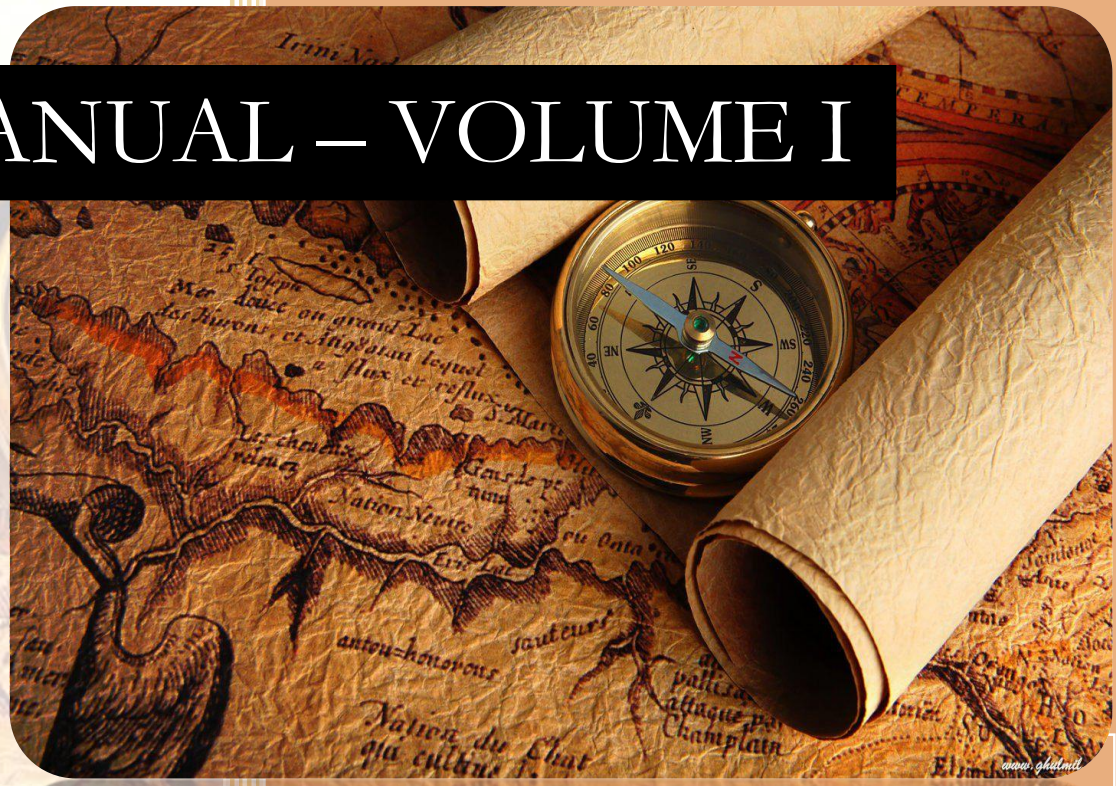
2016

GIS MANUAL – VOLUME I



DEPARTMENT OF GEOGRAPHY

UNIVERSITY OF COLOMBO

L. MANAWADU

V.P.I.S. WIJERATNE

S.M.A.T. NANDASEELA

P. RANASINGHE

M.A.D. SAMANMALI

DEPARTMENT OF GEOGRAPHY

TABLE OF CONTENT

CHAPTER ONE

INTRODUCTION TO GIS

1.1 Introduction

Geographical Information Systems or GIS is highly demanded tool in many fields of studies under decision making when comes to planning. The concepts used in GIS are not alienated but modified with digital approach to match the modern world to work with more efficient and productive manner. Therefore, it is said that concepts of GIS is like old wine in new bottle. Today, GIS is one of the most powerful analytical tools in many research areas. The acronym GIS, which stands for **"Geographical Information System"** came into fashion around 1970. It offers number of different technologies, processes and methods. It attached to many operations and also has many applications related to Geography, Engineering, Hydrology, Planning, Telecommunication, Transport, Forestry, and Business etc. GIS can use any information with location or data represented in spatially. The location can be expressed as latitude and longitude. The system include data about people (population, income or education), land (land-use types, streams, vegetation types and soil types), sites

of factories, farms and schools or storm drains, road and electric power lines etc. Therefore, GIS is very popular and important in the field of research as well.

1.2 Definition and Overview

Many scholars define GIS in different ways. In general, GIS defines as a computer based system for capturing, storing, analyzing, interpreting and visualizing data of earth system.

A powerful set of tools for collecting, storing, retrieving, transforming, and displaying spatial fundamentals of Geographic Information System (GIS) (Burroughs, 1986).

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

Data capture and preparation
Data management (storage and retrieval)
Data manipulation and analysis
Data presentation

(Aronoff, 1989)

A geographic information system (GIS) lets us visualize, question, analyze, and interpret data to understand relationships, patterns and trends (ESRI).

1.3 History and Concept of GIS

GIS is not a new technology and it is a modern extension of traditional cartography. There are some differences and some similarities between cartography and GIS. Both GIS and cartography attempt to represent phenomenon on the surface of the Earth in "map" format. However, there are no limitations for data adding in GIS and also spatial and statistical methods of analysis can be used for representation with the combination of both spatial and aspatial data.

