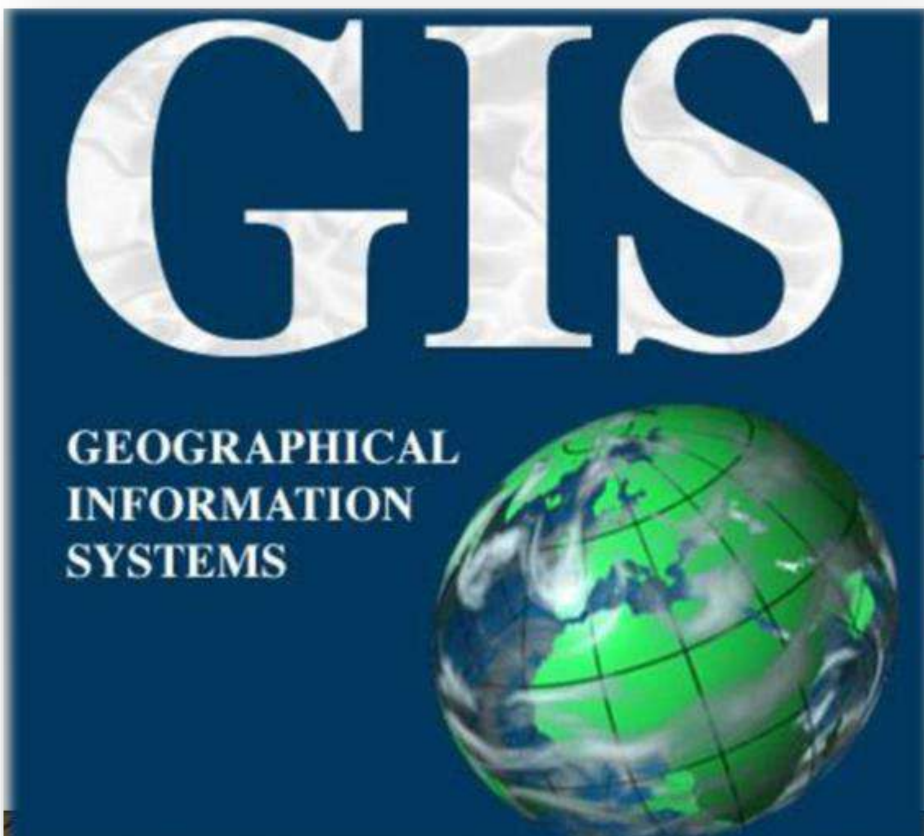
الجامعة التكنولوجية

قسم علوم الحاسوب



Dr .Ali Adel **2024-2023**

Sleibas

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1. The Nature of GIS

GIS stands for Geographical Information System. GIS has different **definitions**:

Def 1-

GIS is defined as an integrated tool, capable of mapping, analyzing, manipulating and storing geographical data in order to provide solutions to real world problems and help for future planning. GIS deals with what and where components of occurrences. For example, to regulate rapid transportation, government decides to build fly-over (what component) in those areas of the city where traffic jams are common .

Def 2--

GIS can also be defined as “a powerful set of tools for collecting, storing, retrieving, transforming and displaying spatial data from the real world for a particular set of purposes.

Figure(1) spatial data

Def-3

GIS is a generic term implying the use of computers to create and display digital maps. The attribute data which describe the various features presented in maps may relate to physical, chemical, biological, environmental, social, economic or other earth surface properties. GIS allows mapping, modelling, querying, analyzing and displaying large quantities of such diverse data, all held together within a single database.

Figure (2):GIS systems

Objectives of GIS

Some of the major objectives of GIS are:

1. Maximizing the efficiency of planning and decision-making.
2. Integrating information from multiple sources to facilitate complex querying and analysis
3. Eliminating redundant data and minimizing duplication.

2. Importance of GIS

GIS allows to store and manipulate information using geography and to analyze patterns, relationships, and trends in that information to help in making better decisions.

1.1.1. Components of a GIS

A GIS has the following components:

Hardware : It consists of the equipment's and support devices that are required to capture, store process and visualize the geographic information. These include computer with hard disk, digitizers, scanners, printers and plotters etc.

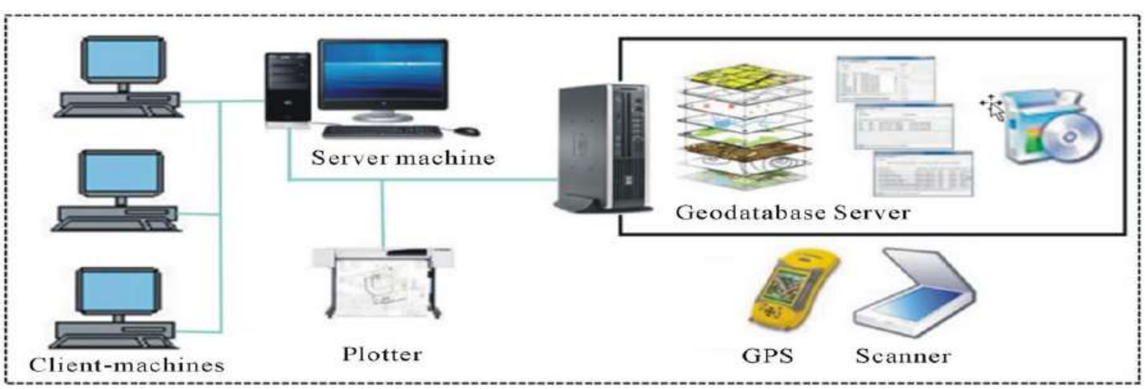
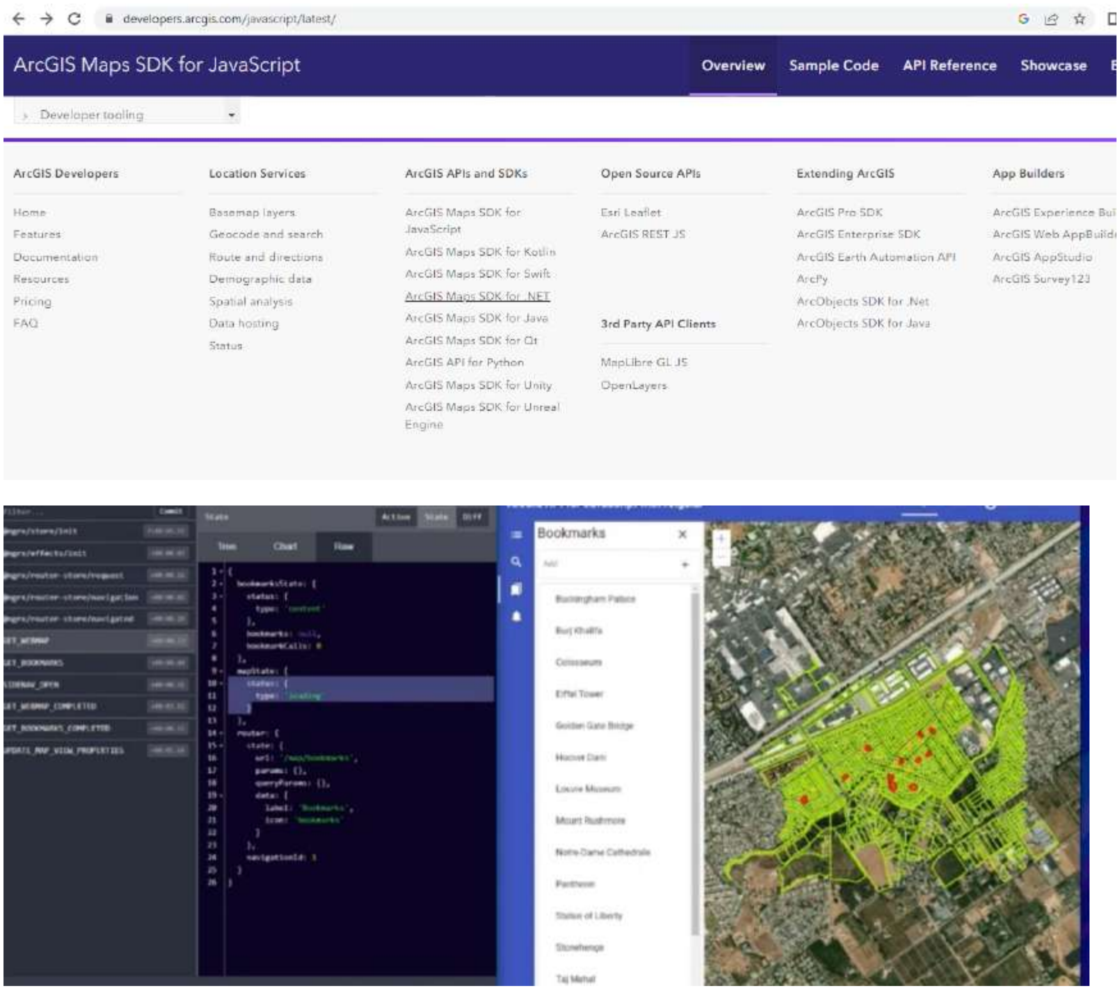


Figure (3) :GIS hardware component

Software: Software is at the heart of a GIS system. The GIS software must have the basic capabilities of data input, storage, transformation, analysis and providing desired outputs. The interfaces could be different for different softwares . The GIS softwares being used today belong to either of the category –proprietary or open source. ArcGIS by ESRI is the widely used proprietary GIS software. Others in the same category are MapInfo, Microstation, Geomedia.



Figure(4) GIS OPEN SYSTEMS

Data : The data is captured or collected from various sources (such as maps, **<u>field observations</u>**, photography, satellite imagery etc.) and is processed for analysis and presentation.

Figure (5) GIS data types

Procedures: These include the methods or ways by which data has to be input in the system, retrieved, processed, transformed and presented.

People: This component of GIS includes all those individuals (such as programmer, database manager, GIS researcher etc.) who are making the GIS work, and the individuals who are at the user end using the GIS services, applications and tools.

GIS stems , GIS science , GIS application

The previous discussion defined a *geographic information system*— in the 'narrow' sense—in terms of its functions as a computerized system that **<u>facilitates the phases of data entry, data management, data analysis and data presentation specifically for dealing with georeferenced data. In the</u>** 'wider' sense, a functioning GIS requires both hardware and software, and also people such as the database creators or administrators, analysts who work with the software, and the users of the end product. For the purposes of this studying we will concern ourselves with the 'narrow' definition, and focus on the specifics of these so-called GI*S systems*.

The discipline that deals with all aspects of the handling of spatial data is called *geographic information science* (often defined geoinformation science or just GIScience).

Geoinformation Science is the scientific field that attempts to integrate different disciplines studying the methods and techniques of handling **spatial information**

Defining GIS

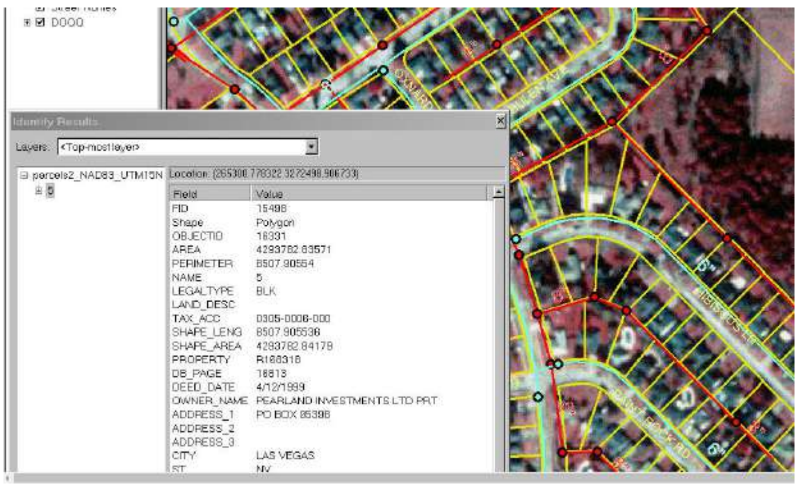
A GIS is a computer-based system that provides the following four sets of capabilities to handle georeferenced data:

1. *Data capture and preparation*
2. *Data management*, including storage and maintenance
3. *Data manipulation and analysis*
4. *Data presentation*

GIS Applications

GIS is involved in various areas. These include topographical mapping, socioeconomic and environment modeling, and education. The role of GIS is best illustrated with respect to some of the representative application areas that are mentioned below:

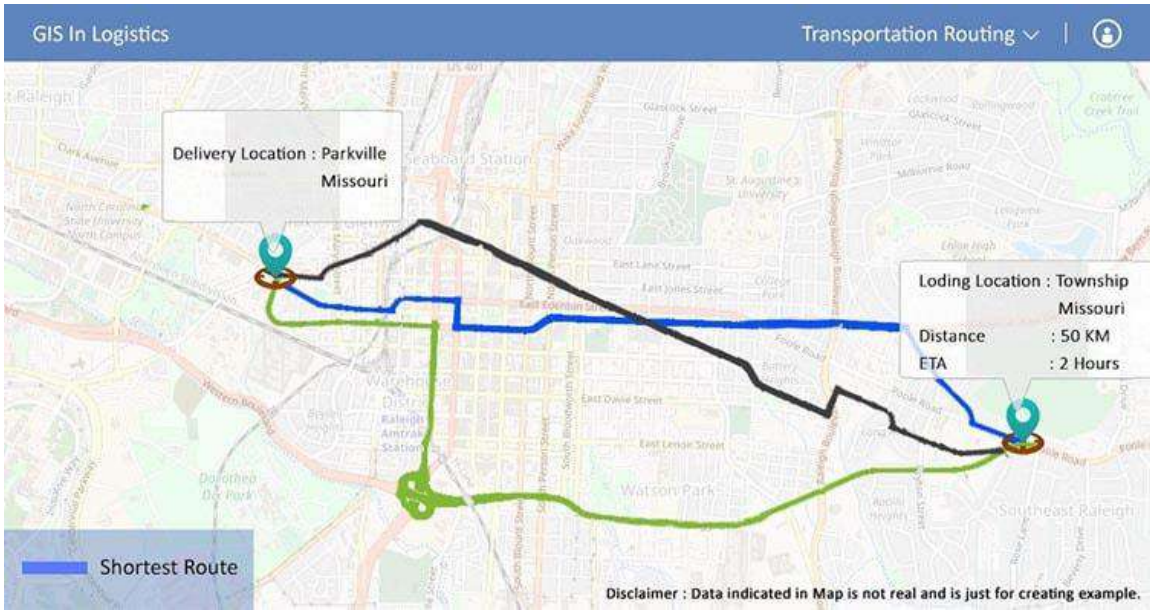
Tax Mapping: The amount of tax payable depends on the value of the land and the property. GIS manage information about property with its geographical location and boundary. Land units stored in parcel database can be linked to their properties. Querying the GIS database can locate similar type of properties in an area. The characteristics of these properties can then be compared and valuation can be easily done.



Figure(6): tax mapping

2.Business: Demographic analysis is the basis for many other business functions: customer service, site analysis, and marketing.

