Geographic Information Systems

for Undergraduted Students

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GIS

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Preface

The Geographical Information System (GIS) is a computer system used for the storage, analysis, and display of geographic knowledge, which is represented using a series of geographically referenced information. In Palestine, GIS is basically used to build maps for illustrative purposes, only very limited attempts have been recorded for the use of GIS as an analysis tool yet several efforts are now in the atmosphere to introduce the Program for this intention. Of these initiatives are the activities that fall under the framework of the Tempus project funded by European Commission, which included the preparation of this tutorial which came as a result of several years of practical experience and application targeting undergraduate students in the fields of geography, civil engineering and water and environmental sciences.

Many of the terms and concepts introduced in this book have been compiled from a variety of different sources that were further enriched with examples that have been tailored to introduce procedures and analysis techniques designed specifically from the local settings. The exercises include step-by-step instructions that are thoroughly annotated. The book comes with a companion CD-ROM that includes the files and folders necessary for hands on application.

Divided into six chapters the book covers a variety of different issues each followed by a number of questions and assignments including: Introduction to the Geographical Information System describing the hardware and software components of the Program, GIS Data Models and Quality illustrating data types, formats, quality, models, and sources, Coordinate Systems and Map Projections explain a variety of Georeferencing techniques, Visualization of Spatial Data and Map Cartography, Querying and Editing GIS Datasets introducing a range of functions available in the software and the essential tools for visualizing, creating, editing, managing, and analyzing geographic data and an Introduction to Geoprocessing.

Introduction to the Geographical Information System

Chapter 1

Introduction to the Geographical Information System

1.1 The Concept Behind the Geographical Information System

1.1.1. Introduction

Geography has been historically used as a language for organizing and communicating the key concepts about the globe. Geographical maps were produced to represent the natural features of the world. As a result, the Geographic Information System (GIS) technology is evolving to provide a critical tool to understand, represent, manage, and communicate the many aspects of physical and human landscapes and to better understand the Earth as a system.

GIS is a computer system used for the storage, analysis, and display of geographic knowledge, which is represented using a series of geographically referenced information. The power of GIS comes from its ability to relate different information in a spatial context and to reach a conclusion about this relationship. GIS and spatial analyses are concerned with the absolute and relative location of features, as well as the properties and attributes of those features.

For example, most of the information we have about our communities contains a location reference, placing that information at some point on the globe. If a building permit is issued it may be useful to know where the house may be located. This can be done by using a location reference system, such as longitude and latitude, and perhaps elevation. Comparing the building permit data with other information, such as the location of roads, may show that certain roads may expect increased traffic. This fact may indicate that these roads are likely to be congested which can help us make the most appropriate decisions about improvements to the road system. GIS, therefore, can reveal important information that leads to better decision making.

GIS operates on many levels. On the most basic level, GIS is used for computer cartography, i.e. mapping. GIS also uses spatial and statistical methods to analyze attribute and geographic information. The end result of the analysis can be derivative information, interpolated information or prioritized information.

1.1.2. GIS Components

A GIS system is a combination from a set of five elements: software, hardware, human resources, datasets as well as a set of organizational methods, procedures and protocols, Figure 1.1. In order to create a successful GIS system; these GIS elements should be well integrated. The selection of software and hardware elements is easy since the market has an abundant variety of GIS software and hardware brand names while data collection and organization, personnel development, and the establishment of protocols and methods for the use of GIS are often more difficult and time-consuming endeavors.

1.1.3. GIS Hardware

In general, GIS uses a huge amount of spatial datasets usually applied over large areas and/or at high spatial resolutions. Therefore, a PC computer with high specifications; including a high speed processor, large memory size and data storage capacities, and high-resolution display is considered the main GIS hardware advantage. Other hardware devices are also required for building a GIS system such as:

1. Input devices such as digitizers and scanners which are used for converting the data that is available in the form of maps and documents into digital form.
2. Global Positioning System (GPS) which is used to register the spatial coordinates and elevation of an observation point from the field and transfer them to the GIS system.
3. Output devices such as printers and plotters which are used to present the data processing results.
4. Data storage devices which could be external hard disks, media disks or network servers.

1.1.3.1. GIS Software

There are two types of software packages used in GIS systems. The first is the software that provides the functions and tools required to store, analyze, display and disseminate geographic information. Today, there are many public domain and commercially available GIS software packages. Most of the commercial packages originated at academic or government-funded research laboratories (e.g. ArcGIS). The second type is classified as an accessory software package which is used to facilitate the transfer of data to the GIS system. Examples of these software packages are:

1. Word processing software (e.g. Microsoft Word) which is used to write Metadata and support the documentation of a GIS dataset.
2. Software that develops extensive data tables containing database information (e.g. Microsoft Excel or Access).
3. Scanning software which could be used to digitize paper maps and images or to translate raster scans to vector coverages.

1.1.3.2. Human Resources

A GIS system is a rigid system without the human expertise that takes advantage of GIS's ability to analyze and solve the real world problems. The human expertise in GIS ranges from technical specialists who design and maintain the system to those who use it to help them perform their everyday work. They may include GIS managers, database administrators, application specialists, systems analysts, and programmers. In summary, people associated with GIS can be categorized into viewers, general users, and GIS specialists as described below:

1. Viewers are the most common GIS users who only need to browse a geographic database for referential material.

2. General users are people who use GIS to conduct business, perform professional services, and make decisions. They include facility managers, resource managers, planners, scientists, engineers, lawyers, business entrepreneurs, etc.
3. GIS specialists are the people who are responsible for the maintenance of the geographic database and the provision of technical support to the other two classes of users.

1.1.3.3. Data

Data is the most important component of the GIS system. All operations and analyses within the system rely on the data; therefore, a complete and accurate dataset of any spatial location is the key issue for reaching the accurate solution to a real state problem. There are three data process stages within GIS: the first is the data collection stage from different sources and in different forms of maps and images, tabular data or surveys. The second is the data entry and manipulation stage while the third includes data processing and analysis.

The data collection stage is the most time consuming and costly phase of initiating a GIS database, during which the quality of the data should be the considered:

1. The description of the source material from which the data were derived and the methods of derivation including all transformations involved in producing the final digital files.
2. Positional accuracy which means the closeness of an entity in an appropriate coordinate system to that entity's true position in the system.
3. The accuracy of the additional attributes that describe some facts about the location (e.g. name of location, elevation, slope, area, etc.).
4. The logical consistency which deals with the logical rules of structure and attribute rules for spatial data and describes the compatibility of a datum with other data in a dataset.
5. Completeness of data, to check if there is any missing data with regards to the features and their attributes.

1.1.3.4. Methods and Procedures

The GIS tasks are based on a series of methods and best practices such as map generation, data editing, analysis and modeling, visualization and information management. A key aspect of successful GIS use is the development and application of a series of implementation plans, rules and procedures.

These plans and rules require not only the necessary investments in hardware and software, but also in recruiting and/or hiring of personnel to utilize the new technology in the proper way. Procedures include how the data will be retrieved, input into the system, stored, managed, transformed, analyzed, and finally presented in a final output form. The procedures are the steps taken to answer the question that needs to be resolved. The ability of GIS to perform spatial analysis and answer these questions is what differentiates this type of system from any other information systems.

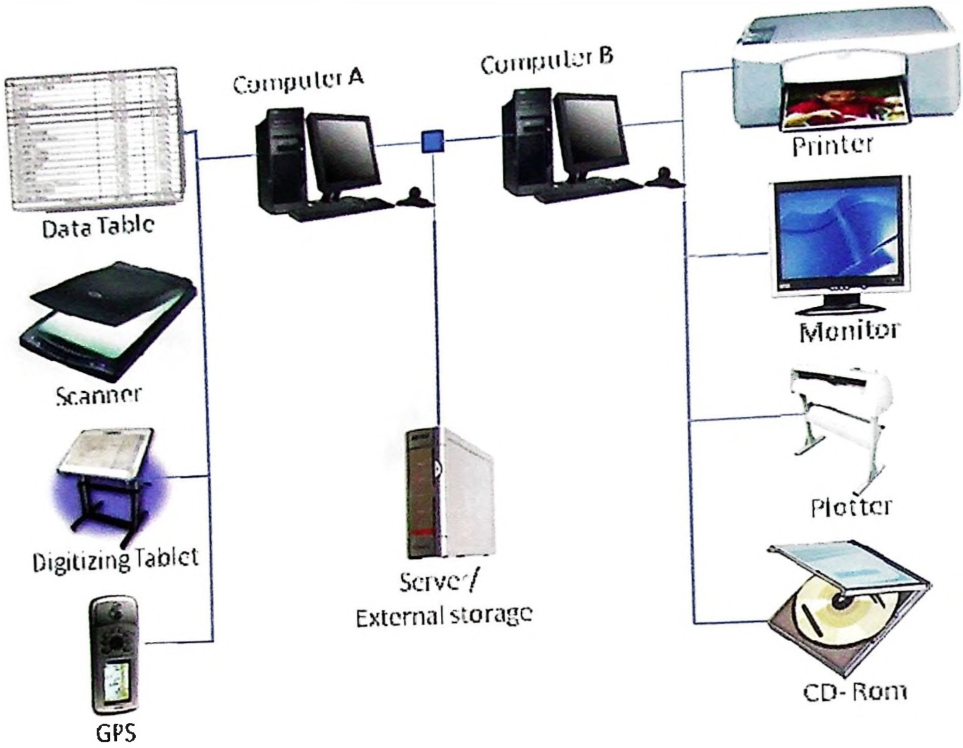


Figure 1.1: Flow chart of the GIS components

1.1.4. GIS Views

One of the strongest features of GIS is that it combines a powerful visualization environment with a strong analytic and modeling framework that is rooted in the science of geography. To support this advantage, GIS needs to support three views for working with geographic information: Geodatabase, Geovisulization and Geoprocessing, Figure 1.2.

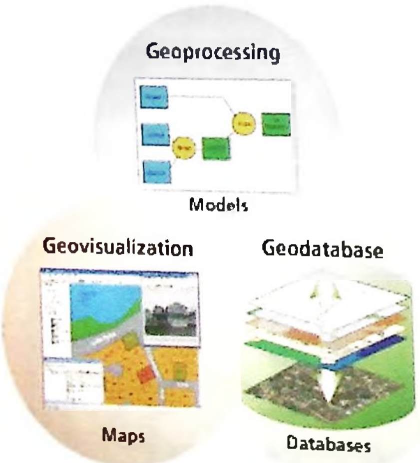
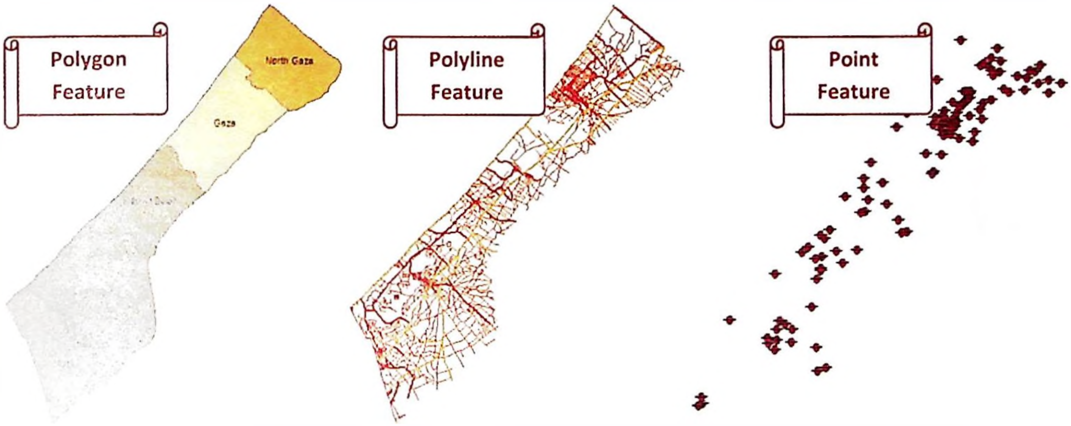


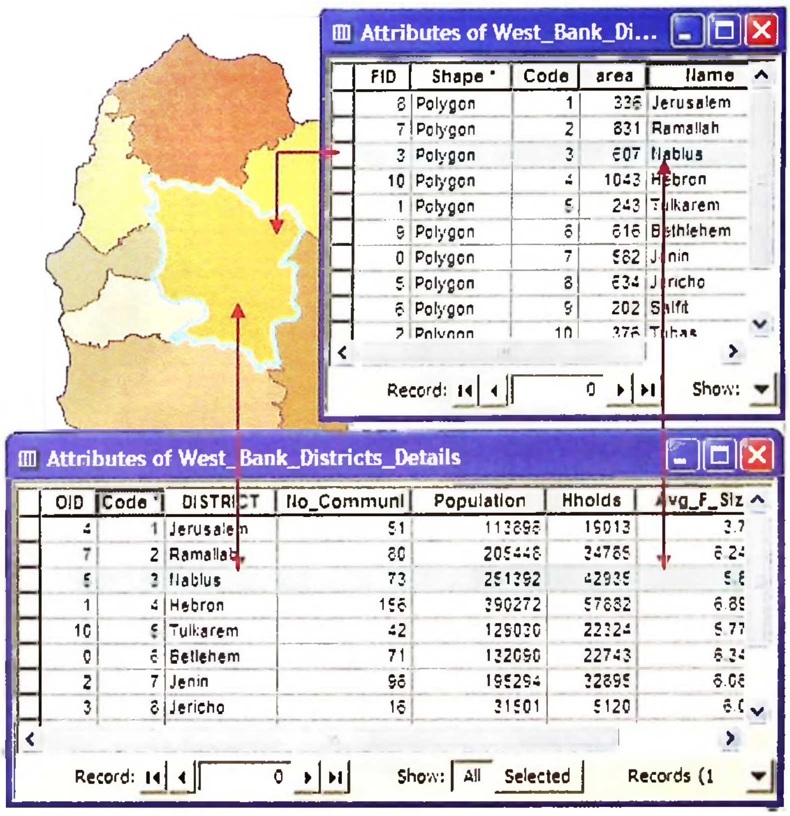
Figure 1.2: Three views of GIS used for working with elements of geographic information

1.1.4.1. Geodatabase View

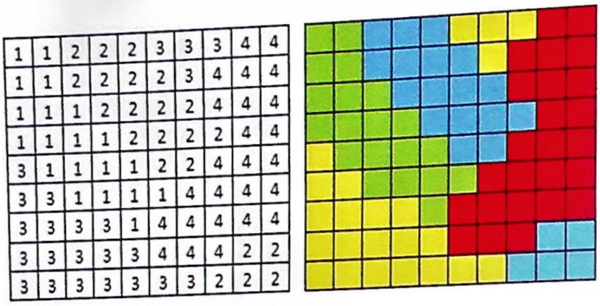
Geographic information can be represented by different types of spatial datasets including feature datasets, raster imagery, attribute tables and so on. GIS provides the ability to store different types of datasets that can be easily accessed, managed and manipulated, Figure 1.3.



(a) Feature classes



(b) Attribute tables



Cell	Property	Cell Color
1	Trees	Green
2	Crops	Blue
3	Sand	Yallow
4	Forst	Red

(c) Raster dataset

Figure 1.3: Different types of GIS datasets

1.1.4.2. Geovisualization View

GIS is a set of intelligent maps and views that illustrates features and feature relationships on the Earth's surface. Various map views of the underlying geographic information can be constructed and used as "windows into the database" to support queries, analysis, and editing of the information, Figures 1.4 & 1.5.

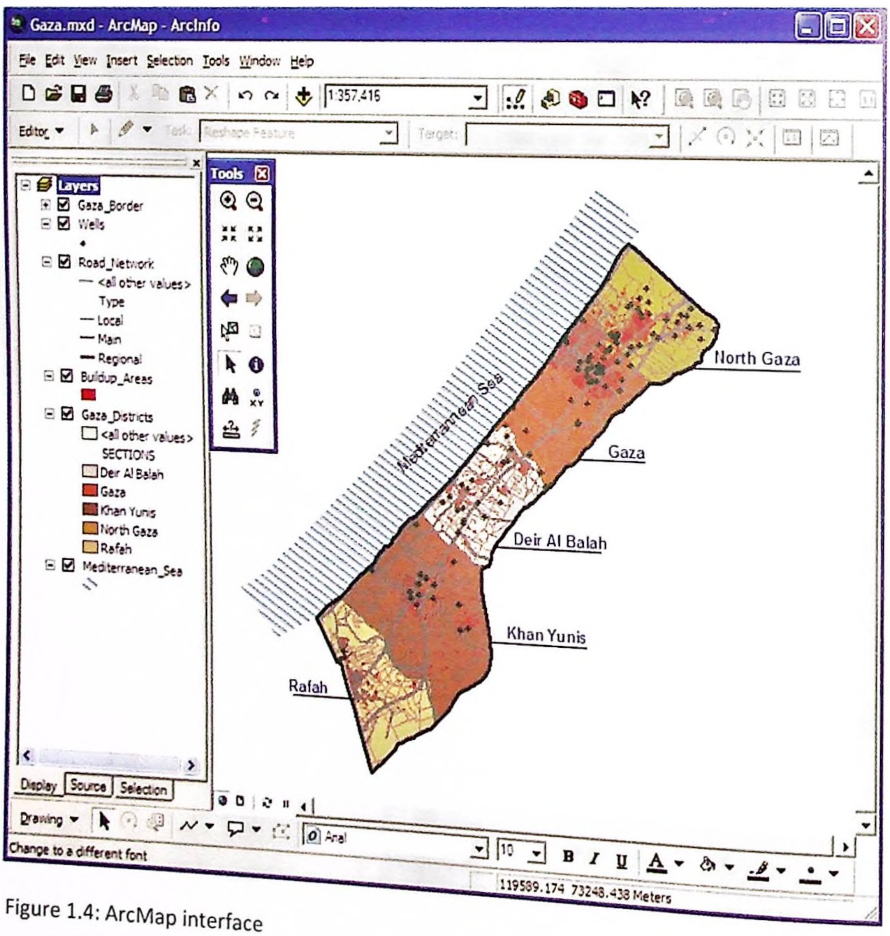


Figure 1.4: ArcMap interface

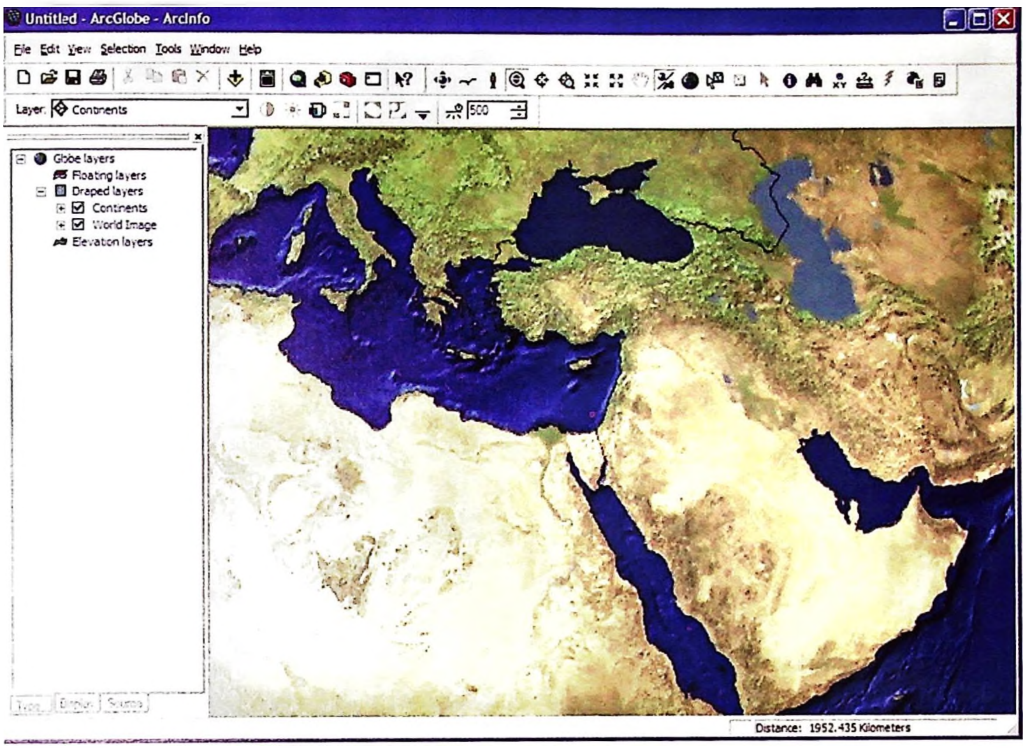


Figure 1.5: ArcGlobe interface

GIS maps are characterized by:

1. Multiscale maps: that can automatically display information at the appropriate level of detail by zooming in and out on the map; from a global view down to a street level or city-block view.
2. Interactive maps: since the user can work with information ad hoc and add new layers of information as they become available.
3. A GIS map has a set of tools as part of the user interface that allows users to work with its contents. Capabilities can vary from common map query and identification tasks, to advanced geographic analysis tasks.
4. GIS maps come in many applications and map sizes and can be deployed as Web maps, 3D maps, specialized map applications, and mobile maps in the field.