The concepts in GIS are mostly derived from the spatial approach along with analytical methods. The very first terminology in GIS is used by Roger Tomlinson in 1869 in his publication "A Geographic Information System for Regional Planning" (http://www.esri.com) However, Dr. John Snow is considered as the father of modern GIS with successful use of GIS methodology in epidemiology in 1854 to find out the source for the Cholera in London City. The map he produces was considered to be a good combination of both cartographic techniques and basics of epidemiology not only to depict but also to analyze clusters of geographically dependent phenomena. The map below (Figure 1.1) indicates the representation of Cholera in London City produced by Dr. John Snow.

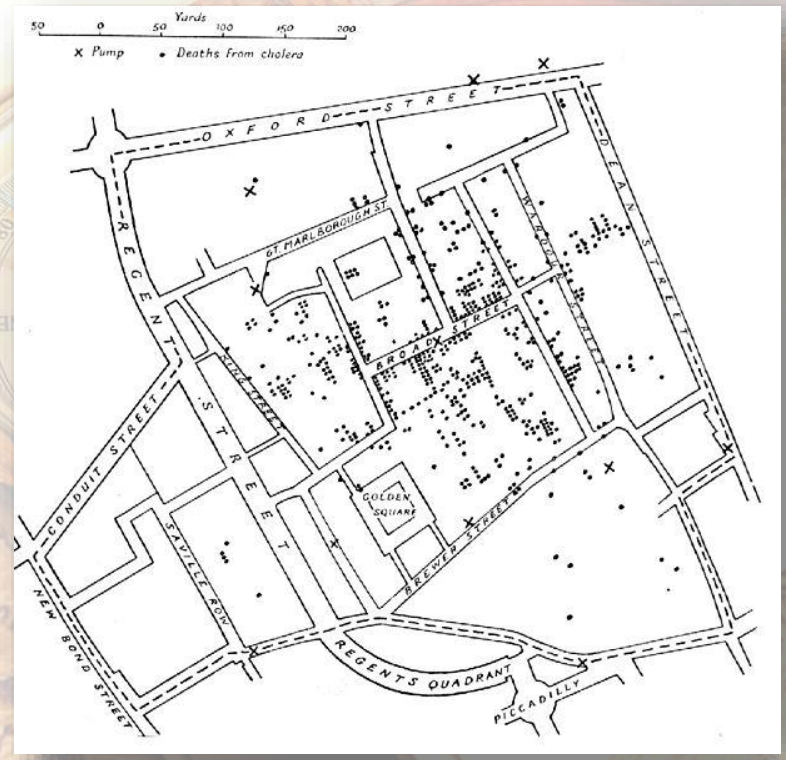


Figure 1.1: Representation of Cholera in London City
Source: https://www1.udel.edu, 15.09.2016

With the development of photo zincography introduced by Sir Henry James in the mid nineteenth century, allowed maps to be split into layers. It helped the draughtsman to work with themes without any confusion when making maps. This work was originally drawn on glass plates but with the invention of plastic it become more easier using less storage space and being less brittle, among others. Then with the invention of the colour printer there were separate plates for each colour. This method enabled the accurate reproduction of images and originally used to create maps during the Ordnance Survey of Great Britain during the 1850s. This is the first step of the separate storage of layers in the GIS was originated.

During early 1960s with the development of computer hardware paved the way towards computer mapping. Canada Geographic Information System (CGIS) developed by Dr. Roger Tomlinson introduced the world's first true operational GIS by the federal Department of Forestry and Rural Development. It was used to store, analyze, and manipulate data collected for the Canada Land Inventory, an effort to determine the land capability for rural Canada by mapping information about soil, agriculture, recreation, wildlife, waterfowl, forestry and land use at a scale of 1:50,000. A rating classification factor was also added to permit analysis (GIS Hall of Fame, Roger Tomlinson).

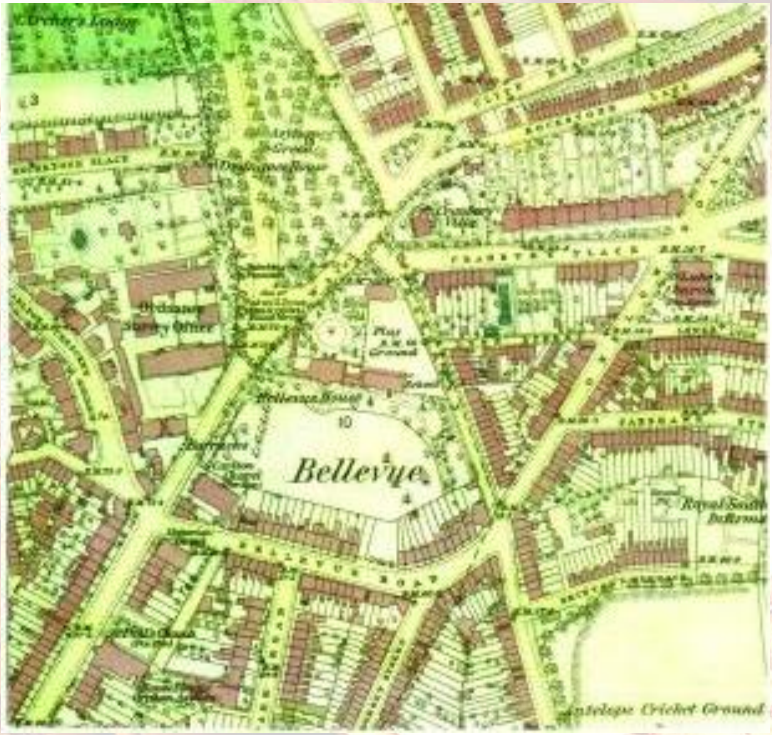


Figure 1.2: The map Ordnance Survey was created in1856.
Source: https://wideandconvenientstreets.wordpress.com, 15.09.2015

Howard T. Fisher, during 1964 has developed the Laboratory for Computer Graphics and Spatial Analysis at the Harvard Graduate School of Design, USA where a number of theoretical concepts in

spatial data handling was introduced and practiced. In 1970 it had distributed seminal software code and systems, such as SYMAP, GRID, and ODYSSEY that served as sources for subsequent commercial development to universities, research centers and corporations worldwide (Lovison Golob & Lucia, Harvard University).