3.Logistics: Logistics is a field that takes care of transporting goods from one place to another and finally delivering them to their destinations. It is necessary for the shipping companies to know where their warehouses should be located, which **routes** should the transport follow that ensures minimum time and **expenditures** to deliver the parcels to their destinations. All such logistics decisions need GIS support.



Figure(7): GIS with logistics operation

4 .Emergency evacuation: The occurrence of disasters is unpredictable but it is important to know in which area the risk is higher, the number of individuals inhabiting that place, the routes by which the vehicles would move to help in evacuating the individuals. Thus preparing an evacuation plan needs GIS implementation.

5 .Environment: GIS is being increasingly involved in mapping the habitat loss, urban sprawl, land use change etc. Mapping such phenomena need historical land use data, human effects, which greatly affect these phenomena, are also brought into GIS domain. GIS models are running to make **predictions for the future**.

2.1 **The real world and representations of it**

One of the main uses of GIS is as a tool to help us make decisions. Specifically, we often want to know the best location for a new facility , the most likely sites for identify areas with a high risk of flooding so that we can formulate the best policy for prevention. In using GIS to help make these decisions, we need to represent some part of the real world as it is, as it was, or perhaps as we think it will be. We need to restrict ourselves to 'some part' of the real world simply because it cannot be represented completely. The fact that we can only represent parts of the real world teaches us to be **humble** about the expectations that we can have about the system: all the data it can possibly generate for us in the future will be based upon the information which we provide the system with. Often, we are dealing with processes or phenomena that **change rapidly**, or which **are difficult to quantify in order to be stored in a computer**. It follows that the ways we collect, organize and structure data from the real world plays a key part in this process.

If we have done our job properly, a computer representation of some part of the real world, will allow us to enter and store data, analyses the data and transfer it to humans or to other systems.

1.2.1Models and modelling

'Modelling' is a term used in many different ways and which has many different meanings. **A representation of some part of the real world can be considered a *model* because the representation will have certain**

<u>characteristics</u> in common with the real world. Specifically, those which we have identified in our model design. **This then allows us to study and operate on the model itself instead of the real world in order to test what happens under various conditions, and help us answer 'what if' questions**. **We can change the data or alter the parameters of the model, and investigate the effects of the changes**.

Models as representations come in many different manning . In the GIS environment, the most familiar model is that of a *map*. A map is a miniature representation of some part of the real world. Paper maps are the most common, but digital maps also exist

Databases are another important class of models. A database can store a considerable amount of data, and also provides various <u>functions</u> to operate on the stored data. The collection of stored data represents some real world phenomena, so it too is a **<u>model</u>**. Obviously, here we are especially interested in ***databases that store spatial data***. Digital models (as in a database or GIS) have enormous advantages over paper models (such as maps). They are more flexible, and therefore more easily <u>changed</u> for the purpose at hand. In principle, they allow ***<u>animations and simulations</u>*** to be carried out by the computer system. This has opened up an important toolbox that can help to improve our understanding of the world.

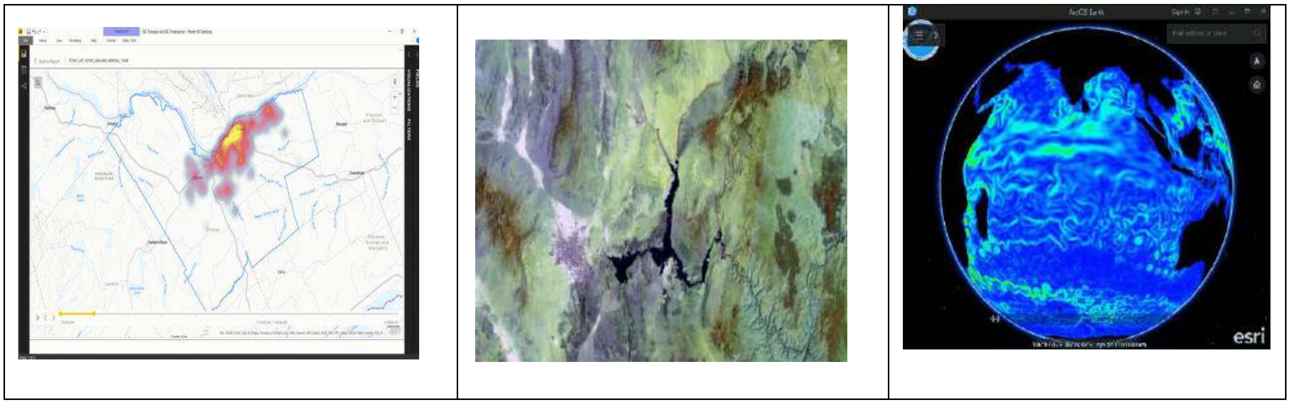
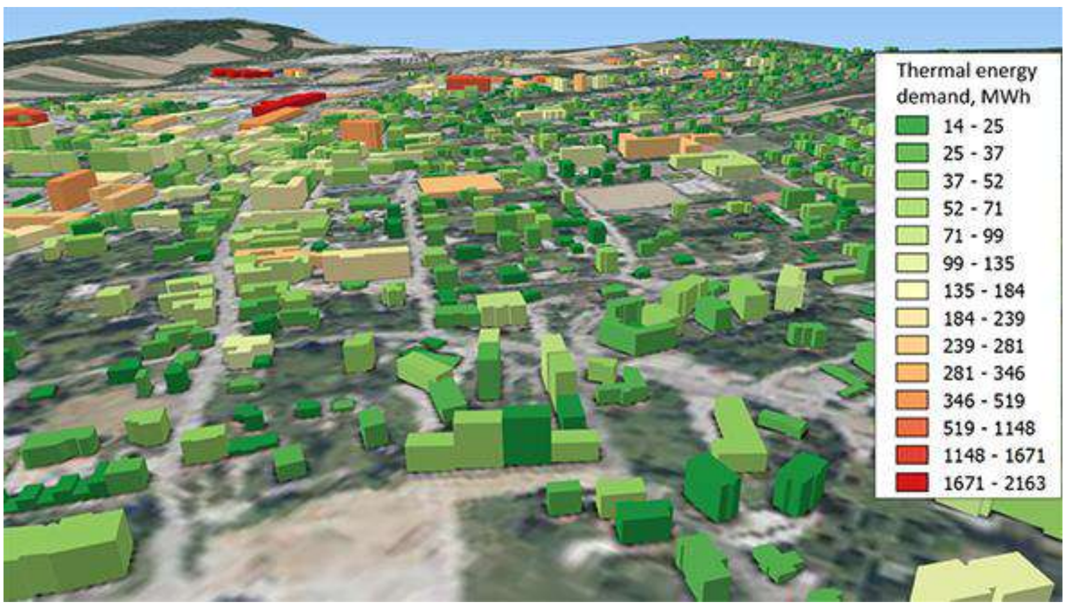


Figure (8) simulation systems



Figure(9) emulation systems

Most maps and databases can be considered static models. At any point in time, they represent a single state of affairs. Usually, developments or changes in the real world are not easily recognized in these models. *Dynamic models* or *process models* address precisely this issue. They emphasize changes that have

taken place, are taking place or may take place sometime in the future. Dynamic models are inherently more complicated than static models, and usually require much more computation. **Simulation models** are an important class of dynamic models that allow the simulation of real world processes.

Maps

As noted above, maps are perhaps the best known (conventional) models of the real world. Maps have been used for thousands of years to represent information about the real world, and continue to be extremely useful for many applications in various domains. Their conception and design has developed into a science with a high degree of sophistication. A disadvantage of the traditional paper map is that it is generally restricted to two-dimensional static representations, and that it is always displayed in a fixed scale. The map scale determines the spatial resolution of the graphic feature representation. The smaller the scale, the less detail a map can show. The accuracy of the base data, on the other hand, puts limits to the scale in which a map can be sensibly drawn. Hence, the selection of a proper map scale is one of the first and most important steps in map design.

A map is always a graphic representation at a certain level of detail, which is determined by the scale. Map sheets have physical boundaries, and features spanning two map sheets have to be cut into pieces. Cartography, as the science and art of map making, functions as an interpreter, translating real world phenomena (primary data) into correct, clear and understandable representations for our use. Maps also become a data source for other applications, including the development of other maps.

With the advent of computer systems, analogue cartography developed into digital cartography, and computers play an integral part in modern cartography .Alongside this trend, the role of the map has also changed accordingly, and the dominance of paper maps is eroding in today's increasingly 'digital' world. The traditional role of paper maps as a data storage medium is being taken over

by (spatial) databases, which offer a number of advantages over 'static' maps, as discussed in the last sections. Notwithstanding these developments, paper maps remain as important tools for the display of spatial information for many applications.

Databases

A *database* is a repository for storing large amounts of data. It comes with a number of useful functions:

1.A database can be used by multiple users at the same time—i.e. it allows

2.A database offers a number of techniques for storing data and allows the use of the most efficient one—i.e. it supports storage optimization,

3.A database allows the imposition of rules on the stored data; rules that will be automatically checked after each update to the data—i.e. it supports data integrity,

4.A database offers an easy to use data **manipulation language**, which allows the execution of all sorts of data extraction and data updates. it has a *query facility*, 5-A database will try to execute each query in the data manipulation language in the most efficient way—i.e. it offers query optimization.

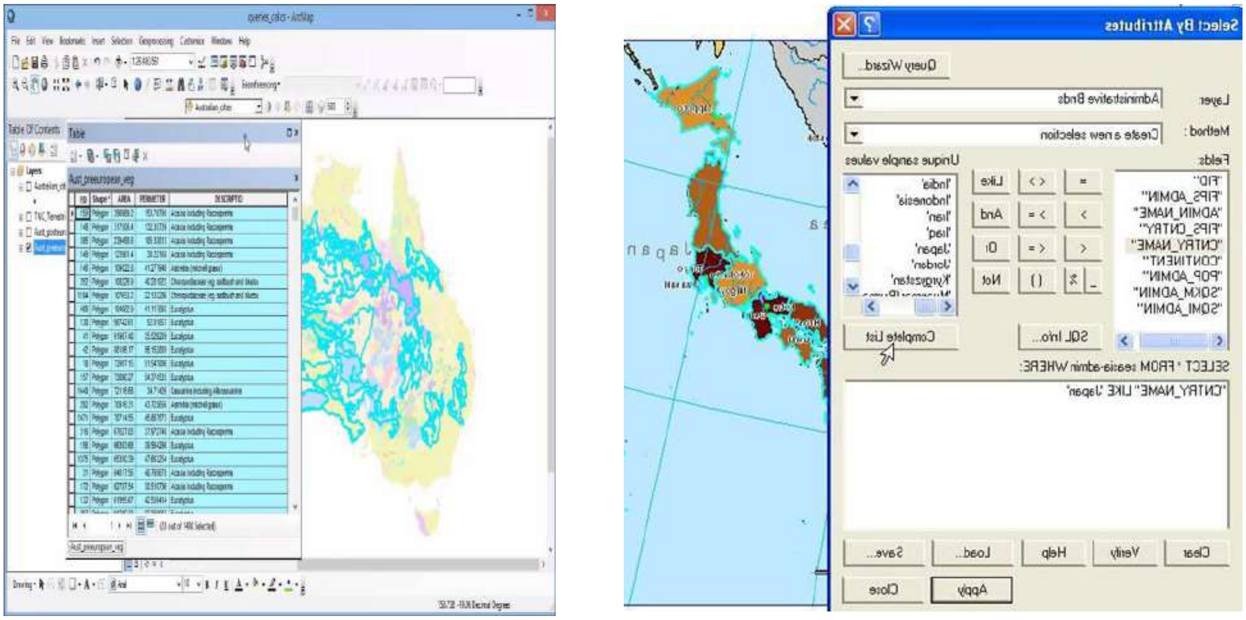


figure (10) :querying processing

Spatial databases and spatial analysis

A GIS must store its data in some way. For this purpose the previous generation of software was equipped with relatively **rudimentary facilities**. Since the 1990's there has been an increasing trend in GIS applications that used a GIS for spatial analysis, and used a database for storage. In more recent years, *spatial databases* (also known as geodatabases) have emerged. Besides traditional administrative data, they can store representations of real world geographic phenomena for use in a GIS. These databases are special because they use additional techniques different from tables to store these spatial representations.

A geodatabase is not the same thing as a GIS, though both systems share a number of characteristics. These include the functions listed above for databases in general: concurrency, storage, integrity, and querying, specifically, but not only, spatial data. A GIS, on the other hand, is tailored to operate on *spatial* data. It

Geodatabases.

geodatabase is a relational database that stores geographic data. At its most basic level, the geodatabase is a container for storing spatial and attribute data and the relationships that exist among them . In a geodatabase, which is a vector data format, features and their associated attributes can be structured to work together as an integrated system using rules, relationships, and topological associations. In other words, the geodatabase allows you to model the real world as simply or complexly as your needs dictate. Geodatabases are created, edited, and managed using the standard menus and tools in ArcCatalog™ and ArcMap™

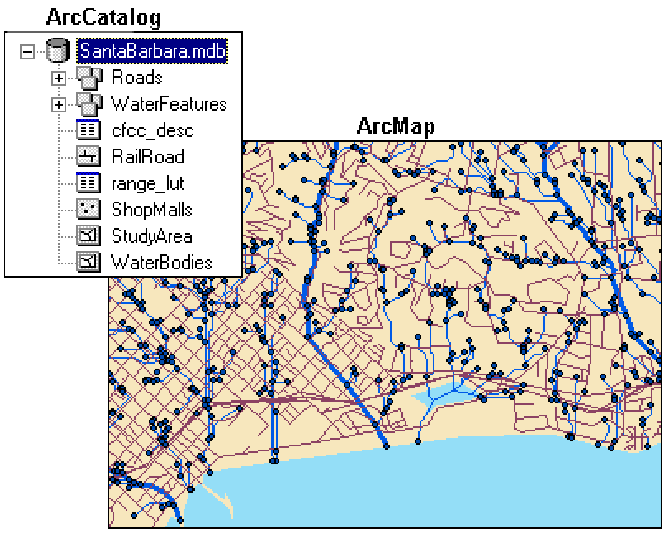


Figure (11): GIS Arc Catalog

Defining geographic phenomena

A GIS operates under the assumption that the relevant spatial phenomena occur in a two- or three-dimensional *Euclidean space*, unless otherwise specified. Euclidean space can be informally defined as a model of space in which locations

are represented by coordinates—(x, y) in 2D; (x, y, z) in 3D—and *distance* and *direction* can defined with geometric formulas .In the 2D case, this is known as the *Euclidean plane*, which is the most common Euclidean space in GIS use.In order to be able to represent relevant aspects real world phenomena inside a GIS, we first need to define what it is we are referring to. We might define a geographic phenomenon as a manifestation of an entity or process of interest that:

- Can be named or described,
- Can be georeferenced

- Can be assigned a time (interval) at which it is/was present.