1.1.4.3. Geoprocessing View

GIS is rich with information transformation tools that derive new information from existing datasets. These geoprocessing functions take information from existing datasets, apply analytic functions, and write results into newly derived datasets.

Geoprocessing is the methodical execution of a sequence of operations on geographic data to create new information. This can range from performing simple tasks such as converting a number of files from one format to another to create a sophisticated analytical model that helps the user understand and solve important scientific problems, Figure 1.6.

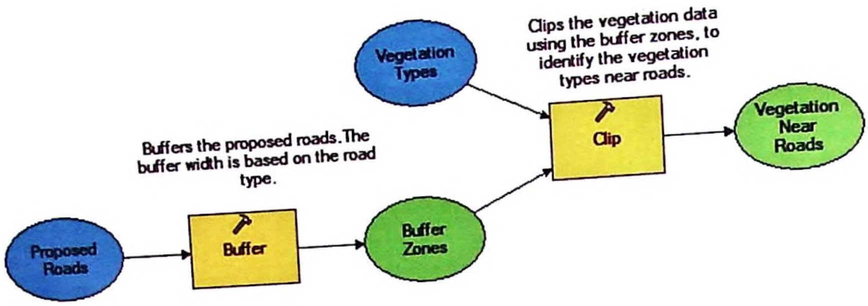


Figure 1.6: Sophisticated analytical model

1.1.5. GIS Software

There are many GIS software packages available in the market. The selection of any of these software packages depends on the budget available, purpose and level of user expertise. Some of the GIS software packages used in Palestine are:

1.1.5.1. ArcGIS

ArcGIS is the most widespread GIS software in Palestine. It is a comprehensive, integrated, scalable system designed to meet the needs of a wide range of GIS users. ArcGIS was developed and distributed by the Environmental Systems Research Institute, Inc. in Redlands, California. It is an integrated collection of GIS software products for building and deploying a complete GIS package wherever it is needed, on desktops, servers, in custom applications over the Web; or in the field.

1.1.5.2. GeoMedia

GeoMedia is a product of Intergraph, Inc. in Huntsville, Alabama. GeoMedia offers a complete set of data entry, analysis, and output tools. A comprehensive set of editing tools may be purchased, including those for automated data entry and error detection, data development, data merging, complex analyses, and sophisticated data display and map composition. Scripting languages may be obtained, as well as programming tools that allow specific features to be embedded in custom programs, and programming libraries to allow the modification of GeoMedia algorithms for special-purpose software.
GeoMedia also provides a comprehensive set of tools for GIS analyses. Complex spatial analyses may be performed, including queries, e.g., to find features in the database that match a set of conditions, and spatial analyses such as proximity or overlap between features. Worldwide web and mobile phone-based applications and application development are well supported.

1.1.5.3. MapInfo

MapInfo is a comprehensive set of GIS products developed and sold by the Map-Info Corporation in Troy, New York. MapInfo was one of the first companies to bring the power of GIS to the Windows environment. Easy to use and powerful, MapInfo has held the lead in the business desktop market. MapInfo offers comprehensive solutions for business and commercial analysis applications including site location, customer analysis, telecommunications, and real estate. MapInfo has also found a footing in natural resource applications such as mining and forestry. MapInfo continues to advance the capabilities of the desktop GIS environment and is now offering complete enterprise solutions

1.1.5.4. IDRISI

IDRISI is a GIS system developed by the Graduate School of Geography of Clark University in Massachusetts. IDRISI differs from the previously discussed GIS software packages in that it provides both image processing and GIS functions. IDRISI offers the functionality on image data collection, manipulation, and output in addition to providing a large suite of spatial data analysis and display functions. It is relatively low in cost, perhaps because of its affiliation with an academic institution, and is therefore widely used in education.

1.1.5.5. ERDAS

ERDAS (Earth Resources Data Analysis System) primarily began as an image processing system. The original purpose of the software was to enter and analyze satellite image data. ERDAS led a wave of commercial products for analyzing spatial data collected over large areas. Product development was spurred by the successful launch of the U.S. Landsat satellite in the 1970s. For the first time, digital images of the entire Earth surface were available to the public.

The ERDAS image processing software evolved to include other types of imagery, and to include a comprehensive set of tools for cell-based data analysis. In addition to that, ERDAS provides data output formats that are compatible with the most common GIS packages.

1.1.5.6. AutoCAD Map

AutoCAD was produced by Autodesk, Inc. in San Rafael, California and began as a drawing and printing tool mainly used by engineers supporting a broad range of disciplines including surveying and civil engineering. AutoCAD Map has a substantial analytical capability of the already complete set of data input, coordinate manipulation, and data output tools. It also provides a substantial set of spatial data analysis capabilities including entry, verification, and output. Data may also be queried to search for features with particular conditions or characteristics.

1.1.5.7. TNTmips

TNTmips is one of the main MicroImage products for geospatial analysis. TNTmips is used for geographic information analysis (GIS), advanced image processing (CAD), desktop cartography, electronic atlas preparation, and other spatial database management and visualization applications.

1.1.5.8. GRASS

GRASS is short for Geographic Resources Analysis Support System. It is an all in one raster-based GIS, vector GIS, image processing, graphics production, data management, and spatial modeling system. Also described as a public domain image processing and GIS system that was initially developed by the U.S. Army Construction Engineering Research Laboratories (USACERL) during the late 1980's and early 1990's.

1.2 ArcGIS Frameworks

ArcGIS provides a scalable framework for implementing GIS for a single user or many users on desktops, in servers, over the Web, and in the field. ArcGIS is an integrated family of GIS software products for building a complete system. It consists of four primary frameworks for deploying GIS, Figure 1.7:

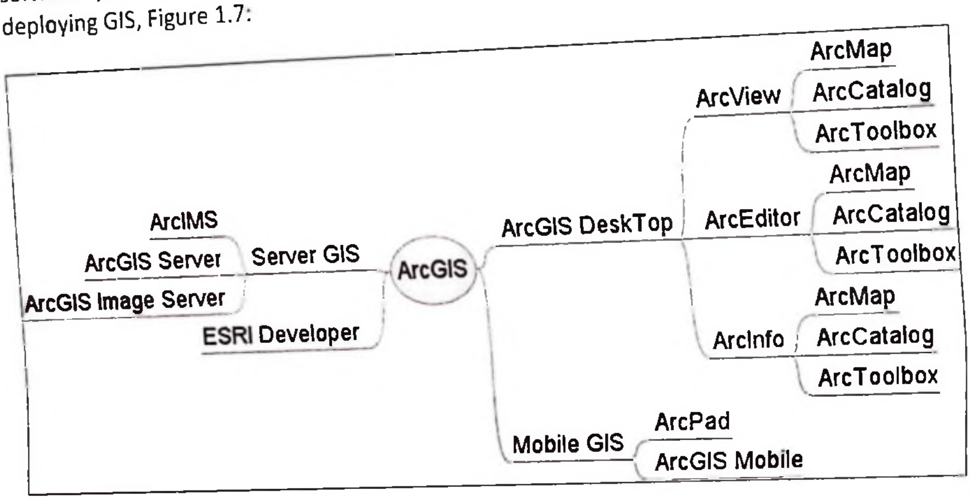


Figure 1.7: ArcGIS software packages

1.1.5.9. ArcGIS Desktop

ArcGIS Desktop is the primary application used by GIS professionals to compile, author, and use geographic information and knowledge. It is available at three functional levels; ArcView, ArcEditor, and ArcInfo. ArcGIS Desktop includes an integrated suite of comprehensive desktop applications: ArcMap, ArcCatalog ArcToolbox, and ArcGlobe. Each application has a rich set of GIS tools and operators. ArcGIS Desktop can also be extended by purchasing a wide range of optional extensions that add specialized capabilities, for example:

- The Spatial Analyst extension adds raster geoprocessing and modeling.
- The 3D Analyst extension adds many 3D GIS capabilities and visualization applications.

1.1.5.10. Server GIS

Server GIS provides the basis for building an integrated, multi-departmental system for collecting, organizing, analyzing, visualizing, managing, and disseminating geographic information. Server GIS solutions are intended to address both the collective and individual needs of an organization and to make geographic information and services available to both GIS and non-GIS professionals. ArcGIS includes three server products:

ArcIMS: A scalable Web mapping server for publishing maps, data, and metadata using open Internet protocols. ArcIMS is deployed in tens of thousands of organizations and is used primarily for GIS Web publishing, delivering data and map services to many users of the Web, and hosting metadata catalog portals on the Web.

ArcGIS Server: A comprehensive Web-based GIS that provides a range of end user applications and services for mapping, analysis, data collection, editing, and management of spatial information. ArcGIS Server provides a cost-effective, standards-based platform upon which ArcGIS Desktop users can easily publish and serve their geographic knowledge to the broader organization. ArcGIS Server also includes the ArcSDE data management technology for managing multiuser, transactional geodatabases using a number of relational database management systems.

ArcGIS Image Server: ArcGIS Image Server provides very fast access to large image collections and significantly reduces the time between image acquisition and use. ArcGIS Image Server can create multiple products dynamically as a Web service and supports image access by a range of client applications.

1.1.5.11. Mobile GIS

Wireless mobile devices enabled with global positioning systems (GPS) are used for focused data collection, map use, and GIS access in the field. Firefighters, waste collectors, engineering crews, surveyors, utility workers, soldiers, census workers, police, and field biologists represent a few types of field workers who use Mobile GIS as a tool. ArcGIS provides a comprehensive suite of Mobile GIS products that are designed for different applications and platform requirements. These include:

ArcPad: provides a rich environment for the GIS-centric field worker on Windows CE-compatible devices.
ArcGIS Mobile: a software development kit used to create and deploy focused mobile applications for Smartphones, Pocket PCs, and Tablet PCs. These applications support wireless synchronization with ArcGIS Server, GIS data replication, and editing.

Figure 1.8: Different examples of mobile devices that use GIS

1.1.5.12. Developer Network

The ESRI Developer Network (EDN) is a developer product that provides a comprehensive system for developing applications with ArcGIS. EDN provides a unified programming environment and tools that enable developers to:

1. Embed GIS and mapping functionality in other applications.
2. Build and deploy custom ArcGIS Desktop applications and extensions.
3. Configure and customize ArcGIS products, such as ArcView, ArcEditor, and ArcInfo.
4. Extend the ArcGIS architecture and data model.
5. Write custom applications using ArcGIS Engine.
6. Build Web services and server-based applications using ArcGIS Server and ArcIMS.

1.3 Desktop GIS: ArcView, ArcEditor, and ArcInfo

ArcGIS Desktop is the primary platform for GIS professionals to manage their complex GIS workflows and projects and to build data, maps, models, and applications. It's the starting point and the foundation to perform and deploy GIS across organizations. ArcGIS Desktop includes a suite of applications including ArcCatalog, ArcMap, ArcToolbox, and ModelBuilder. Using these applications and interfaces in unison, users can perform any GIS task, from simple to advanced. ArcGIS Desktop is scalable and can address the needs of many types of users. It is available at three functional levels:

1. ArcView: provides comprehensive mapping, data use, analysis, and visualization tools along with simple editing and geoprocessing.
2. ArcEditor: includes advanced editing capabilities for shapefiles and geodatabases in addition to the full functionality of ArcView. ArcEditor also includes the ability to administer and use ArcSDE geodatabases in Microsoft SQL Server Express.
3. ArcInfo is a complete, professional GIS desktop containing comprehensive GIS functionality, including rich geoprocessing tools.

1.1.5.13. ArcMap

The main application tool in ArcGIS is ArcMap, which is used for all mapping and editing tasks as well as for map-based query and analysis. It's the primary application for all map based tasks including cartography, map analysis, and editing. ArcMap is a comprehensive map authoring application for ArcGIS Desktop.

ArcMap represents geographic information as a collection of layers and other elements in a map view, Figure 1.9. Common map elements include the data frame containing map layers for a given extent, plus a scale bar, north arrow, title, descriptive text, and a symbol legend Figure 1.10.

There are two primary map display panels in ArcMap: the data frame and the layout view. The data frame provides a geographic "window" or map frame in which you can display and work with geographic information as a series of map layers. The layout view provides a page view where map elements (such as one or more data frames, a scale bar, and a map title) are arranged on a page.

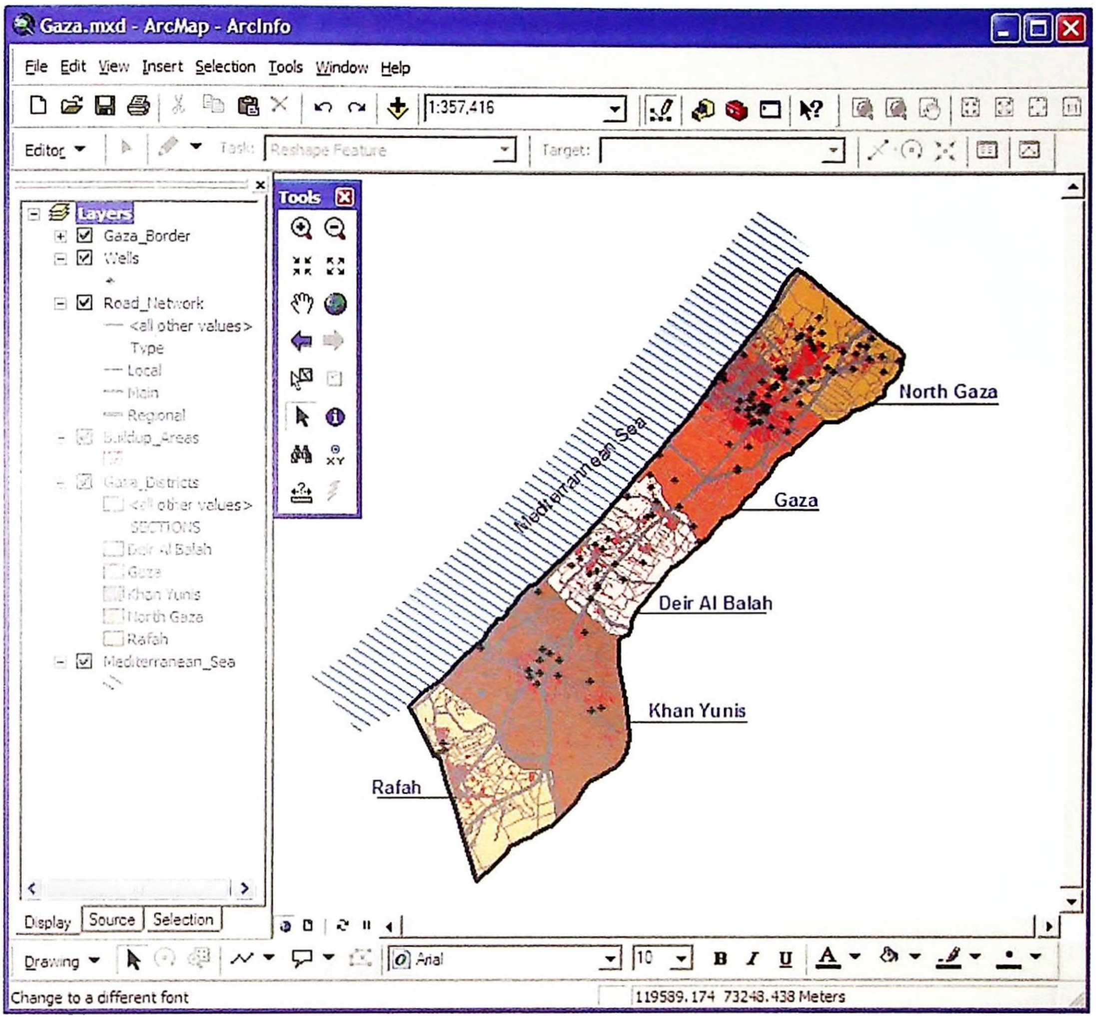


Figure 1.9: Data frame in an ArcMap interface

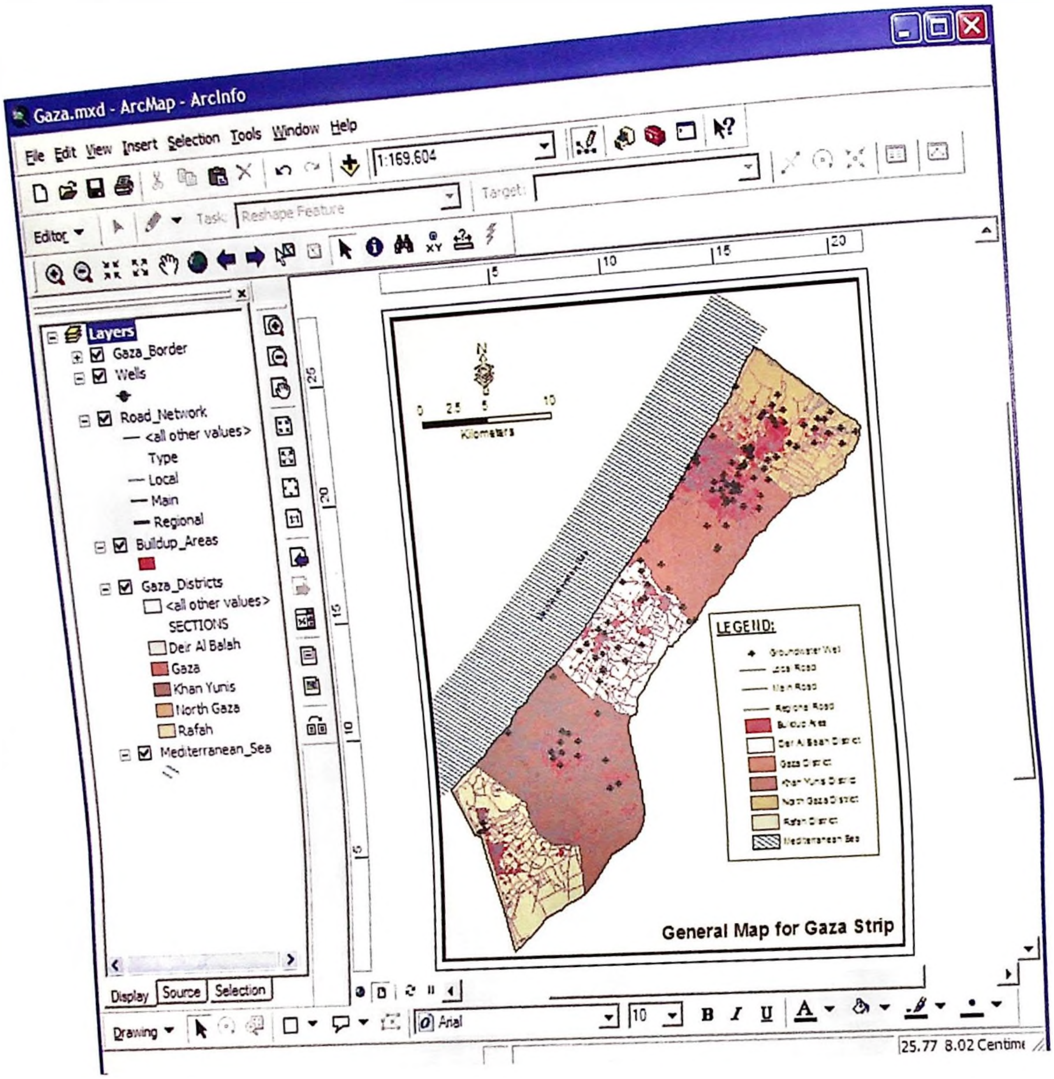


Figure 1.10: Layout frame in an ArcMap interface

1.1.5.14. ArcCatalog

The ArcCatalog application helps users organize and manage all geographic information, such as maps, globes, data files, geodatabases, geoprocessing toolboxes, metadata, and GIS services. It includes tools to:

1. Browse and find geographic information.
2. Record, view, and manage metadata.
3. Define, export, and import geodatabase data models.
4. Search for and discover GIS data on local networks and the Web.
5. Administer and manage ArcSDE geodatabases running in SQL Server Express.
6. Administer and manage file and personal geodatabases.
7. Administer and manage a series of GIS services.