By the late 1970s two programmes known as MOSS and GRASS GIS were introduced as public domain GIS systems. By the early 1980s, M&S Computing (later Intergraph) along with Bentley Systems Incorporated for the CAD platform, Environmental Systems Research Institute (ESRI), CARIS (Computer Aided Resource Information

System), MapInfo Corporation and ERDAS (Earth Resource Data Analysis System) emerged as commercial vendors of GIS software, successfully incorporating many of the GIS features, combining the first generation approach to separation of spatial and attribute information with a second generation approach to organizing attribute data into database structures. (http://wiki.osgeo.org, 15.09.2016). Mapping Display and Analysis System (MIDAS) was introduced in 1986 as the first desktop GIS product for the DOS operating systems. It was renamed as MapInfo for Windows operating system in 1990. By the end of 20th century with the development of technology more developed platforms in both open source and commercial were introduced. With the advancement of the technology the applications of GIS has also been increased rapidly and interdisciplinary approaches have introduced to the field of GIS.

1.4 Basic Components of GIS

GIS integrates five key components; Hardware, Software, Data, Approaches and People which are shown in figure below.

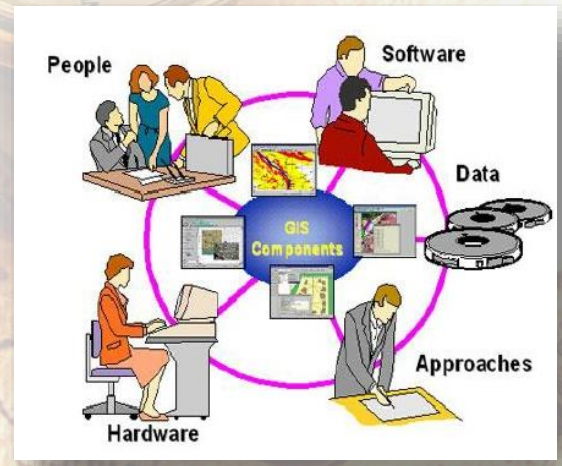


Figure 1.3: Basic Components of GIS
Source: http://www.uaex.edu, 15.09.2016

CHAPTER TWO

INTRODUCTION TO ARCGIS

2.1 Introduction to ArcGIS

ArcGIS is useful to work with maps and geographic data. ArcGIS is a collection of software products created by Environmental Systems Research Institute (esri), the GIS software that includes desktop GIS, server GIS, mobile GIS, host GIS, and online GIS products and all products describe in below, but this manual focuses on the ArcGIS 10.1 desktop applications, only.

Figure 2.1: ArcGIS Packages

The desktop GIS products allow users to integrate and edit data, create new map layers, and produce maps. ArcGIS desktop includes a series of saleable products and they have more functionality. ArcGIS desktop is licensed under three functionality levels.

ArcView

ArcView is a part of the ArcGIS collection and it is for a general audience. It is the most popular GIS software program and it provides the base mapping and analysis tools.

ArcEditor

ArcEditor includes all the functionality of ArcGIS, adding the ability to edit features in a multiuser geodatabase, so that multiuser editing and versioning are possible. ArcEditor also adds the ability to edit topologically integrated features in a geodatabase.

ArcInfo

ArcInfo is Esri's professional GIS software. It includes all of the functionality in ArcGIS and ArcEditor, adding some advanced geoprocessing and data conversion capabilities.

While these levels are crucial to consider when purchasing software, it is also important to be aware of the limitation of the level you are using.

ArcReader

It is a free product for viewing maps. It can explore and query data layers. However, it cannot change symbology or create new data like in ArcGIS Desktop. ArcReader is a good way to share the maps which have created in ArcGIS with people who don't have access to the licensed software.

2.2 Extension for ArcGIS Desktop

This manual discusses about ArcGIS Desktop version and this desktop product include large amount of functionality and extensions. Some of extensions are very important for particular data generate and analysis. Some analyst are;

- Spatial Analyst

  Use for modeling and raster (cell-based) analysis. Example: Create density surfaces and conducting map algebra.

- 3D Analyst

  Allows users to view, visualize and analyze spatial data in 3D level. Example: Extruding polygons (such as parcels and building footprints) and draping surfaces (such as orthophotos) on elevation models.

- Geostatistical Analyst

  This sophisticated tool allows users to analyze raster (cell-based) and point data using advanced statistical methods. Such as, Kriging and inverse distance-weighting.

- Network Analyst

  Network-based analysis includes routing, determining closest facility, or service areas. Networks can store information about traffic flow, one-way streets, and travel time.

- Tracking Analyst

  Makes it possible to animate point data representing events at discrete times and places. We can view events happening across time and space using the "playback" feature.

CHAPTER THREE

WORKING WITH ARCMAP DATA

3.1 Adding Data though ArcMap

In order to work with ArcMap document you need layers or data as a source. Therefore, you will need to use **Add Data** command to add any data to the ArcMap document. There are two methods to add data.