Computer representations of geographic information

In order to represent such a phenomenon faithfully in computer memory, we could either: faithfully

- Try to store as many (*location, elevation*) observation pairs as possible, or
- Try to find a symbolic representation of the elevation field function, as a formula in x and y—like ($3.0678x^2 + 20.08x\ 7.34y$) or so—which can be evaluated to give us the elevation at any given (x, y) location
- Both of these approaches have their drawbacks. *The first suffers* from the fact that we will never be able to store *all* elevation values for all locations; after all, there are infinitely many locations. *The second approach* suffers from the fact that we do not know just what this function should look like, and that it would be extremely difficult to derive such a function for larger areas. In GISs, typically a combination of both approaches is taken. *We store a finite, but intelligently chosen set of (sample) locations with their elevation. This gives us the*

elevation for those stored locations, but not for others. We can use an ***interpolation*** function that allows us to infer a reasonable elevation value for locations

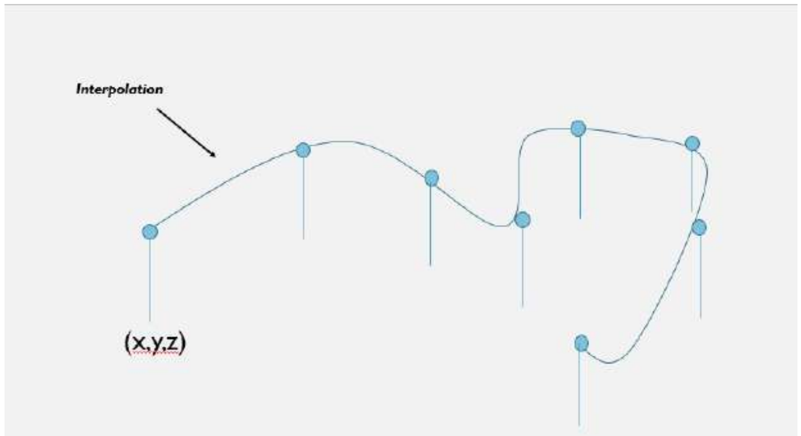


Figure (12) interpolation approximation process

3.1.1 Vector Data Model (vector representation)

The vector data model is closely linked with the discrete object view. In vector data model, geographical phenomena are represented in three different forms;-point, line and polygon. The shape of a spatial entity is stored using two-dimensional (x, y) coordinate system.

Point: A location depicted by a single set of (x, y) coordinates at the scale of abstraction. The wells in a village, electricity poles in a town and cities in the world map are the examples of spatial features described by points.

Note: A city can be marked as a single point on a world map but would be marked as a polygon on a state map. The scale plays an important role in deciding the geometry of a geographical feature.

Line/Arc: Ordered sets of (x, y) coordinate pairs arranged to form a linear feature. The curves in a linear feature are generated by increasing the density of points/vertices.

The roads, rails and telephone cables are the examples of the spatial features described by lines.

Polygon: The set of(x,y) coordinate pairs enclosing a homogeneous area.

The land parcels, agricultural farms and water bodies are the examples of the spatia features described by polygons.

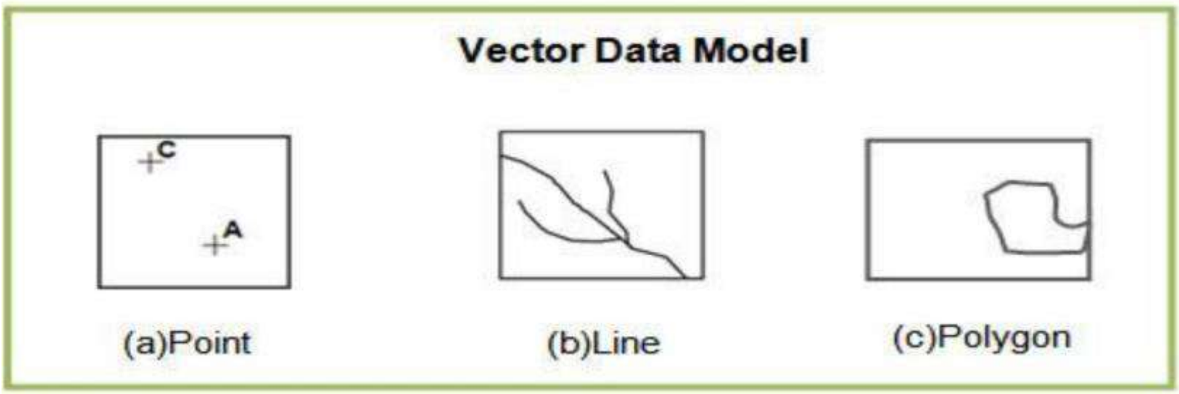


Figure (13) Vector data Representations

b. Raster Data Model

The raster data model is commonly associated with the field conceptual model. Here, geographic space is represented by array of cells or pixels (aka picture elements) which are arranged in rows and columns. Each pixel has a value that represents information. The value can be in the form of integer, floating points or alphanumeric.

A point can be represented by a single pixel in raster model. A line is a chain of spatially connected cells with the same value. Similarly, a water body in raster data is represented as a set of contiguous pixels having same value that represents a homogeneous area.

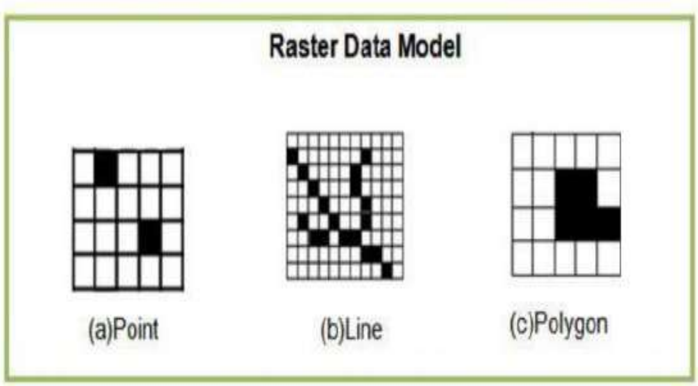
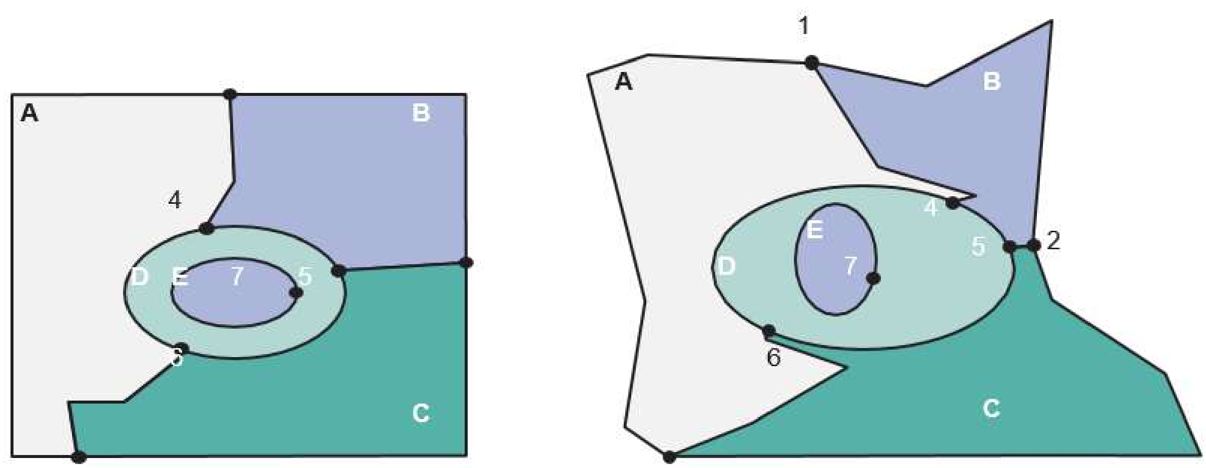


Figure (14): Raster data Representations

Topology refers to the spatial relationships between geographical elements in a data set that do not change under a continuous transformation

Topology deals with spatial properties that do not change under certain transformations. For example, features drawn on a sheet of rubber (as in Figure) can be made to change in shape and size by stretching and pulling the sheet. However, some properties of these features do not change:

- Area *E* is still inside area *D*
- The neighborhood relationships between *A*, *B*, *C*, *D*, and *E* stay intact , and their boundaries have the same start and end nodes, and
- The areas are still bounded by the same boundaries, only the shapes and lengths of their perimeters have changed.



Figure(15) : Topology processing

Vector data structure

Geographic entities encoded using the vector data model, are often called features. The features can be divided into two classes:

a. Simple features

These are easy to create, store and are rendered on screen very quickly. They lack connectivity relationships and so are inefficient for modeling phenomena conceptualized as fields.

b. Topological features

A topology is a mathematical procedure that describes how features are spatially related and ensures data quality of the spatial relationships. Topological relationships include following three basic elements:

I. Connectivity: Information about linkages among spatial objects

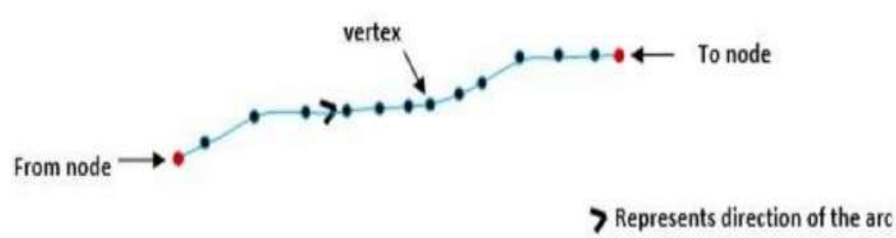
II. Contiguity: Information about neighboring spatial object

III. Containment: Information about inclusion of one spatial object within another spatial object

Connectivity

Arc node topology defines connectivity - arcs are connected to each other if they share a common node. This is the basis for many network tracing and path finding operations.

Arcs represent linear features and the borders of area features. Every arc has a from-node which is the first vertex in the arc and a to-node which is the last vertex. These two nodes define the direction of the arc. Nodes indicate the endpoints and intersections of arcs. They do not exist independently and therefore cannot be added or deleted except by adding and deleting arcs.



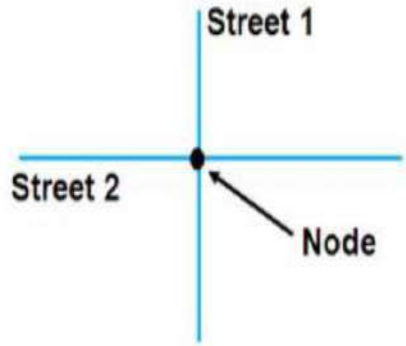
Arc-node Topology

Nodes can, however, be used to represent point features which connect segments of a linear feature (e.g., intersections connecting street segments, valves connecting pipe segments).

Figure (16): Arc node topology

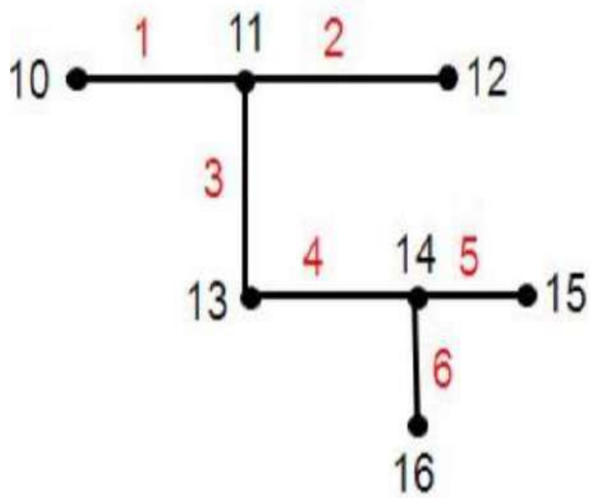
Arc-node Topology

Nodes can, however, be used to represent point features which connect segments of a linear feature (e.g., intersections connecting street segments, valves connecting pipe segments).



Node showing intersection

Arc-node topology is supported through an arc-node list. For each arc in the list there is a *from node a*nd a *to no*de. Connected arcs are determined by common node numbers.

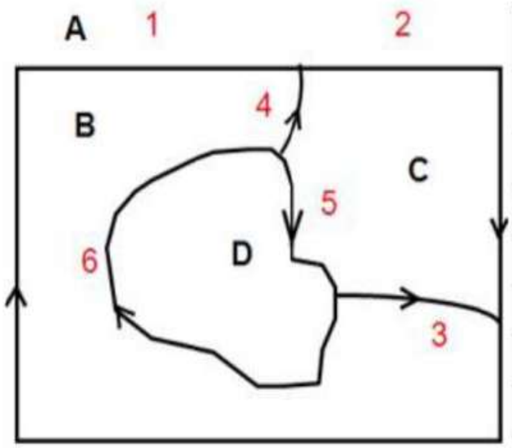


Arc-Node List		
Arc	***From node***	***To node***
1	10	11
2	11	12
3	11	13
4	13	14
5	14	15
6	14	16

Arc-Node Topology with list

Contiguity

Polygon topology defines contiguity. The polygons are said to be contiguous if they share a common arc. Contiguity allows the vector data model to determine adjacency.



Left-Right Topology		
Arc	**Left Polygon**	**Right Polygon**
1	A	B
2	A	C
3	C	B
4	B	C
5	C	D
6	B	D

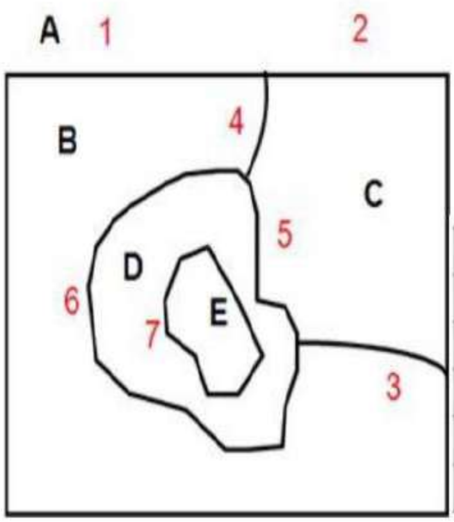
Polygon Topology

The *from* node and *to* node of an arc indicate its direction, and it helps determining the polygons on its left and right side. Left-right topology refers to the polygons on the left and right sides of an arc. In the illustration above, polygon B is on the left and polygon C is on the right of the arc 4.

Polygon A is outside the boundary of the area covered by polygons B, C and D. It is called the external or universe polygon, and represents the world outside the study area. The universe polygon ensures that each arc always has a left and right side defined.