Users can employ ArcCatalog to find, organize, and use GIS data as well as to document data holdings using standards-based metadata. A GIS database administrator uses ArcCatalog to define and build geodatabases. A GIS server administrator uses ArcCatalog to administer the ArcGIS server framework. ArcCatalog has three main views:

1. The contents window: is used to present geographic data and their details for the folder selected from the ArcCatalog tree, Figure 1.11.
2. The preview window: illustrates the geography or attribute table for any selected shapefile, Figure 1.12.
3. The metadata window: illustrates a detailed description about geographic data such as source of data, ownership, creation date, purpose, etc., Figure 1.13.

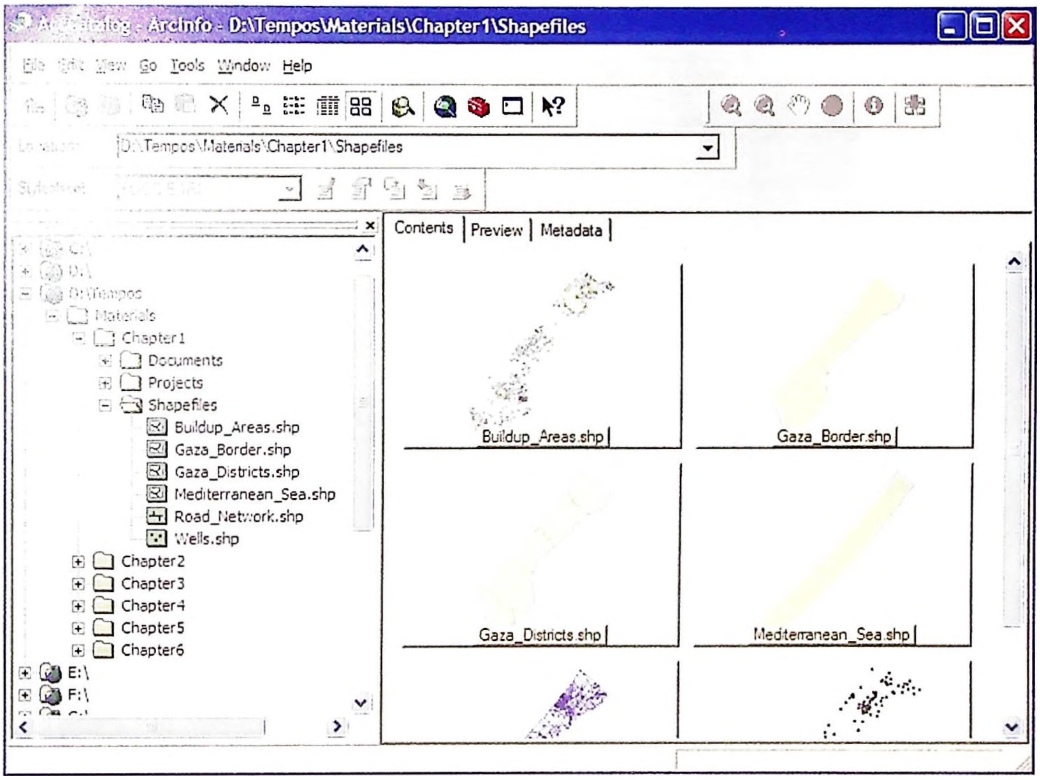


Figure 1.11: ArcCatalog interface, Contents window

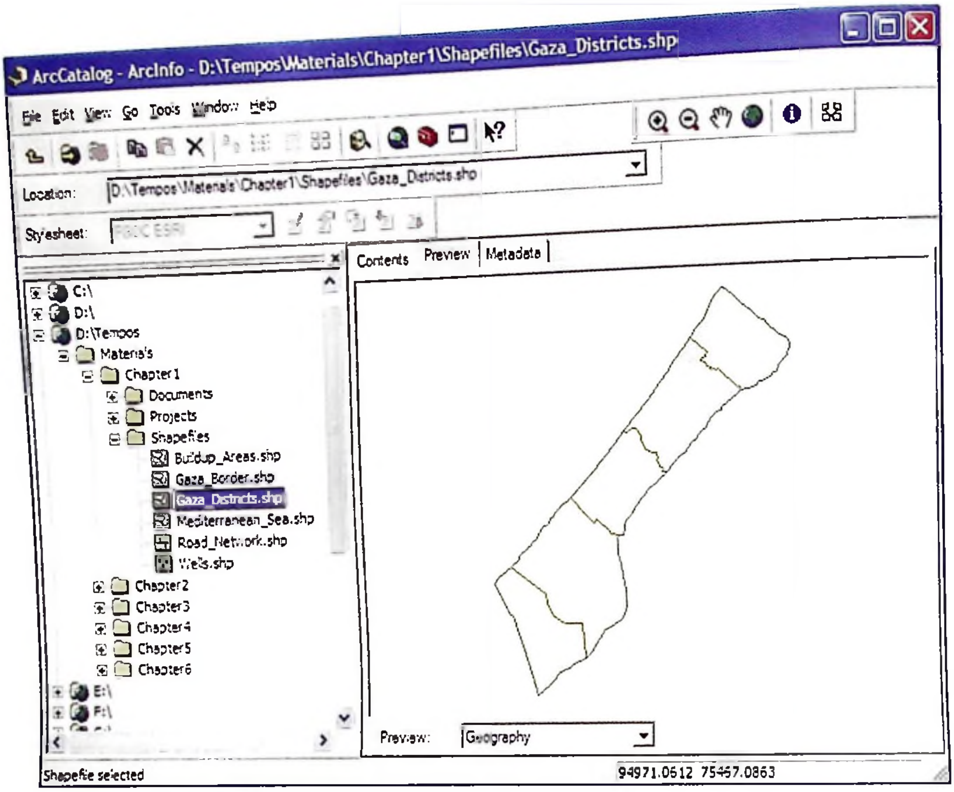


Figure 1.12: ArcCatalog interface, Preview window

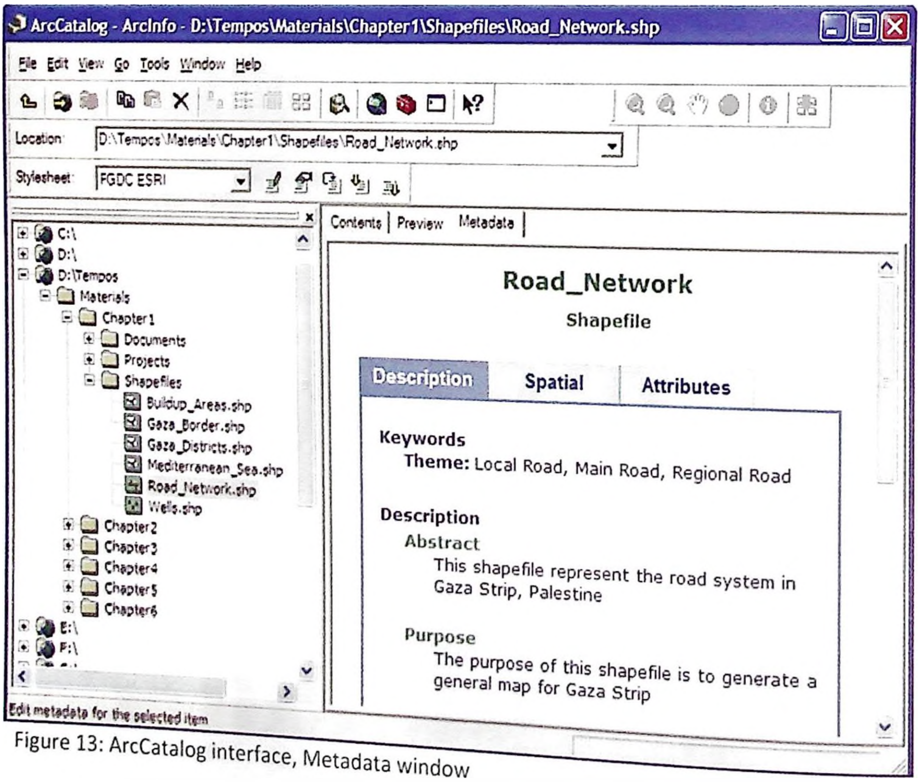


Figure 13: ArcCatalog interface, Metadata window

1.1.5.15. Geoprocessing in ArcGIS Desktop

Almost all applications of GIS involve the repetition of work, which generates the need for methods to automate, document, and share multistep procedures known as workflows. Geoprocessing supports the automation of workflows by providing a rich set of tools and a mechanism to combine a series of tools in a sequence of operations using models and scripts.

Geoprocessing is based on a framework of data transformation. A typical geoprocessing tool performs an operation on an ArcGIS dataset (such as a feature class, raster, or table) and produces a new dataset as the result of the tool. Each geoprocessing tool performs a small yet essential operation on geographic data, such as projecting a dataset from one map projection to another, adding a field to a table, or creating a buffer zone around features.

ArcGIS includes hundreds of such geoprocessing tools. Geoprocessing allows the user to chain sequences of tools, feeding the output of one tool into another. The user can take advantage of this option to compose a variety of geoprocessing models (tool sequences) that help the user automate the work, perform analysis, and solve complex problems. ArcGIS Desktop provides a geoprocessing framework. This framework facilitates the creation, use, documentation, and sharing of geoprocessing models. The two main parts of the geoprocessing framework include:

1. ArcToolbox: an organized collection of geoprocessing tools, Figure 1.14.

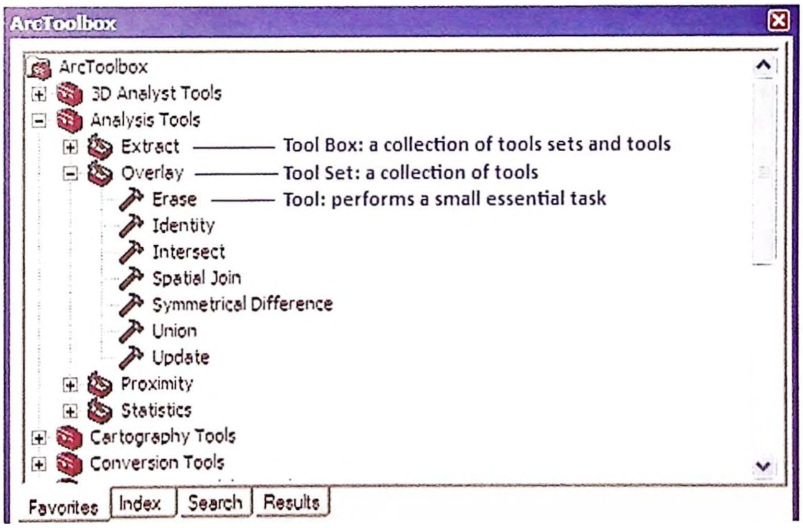


Figure 1.14: Interface of ArcToolbox

2. ModelBuilder: provides a graphical modeling framework for designing and implementing geoprocessing models that can include tools, scripts, and data. Users can drag tools and datasets onto a model and connect them to create an ordered sequence of steps to perform complex GIS tasks. ModelBuilder provides an interactive mechanism for building and executing complex GIS procedures, Figure 1.15.

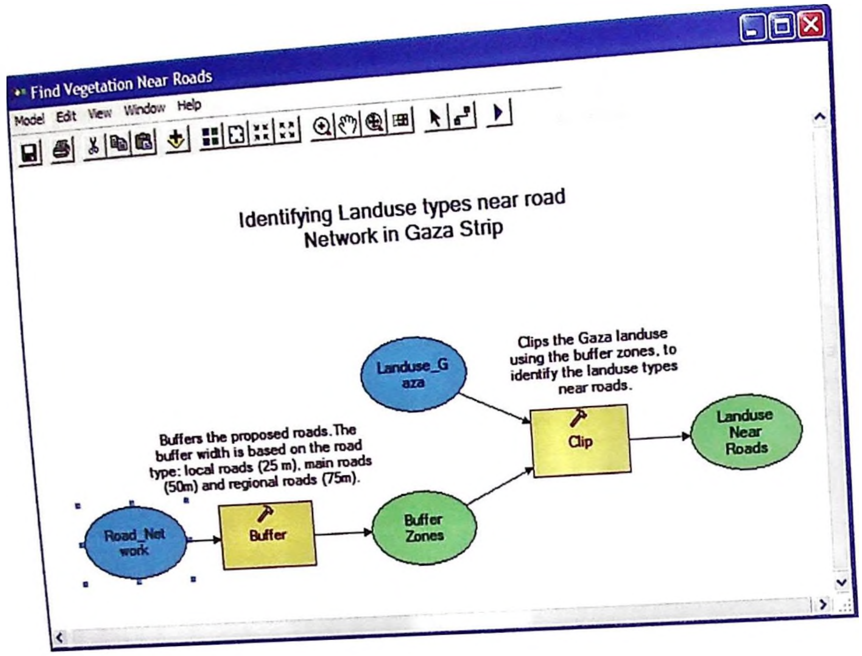


Figure 1.15: ModelBuilder interface

Geoprocessing is included in ArcView, ArcEditor, and ArcInfo. Each product level includes additional geoprocessing tools:

- ArcView supports a core set of simple data loading and translation tools as well as fundamental analysis tools.
- ArcEditor adds a number of tools for geodatabase creation, loading, and schema management.
- ArcInfo provides a comprehensive set of tools for vector analysis, data conversion, data loading, and coverage geoprocessing.

1.4 Getting Started with ArcGIS Desktop

1.4.1 Practicing ArcMap

This exercise is prepared for exploring a database built for Tulkarem Governorate. Boundaries, roads network, locations of dump sites and groundwater wells will be illustrated using ArcMap. You will create a map showing the locations of groundwater wells that are close to the solid waste dump sites in the Governorate in order to define those subject to potential contamination. A one kilometer buffer zone was defined for each dump site, which encompasses areas with possible sources of pollution. Therefore, wells located in these zones should be monitored to avoid abstracting contaminated water.

The material for this exercise can be found on "C:\GIS_Tutorial\Chapter1\", to do this exercise, it is recommended to copy the material into another temporary folder.

1.4.1.1 Starting ArcMap

1. Click the Start button on the Windows taskbar.
2. Click Programs
3. Go to ArcGIS then click ArcMap, Figure 1.16.

Figure 1.16: Opening ArcMap

1.4.1.2 Opening an Existing Map Document

By starting ArcMap, the Startup dialog box appears. The Startup dialog box offers several options for starting an ArcMap session. For this exercise, an existing map document will be opened.

1. Double-click Browse for maps, and then click OK. The Open dialog box will appear, Figure 1.17.

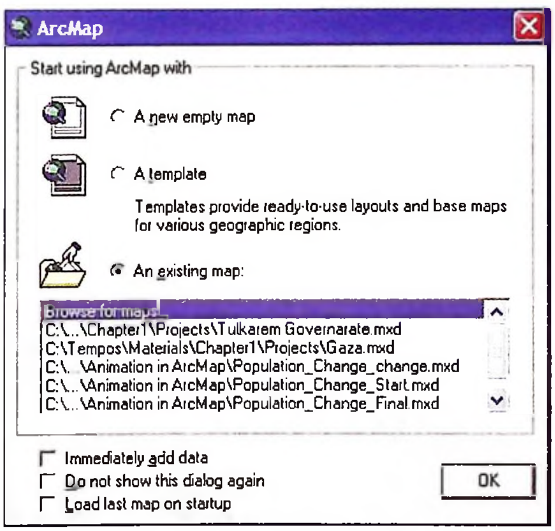


Figure 1.17: Dialog box for opening an ArcMap document

2. In the dialog box, click the Look in: dropdown arrow, and navigate to the project folder on "C:\GIS_Tutorial\Chapter1\".

3. Double-click Tulkarem Governorate.mxd. ArcMap then opens the map, Figure 1.18.

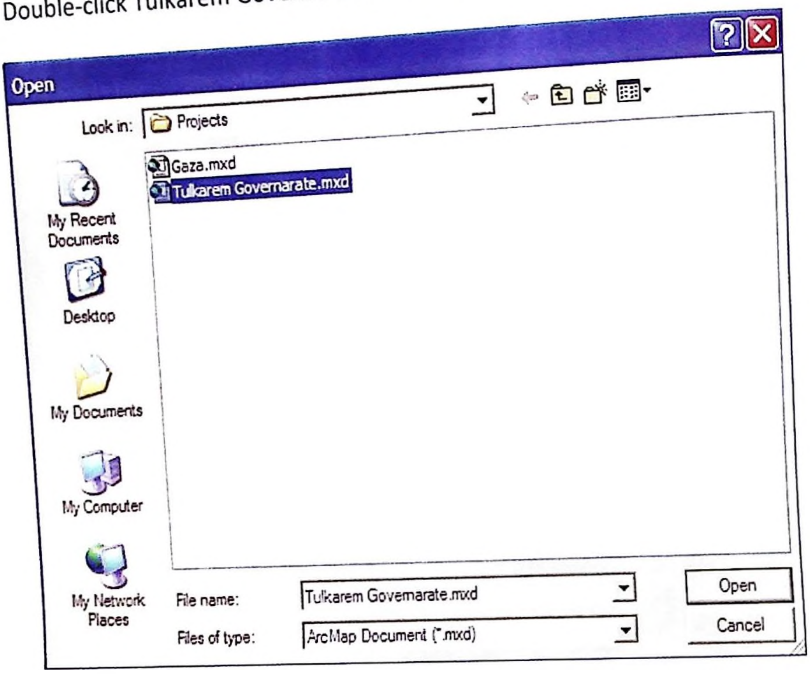


Figure 1.18: Opening an existing project

ArcMap stores a map as a map document (.mxd) enabling the user to redisplay, modify, or share it with other ArcMap users. The map document does not store the actual data, but rather references the data stored on disk along with information about how it should be displayed. The map document also stores other information about the map, such as its size and the map elements it includes (title, scale bar, and so on).

To the left of the ArcMap display window is the table of contents, showing you which geographic layers are available for display. To the right is the map display area, Figure 1.19. This particular map contains the following layers (shapefiles) in a data frame called "Tulkarem":

1. Tulkarem Dump Sites: location of dump sites in Tulkarem Governorate.
2. Wells: location of groundwater wells in Tulkarem Governorate.
3. Tulkarem Roads: Road network
4. Dumping Sites_1km buffer: a one kilometer buffer around the dump sites.
5. Tulkarem District: boundary of Tulkarem Governorate.

The map currently displays all shapefiles. Their boxes are checked in the table of contents.