- File → Add Data
- Standard Toolbar → Add Data

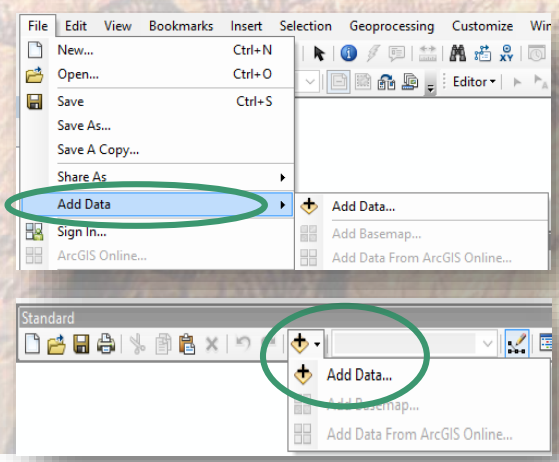


Figure 3.1: How to Add Data

If you select **Add data** button, the add data window will appear and you can set the folder path. Then select data layers which you want to add and click on the **Add** button. It will display as follows;

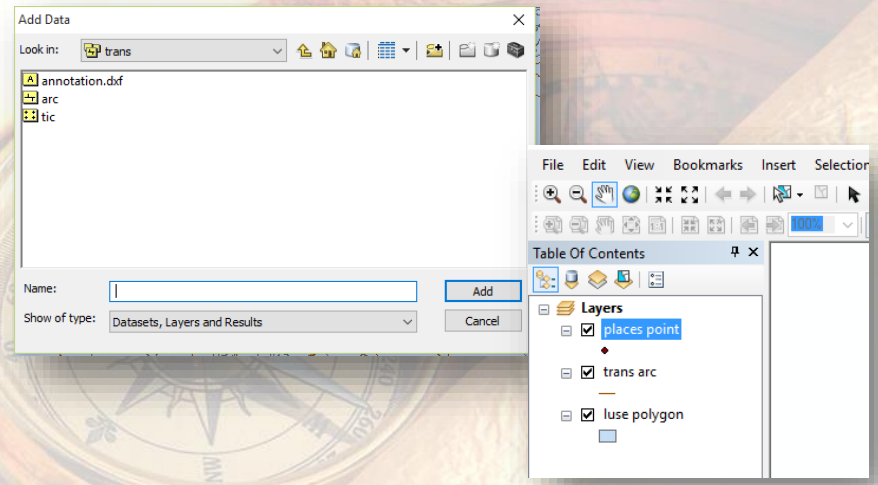


Figure 3.2: How to set Folder Path

On the left hand side of the document view (Table of Content) selected layers will be appeared. To the left side of each layer has a little check mark box and when it is turned on particular layer will be displayed in the Display area. If you uncheck them, that particular layer/layers no longer be visible. In ArcGIS 10.1, you can use **Add Data** button to access other options such as Add Basemap and Add Data from ArcGIS Online. From the **Add Basemap** option, you can import Bing and Google aerial images,

street and topo maps, and others. Through **ArcGIS Online**, you can import data and can create many additional layers.

3.2 Identifying Attributes of Features

Every vector map layers have attribute table and it contains all details about that feature. Example, if you are adding a line feature to road layer it has attributes for location, road type, length etc. You can access this information in several different ways.

Using the **Identify Tool**, click on the map feature in the map display (Figure3.3). An **Identify results box** will display with all of the information identified regarding that feature. The default in ArcMap is to display information only about the top-most layer. You can change this using the dropdown menu at the top of the **Identify pop-up box.**

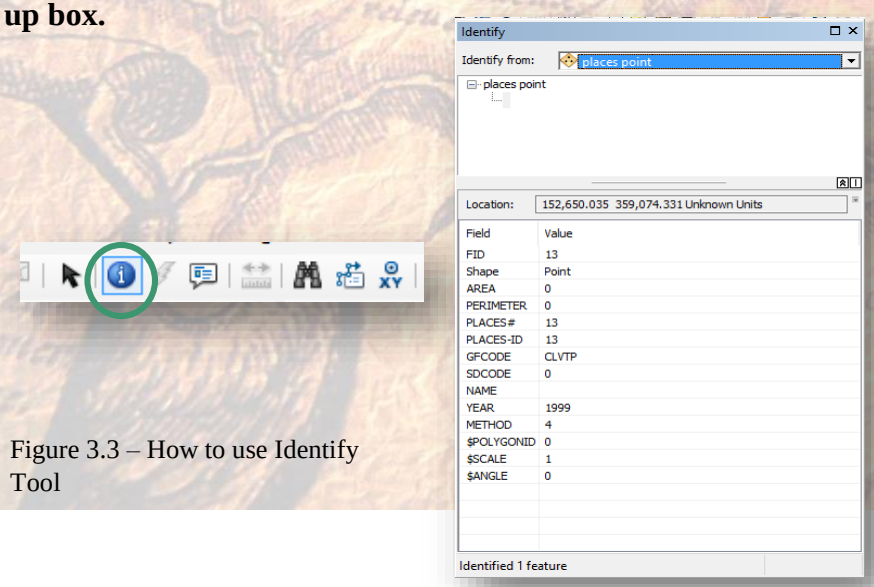


Figure 3.3 – How to use Identify Tool

3.3 Selecting Features

You can also use the **Select Features Tool** to identify attributes of the layer. It can be done by clicking on a particular map feature or by drawing a rectangle, polygon, circle, line or using the lasso selection tool. The selected features should become highlighted with a blue outline.