Containment

Geographic features cover distinguishable area on the surface of the earth. An area is represented by one or more boundaries defining a polygon. The polygons can be simple or they can be complex with a hole or island in the middle. In the illustration given below, assume a lake with an island in the middle. The lake actually has two boundaries, one, which defines its outer edge, and the other (island) which defines its inner edge. An island defines the inner boundary of a polygon. The polygon D is made up of arc 5, 6 and 7. The 0 before the 7 indicates that the arc 7 creates an island in the polygon



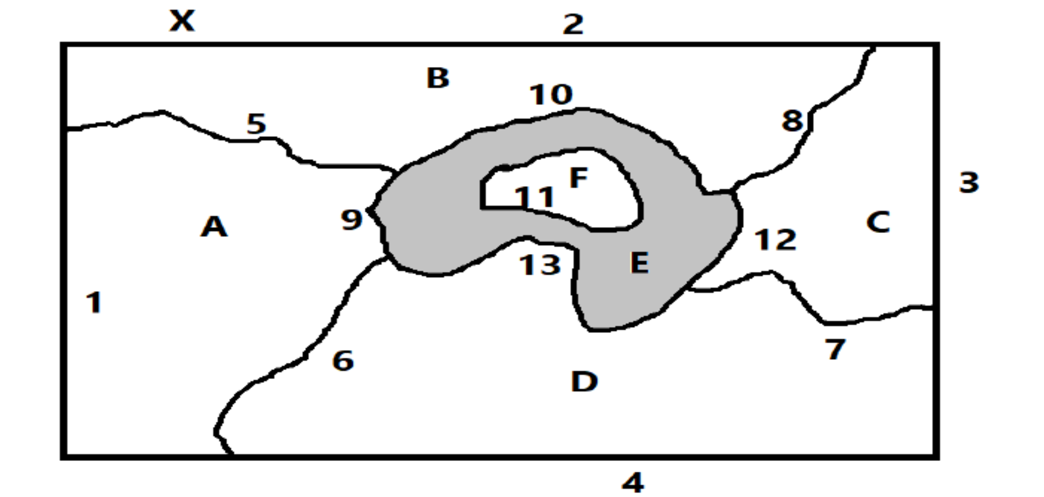
Polygon arc topology	
Polygon	Arc List
B	1, 4, 6, 3
C	2, 3, 5, 4
D	5, 6, 0, 7
E	7

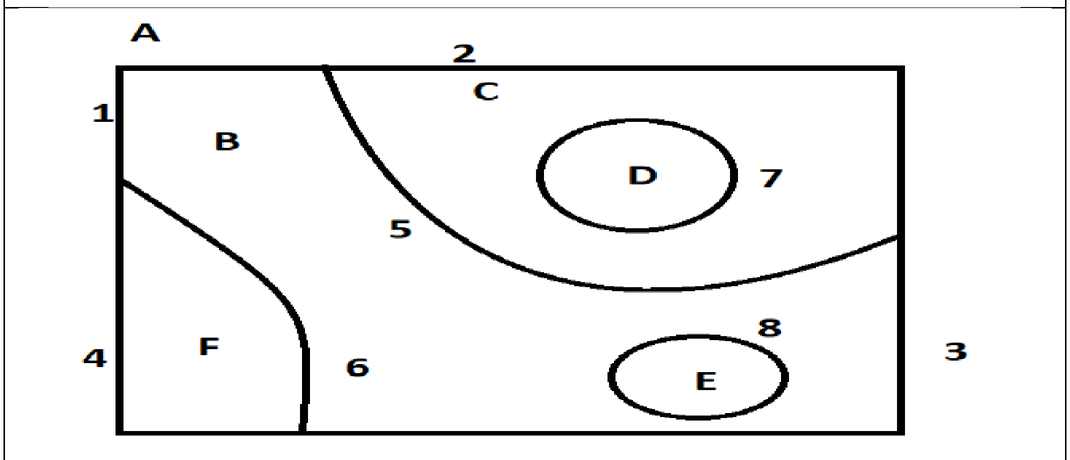
Polygon arc topolgy

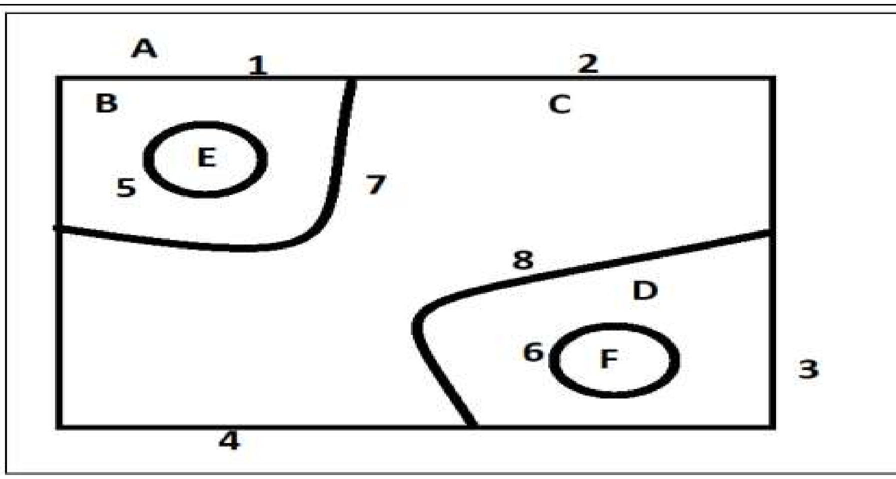
Polygons are represented as an ordered list of arcs and not in terms of X, Y coordinates. This is called ***Polygon-Arc topology***. Since arcs define the boundary of polygon, arc coordinates are stored only once, thereby reducing the amount of data and ensuring no overlap of boundaries of the adjacent polygons.

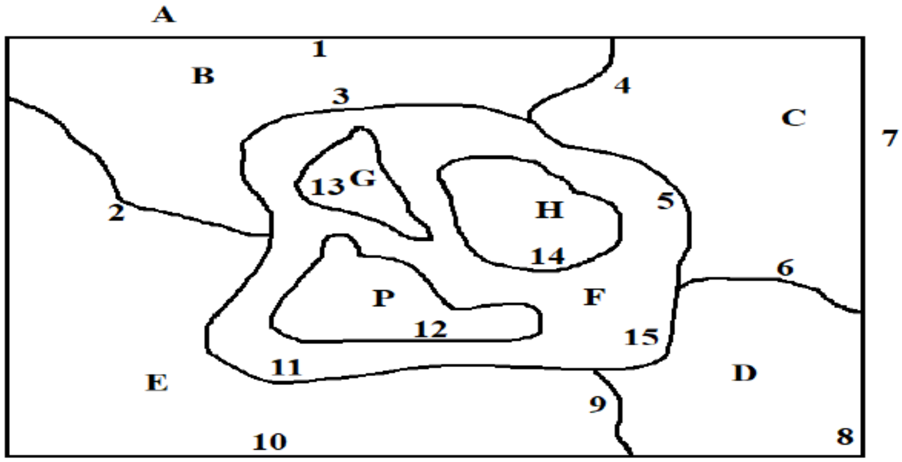
Examples

1-Consider at the figures below and write (polygon ARC topology)








A
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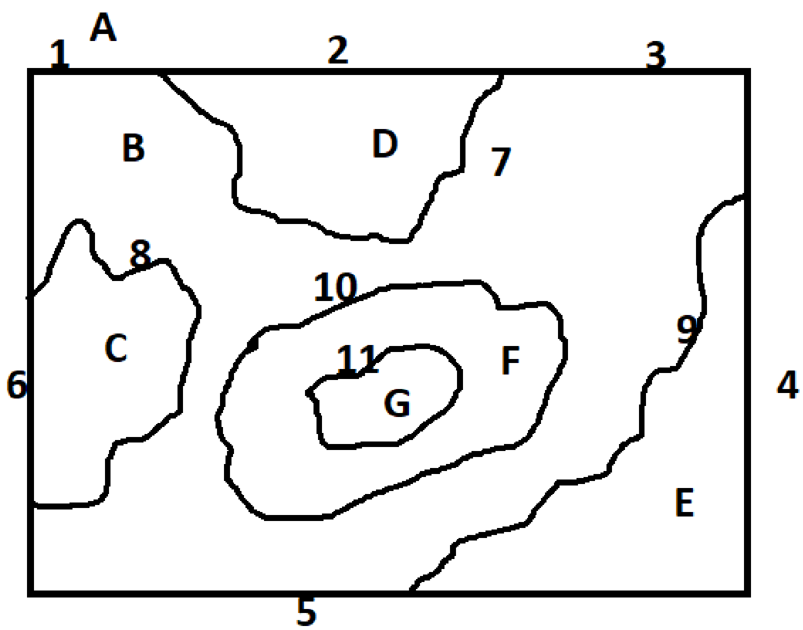
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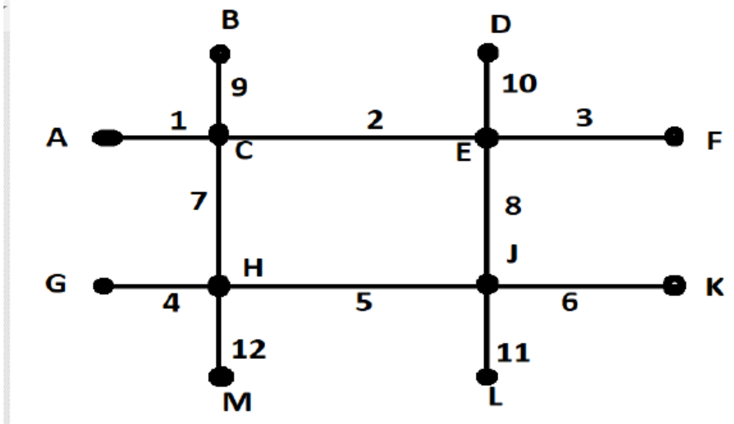
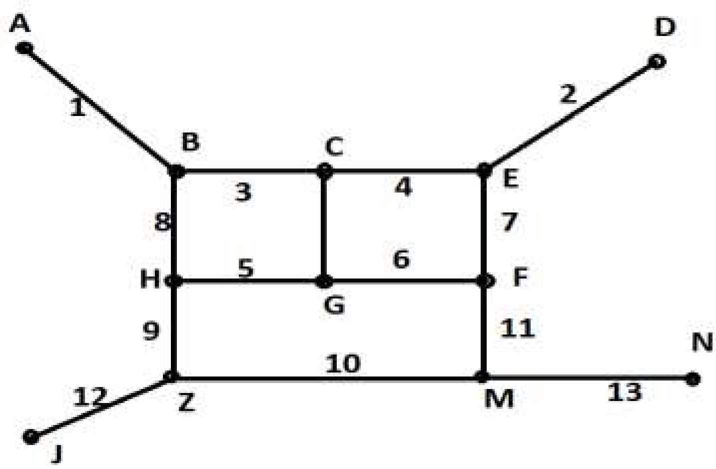
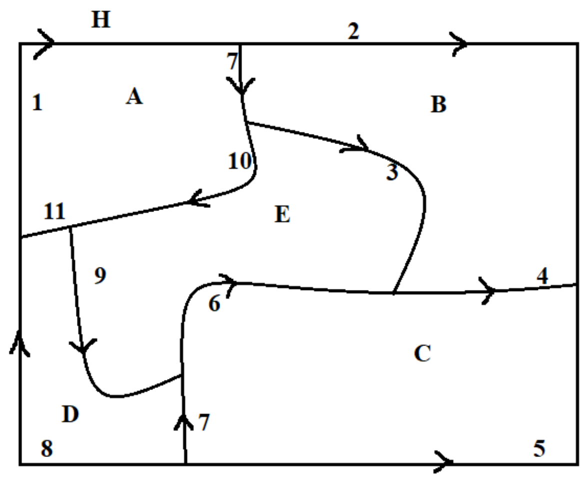
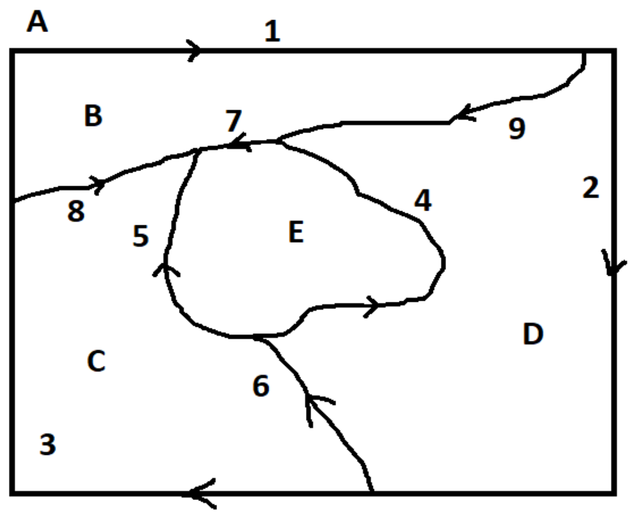
2-consider at the figure below and write (ARC- Node topology).

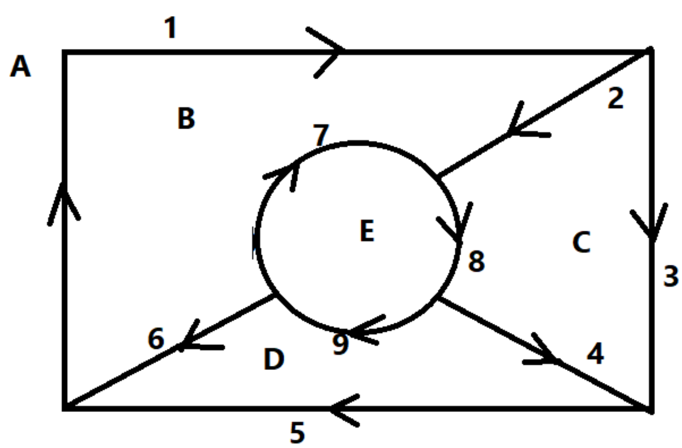




3-Consider at the figures below and write (polygon topology)







Homework : from google maps select a position area and write polygon arc topology using google map

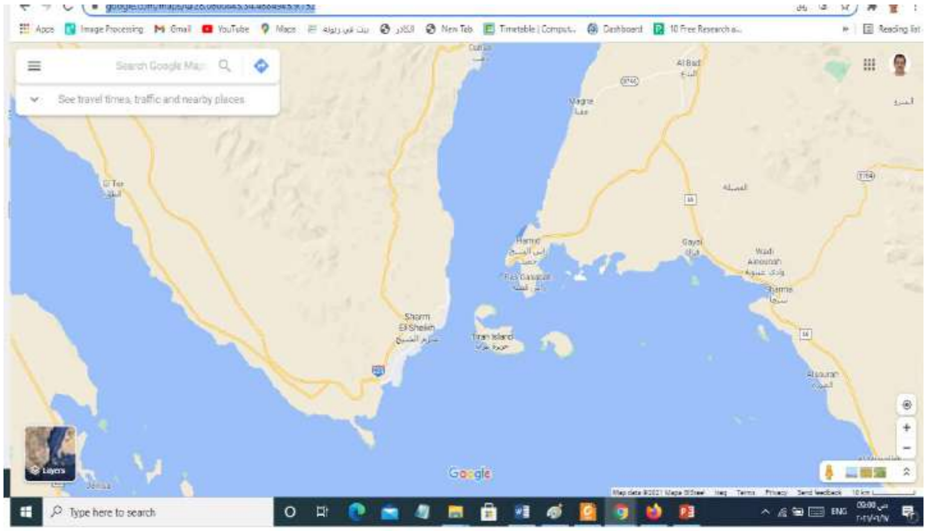


Figure (16) google Map

Primary key and foreign key

A **primary key** is used to ensure data in the specific column is unique. A **foreign key** is a column or group of columns in a relational database table that provides a **link between data** in two tables. ...