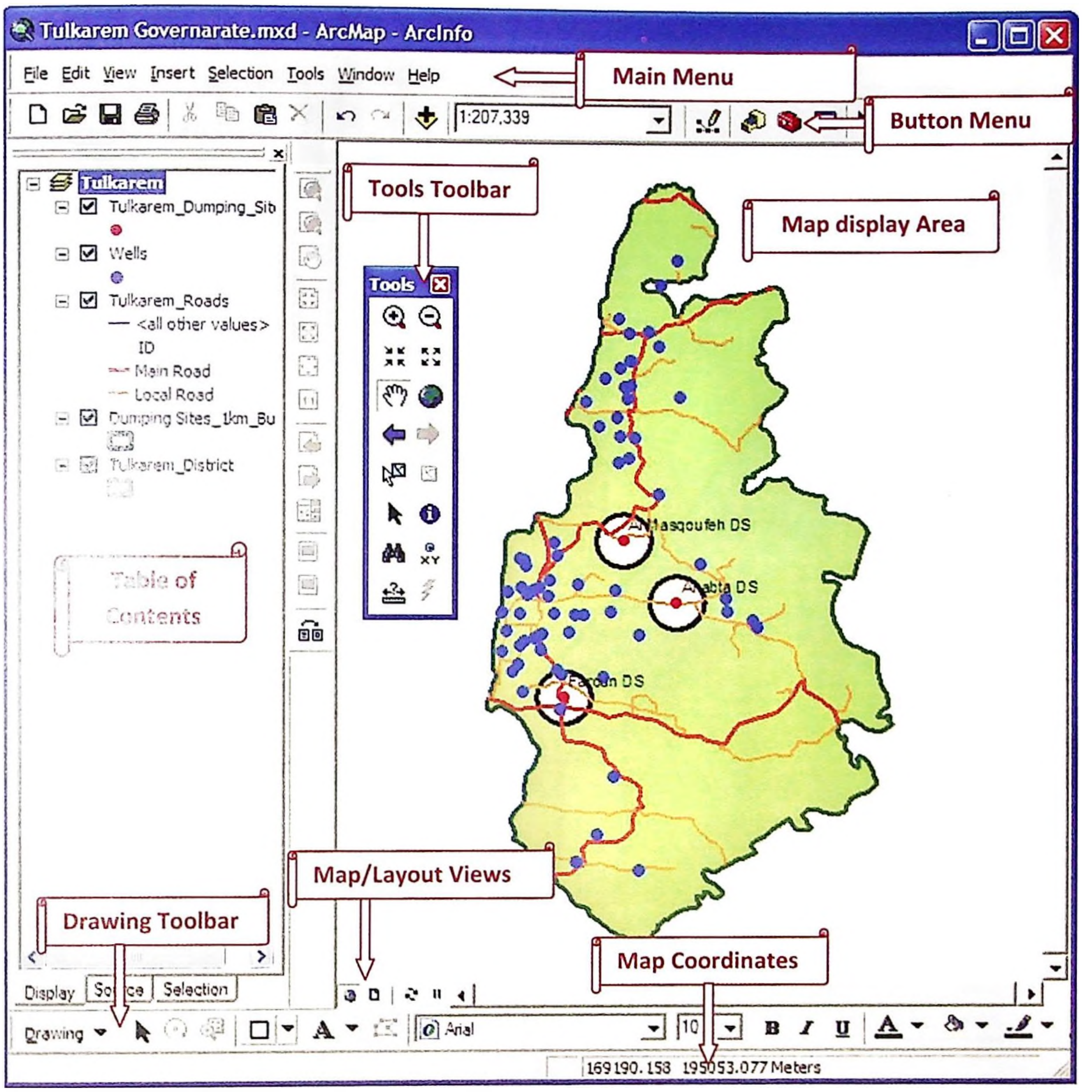


Figure 1.19: Main interface components of ArcMap

1.4.1.3 Moving Around the Map

The Tools toolbar enables the user to move around the map and query its features. Place your pointer over each icon (without clicking) to view a description of each tool, Figure 1.20. For example, to closely view Faroun DS, you can zoom in using the Zoom In tool. Place the pointer on the upper-left part of the contour, press the mouse button, and hold it down while dragging to the lower right corner. A box is drawn on the screen. When the mouse button is released, ArcMap zooms in to the area defined by the box, Figure 1.21.

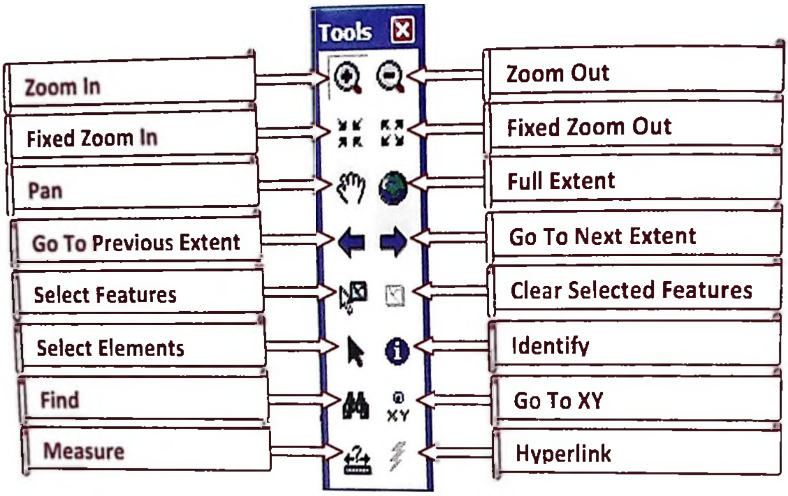


Figure 1.20: Components of the Tools toolbar.

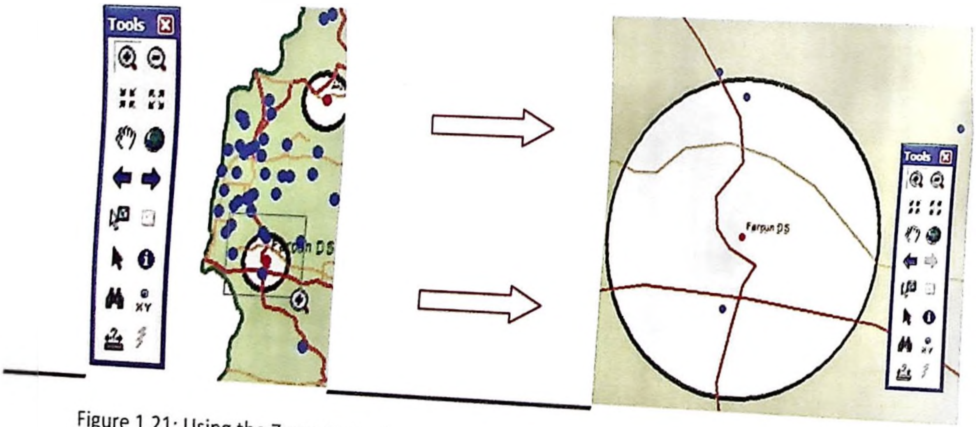


Figure 1.21: Using the Zoom In tool.

1.4.1.4 Displaying a Layer

The table of contents lets you turn layers on and off in the display. To display a layer, check the box next to its name. To turn it off, uncheck it. Display the Tulkarem_Roads by checking its box in the table of contents, Figure 1.22.

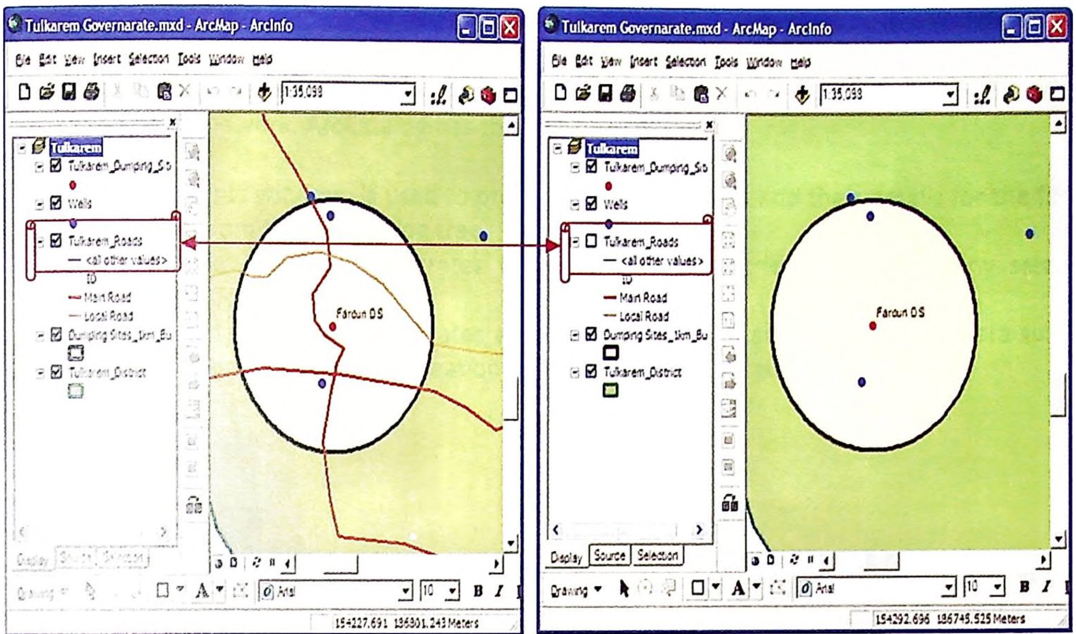


Figure 1.22: Turning off a layer

1.4.1.5 Changing the Display Symbol

ArcMap gives you the option of changing the colors and symbols of display features. To change the symbols of the Wells from a dot to a standard symbol:

1. Click on the dot symbol in the table of contents to display the Symbol Selector window.
2. Scroll down until the Well, Drilled, Public symbol is found, and then click it.
3. Click OK. The Wells are then plotted with the new symbol.

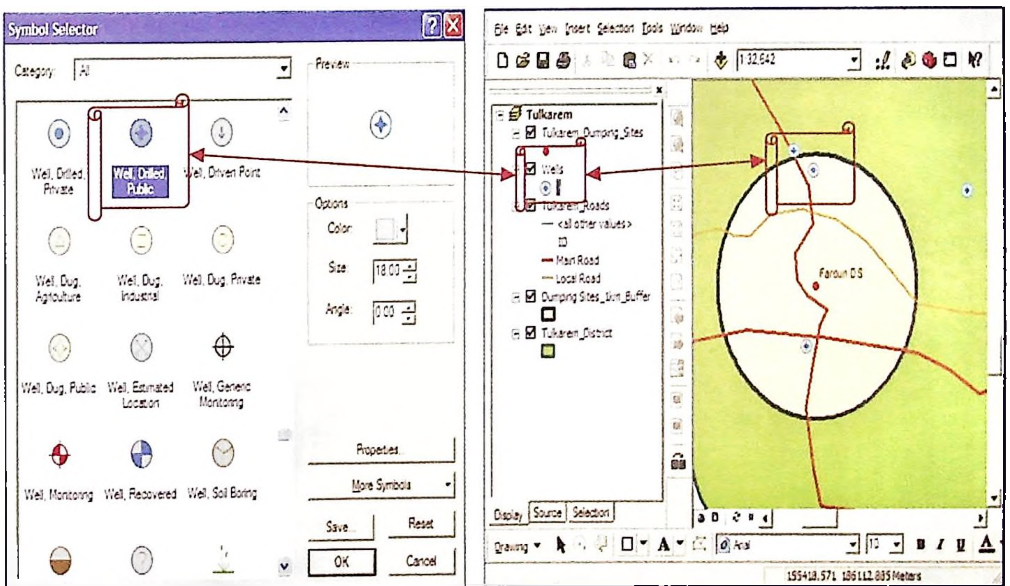


Figure 1:23: Changing a symbol feature

1.4.1.6 Identifying a Feature

There are two wells located in the buffer zone around Faroun dump site.

1. Click the Identify tool on the Tools toolbar. The Identify window appears, Figure 1.24.
2. Move the pointer over one of the wells within the buffer zone and click. The name of the well (Wasfi Abed Al Kareem), well ID and other well details are listed in the Identify window.

Note, that only the features in the topmost layer are identified. The user can also identify features in other layers by choosing the specific layers desired by clicking the Layers dropdown arrow in the dialog box.

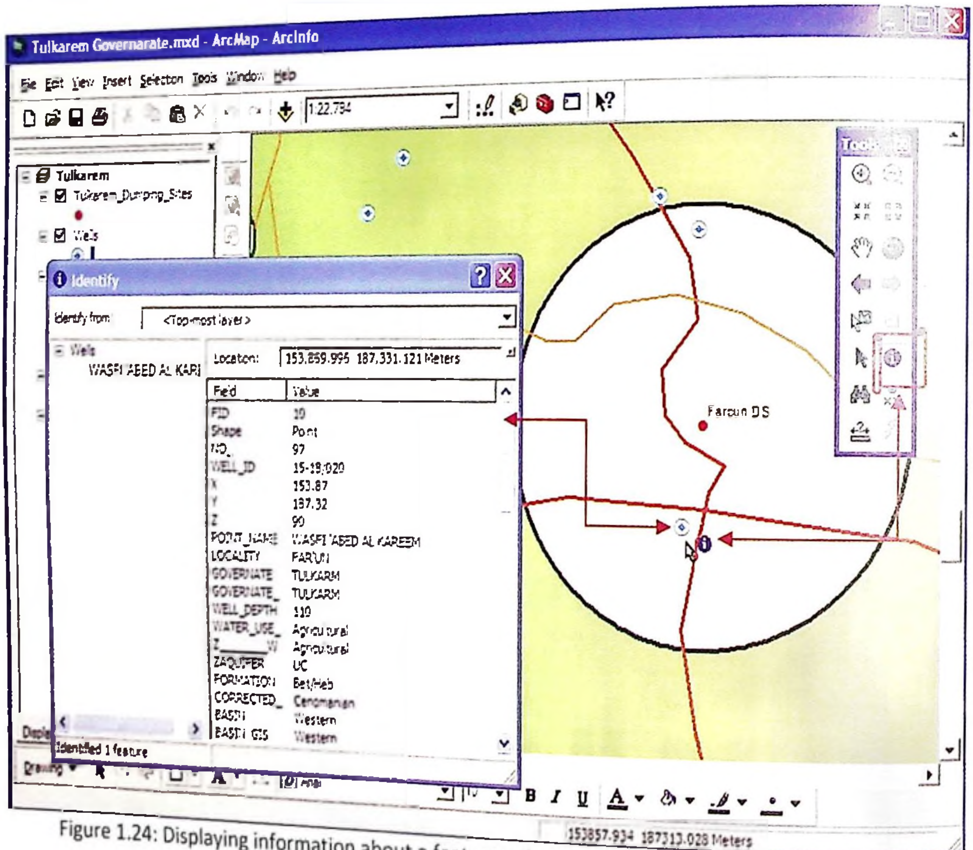


Figure 1.24: Displaying information about a feature using the Identify tool.

1.4.1.7 Adding Graphics

You can add text and other graphics to your display using the Draw toolbar at the bottom of the ArcMap window, Figure 1.25:

1. Click the New Text button. The pointer changes to a crosshair with an A.
2. Move the pointer near the well you identified and click.
3. In the text box that appears, type "Wasfi Abed Al Kareem", and press Enter. A blue dotted line surrounds the text, indicating that it is currently selected. You can drag the

text to a new position by clicking and holding down the mouse button while dragging the text, then releasing the button.

4. When you are finished positioning the text near the well, click outside the text box to deselect it.

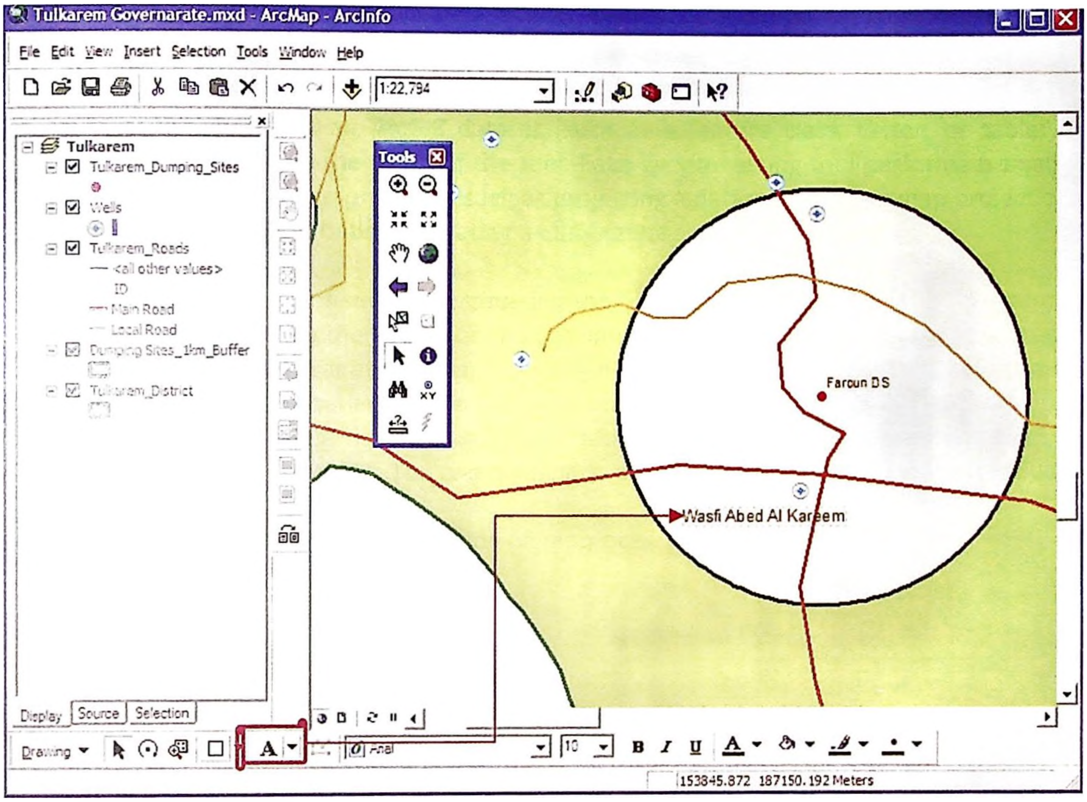


Figure 1.25: Adding graphics to a map

1.4.1.8 Laying Out a Map

In ArcMap you can work in either the data view or layout view. The data view focuses on a single data frame while the layout view shows you what the map page looks like. The layout view is used for composing and printing a map for display. The user can also explore and edit data in the layout view or change the size and orientation of the page.

1. Click the Zoom to Full Extend button on the Tools toolbar to view the entire map.
2. Click the View menu and then choose Layout View. The Layout toolbar appears, and the display changes to show the page layout with rulers along the sides, Figure 1.26.
3. Right-click anywhere on the layout background and click Page and Print Setup, you can also access Page and Print Setup from the File menu.
4. Make sure the Use Printer Paper Settings box is not checked; otherwise, the page size will default to be the same as that of your printer.
5. Check Scale Map Elements proportionally to changes in Page Size. That way, the data will be rescaled to fit the page.
6. Select the A4 page size from the Standard Sizes dropdown list, Figure 1.27.

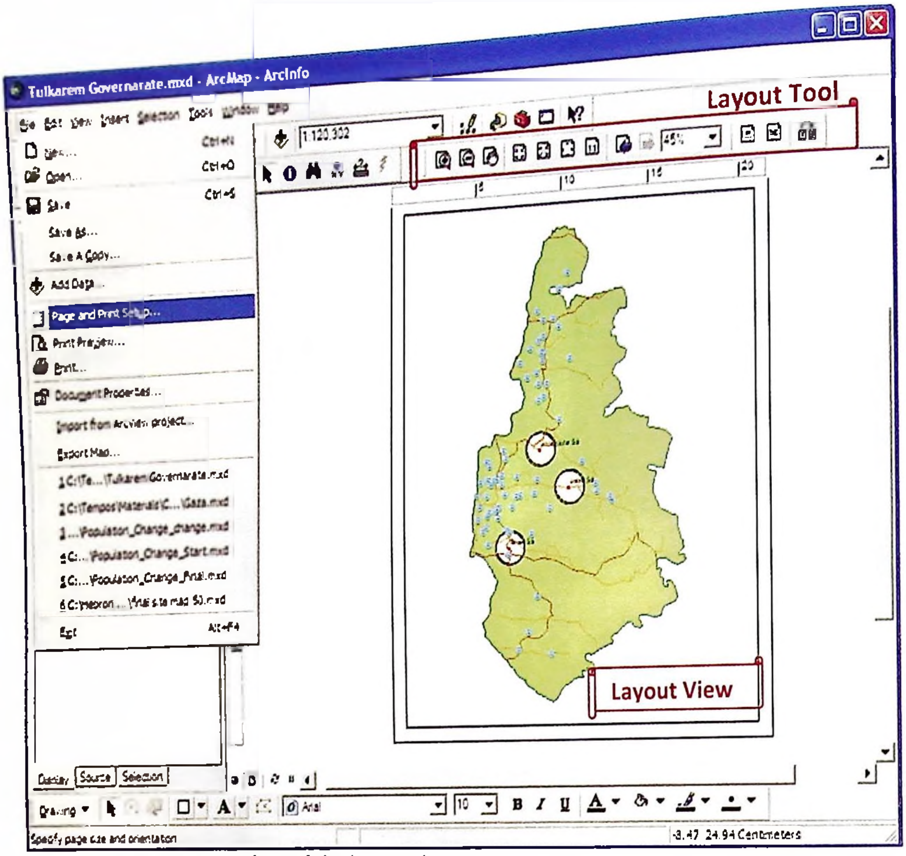


Figure 1.26: Interface of the layout view

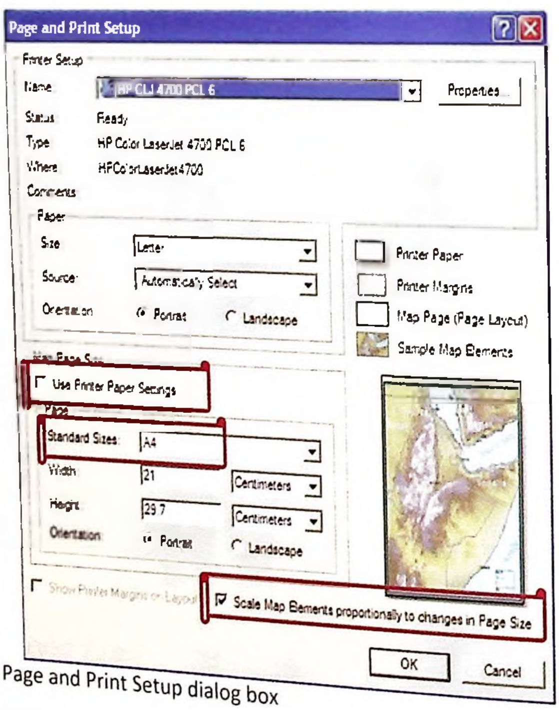


Figure 1.27: Page and Print Setup dialog box

7. Click OK. The page and rulers change to reflect the new size and orientation.
8. Resize your data frame manually to make it look like the map shown in Figure 1.26. To do this, click the Select Elements tool on the Tools toolbar, click the data frame, and resize the data frame using the blue selection handles.