For **Select Features**: Go to **Tools Toolbar → Select on the select features tool**

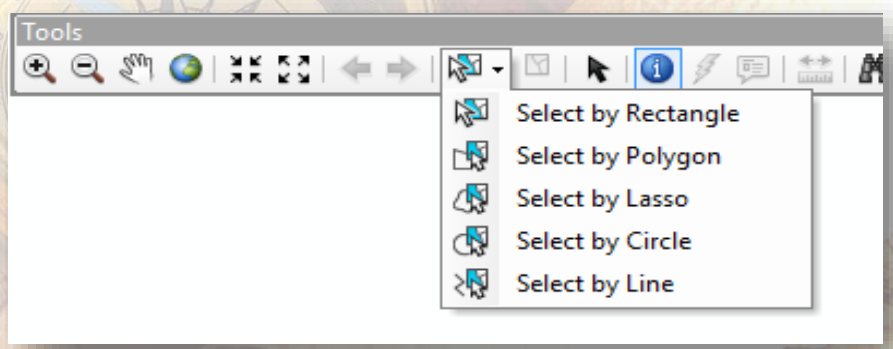


Figure 3.4: How to use Select Feature Tool

In the Attribute table, you can see the selected feature details. Right click on the map layer that contains the feature(s) that you wish to investigate and go to **Open attribute table**. This table shows all possible attributes of that particular layer. In order to view only the selected feature/features, click on the **Show Selected Features**

CHAPTER FOUR

WORKING WITH MAP PROJECTION

4.1 Georeferencing Image

Georeferencing allows you to **convert paper map into a digital map layer.** Georeferencing is the process of aligning a Raster data set to a known Map Coordinates and assigning a Coordinate System. The process includes assigning X and Y coordinates to points on your digital map image, Shifting, Rotating, and Scaling your map. Afterward, you can view it as a digital Map Layer along with your Shapefiles. This is important for interpret historical map or an aerial photographs.

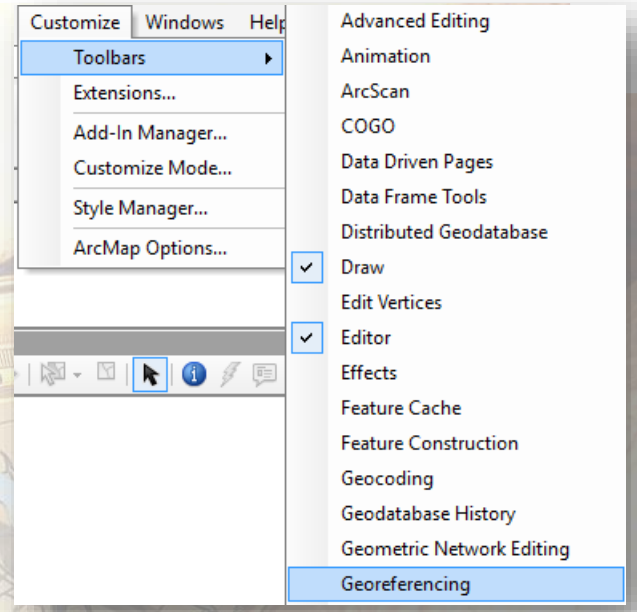


Figure 4.1: How to add Georeferencing Tool Bar

Figure 4.2 : Georeferencing Tool Bar

Steps of Georeferencing

1. Open your scanned map (.jpeg or .TIFF) into ArcGIS.
2. Turned-on **Georeferencing Toolbar** in ToolBars.
3. From the Georeferencing Menu, choose **Fit to Display**. Now your reference layer(s) should display on the top of your Scanned map image on the Map View Window. If your scanned map is upside down, use the **Flip or Rotate** tools

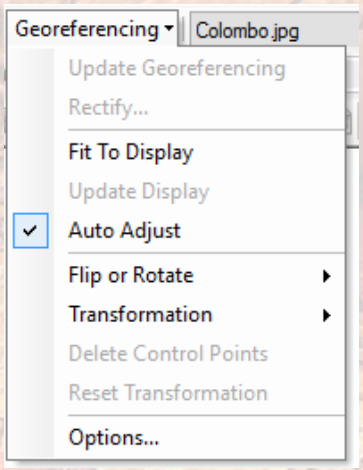


Figure 4.3: Fit To Display Feature/Filp to Rotate

4. Then click **Add Control Points** button. There are two methods to give control points.

   - **Method 1**- Create your first control point on your image by **click one time on your scanned map**, then **click on the Shapefile** in the corresponding spot. Your image should shift closer to your shapefile. If it gets further away, you probably reversed the order. Be sure to click on your scanned map first, then the shapefile.

   - **Method 2** - If you know actual Ground Control Points (X,Y values), first **Right Click on the** icon below first(figure 4.4) and then on the **selected scanned map**. Then **Add X Y** values and click **Enter**.

Figure 4.4 Add Control Points Icon

In most situations, your map image will not line up perfectly with the shapefile, and you should not accept it.

When it not align perfectly,

Georeferencing Menu → Georeferencing Toolbar → Delete Control Points and **Reset Transformation →** choose F**it to Display again**.

CHAPTER FIVE

SCREEN DIGITIZING AND TABLE EDITING

Sometimes, you may have to use paper maps, satellite or aerial photograph and create maps from them or you may have to work with shapefiles that someone else created. Therefore, if you need a layer that doesn't exist, you will have to create it by yourself. In that situation **Digitizing** is very important. **Digitizing is the process of drawing or tracing map features to create a new digital layer**. This process involved tracing a paper map on a digitizing and then assigning real world coordinates to certain parts. But, ArcGIS has on-screen digitizing tools which allow you to create new shapefiles without any additional hardware or software.