Example: Refer the figure –STUD_NO in STUDENT_COURSE is a foreign key to STUD_NO in STUDENT relation

STUDENT

STUD_NO	STUD_NAME	STUD_PHONE	STUD_STATE	STUD_COUNTRY	STUD_AGE
1	RAM	9716271721	Haryana	India	20
2	RAM	9898291281	Punjab	India	19
3	SUJIT	7898291981	Rajsthan	India	18
4	SURESH		Punjab	India	21

Table 1

STUDENT_COURSE

STUD_NO	COURSE_NO	COURSE_NAME
1	C1	DBMS
2	C2	Computer Networks
1	C2	Computer Networks

Table 2

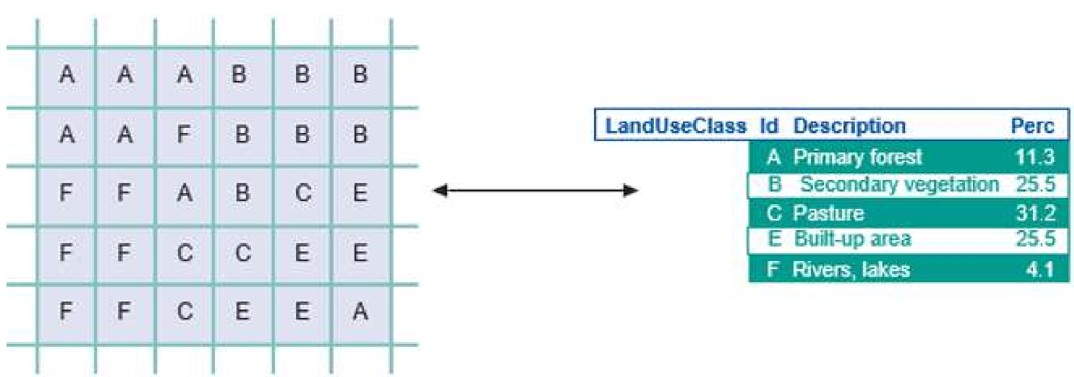
Linking GIS and DBMS

GIS software provides support for *spatial* data and thematic or *attribute* data. GISs have traditionally stored spatial data and attribute data separately. This required the GIS to provide a link between the spatial data (represented with ***raster or vectors***), and their nonspecial attribute data.. The strength of technology lies in its built-in 'understanding' of geographic space and all functions that derive from this, for purposes such as ***storage, analysis, and map production***. GIS packages themselves can store tabular data, however, they do not always provide a full-fledged query language to operate on the table

- DBMSs have a long tradition in handling attribute (i.e. administrative, non spatial, tabular, thematic) data in a secure way, for multiple users at the same time. Arguably, DBMSs offer much better table functionality, since they are specifically designed for this purpose. **A lot** of the data in GIS applications is.

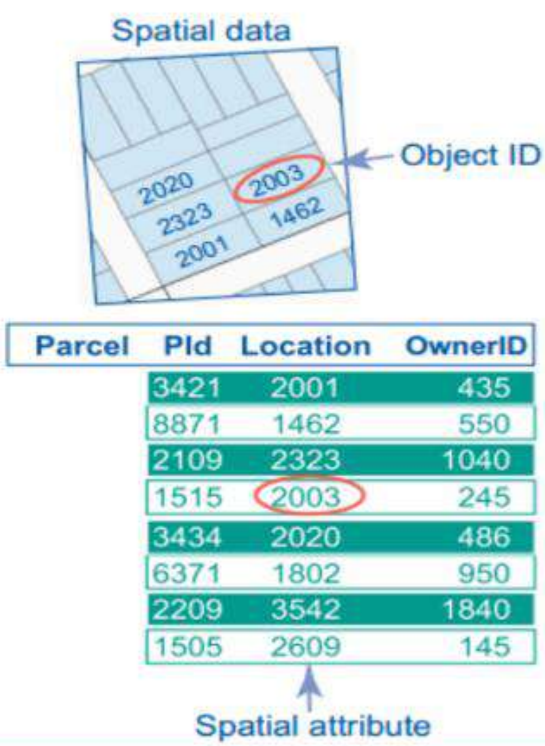
- **attribute data, so it made sense to use a DBMS for it. For this reason, many GIS applications have made use of external DBMSs for data support. In this role, the DBMS serves as a centralized data repository for all users, <u>while each user runs her/his own GIS software that obtains its data from the DBMS</u>. This meant that a GIS had to link the spatial data represented with raster or vectors, and the attribute data stored in an external DBMS.**

- With raster representations, each **raster <u>cell stores</u>** a characteristic value. This value can be used to look up **attribute data** in an accompanying database table. For instance, the land use raster of Figure below indicates the land use class for each of its cells, while an accompanying table provides full descriptions for all classes, including perhaps some statistical information for each of the types. Observe the similarity with the key/foreign key concept in relational databases.



Figure(17): database linking process with raster form

- With vector representations, our spatial objects whether they are points, lines or polygons—are automatically given a unique identifier by the system. This identifier is usually just called the object ID or feature ID and **<u>is used to link the spatial object (as represented in vectors) with its attribute data in an attribute table</u>**. The principle applied here is similar to that in raster settings, but in this case each object has its own identifier. The ID in the vector system functions **<u>as a key,</u> and any reference to an ID value in the attribute database is a foreign key reference to the vector system.** For example, in Figure below , parcel is a table with attributes, linked to the spatial objects stored in a GIS by the Location column.



Parcel	PId	Location	OwnerID
	3421	2001	435
	8871	1462	550
	2109	2323	1040
	1515	2003	245
	3434	2020	486
	6371	1802	950
	2209	3542	1840
	1505	2609	145

Figure(18): database linking process with vector form

Working with Tables

Most databases instead of keeping their data together in a single table, organize the data into multiple tables each focusing on a specific topic. A user can link these tables if required information isn't present in a single table. The records in one table can be associated with records in the other table through a common field. The temporary associations can be made by joining and relating the tables.

Join

Joining appends the fields of one table to fields of another through an attribute/field common to both the tables

StID	Age
N002	19
N005	21
N012	20
N015	19

Join Table

StID	Rank
N002	2
N005	3
N012	4
N015	1

Target

➡

StID	Age	Rank
N002	19	2
N005	21	3
N012	20	4
N015	19	1

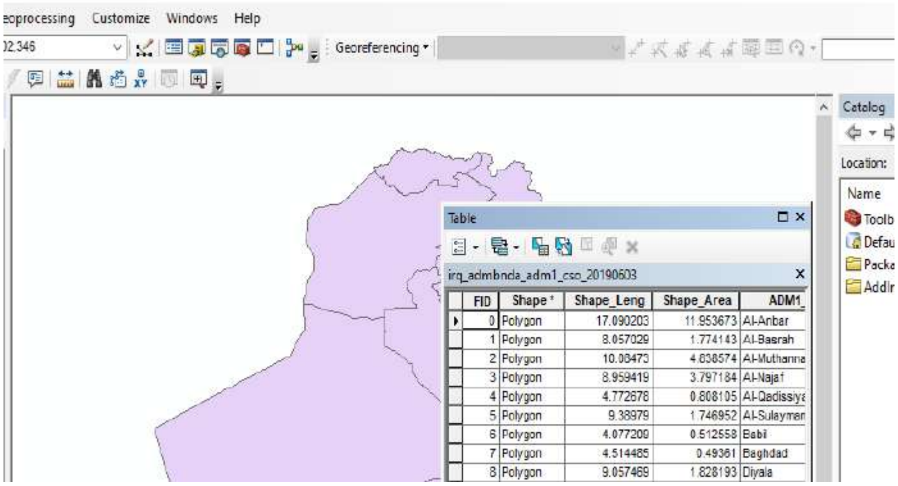
Spatial database functionality

A *spatial database* allows users to store, query and manipulate collections of spatial data.

spatial data can be stored in a special database, column known as the geometry column, (or feature or shape, depending on the specific software package), as shown in Figure below. This means GISs can rely fully on DBMS support for spatial data, making use of a DBMS for data query and storage (and multi-user support), and GIS for spatial functionality. Small-scale GIS applications may not require a multi-user capability, and can be supported by spatial data support from a personal database.

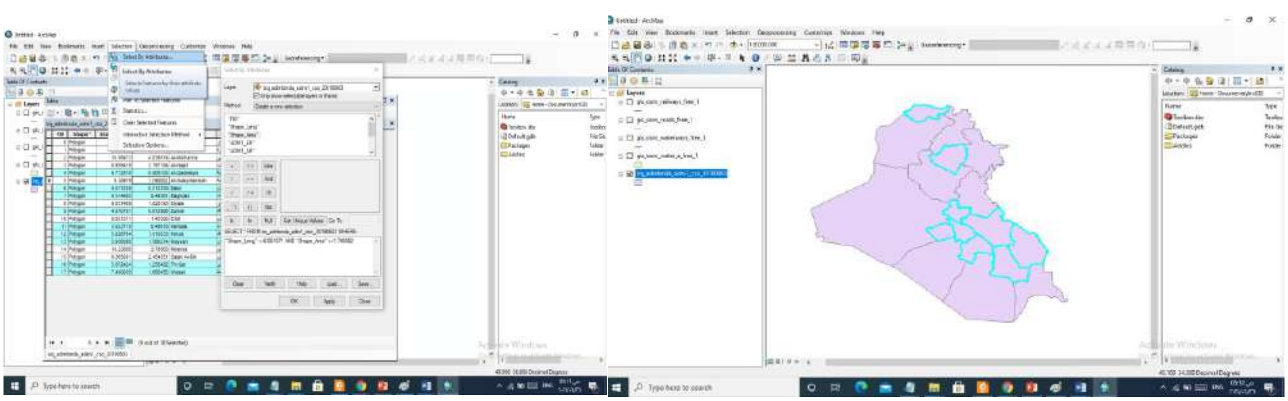
Parcel	PId	Geometry	OwnerID
	3421	"MULTIPOLYGON(((257462.704979333 464780.750851061,257463.89798...)))"	435
	8871	"MULTIPOLYGON(((257409.813950544 464789.91585049,257407.896903...)))"	550
	2109	"MULTIPOLYGON(((257785.714911912 464796.839972167,257782.59794...)))"	1040
	1515	"MULTIPOLYGON(((257790.672100448 464807.13792585,257788.608078...)))"	245
	3434	"MULTIPOLYGON(((257435.527950478 464803.92887633,257428.254887...)))"	486
	6371	MULTIPOLYGON(((257432.476077854 464813.848852072,257433.147910...)))"	950
	2209	"MULTIPOLYGON(((257444.888027332 464826.555046319,257446.43201...)))"	1840
	1505	"MULTIPOLYGON(((256293.760107491 464935.203846095,256292. 00881...)))"	145

Figure(19): spatial data representing



Querying a spatial database

A Spatial DBMS provides support for geographic coordinate systems and transformations. It also provides storage of the relationships between features, including the creation and storage of topological relationships. As a result one is able to use functions for ‘spatial query’ (exploring spatial relationships).



Figure(20): querying processing

Spatial Referencing

1. Coordinate systems

A coordinate system is a reference system used for locating objects in a two or three dimensional space

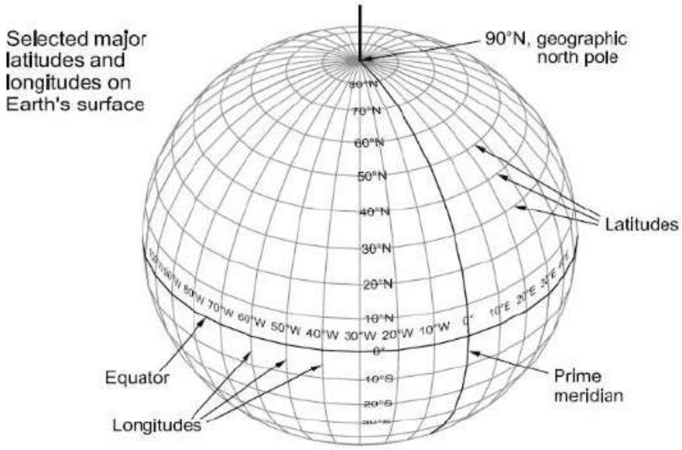
Geographic Coordinate System

A geographic coordinate system, also known as global or spherical coordinate system is a reference system that uses a three-dimensional spherical surface to determine locations on the earth. Any location on earth can be referenced by a point with longitude and latitude.

Pole: The geographic pole of earth is defined as either of the two points where the axis of rotation of the earth meets its surface. The North Pole lies 90º north of the equator and the South Pole lies 90º south of the equator

Latitude : Imaginary lines that run horizontally around the globe and are measured from 90º north to 90º south. Also known as parallels, latitudes are equidistant from each other.

Equator : An imaginary line on the earth with zero degree latitude, divides the earth into two halves–Northern and Southern Hemisphere. This parallel has the widest circumference.



Figure(21): Earth Coordinate System

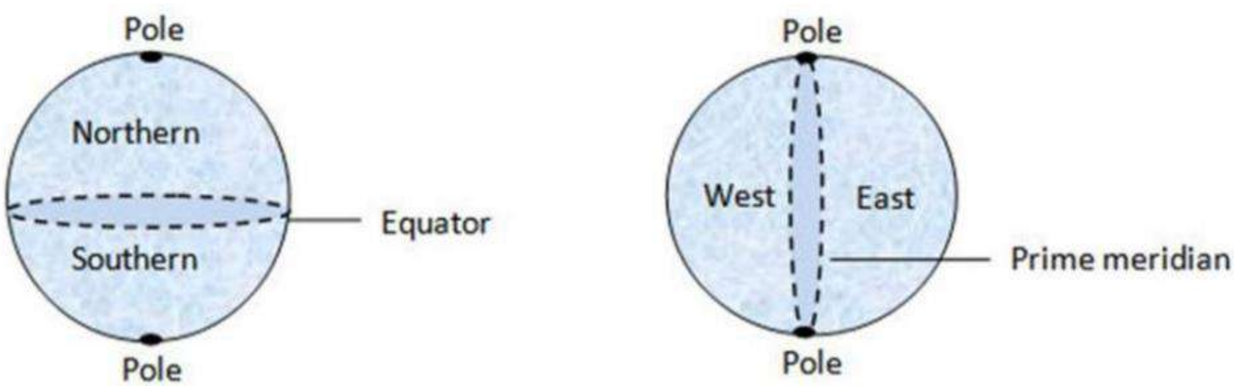


Figure3.5: Division of earth into hemispheres

Longitude : Imaginary lines that run vertically around the globe. Also known as meridians, longitudes are measured from 180º east to 180º west. Longitudes meet at the poles and are widest apart at the equator

Prime meridian : Zero degree longitude which divides the earth into two halves–Eastern and Western hemisphere. As it runs through the Royal Greenwich Observatory in Greenwich, England it is also known as Greenwich meridian

Latitude and longitude values are traditionally measured either in decimal degrees or in degrees, minutes, and seconds (DMS). Latitude values are measured relative to the equator and range from -90° at the South Pole to +90° at the North Pole. Longitude values are measured relative to the prime meridian. They range from -180° when traveling west to 180° when traveling east. If the prime meridian is at Greenwich, then Australia, which is south of the equator and east of Greenwich, has positive longitude values and negative latitude values.