1.4.1.9 Zooming in on the Page

The Layout toolbar controls the scale and position of the whole map, as opposed to the data layers on the map. By default, the map size is set so that the user can view the whole image; however, at this scale, it is difficult to read the names of the dump sites.

1. Click Zoom to 100% on the Layout toolbar. The page is displayed at the actual printed size so that you can see the detail, Figure 1.28.
2. Click the Pan tool on the Layout toolbar and drag the map until the names of the dump sites appear.

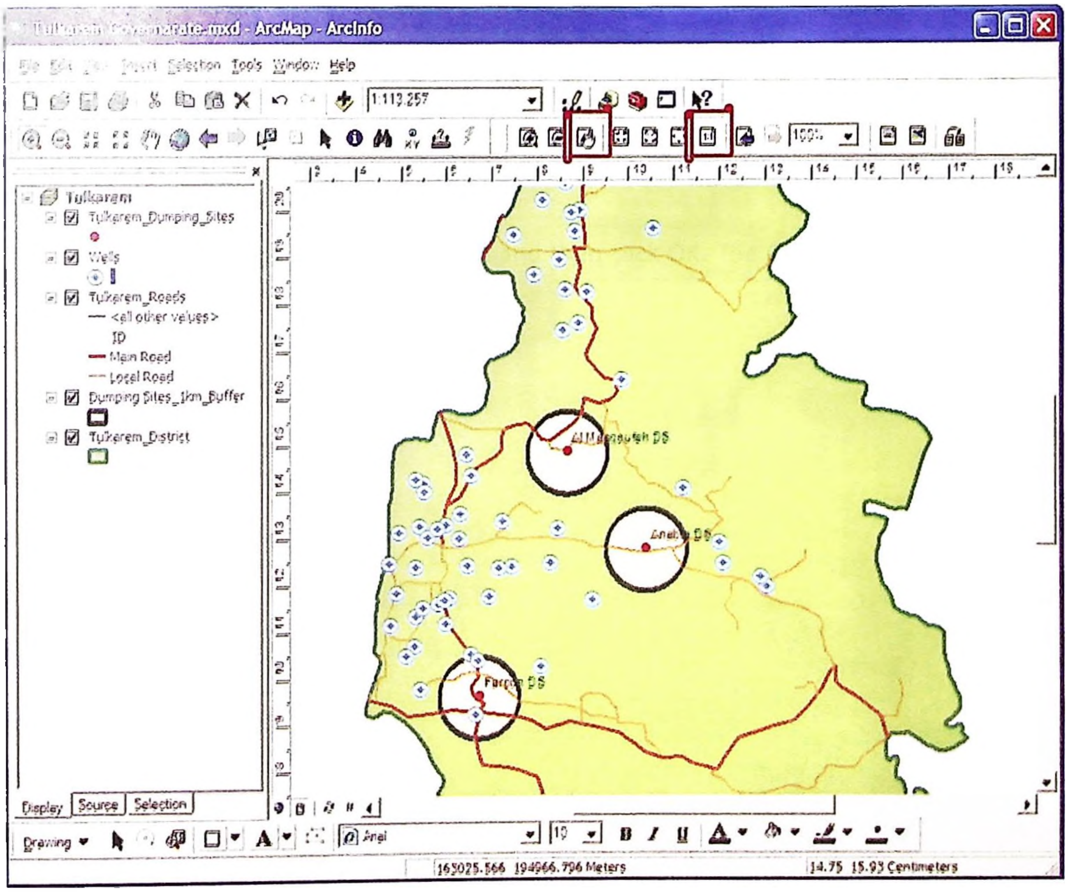


Figure 1.28: Zooming to actual print size

3. Click the Zoom Whole Page button on the Layout toolbar to view the entire page again, Figure 1.29.

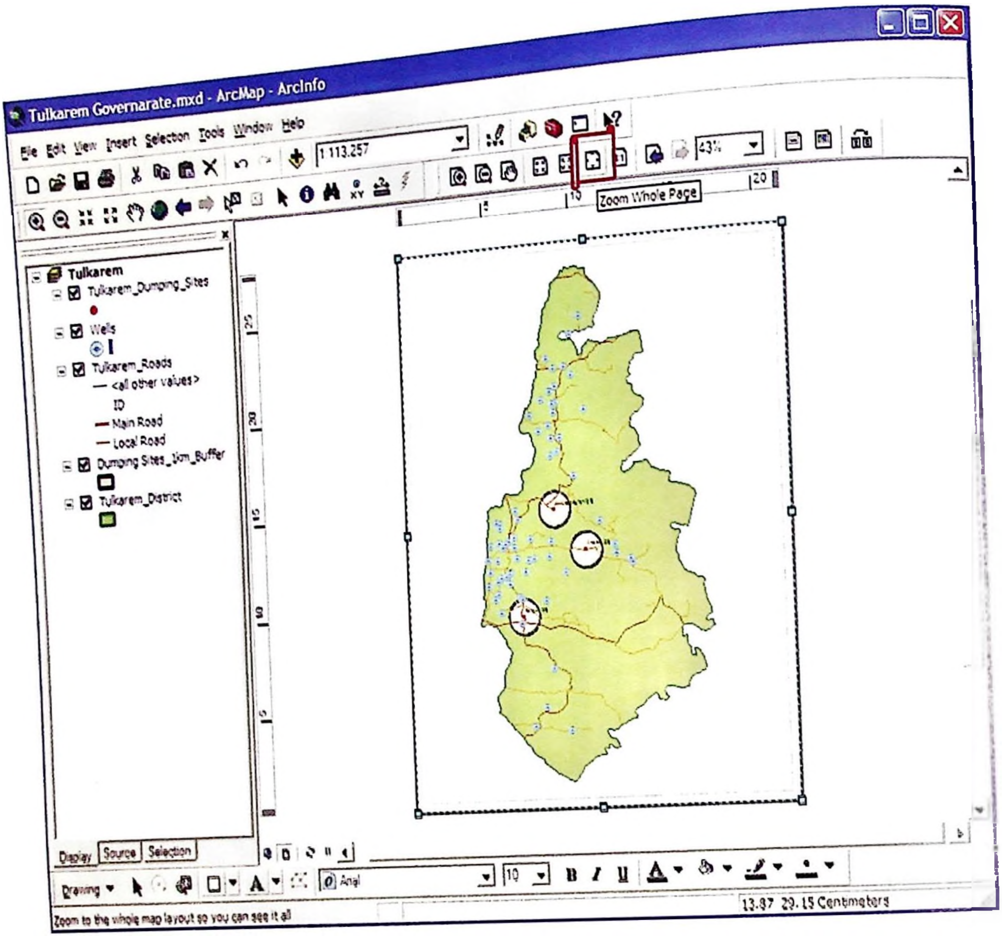


Figure 1.29: Zooming to entire page size

1.4.1.10 Inserting Map Elements

ArcMap makes it easy to add titles, legends, North arrows, and scale bars to the map as follows:

1. Click Insert on the Main menu and click Title. In the box that appears, type the title for the map "Location of Dumping Sites-Tulkarem Governorate", and press Enter.
2. On the Draw toolbar at the bottom of the window, click the Text Size dropdown arrow and click 22 to change the title to 22 points.
3. Click the title and drag it until it is centered at the top of the map, Figure 1.34.

From the Draw toolbar the user can add and change the format, font, size, color, and so on of the text and graphic elements, such as boxes, callout lines, or circles, on the map:

4. Click Insert and then Legend. The Legend Wizard appears, Figure 1.30.
5. Click Next several times to step through the wizard accepting the default legend parameters. Click Finish when done, Figure 1.34.

By default, ArcMap scales the legend to the page and includes all the layers that are currently displayed. The user can modify the legend by right-clicking it and choosing properties from the menu that appears.

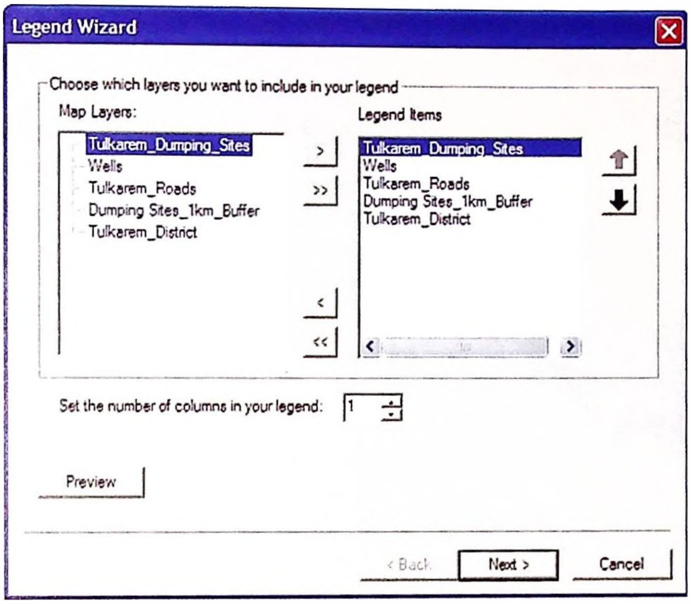


Figure 1.30: Legend Wizard

6. Click Insert and then North Arrow. The North Arrow Selector window appears, Figure 1.31.
7. Click ESRI North 9 and then OK. Click on and drag the North Arrow to the right corner of the map, Figure 1.34.

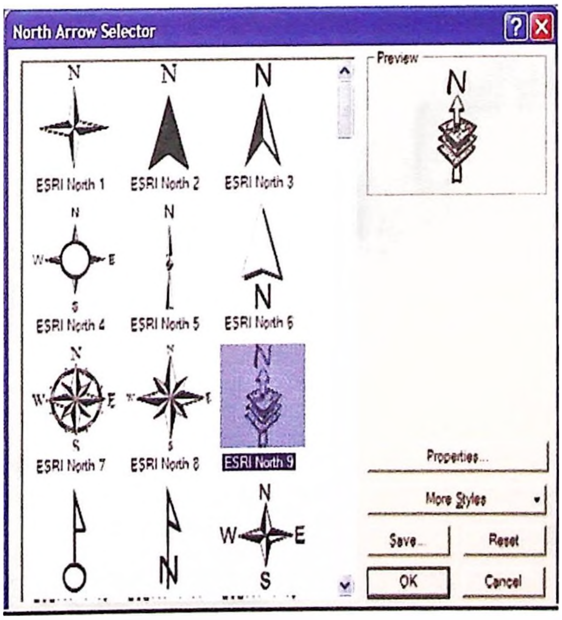


Figure 1.31: North Arrow Selector window.

8. Insert a scale bar from the Insert menu, Figure 1.32. Click Alternating Scale Bar 1 and then Properties, Figure 1.33.
9. Click the Scale and Units tab.
10. Check the box to display zero division before zero and change the division units to Kilometers. Change the label position to Below Bar, then, click OK on all dialog boxes.
11. Click and drag the scale bar under the North arrow, Figure 1.34.

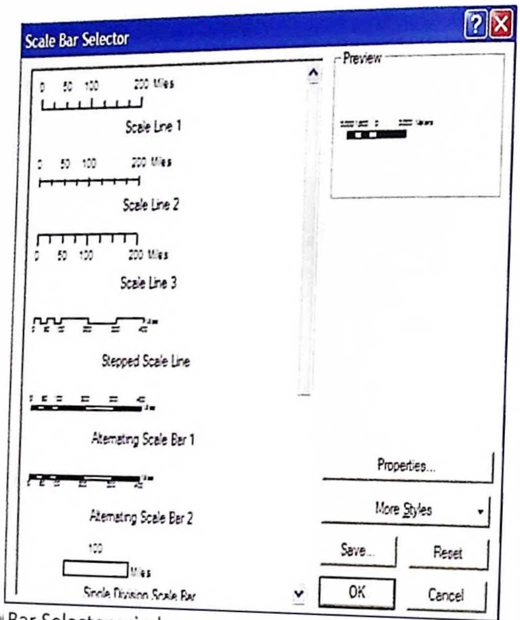


Figure 1.32: Scale Bar Selector window.

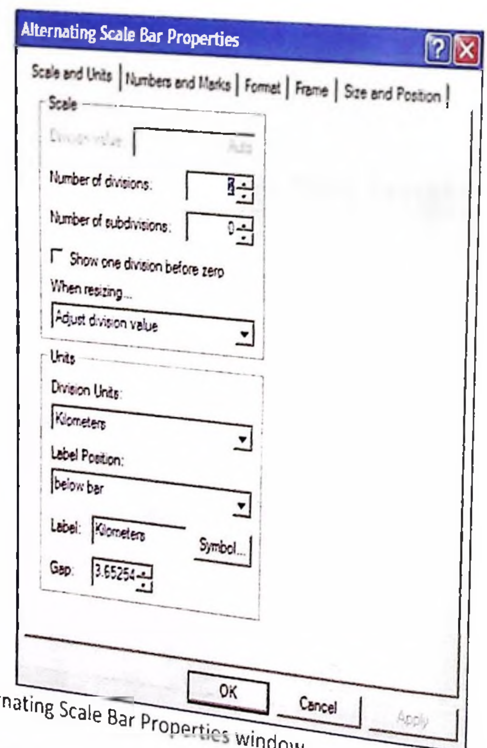


Figure 1.33: Alternating Scale Bar Properties window.

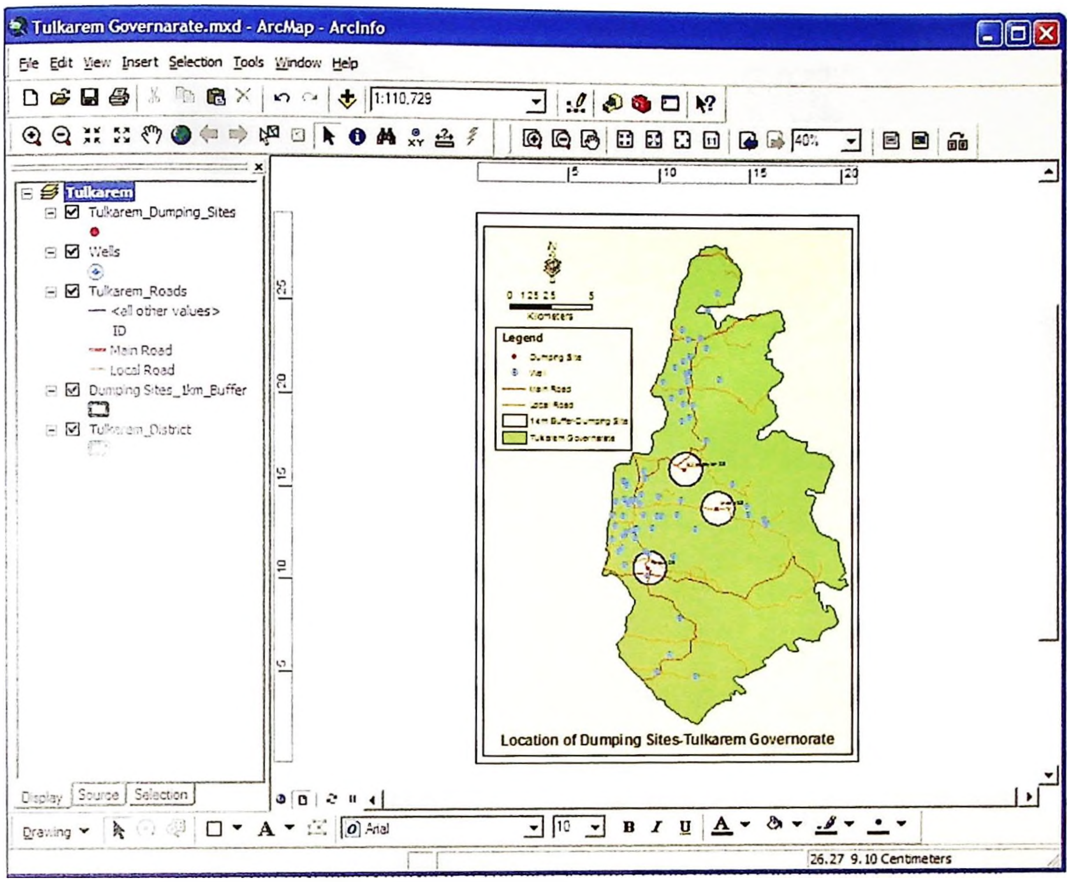


Figure 1.34: Layout of Tulkarem Governorate.

1.4.1.11 Printing a Map

The user can then print the map by clicking on Print in the File menu.

1.4.1.12 Saving a Map

1. To save the changes on the map, click File then Save.
2. To save a copy of the map click File and Save As. In the File name box type a new name for the map and then click Save.

1.4.2 Practicing ArcCatalog

1.4.2.1 Starting ArcCatalog

To open ArcCatalog click the Start button on the Windows taskbar, point to Programs, ArcGIS then click ArcCatalog, Figure 1.35. Or the user can open ArcCatalog directly from ArcMap by clicking on the ArcCatalog button in the main button menu.

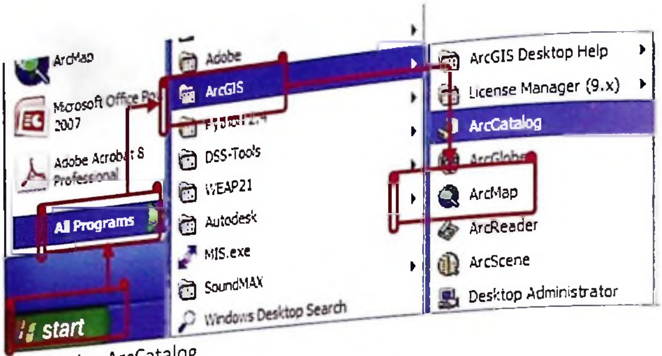


Figure 1.35: Opening ArcCatalog

1.4.2.2 Look in a Folder Connection

When a folder connection in the Catalog tree is selected, the Contents tab lists the items it contains. Unlike Windows Explorer, the Catalog doesn't list all files stored on disk; a folder might appear empty even though it contains several files. Folders containing geographic data sources have a different icon to make your data easier to find, Figure 1.36.

1. Click a folder connection in the Catalog tree. The items it contains appear in the Contents tab.
2. Double-click a folder in the Contents list. That folder is selected in the Catalog tree, and the Contents tab lists the folders and geographic data it contains.

By using this method, you can browse through the contents of disks looking for geographic data.