5.1 Create a shapefile

If you need to create new Shapefile (Point, Polygon or Line) you can use ArcCataloge window.

Create a New Shapefile

Right click in a folder within the Catalog Window → Select **New** → Select **Shapefile → New Shapefile**

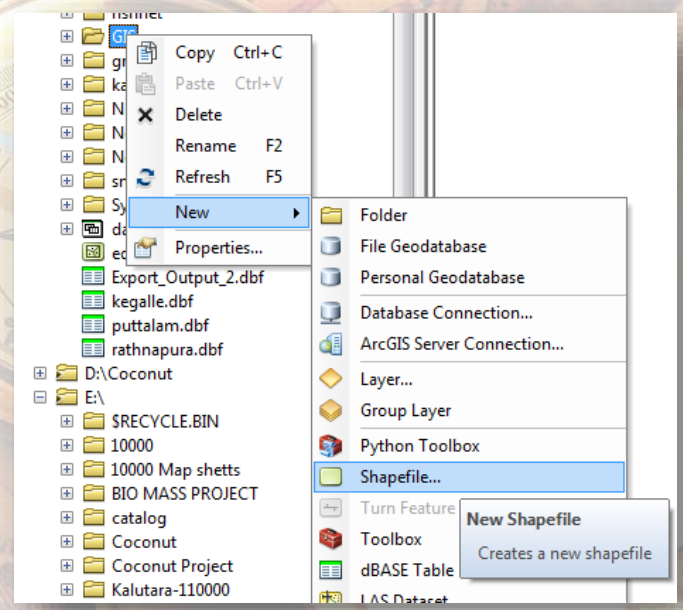


Figure 5.1: How to create a Shapefile

- Upon that **Create New Shapefile** window will appear and you can give a suitable file name and select a Feature type (Point, Polyline or Polygon).

To define a Coordinate System click on the **Edit** button

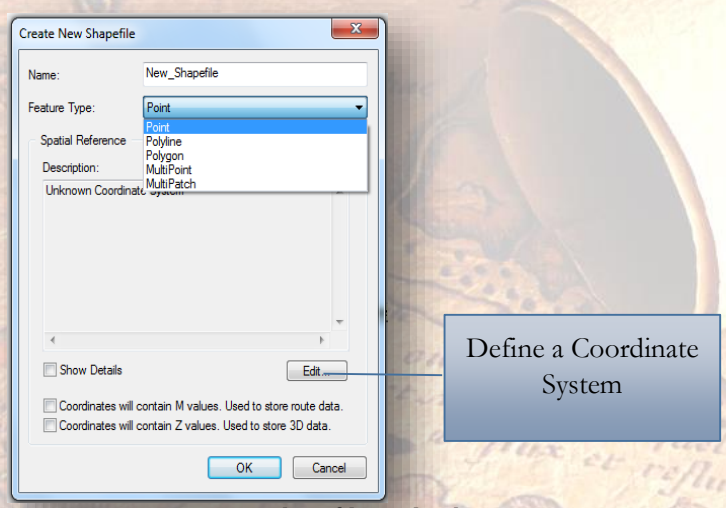


Figure 5.2: Create New Shapefile Dialog box

- When you click **Edit** in the Create a New Shape File dialog box, **Spatial Reference Properties Dialog Box** will appear
- Select **Pre-Defined Coordinate System** or **import coordinate system from an existing geodataset**.

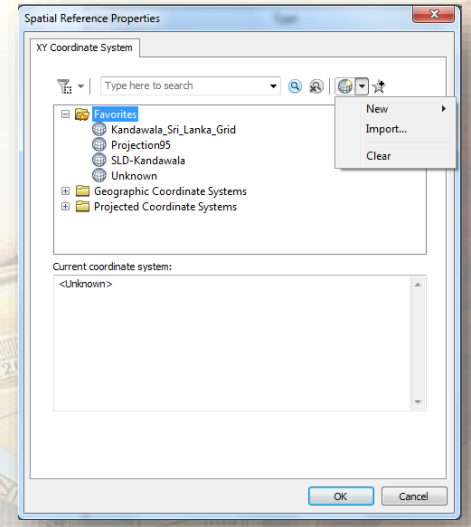


Figure 5.3: Spatial References Properties Dialog box

5.2 On-Screen Digitizing

- You can create a new map and define the shapefile. For that **close the ArcCataloge and open your ArcMap project**.
- Then **add your shape file to the map window** or **drag it from ArcCatalog window**.
- Before start the digitizing make sure to **verify map units and display units**. Open **Data Frame Properties** and change map units and distance units into **Meters**.
- Switch on the **Editor Toolbar** from Toolbars.

CHAPTER SIX

DESIGNING MAP LAYOUTS

1.1 Layout View

Layouts are way of allowing you to make a professional quality presentation. When you switch to the **Layout View**, you have access to a different range of tools. You can use the **Layout Toolbar** to navigate.