Coordinate measurement

The geographic coordinates are measured in angles. The angle measurement can be understood as per following:

A full circle has 360 degrees   1 circle = 360º

A degree is further divided into 60 minutes   1º = 60′

A minute is further divided into 60 seconds   1′ = 60″

An angle is expressed in Degree Minute Second.

While writing coordinates of a location, latitude is followed by longitude. For example, coordinates of Delhi is written as 28° 36′ 50″ N, 77° 12′ 32″ E.

Decimal Degree is another format of expressing the coordinates of a location. To convert a coordinate pair from degree minute second to decimal degree following method is adopted:

We have 28 full degrees, 36 minutes - each 1/60 of a degree, and 50 seconds - each 1/60 of 1/60 of a degree

While writing coordinates of a location, latitude is followed by longitude. For example, coordinates of Delhi is written as

Similarly 77° 12′ 32″ can be written as 77.2088. So, we can write coordinates of Delhi in decimal degree format as: 28.6138 N, 77.2088 E

Local Time and Time Zones

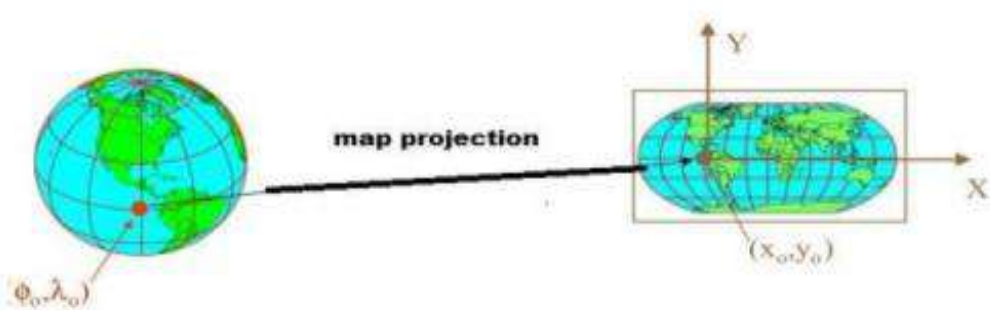
With rotation of earth on its axis, at any moment one of the longitudes faces the Sun (noon meridian), and at that moment, it is noon everywhere on it. After 24 hours the earth completes one full rotation with respect to the Sun, and the same meridian again faces the noon. Thus each hour the Earth rotates by 360/24 = 15 degrees.

This implies that with every 15º of longitude change a new time zone is created which is marked by a difference of one hour from the neighboring longitudes specified at 15º gap. The earth's time zones are measured from the prime meridian (0º) and the time at Prime meridian is called Greenwich Mean Time. Thus, there are 24 time zones created around the globe.

A map projection is one of many methods used to represent the 3-dimensional surface of the earth or other round body on a 2-dimensional plane in cartography

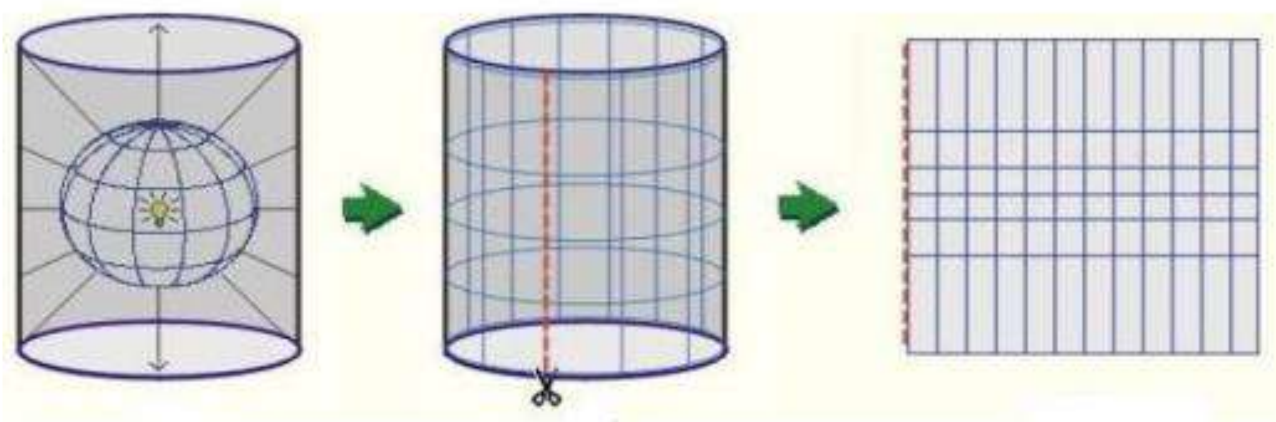
Definition

- **Maps are models of reality.**
- **A map projection is a mathematically described technique of how to represent the Earth's curved surface on a flat map.**



Geometric shape – Cylindrical

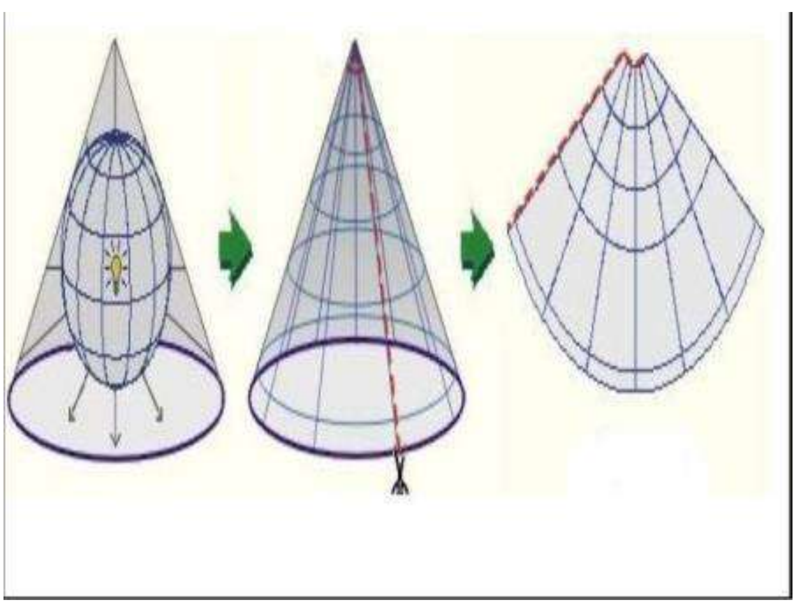
- The reference spherical surface is projected onto a cylinder wrapped around the globe.
- The cylinder is then cut lengthwise and unwrapped to form a flat map.
- In flattened form, a cylindrical projection produces a rectangular map with the equator in the middle and the poles at the top and bottom.
- General characteristics
  - Lines of latitude and longitude intersect at 90 degrees
  - Meridians are equidistant
  - Forms a rectangular map
  - Scale along the equator or standard parallels is true



Figure(22): cylindrical map projection process

Geometric shape – Conic

- The reference spherical surface is projected onto a cone placed over the globe.
- The cone is then cut along a convenient meridian and unfolded into a flat surface in the shape of a circle with a sector missing.
- All parallels are arcs of circles with a pole (the apex of the original cone) as their common center.
- Meridians appear as straight lines converging toward the apex of the original cone.



Figure(23): conic map projection process

Geometric shape – Conic

- **General characteristics**
  - Lines of latitude and longitude are intersecting at 90 degrees
  - Meridians are straight lines
  - Parallels are concentric circular arcs
  - Scale along the standard parallel(s) is true
  - The pole is represented as an arc or a point

Point data transformation

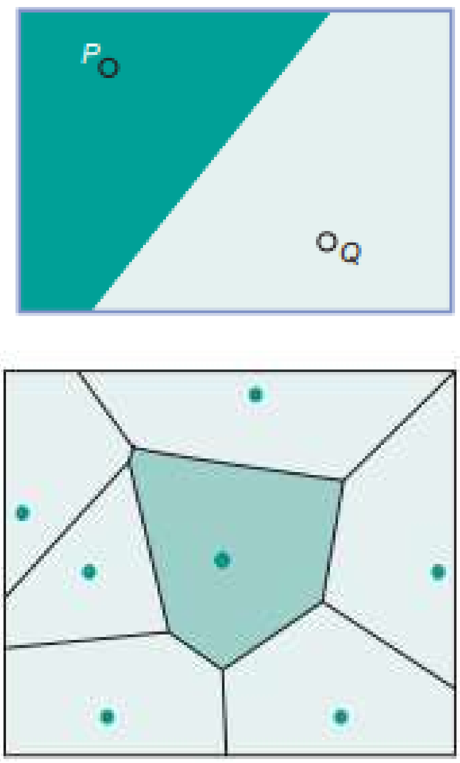
This section looks at several methods of transforming point data in a GIS. We may have captured a sample of points (or acquired a dataset of such points), but wish to derive a value for the phenomenon at another location or for the whole extent of our study area.

We may want to transform our points into other representations in order to facilitate interpretation and/or integration with other data. Examples include defining homogeneous areas (polygons) from our point data, or deriving contour lines. This is generally referred to as *interpolation*, i.e. the calculation of a value from 'surrounding' observations. The principle of spatial autocorrelation plays a central part in the process of interpolation

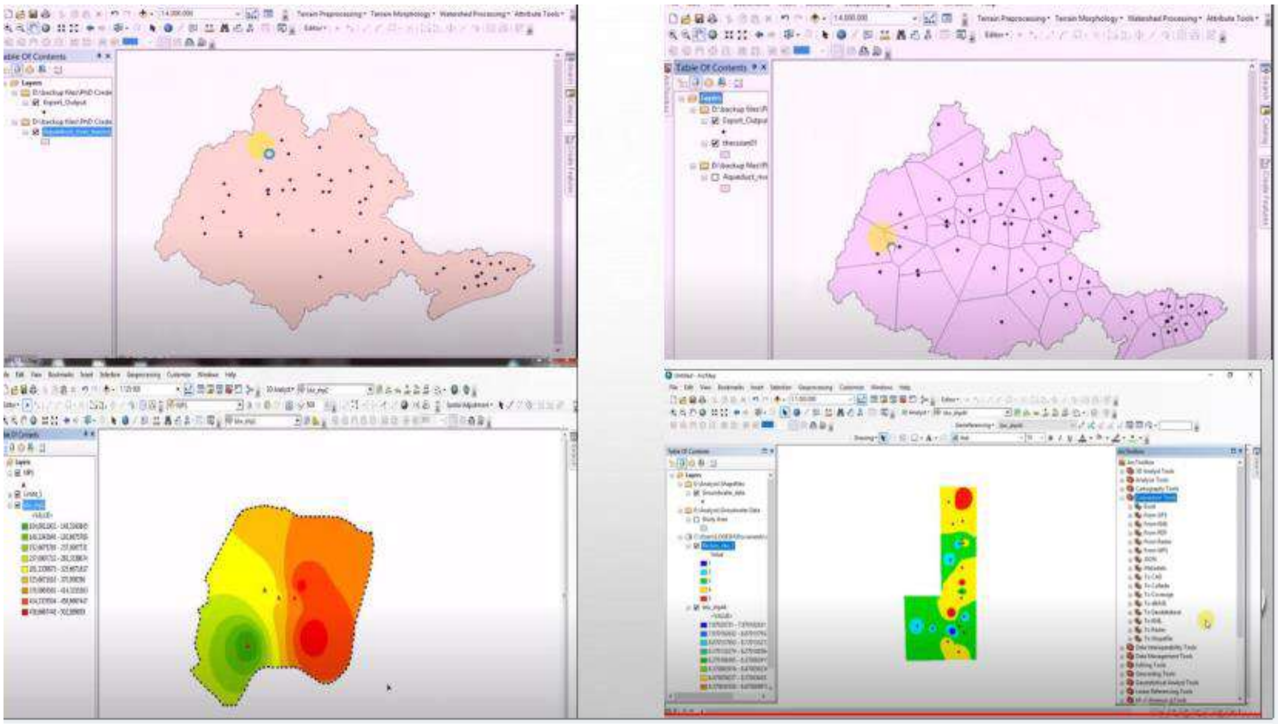
In order to predict the value of a point for a given (x, y) location, we could simply find the 'nearest' known value to the point, and assign that value. This is the simplest form of interpolation, known as *nearest-neighbour* interpolation. We might instead choose to use the distance that points are away from (x, y) to weight their importance in our calculation.

1-Interpolating discrete data

If we are dealing with discrete data, we are effectively restricted to using nearest- neighbor interpolation. This is the situation shown in Figure a though usually we would have many more points . In a nearest- Neighbor interpolation, each location is assigned the value of the closest measured point. Effectively, this technique will construct 'zones' around the points of measurement, with each point belonging to a zone assigned the same value. Effectively, this represents an assignment of an existing value (or category) to a location. If the desired output was a polygon layer, we could construct *Thiessen polygons* around the points of measurement. The boundaries of such polygons, by definition, are the locations for which more than one point of measurement is the *interpolation* closest point. An illustration is provided is Figure



Figure(23): Interpolating discrete data Models



Figure(24): Interpolating discrete data Models process in ARC view

2-Interpolating continuous data

Interpolation of values from continuous measurements is significantly more complex. This is the situation of Figure (b), but again, usually with many more point measurements. Since the data are continuous, we can make use of measured values for interpolation. There are many continuous geographic fields— elevation, temperature and ground water salinity are just a few examples. Commonly, continuous fields are represented as rasters, and we will almost by default assume that they are. Alternatives exist

Figure(23): Interpolating continuous data Models

Geographic information system environment

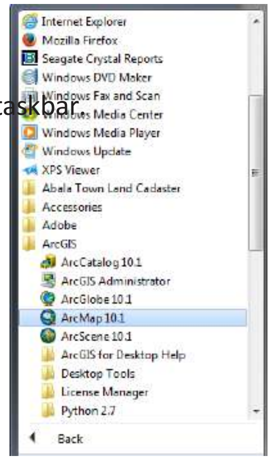
1.Starting ArcMap

1.1Open ArcGIS

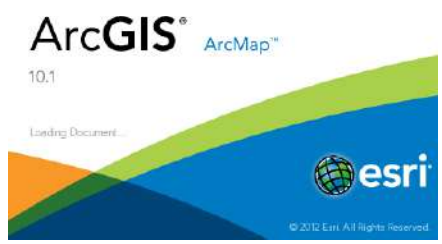
ArcMap lets you explore your geographic data and create maps for display.