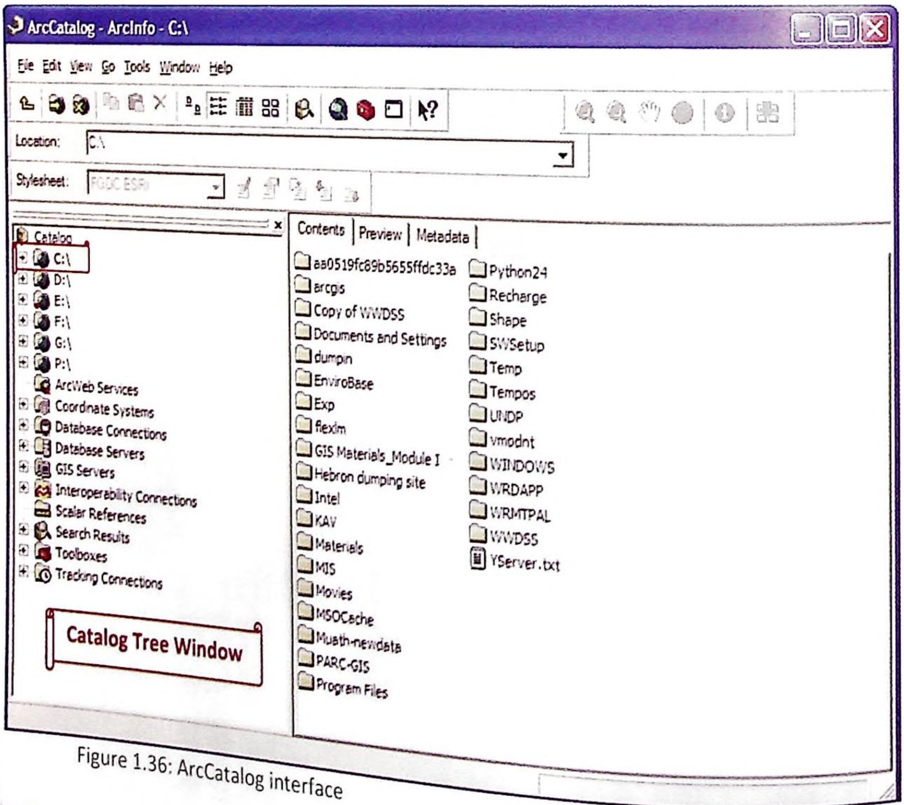


Figure 1.36: ArcCatalog interface

1.4.2.3 Create a Backup Copy of the Tutorial Data

1. Locate the tutorial folder, browse to "C:\GIS_Tutorial\Chapter1" using the Catalog Tree window.
2. Right-click on the Chapter1 folder in the Catalog Tree window. Select New then click on Folder.
3. Type "Backup" as the name of the created folder.
4. Click the Shapefiles folder in the Contents tab, then click the Copy button.
5. Click the Backup folder from the Catalog tree.
6. Finally click the Paste button. A new folder called Shapefiles will appear in the Contents list in the "C:\GIS_Tutorial\Chapter1\Backup" folder, Figure 1.37.

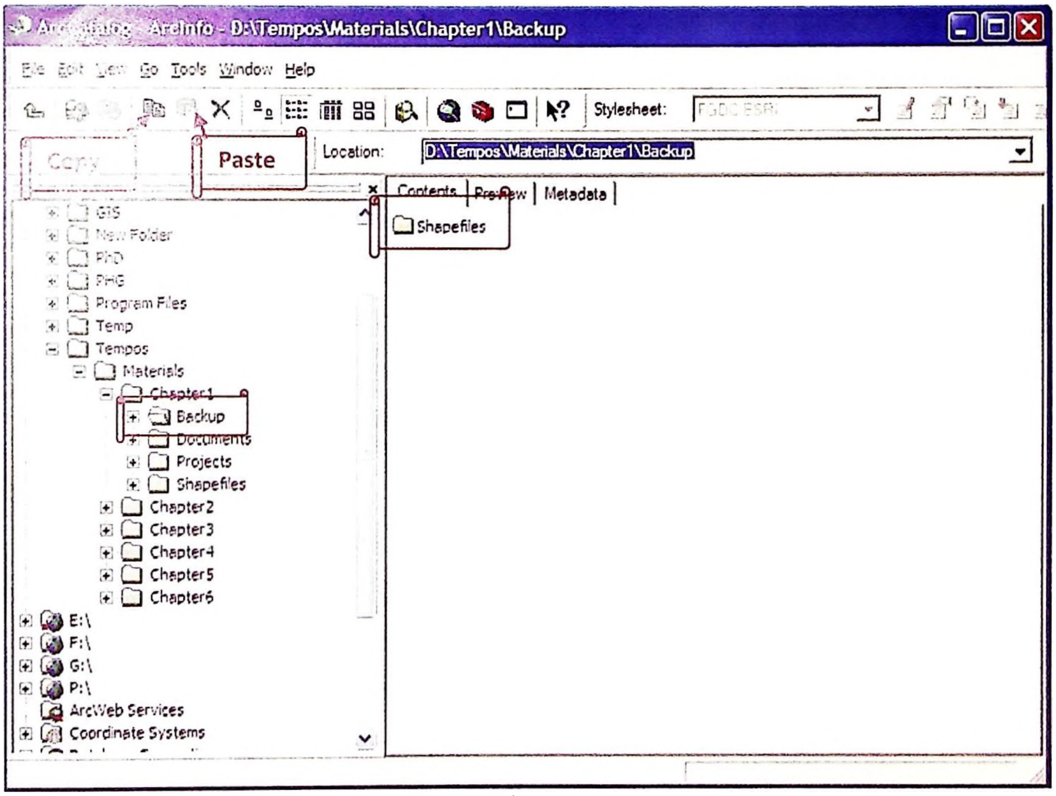


Figure 1.37: Creating backup for the Shapefile folder

1.4.2.4 Connect Directly to the Backup Folder

Folder connections in the Catalog can access specific folders on disk. The user may establish several connections to different folders on the same disk. You don't have to see all the data on any drive on the hard disk. To create a connection that directly accesses the Backup folder the user can use a shortcut provided by the Catalog:

1. Click the Catalog folder in the Contents list.
2. Scroll to the top of the Catalog tree.

3. Drag the Catalog folder from the Contents tab and drop it on the Catalog at the top of the Catalog tree. A new folder connection is added to the Catalog.
4. You can remove the connection by clicking on the connected folder and then on the Disconnect from Folder button, Figure 1.38.

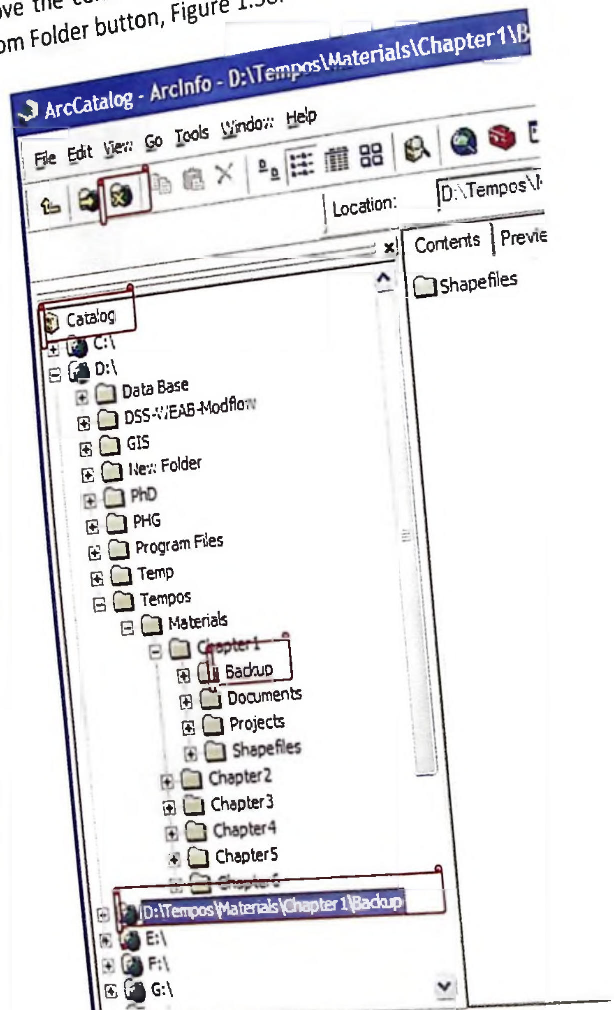


Figure 1.38: Connect/un-connect folders in ArcCatalog

1.4.2.5 The Contents Tab

When items are selected, such as folders in the Catalog tree, the Contents tab lists the items they contain. To change the appearance of the Contents list, the appropriate buttons on the Standard toolbar must be used, Figure 1.39.

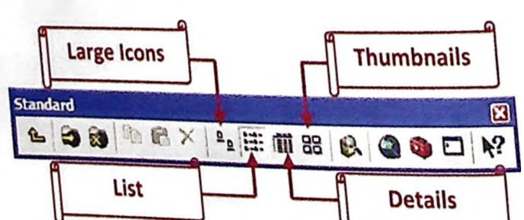


Figure 1.39: Standard toolbar

1. The Large Icons view represents each item in the list with a large icon, Figure 1.40.
2. The List view uses small icons, Figure 1.41.
3. The Details view illustrates the properties of each item in the columns; you can sort the list according to property values by clicking the headings of the name column, Figure 1.42.
4. Thumbnails display a snapshot for each item in the list, providing a quick illustration of the item's geographic data, Figure 1.43.

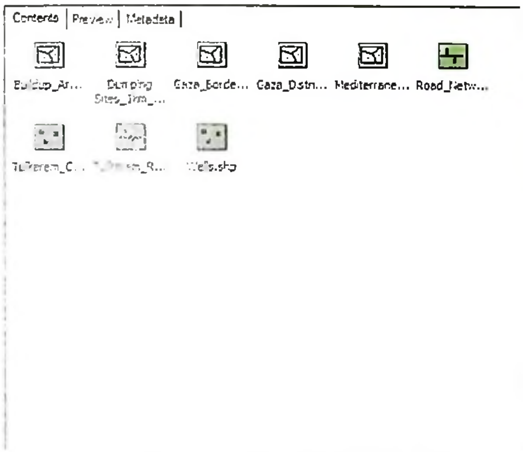


Figure 1.40: List of shapefiles-large icons

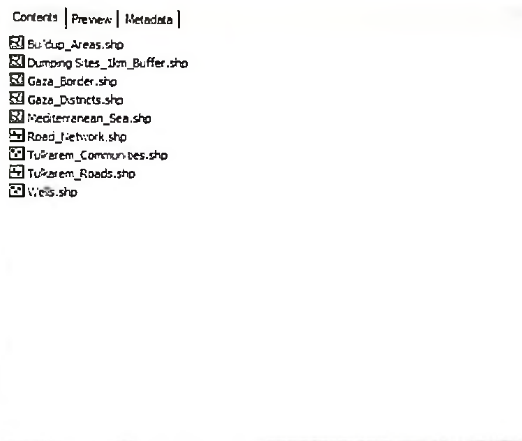


Figure 1.41: List of shapefiles-small icons

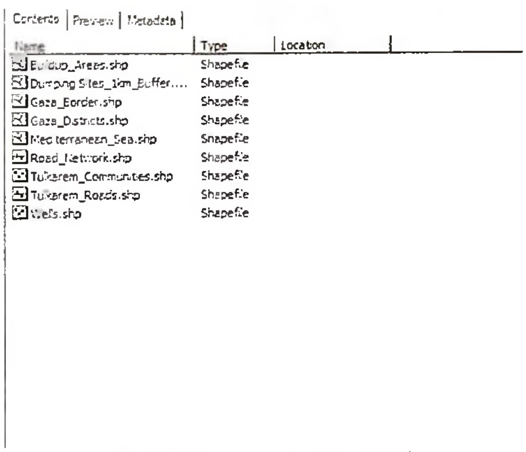


Figure 1.42: List of shapefiles-details

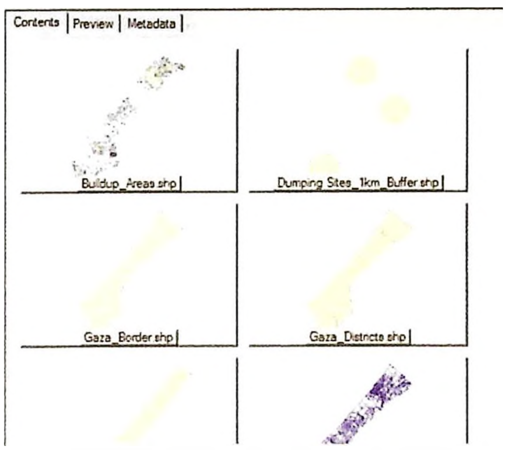


Figure 1.43: List of shapefiles-thumbnails view

1.4.2.6 The Preview Tab

The preview tab helps the user explore the selected item's data in either geography or table view. For items containing both geographic data and tabular attributes, you can toggle between the geography and table views using the dropdown list at the bottom of the preview tab, Figure 1.44.

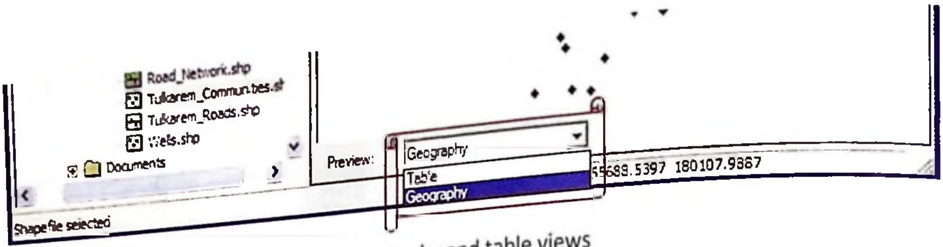


Figure 1.44: Changing between geography and table views

The Geography Preview draws each feature in a vector dataset. When drawing geographic data, the Catalog uses a default set of symbology. The selected item's geographic data can be explored using the buttons on the Geography toolbar. The table view draws all rows and columns and the value for each cell in the selected item's table. The values in the table can be explored using the scroll bars, the buttons at the bottom of the table, and the context menus that are available from the column headings.

1.4.2.7 Viewing the Shapefiles Folder in Geography View

Use the Geography Preview to look at the data contained by the items in the Shapefiles folder. When using the Geography Preview, the Geography toolbar is enabled, Figure 1.45. You can use the Zoom In, Zoom Out, Pan, Full Extent, and Identify buttons on the toolbar to explore geographic data.

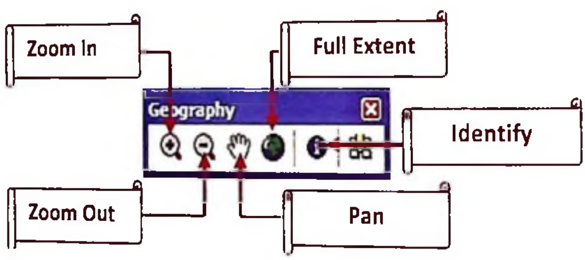


Figure 1.45: Geography toolbar

While you review the data in the Shapefiles folder, you may wish to explore the geographic features in more detail using the following tools:

1. Click the Tulkarem_Communities shapefile in the Catalog tree. This shapefile contains the coordinates of all communities located in Tulkarem Governorate.
2. Click the Preview tab. The shapefile is plotted using the default symbol (dots) and in the default color.
3. Click the Gaza_Districts shapefile in the Catalog tree which contains the boundary of Gaza Strip as well as the boundaries of the Gaza Strip Governorates.
4. Click the Identify button on the Geography toolbar and click one of the polygons in the Preview tab. Its attributes appear in the Identify Results window.
5. Click the Close button in the upper right corner of the dialog box to close the Identify Results window
6. Click the Preview dropdown arrow at the bottom of the Preview tab and click Table.
7. In the Catalog tree, click some shapefiles and look at their contents in table view. Note that all shapefiles have FID and Shape columns.

1.4.2.8 Explore the Contents of a Table

Using the table exploration tools available in the Catalog, you can learn a great deal about the contents of a table. You can search for values in the table and sort records according to the values in one or more columns. The West Bank_Districts shapefile contains data about the West Bank Governorates. The West Bank_Districts_Details table contains general information about each Governorate, such as name, population, average family size, etc.

With the tools available in the table view you can explore the contents of the West Bank_Districts_Details table.

1. Click the West Bank_Districts_Details dBASE table in the Catalog tree.
2. Explore the table's values using the buttons at the bottom of the table. Once you click anywhere on the table you can also use the arrow keys on the keyboard, Figure 1.46.

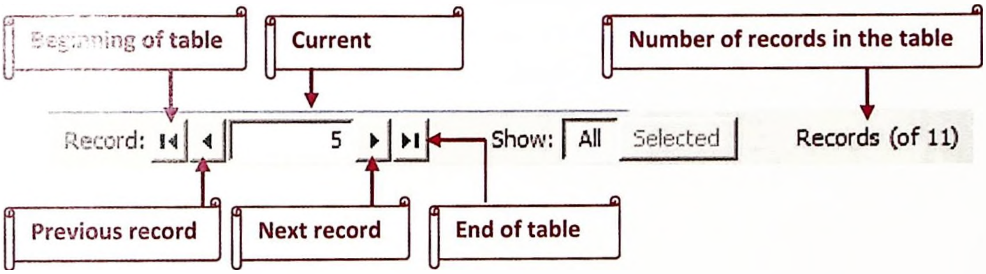


Figure 1.46: Table toolbar

3. Type "5" into the Current record textbox and press Enter. The Current record icon appears next to the fifth row in the table. The Object ID value for this record, which is located in the OID column, is four; the OID values begin counting at zero.
4. Right-click the heading of the District column and click Freeze/Unfreeze Column. The District column is frozen in position at the left of the table, and a heavy black line appears to its right, Figure 1.47.

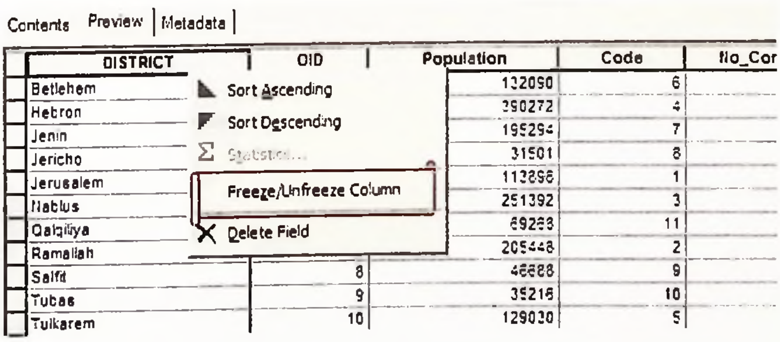


Figure 1.47: Freeze/unfreeze columns

5. Scroll horizontally through the table. The District column stays in place while the other columns scroll normally. Align the Type column to the right of the District column.
6. Position the mouse pointer over the right edge of the District column's heading. The mouse pointer changes.
7. Click and drag the edge of the District column's heading to the left. The red line indicates the edge's original position, while the black line shows its new location. Drop the edge of the column. The column is narrower.
8. Right-click the heading of the Code column and click Freeze/Unfreeze Column. The heavy black line is now to the right of the Code column. Scroll horizontally through the table. Both the District and Code columns stay in place while the other columns scroll normally.
9. Click the Code column's heading. The column is highlighted in light blue.
10. Click and drag the Code column's heading to the left of the District column. The red line indicates the Code column's new position. Drop the column in the new location. The Code column now appears to the left of the District column, and the heavy black line appears to the right of the District column.
11. Right-click the heading of the Code column and click Sort Ascending.
12. The rows in the table are sorted numerically in ascending order according to the values, Figure 1.48.

Code	DISTRICT	Population	No_Communi	Hholds
1	Jerusalem	113899	51	19
2	Ramallah	205448	80	34
3	Nablus	251392	73	42
4	Hebron	390272	156	57
5	Tulkarem	129030	42	22
6	Betlehem	132090	71	22
7	Jenin	195294	96	32
8	Jericho	31501	16	9
9	Salfit	46668	23	7
10	Tubas	35216	23	9
11	Qalqilya	69268	35	11

Figure 1.48: Sorting column contents

1.4.2.9 The Metadata Tab

The metadata tab illustrates descriptive information about the selected item in the Catalog tree. Metadata includes properties that are derived from the data source and documentation is information provided by a person.

Metadata is stored as extensible markup language (XML) in a file with the original data or in a geodatabase. ArcCatalog uses XSL Transformations (XSLT) stylesheets to transform the XML data into a hypertext markup language (HTML) page. You can change the metadata's form by changing the current stylesheet using the dropdown list on the Metadata toolbar, Figure 1.49.