To switch to Layout View

Click on the **Layout View Icon** at the bottom of your Map Display or from the **View menu → Layout View**

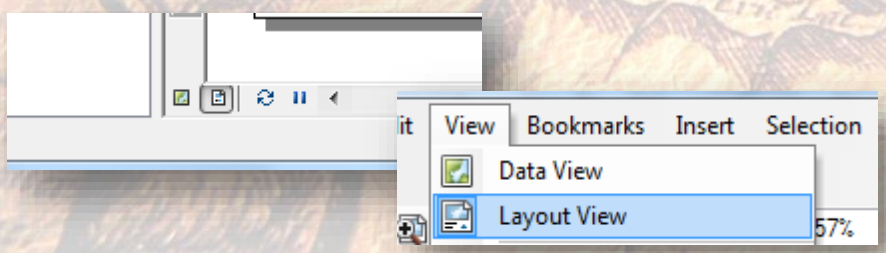


Figure 6.1: How to Switch to Layout View

When you are switch to the Layout View, your map will be visible as a Layout. It gives you a better idea of how your map want to print. ArcMap automatically place a border around the map and it is called as a **Data Frame**. You can use more than one Data Frame and more than one map can be displayed at the same Layout View.

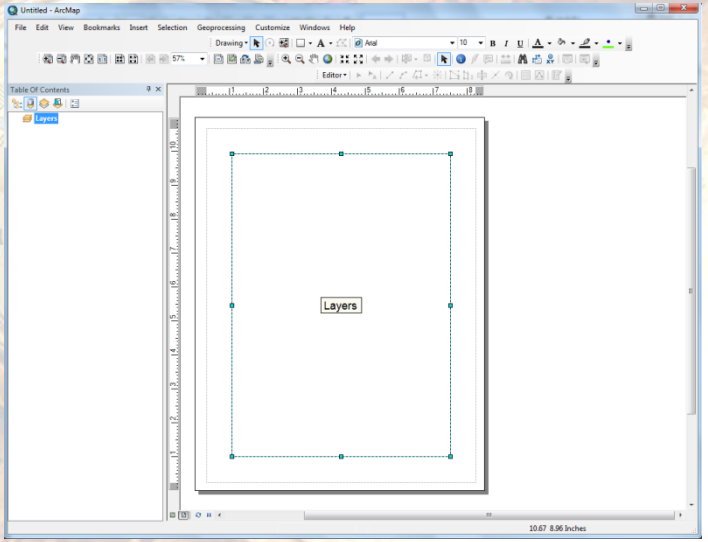


Figure 6.2: Layout View

You can add additional data frames to a map to compare two areas side by side.

You can see all of the data frames on your map in Layout View. If you switch back to Data View, you will see the layers that used in the

active data frame. **The Active Data Frame** is highlighted in the Table

of Contents. In **Layout View** you can change the shape and position of the data frame, add other map elements such as Scale Bars, Legends to the Map and can change the Page Size and Orientation.

The Layout Toolbar is added to the ArcMap interface when you choose Layout View. By using **Layout Toolbar** it is possible to Zoom In, Zoom Out, Pan, Fixed Zoom In, Fixed Zoom Out, Zoom to Whole page, Zoom to 100%, go back and forward between extents and change the percentage of zooming. Those tools can be find in Layout Toolbar in the Data View.

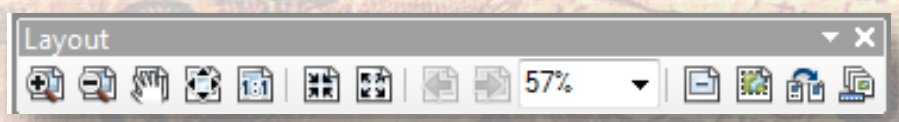


Figure 6.3 : Layout Tool Bar

When you are in the Layout View, **Insert Menu** which has number of options become active. These options allow you to add elements including Title, Legend, North Arrow, Scale Bar, and Image to Your Layout.

❖ **Change Page and Print Setup**

You can change properties of your layout page such as page size, orientation etc. You can decide how it need to be changed and you can use:

File → Page and Print Setup

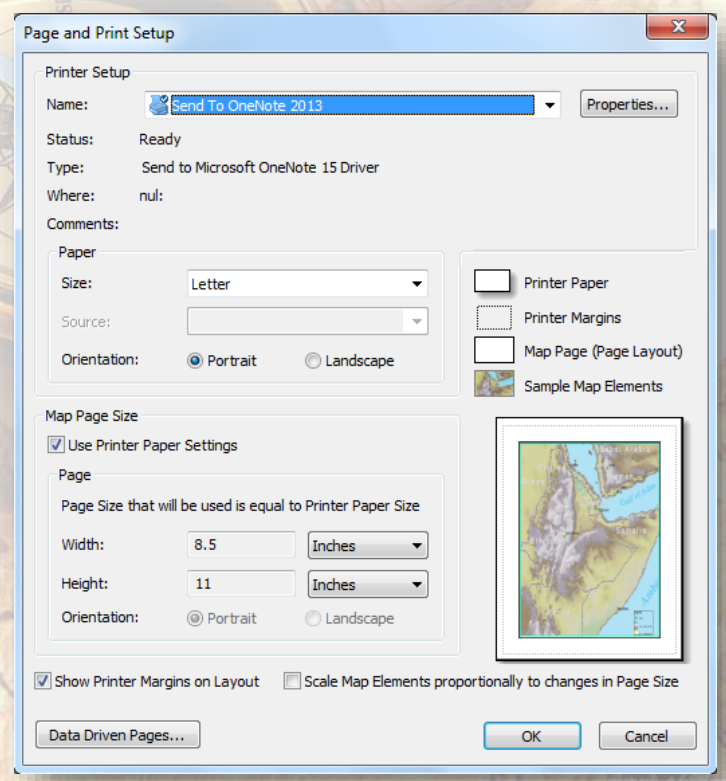


Figure 6.4: Page and Print Setup Dialog Box

CHAPTER SEVEN

GEOPROCESSING

Geoprocessing is one of an important tool and commonly use tool in ArcGIS and it has tools and framework for conduct analysis and manage your geographic data. Geoprocessing offers a large number of tools for perform GIS tasks.