To open ArcGIS 9.2

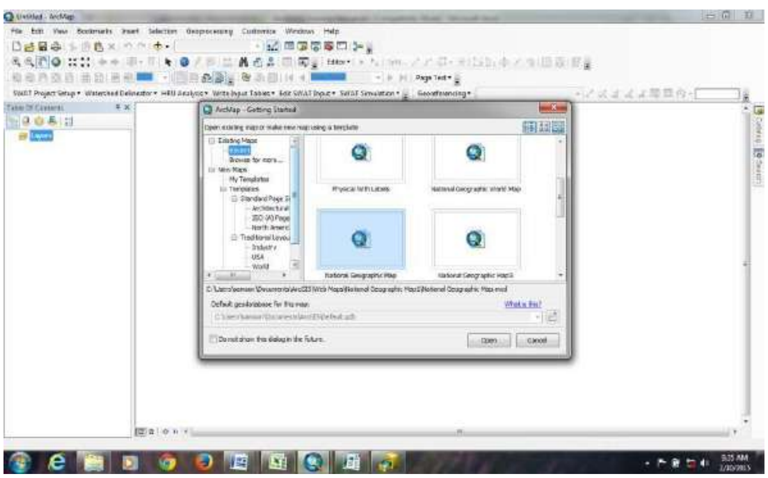
1. Click the Start button on the Windows taskbar.
2. Point to All Programs.
3. Point to ArcGIS.
4. Click ArcMap.



3



The ArcMap opining wizard can be opened. There are three options these are:-

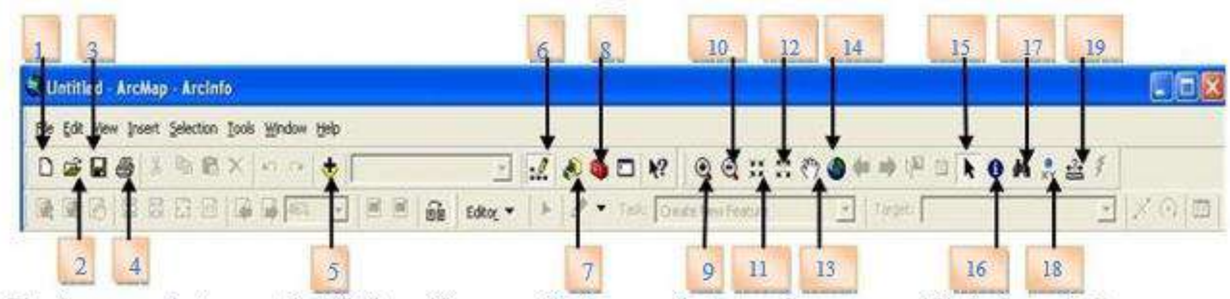


1. A new empty map:- if you want to open a new project ClickCancel Button
2. A template:- if you want to use the existing readymadetemplate click on template and select one template
3. An existing Map:- if you want to open the existing projectclick the one you

want to open it
4. Click Ok

Exploring ArcMap:-

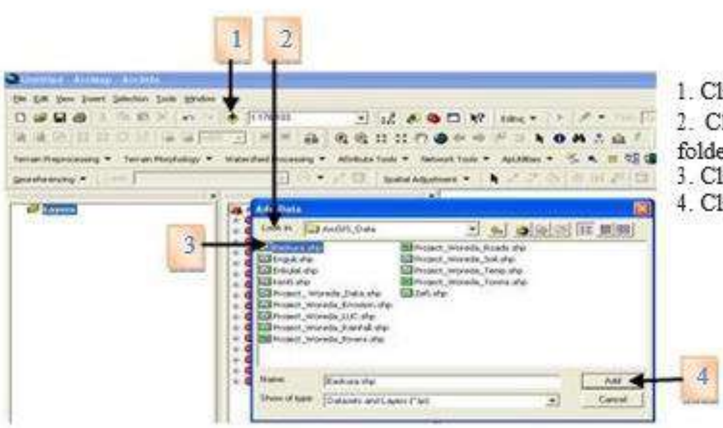
1. Open new project
2. Open existing Project
3. Save project
4. Print Map
5. Add Layer/Map
6. Edit Function
7. Open ArcCatalog
8. Open ArcTools
9. Zoom In
10. Zoom Out
11. Fixed Zoom Out
12. Fixed Zoom in
13. Pan
14. Full extent
15. Select element
16. Identify
17. Find
18. Add xy
19. Measurement



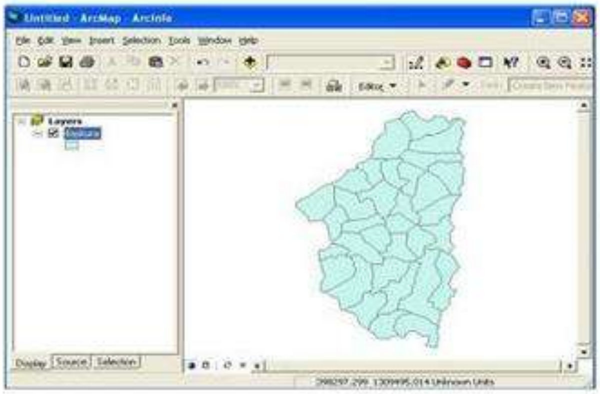
The above menu buttons are the default one if you can add other more buttons as far as you need for further analysis.

N.B. explore all the menu in your ArcGIS project by opening each of theme

4.3 Adding a layer file in ArcMap



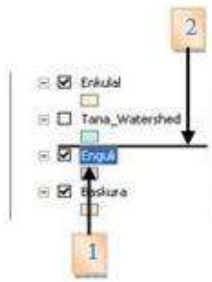
1. Click Add Data button
2. Click the Look in dropdown arrow and navigate to the folder /ArcGIS Data/ containing your layer file.
3. Click the layer file
4. Click Add.



ArcMap adds the layer to your table of contents using the special properties it was saved with. i.e if the layer is point you can get the point symbol, if the layer is line you can get a line symbol and if the layer is polygon you can get a polygon symbol.

4.3.1 Moving a layer to change its drawing order

1. In the table of contents, click the layer
2. Drag the layer up or down. A black bar indicates where the layer will be placed. This bar indents to reflect the position in the layer hierarchy where the drop will occur.
3. Release the mouse pointer to drop the layer in its new position.



Changing the name of a layer

1. In the table of contents, click the layer to select it.
2. Click again over the name. This will highlight the name and allow you to change it.
3. Type the new name and press Enter.

N.B: This does not change the actual filename.

4.3.3 Removing a layer

1. In the table of contents, right click the layer or layers you want to remove.
2. Click Remove.

4.3.4 Removing several layers

1. In the table of contents, click the first layer you want to remove.
2. Hold down the Shift or Ctrl key and click to select additional layers.
3. Right-click the selection and click Remove.

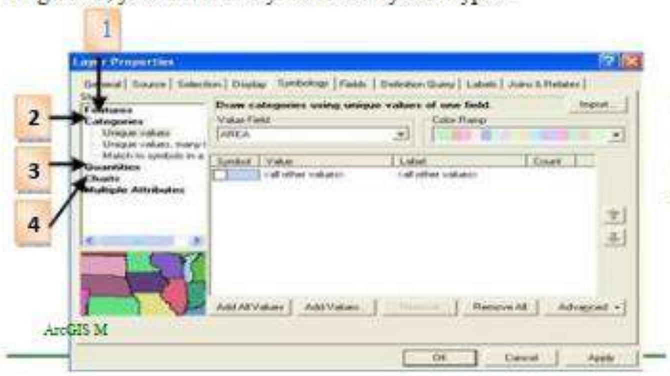
Exercise:-

1. Add Baskura, Enguli, Project woreda, town and road layer /try to see the watershed maps in your document
2. Rename Baskura and Enguli to Watershed boundary
3. Move Watershed boundary on top of project woreda layer
4. Remove Baskura from the map document
5. Remove town, road and Enguli at the same time

Coloring and Styling Features

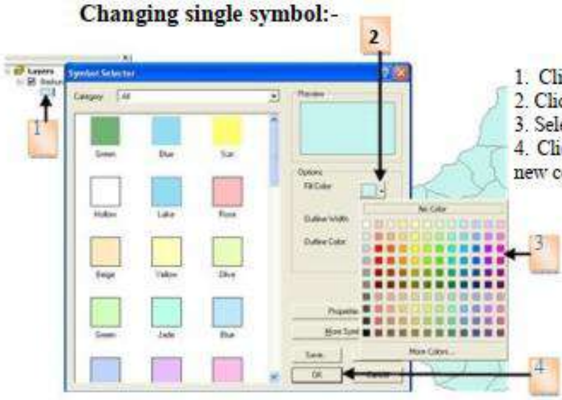
Choosing how to represent your data on a map may be the most important mapmaking task. How you represent your data determines what your map communicates. On some maps, you might simply want to show where things are. The easiest way to do this is to draw all the features in a layer with the same symbol. On other hand you need to display maps in different color or you might draw features based on an attribute value or characteristic that identifies them. For example, you could map roads by type, or map different landuse type etc.

In general, you can draw layers in four symbol type:-



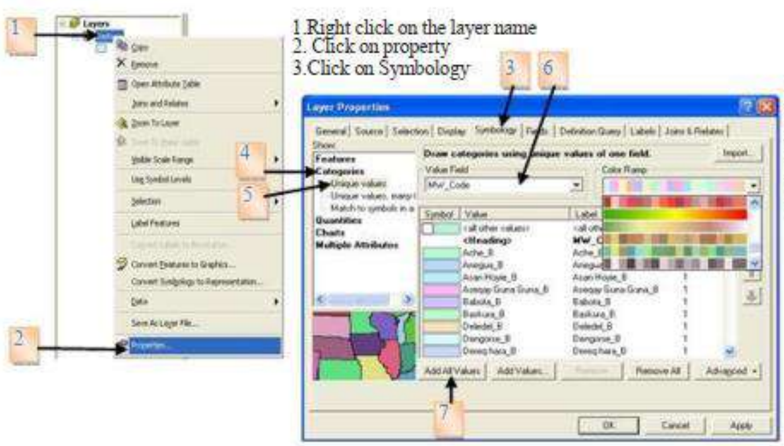
1. Features:- this uses for single symbol
2. Categories:- uses to get unique value
3. Quantities:- uses for graduated color, graduated symbol and proportional symbol
4. Charts:- uses to display in different symbols.

Changing single symbol:-



1. Click on the map symbol
2. Click on Fill Color button. The color panel will appear
3. Select your color from the color panel
4. Click Ok. The color symbol of your map changes to the new color.

4.4.2 Changing color by category:- it uses for qualitative and homogeneous or no rank /value data



1.Right click on the layer name
2. Click on property
3.Click on Symbology
4.Click on category
5.Click on unique values
6.Select the value field in the combo box
7.Click on Add All Values button

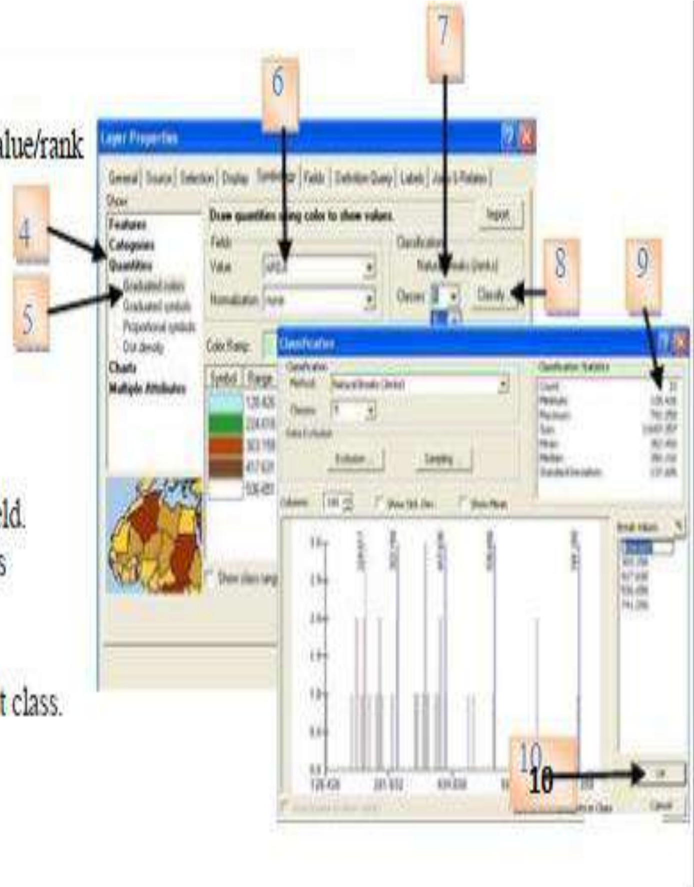
Changing color by Quantity:- to show value/rank

4.4.3.1 Graduated color

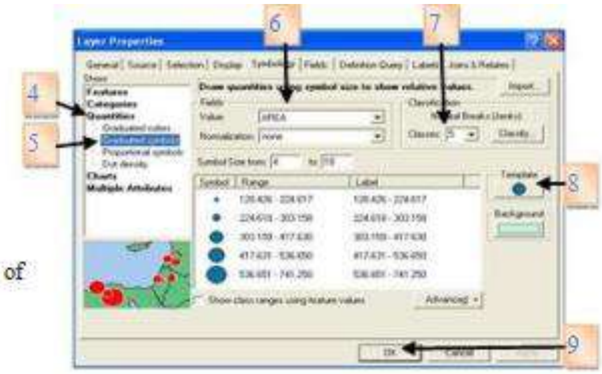
1. Right click on the layer name
2. Click on property
3. Click on symbology
4. Click on quantity
5. Click on graduated color
6. Select the field value. This field should numeric field.
7. You can change the number of class and class limits

To change the class limits:-

8. Click on classify button
9. Change the upper limit of each class except the last class.
10. Click ok

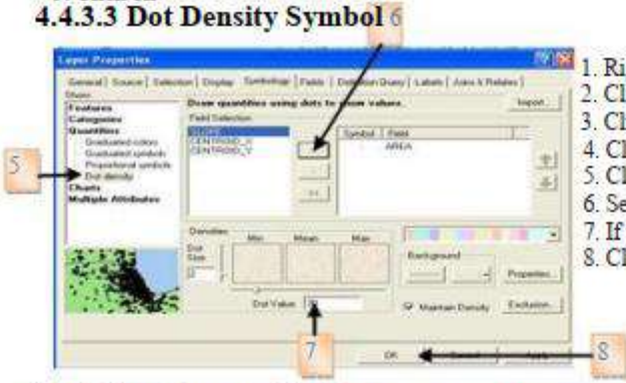


Graduated Symbol



1. Right click on the layer name
2. Click on property
3. Click on symbology
4. Click on quantity
5. Click on graduated symbol
6. Click on field value
7. Like graduated color if you want to change number of class and class limits, you can change here also
8. If you want change the min and max size of the symbol
9. Click ok