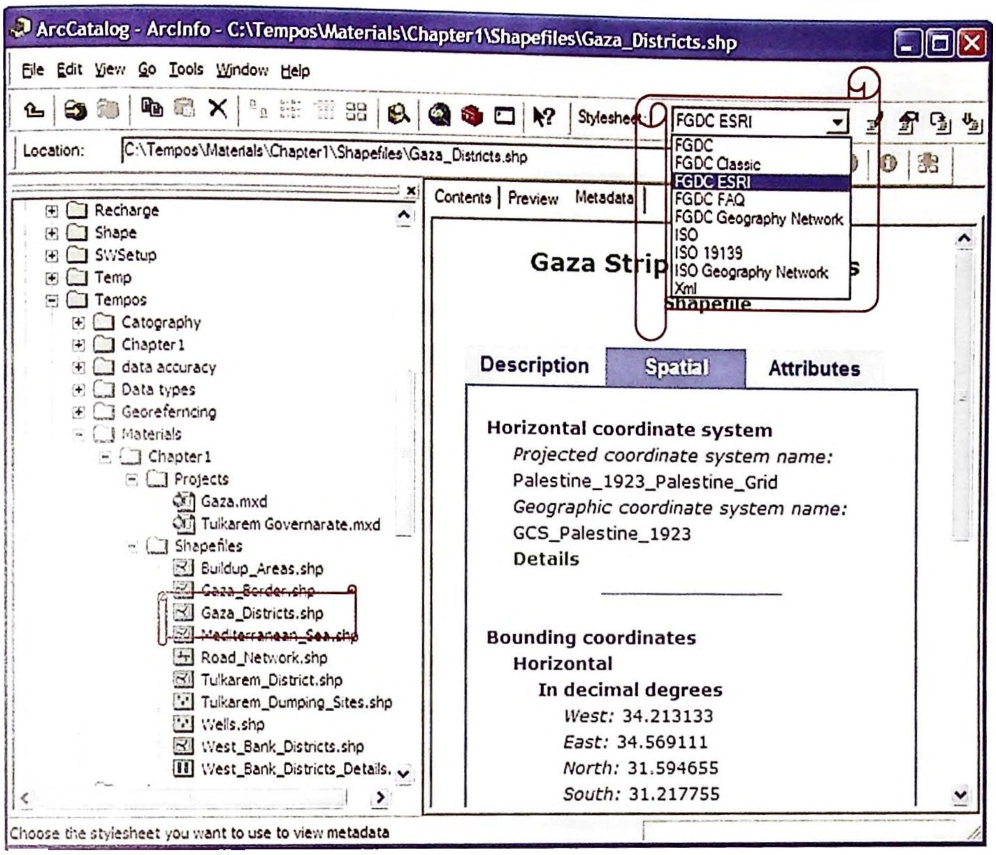


Figure 1.49: Different options for viewing metadata sheet

You can use the Edit, Create/update, Import and Export metadata buttons on the toolbar to manage the metadata for any of the shapefiles, Figure 1.50.

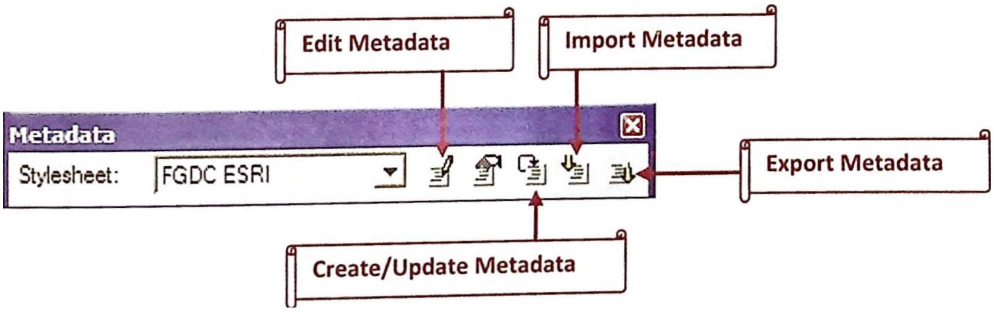


Figure 1.50: Metadata toolbar

1.4.2.10 Add a Layer to a Map

The Project folder contains two map documents. The Gaza.mxd map already includes data such as roads and boundaries. However, groundwater wells still have to be added to the map.

Adding data to a map is easy; all you have to do is drag data from the Catalog and drop it on the map. When you drop a layer onto a map, a copy of the layer is created and stored inside the map document. In this way, you can create a layer once and use it in many different maps. Before you can add more data to the Gaza map, you must open the map document in ArcMap.

1. Click the Project folder in the Catalog tree. (Under the Chapter1 folder).
2. Double-click the Gaza map document in ArcCatalog; this opens it in ArcMap, Figure 1.51.

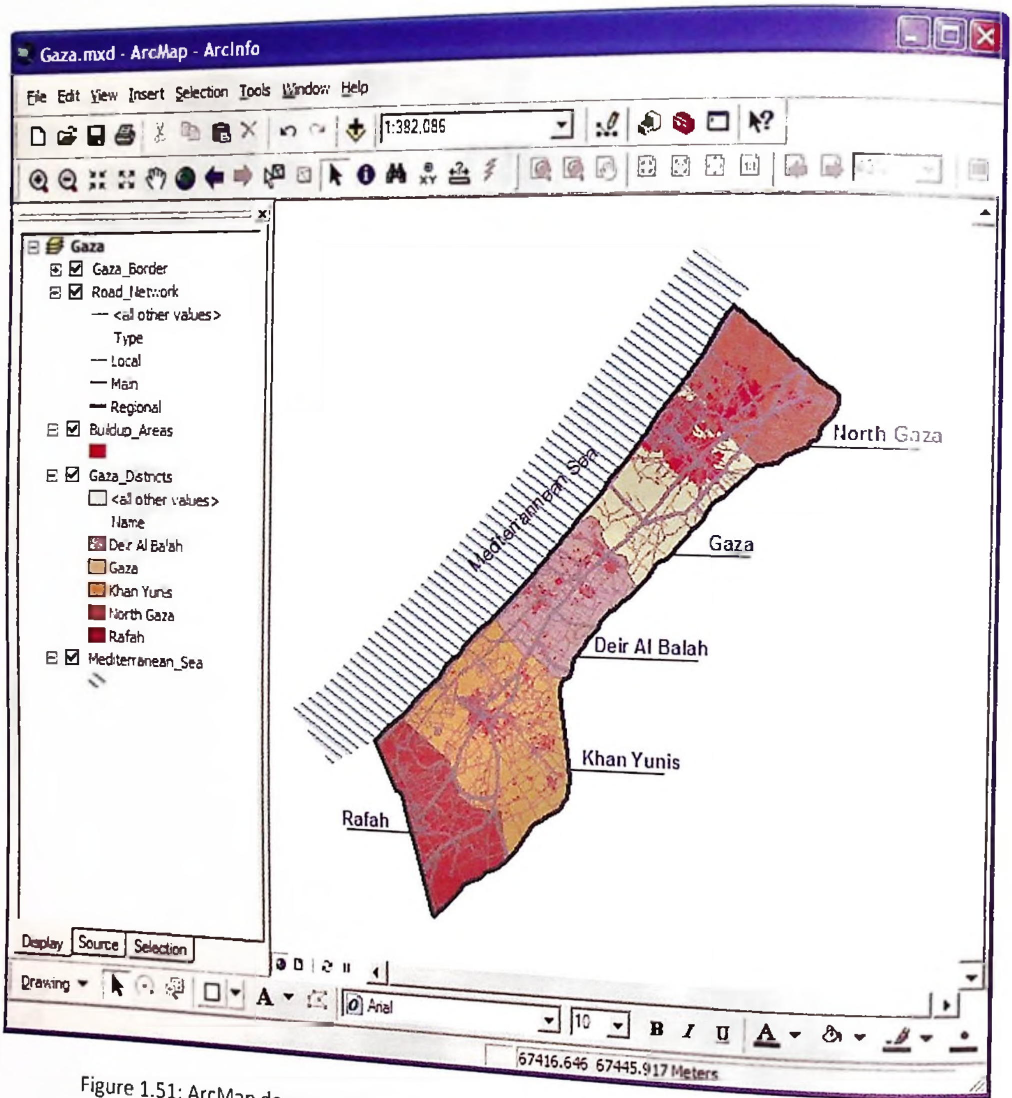


Figure 1.51: ArcMap document (Gaza.mxd) opened from ArcCatalog

3. Arrange the ArcMap and ArcCatalog windows so that you can see the table of contents in ArcMap and the Catalog tree at the same time, Figure 1.52.

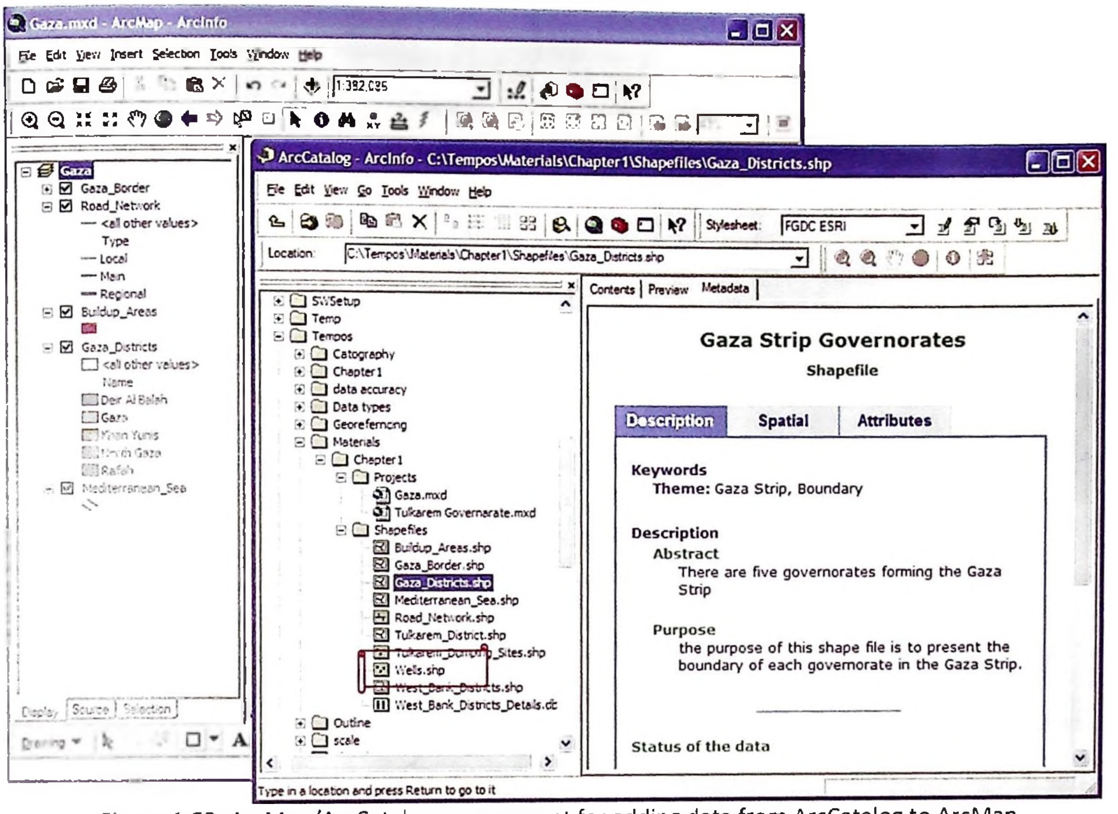


Figure 1.52: ArcMap/ArcCatalog arrangement for adding data from ArcCatalog to ArcMap

The table of contents reflects the order in which layers are drawn. Wells, in this example, should be added underneath the Gaza Border shapefile and above the Roads_Network shapefile.

4. Click and drag the Wells shapefile from ArcCatalog and drop it in the table of contents below the Gaza Border shapefile in the Gaza data frame in ArcMap. The wells features are now drawn on the map.

1.5 Discussion

Based on the previous literature and your understanding of the Geographical Information System (GIS), discuss the following questions:

1. What makes GIS distinctive?
2. How does GIS use geography?
3. What are the sectors that may benefit from GIS? And how?
4. Name organizations in Palestine that can benefit from GIS applications?
5. How can organizations benefit from using GIS?

1.6 Assignment

Prepare a research entitled "Geographical Information in Palestine" focusing on the following points:

1. What type of organizations use GIS? And how are they using it?
2. Which GIS software packages are mostly used?
3. What are the job levels/positions of the users, are they decision makers for example?
4. Does any organization provide GIS services to the public?
5. Conclusions and recommendations

GIS Data Models and Quality

2

Chapter

GIS Data Models and Quality

2.1 GIS Data Types

2.1.1 Introduction

The science of GIS attempts to simulate the real world enabling computer systems to represent real geographical elements as graphical elements in a computerized software. Basically geographical data comes in two main data types which are spatial (raster and/or vector datasets) and non-spatial (Attribute data). Spatial data is a geographical representation of features. For example, the representation of the road system within a city or groundwater wells in an aquifer system. In other words, spatial data is what we actually see in the form of maps on a computer screen, Figures 2.1a, 2.1b, 2.1c.

Figures 2.1a: Real world image (Image from Tulkarem District, GoogleEarth)

Figures 2.1b: Vector data model (representing the real world image in Figure 2.1a)

Figures 2.1c: Raster data model (representing the real world image in Figure 2.1a)

2.1.2 Vector Data Model

Discrete features, such as spring locations, are usually represented using vector datasets. A vector dataset (or features) can be discrete locations (points), lines (a series of points), or areas. Lines, such as streams or roads, are represented as a series of coordinate pairs. Areas are defined by borders, and are represented by closed polygons, Figure 2.2.

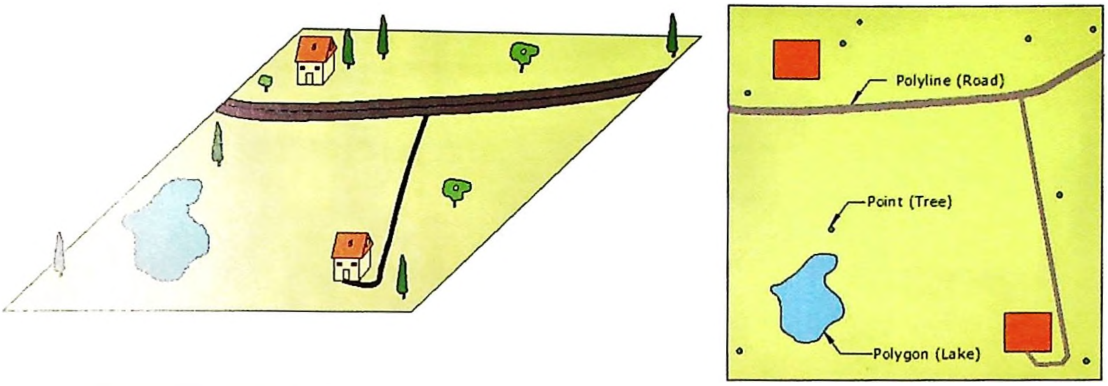


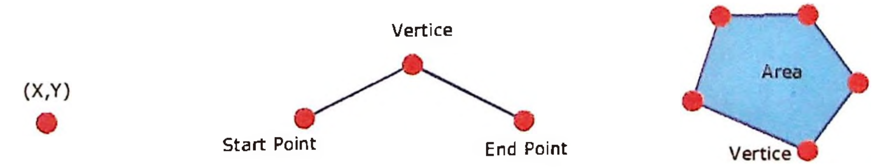
Figure 2.2: Vector representation

The geometric description of vector types could be illustrated as follows:

Points: A point represents anything that can be described with x, y coordinates on the face of the Earth, such as the location of cities, wells, weather stations, trees, etc. (Figure 2.3a).

Lines: A line should at least connect two points. The start and end points of a line are referred to as nodes while points on curves are referred to as vertices. In other words, a line represents anything having a length, such as streets, highways, and rivers, Figure 2.3b.

Polygons: A polygon is a closed line with an area. It takes a minimum of three pairs of coordinates to represent an area or polygon. It describes anything having boundaries, whether natural, political or administrative, such as the boundaries of countries, governorates, cities, administrative zones, etc. (Figure 2.3c).



(a) Point (b) Line (c) Polygon

Figure 2.3: Geometrical representation of vector models

In general, selecting a point, line or polygon for representing an element is based on the purpose as well as the scale of the developed map. There is no unique method to represent an element. For instance, when using a small scale map it's impossible to plot the roads or buildings as polygons, this is why the roads are represented as lines and buildings as points, Figure 2.4a & b. In other cases, the nature of the study requires their representation as polygons.

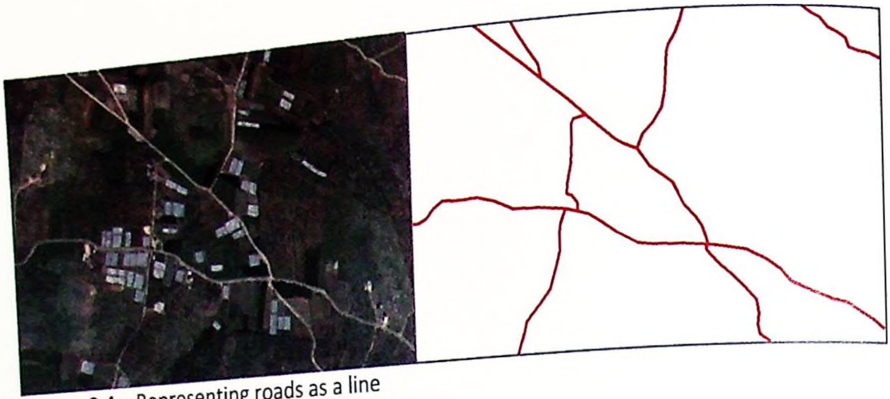


Figure 2.4a: Representing roads as a line

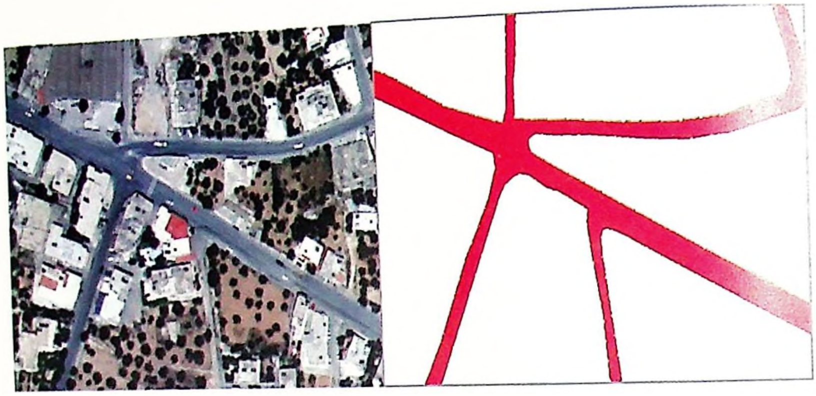


Figure 2.4b: Representing roads as a polygon

2.1.3 Raster Data Model

A raster based system displays, locates, and stores graphical data by using a matrix of grids, cells or pixels. Each cell contains only one data value, Figure 2.5. Each group of cells that have the same value is linked to a record in an attribute table.