Geoprocessing is based on a framework of data transformation. Geoprocessing Tool usually associates with an ArcGIS dataset (feature class, raster, or table), and while undergoing Geoprocessing, it produces a new dataset as the result of the tool.

Due to variability of numerous Geoprocessing Tools, it provided the opportunity to compose countless number of Geoprocessing models which can be used to analysis complex problems and find solutions to them.

To Start: Click on **Geoprocessing Menu** in the Menu bar

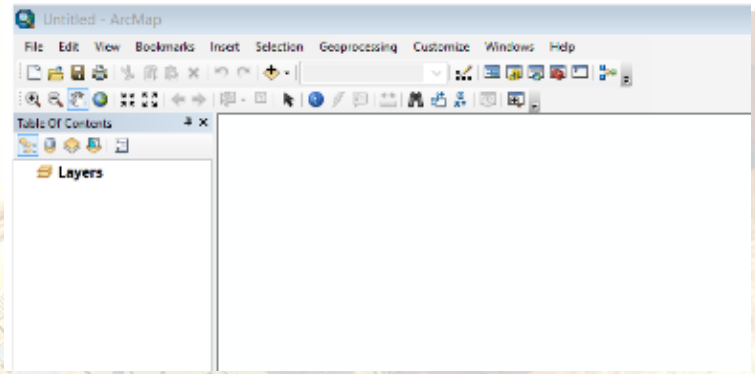


Figure 7.1: Geoprocessing Menu in the Menu Bar

Geoprocessing Tool has six basic Tools commonly used by any GIS user regardless of the analyzing area. In this chapter we discuss about those six fundamental tools listed below according to the order of tools provided by the Geoprocessing Tool in ArcGIS Map.

- Buffer
- Clip
- Intersect
- Union
- Merge
- Dissolve

7.1. Merge

In this operation, multiple features can be combine in to another feature. It usually combines same feature class (Point, Polyline and Polygon) together. In the Output/ merged version should not be overlapped and it's very important to use the same coordinate system. Even there are no options like Spatial Join, it is very important to join spatial features in order to have a good spatial relationship. As an example there are lot of GN boundaries in a District and you can use Merge operation if you want to combine all of those features.

Method 1**:** Right click on **Geoprocessing Tool** in Standard Tool Bar → Select **Merge**

Method 2**: ArcToolbox → Data Management Tools → General → Merge**

Figure7.2: Illustration of MERGE

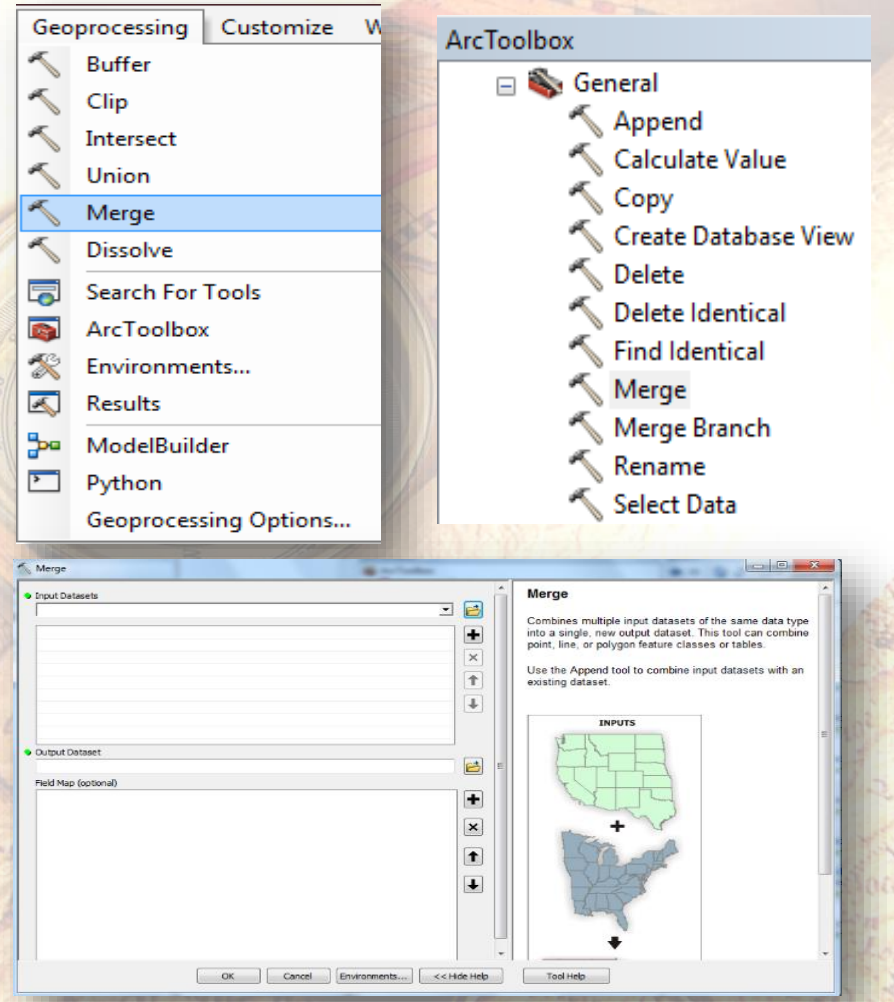


Figure 7.3: Steps to MERGE