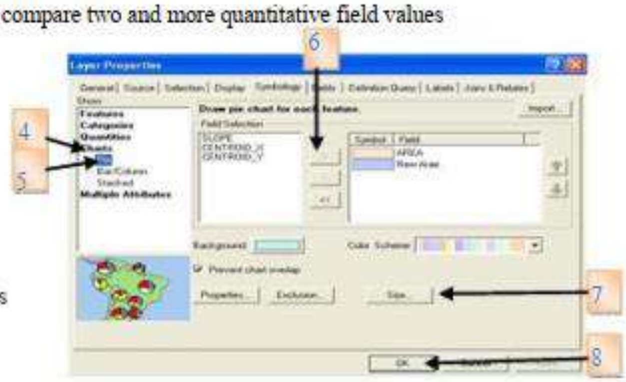
4.4.3.3 Dot Density Symbol



1. Right click on the layer name
2. Click on property
3. Click on symbology
4. Click on quantity
5. Click on Dot density
6. Select the field and click add arrow
7. If you want you can change the value of one point
8. Click ok

4.4.4 Changing color by Charts:- It uses to compare two and more quantitative field values

4.4.4.1 Pie Charts



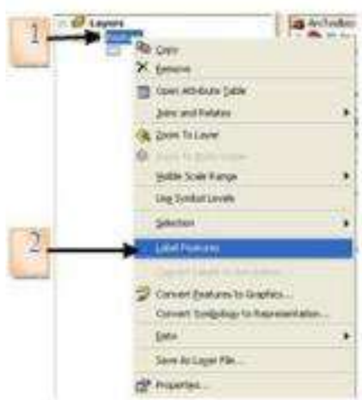
1. Right click on the layer name
2. Click on property
3. Click on symbology
4. Click on Charts
5. Click on Pie
6. Select the field and click add arrow
7. If you want you can change the size of pie charts
8. Click ok

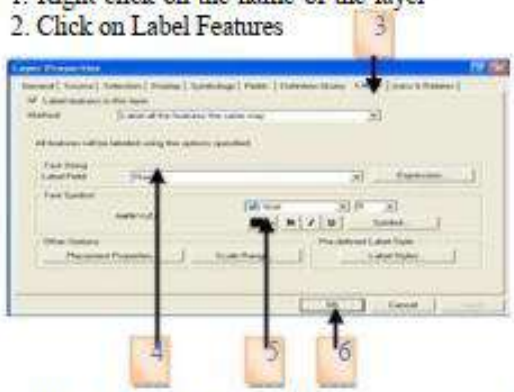
Labeling Features

Labeling is the process of placing descriptive text onto or next to features on the map. It is useful to add descriptive text to your map for many features. Labeling can be a fast way to add text to your map, and it avoids you having to add text for each feature manually. In addition, ArcMap labeling dynamically generates and places text for you.

To label features:-

1. Right click on the name of the layer
2. Click on Label Features





N.B if you want to change the property of labels

3. Click Labels
4. Change the label field
5. Change the size and color of text symbol
6. Click ok

4.6 Maplex function

Maplex function helps to make your label readable automatically

1. Right click on the top of your document and Click Labeling
2. Click on labeling and click Use Maplex Engine.

Save ArcMap Document

Like any other computer application, you can save your ArcMap document by clicking the save button or go to file then select save or save as option and give the appropriate drive and file name.

Displaying Attribute table

A table is a database component that contains a series of rows and columns, where each row, or record, represents a geographic feature—such as a Landuse, SWC structures, Soci-economic Infrastructures, and etc. each column, or field, describes a particular attribute of the feature—such as its Type, Name, depth, and so on.

To open Attribute table

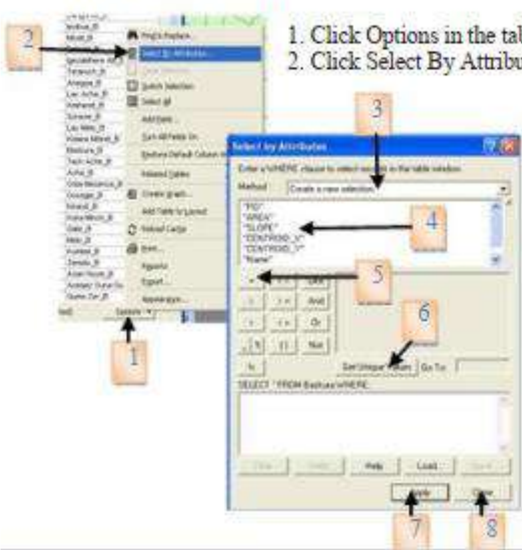
1. Right click on layer.
2. Click Open Attribute Table.

The layer's attribute table opens.

1. Move to first record
2. Move to previous record
3. Current record
4. Move to next record
5. Move to last record
6. To show selected record
7. Table options /it help to perform different editing & selection tasks

Querying attribute table

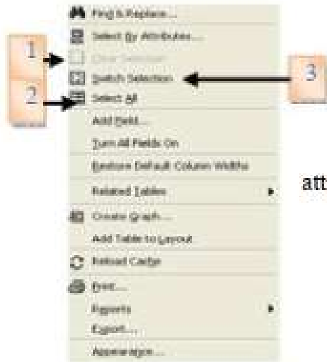
Selecting records by attributes



1. Click Options in the table you want to query
2. Click Select By Attributes.
3. Click the Method dropdown arrow and click the selection procedure you want to use.
4. Double-click the field from which you want to select.
5. Click the logical operator you want to use.
6. Click the Get Unique Values button, then scroll to and double-click the value in the Unique Values list you want to select. Alternatively, you can type a value directly into the text box.
7. Click Apply and
8. Click close

Your selection is highlighted in the table. Use Apply if you intend to run more than one query or if you want to check your results before closing the Select By Attributes dialog box.

To select all attribute, to Clear selection and to switch selection



1. Click on Clear Selection option
2. Click on Select All option
3. Click Switch Selection option. This function uses to clear the selected attribute and select those previously unselected attributes

Exercise:-

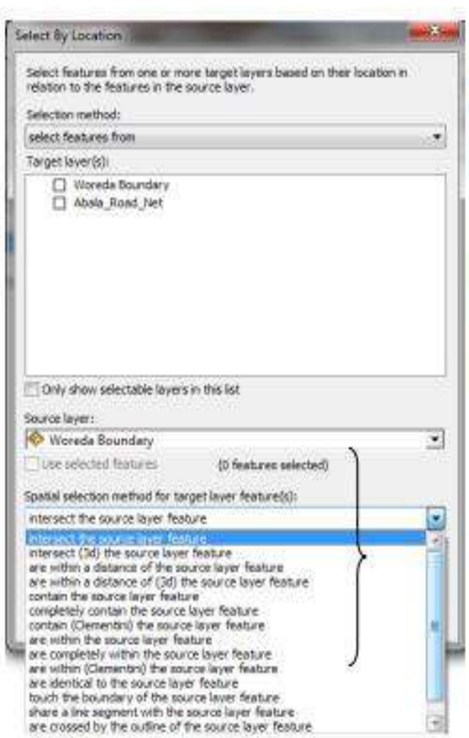
1. Open the attribute table of Enkulal Sub watershed and find Zeba community Watershed
2. Select Bahir Dar Town from the Town layer
3. Select roads owned by ARA and RRA
4. Select those community watersheds from kentai which has an area between 300 to 800
5. Select cultivation land use those have Eutric Cambisols, Erosion rate of 3.125 in Hana mariam kebele in East Estie woreda.

TIP:- Add Town layer, Road layer, Kentai subwatershed layer and Project_Woreda_Mostmerged_Da layer

Spatial query /Select by location

Select By Location dialog box, helps to select features based on their location relative to other features, so you need at least two features in your ArcMap document to use this select by location function. You can use a variety of methods to select the point, line, or polygon features.

1. Select your area of interest from the reference layer
2. Click Selection from the menu bar
3. Click Select by Location
4. Select the different option from the I Want to options
5. Select /thick mark on the targeted layer
6. Select one from the That option
7. Click Apply



Descriptions for different selection methods in Select by Location function

Intersect the source layer feature

This method is similar to the Are crossed by the outline of method but also selects any features bordered by the reference features.

Are within a distance of the source layer feature

This method selects features near or adjacent to features in the same layer or in a different layer.

Have their center in the source layer feature

This method selects the features in one layer that have their center in the

Data Management

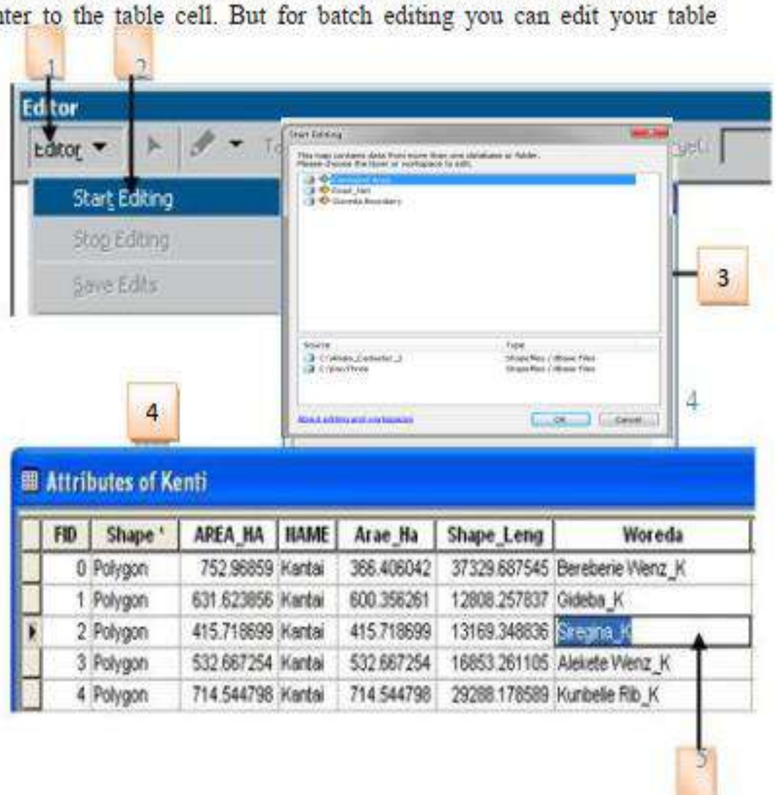
1 Updating Attribute Table

You can make change or delete any data on your attribute table. To make change on specific record first the layer should be in editing mode, otherwise the curser will not enter to the table cell. But for batch editing you can edit your table without entering to the edit mode.

.1.1 Editing or adding text in records

1. If you haven't started an edit session, click the Editor menu on the Editor Toolbar and
2. Click Start Editing.
3. Select the layer you want to edit
4. Open the table you want to edit.
5. Click the cell containing the attribute value you want to change.
6. Type the new values and press Enter.

The table is updated.



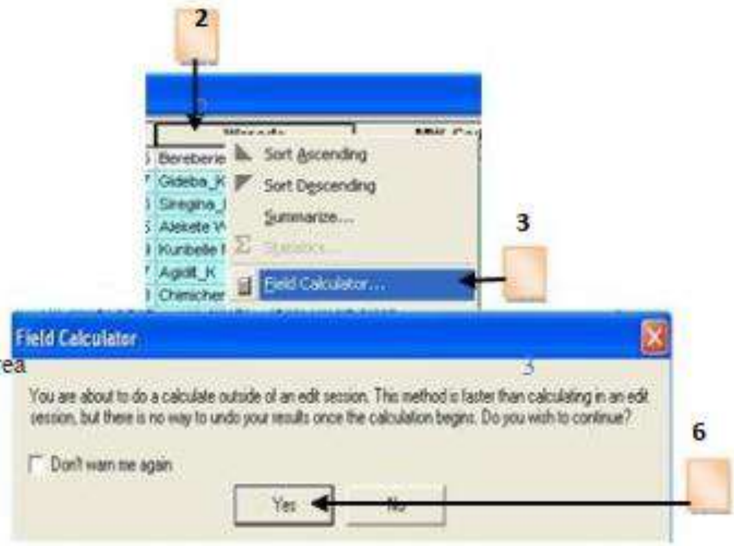
.1.2 Deleting records

1. If you haven't started an edit session, click the Editor menu on the Editor Toolbar and click Start Editing.
2. Open the table you want to edit.
3. Select the records you want to delete. Press and hold the Ctrl key while clicking to select more than one record.
4. Press the Delete key on the keyboard.

Any geographic features associated with the records are also deleted.

1.3 Editing or adding many text in records

1. Open the attribute table
2. Right click on the field/column name
3. Click on Field calculator
4. Accept the warring by clicking ok button
5. Enter the new value /calculation formula in whit area
6. Click ok

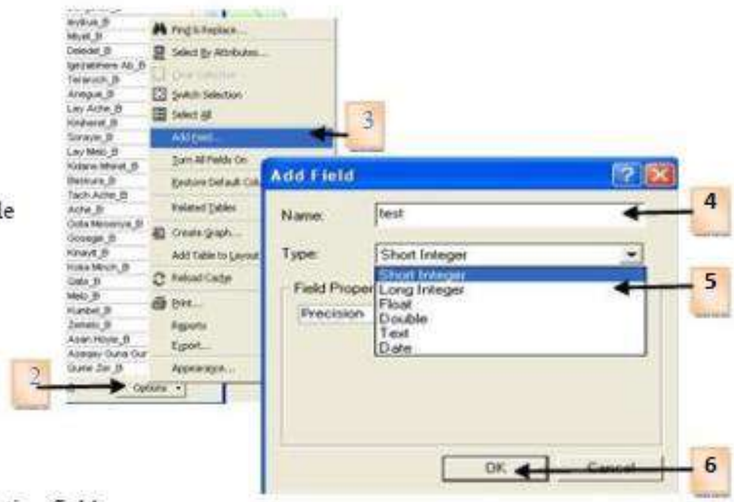


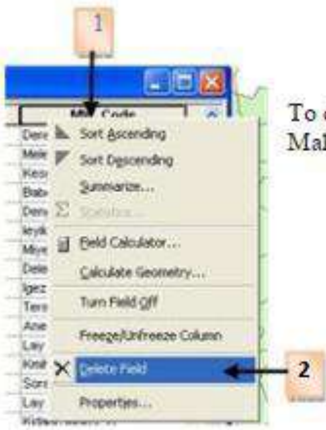
Creating, deleting and hiding Fields

If you want to add or delete fields from your table you should be out from edit session.

To Add new field in your table

1. Open the attribute table
2. Click on option in the top of the table
3. Click Add Field
4. Enter field name
5. Select the data type /for area choose Double for text select text type/
6. Click ok





To delete the existing field
Make sure you are not in edit session.

1. Right click on the field /column you to delete
2. Click on delete field
3. Accept the warring by clicking on yes button

To hide the existing field

1. Right click on the field
2. Click on Turn field off