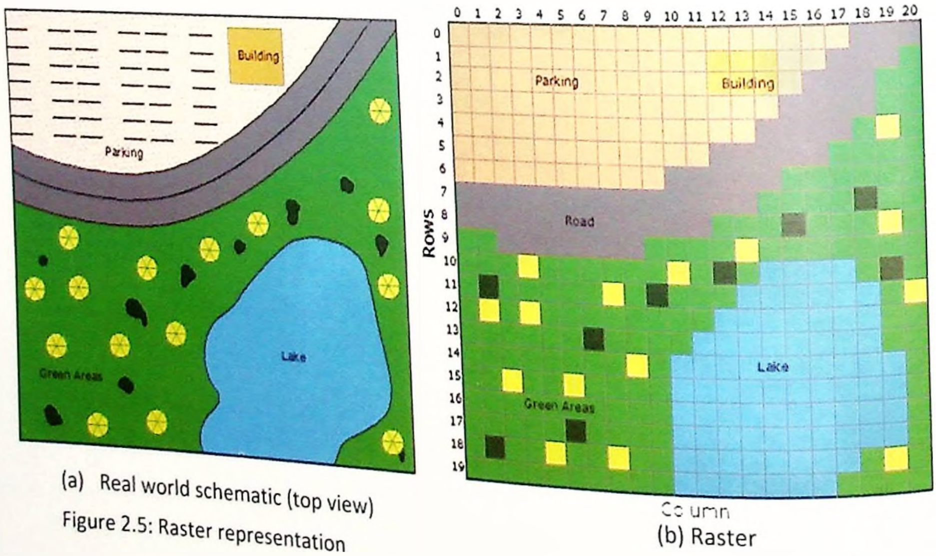
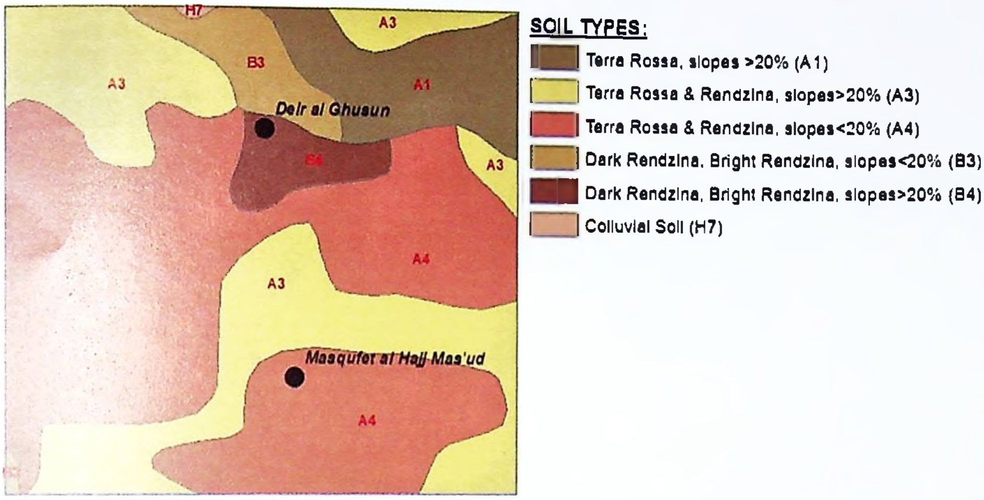
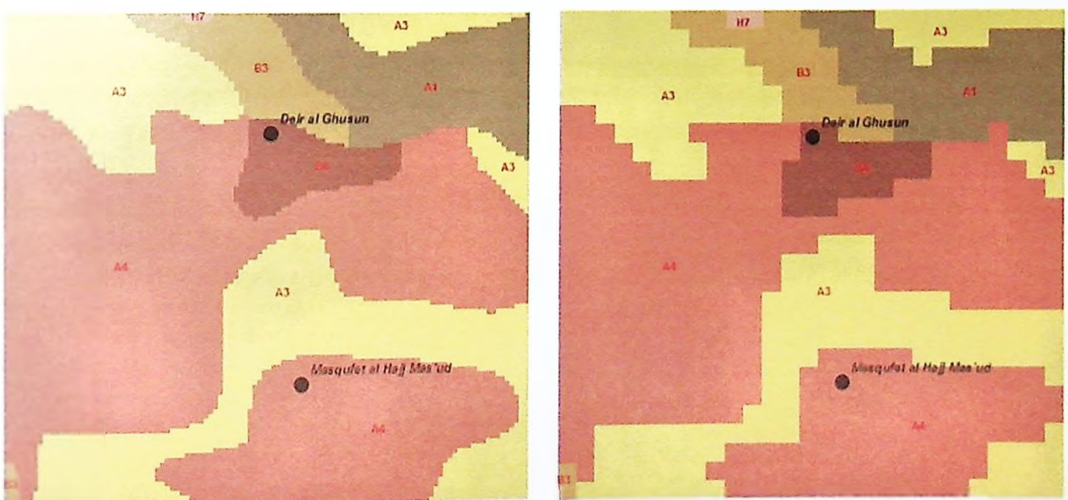


Figure 2.5: Raster representation

For example, if the raster details the soil type, then each cell in this raster dataset has a value that reflects the type of soil at that particular point. Thus the smaller the cell size, the more accurate the data but the larger the storage size needed, Figure 2.6.



(a) Soil map presented by a vector model



(a) Raster model (cell size 25m) (b) Raster model (cell size 100m)

Figure 2.6: Raster representation using different grid sizes

It should be noted that raster based data structures are excellent for storing data on continuous spatial processes, Figure 2.7, such as temperature distribution, elevations, water qualities, rainfall or population density. Raster data is commonly obtained by scanning maps, collecting aerial photographs and/or obtaining raw satellite images.

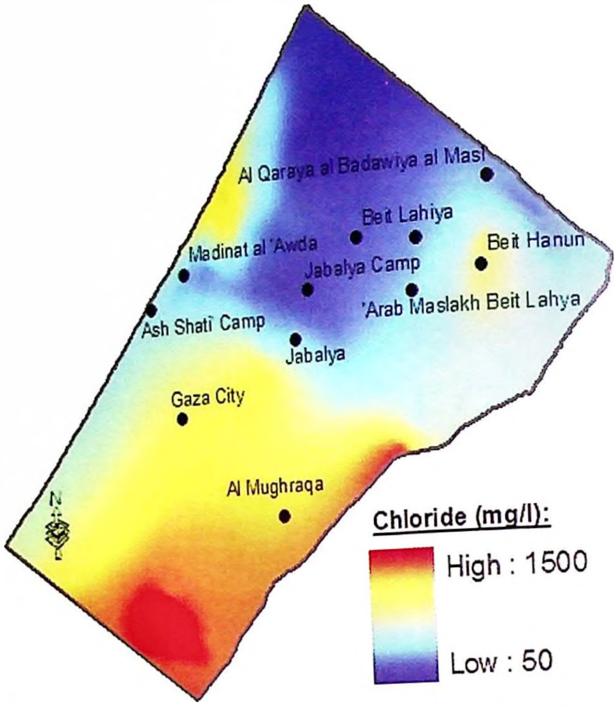


Figure 2.7: Continuous representation of spatial data (chloride concentration in part of the Coastal Aquifer Basin, 2005)

2.1.4 Special Types of Raster Data

2.1.4.1 Digital Elevation Model (DEM)

A digital elevation model (DEM), Figure 2.8, is a digital file consisting of terrain elevations for ground positions at regularly spaced intervals. DEMs may be used in the generation of three-dimensional graphics displaying terrain slope, Figure 2.9, aspect (direction of slope), and terrain profiles between selected points.

Figure 2.8: Digital Elevation Model for Salfit Governorate (20 m Resolution)

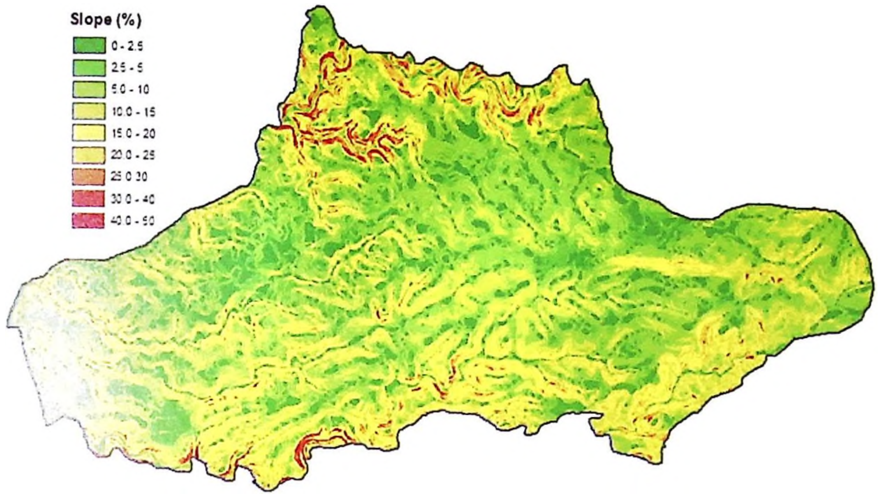


Figure 2.9: Slope derived from Salfit Governorate DEM (25 m Resolution)

2.1.4.2 Triangulated Irregular Network (TIN)

The Triangulated Irregular Network (TIN) model represents a surface as a set of contiguous, non-overlapping triangles. Within each triangle the surface is represented by a plane, Figure 2.10. The triangles are made from a set of points called mass points.

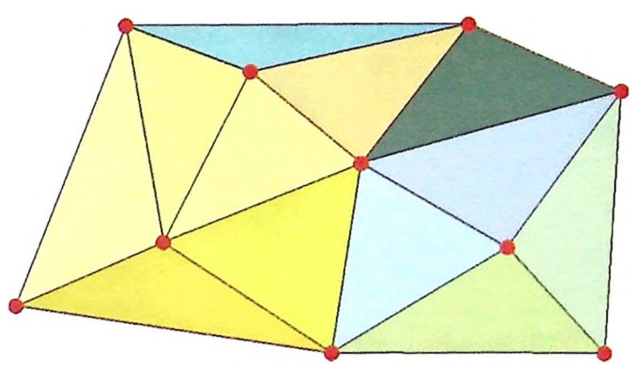
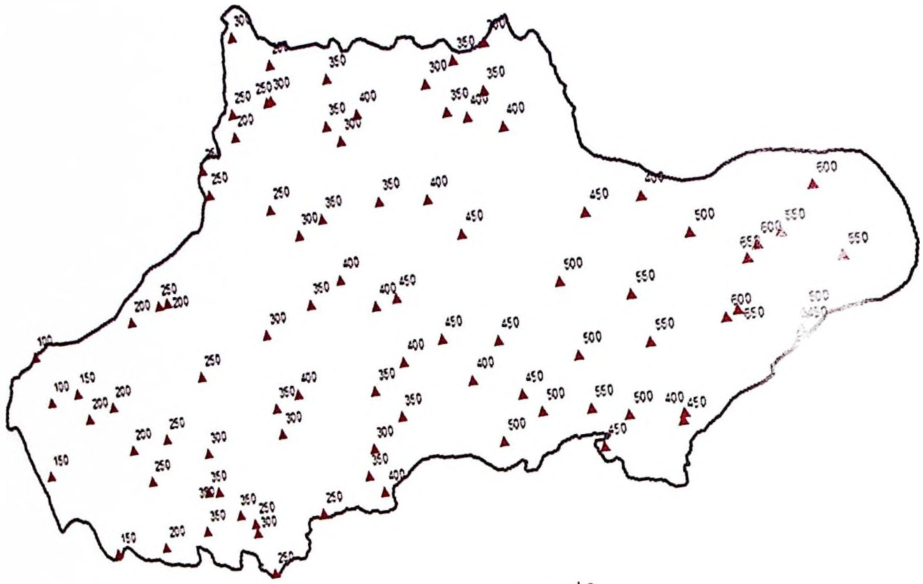


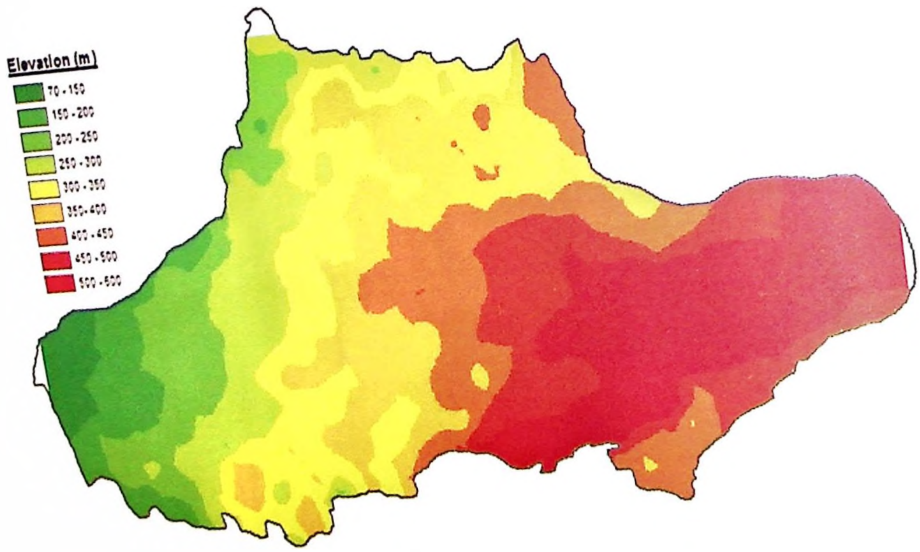
Figure 2.10: Non-overlapping triangles that form a TIN

Mass points can be placed at any location, the more carefully selected, the more accurate the model of the surface, Figure 2.11. Well-placed mass points occur where there is a major change in the shape of the surface, for example, at the peak of a mountain, the floor of a valley, or at the edge (top and bottom) of cliffs.

The TIN model is attractive because of its simplicity and low cost and also because it is a significant alternative to the regular raster of the GRID model.



(a) Elevation points (mass points) within Salfit Governorate



(b) Triangulated Irregular Network (TIN) for Salfit Governorate

Figure 2.11: Triangulated Irregular Network (TIN) derived from elevation points (50 m Resolution)

2.1.5 Non-Spatial Data (Attribute Data)

Attributes attached to spatial data are referred to as non-spatial data that is descriptive information that GIS links with the map features. Attribute data is collected and compiled for specific areas like governorates, cities, and so on and often comes packaged with map data.

Attributes of spatial data may contain a unique identifier for each object. There may be other fields that also contain properties/information related to a spatial feature. For example, each groundwater well must have its unique well ID. Other attributes may include well abstraction rates, depth, tapped aquifer, usage, etc. (Figure 2.12).

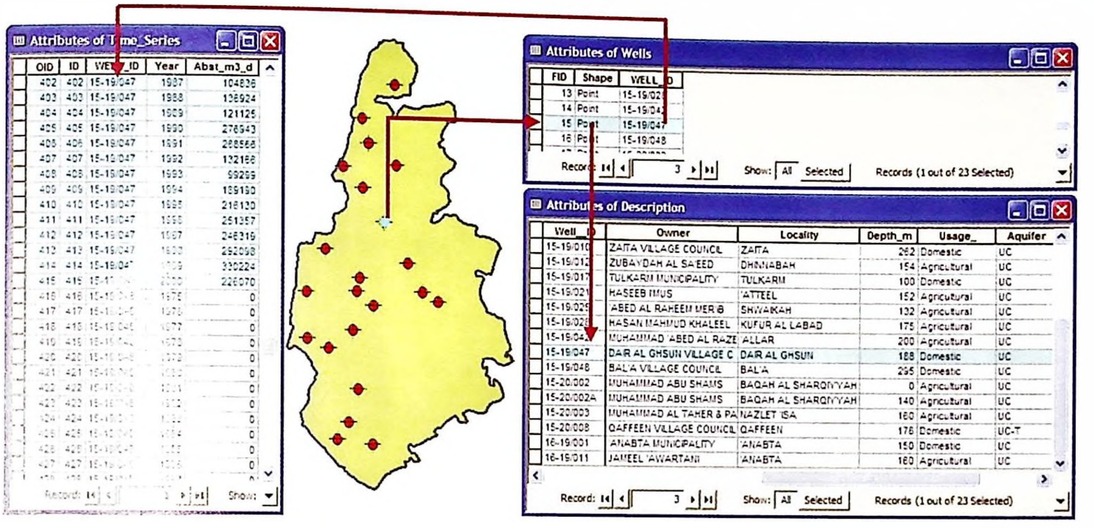


Figure 2.12: Groundwater wells connected to non-spatial data (well description and yearly abstraction rate)

2.2 GIS File Format

There are many types of data formats used for GIS datasets. In many cases, the same data could be stored in more than one form. Figure 2.13 shows different types of GIS file formats.

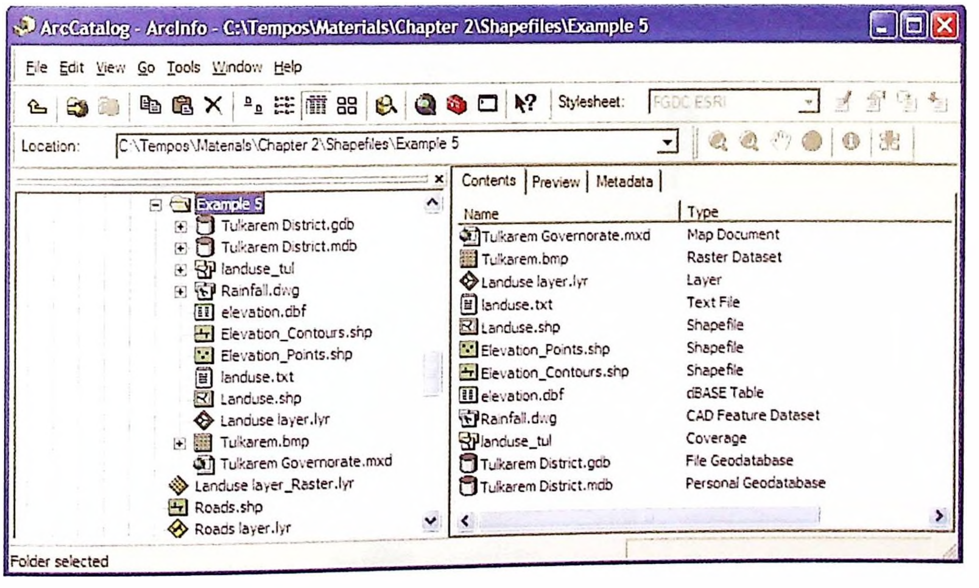


Figure 2.13: Different GIS file formats

2.2.1 Shapefiles

Shapefiles are a simple, non-topological format for storing the geometric location and attribute information of geographic features. Geographic features in a shapefile can be represented by points, lines, or polygons (areas) as described in the previous sections.

Because shapefiles do not have the processing overhead of a topological data structure, they have advantages over other data formats including faster drawing speed and edit ability. They also typically require less disk space and are easier to read and write.

The shapefile format defines the geometry and attributes of geographically referenced features in three or more files with specific file extensions that should be stored in the same folder. They are:

- *.shp: the main file that stores the feature geometry.
- *.shx: the index file that stores the index of the feature geometry.
- *.dbf: the dBASE table that stores the attribute information of features.

There is a one-to-one relationship between geometry and attributes in a shapefile, which is based on record number. Each file must have the same prefix, for example: roads.shp, roads.shx, and roads.dbf. Viewing shapefiles in ArcCatalog or any other ArcGIS program will only use one file; however, Windows Explorer is used to view all the files associated with a shapefile, Figure 2.14. A shapefile, can be copied using two options: either using ArcCatalog or a recommended geoprocessing tool, or copy it from outside ArcGIS using, for example, Windows Explorer. In this case the user should be sure to copy all the files that make up the shapefile.

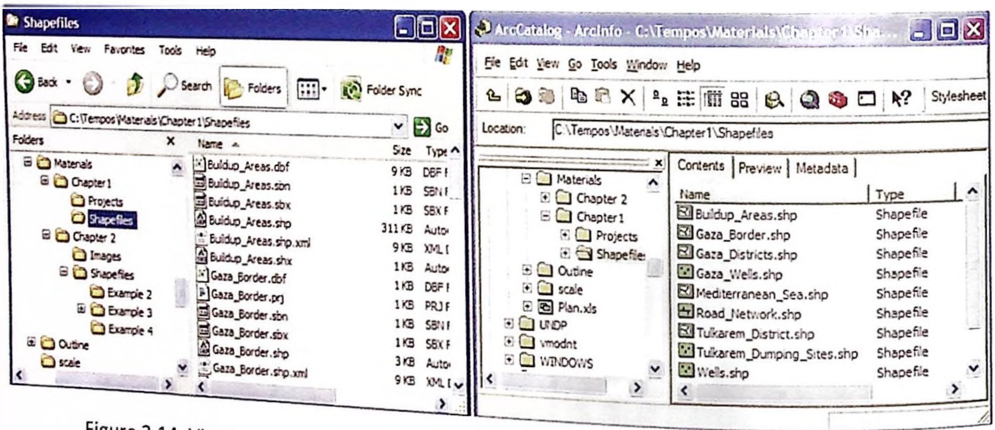


Figure 2.14: Viewing shapefiles in ArcCatalog and Windows Explorer

2.2.2 Layer files

Layer files are not in themselves actual datasets but contain source information about the dataset that they refer to, and therefore when loaded appear as datasets. Layer files can store and display information such as symbology, labels and some definitions, such as conditions to exclude parts of the dataset. Layer files can be created and used with any data formats compatible with ArcGIS (see Section 2.6.3.1).

2.2.3 Coverage

Coverage is the main type of feature datasest used in the ArcInfo workstation It contains multiple geographic feature types, which each correspond to a feature class, Figure 2.15. The folder that contains all of these feature classes is the actual coverage. Within it, the geometric and attribute information which is stored in hidden binary files can be displayed using ArcCatalog's Preview and Table Preview, respectively.

The dataset is structured as a series of files held in a pair of folders, one named as that defined for the dataset, and the other called info. Both need to be kept together in the same directory for the dataset to work. Note that if there is more than one coverage in the same folder, then they will share the same info file.

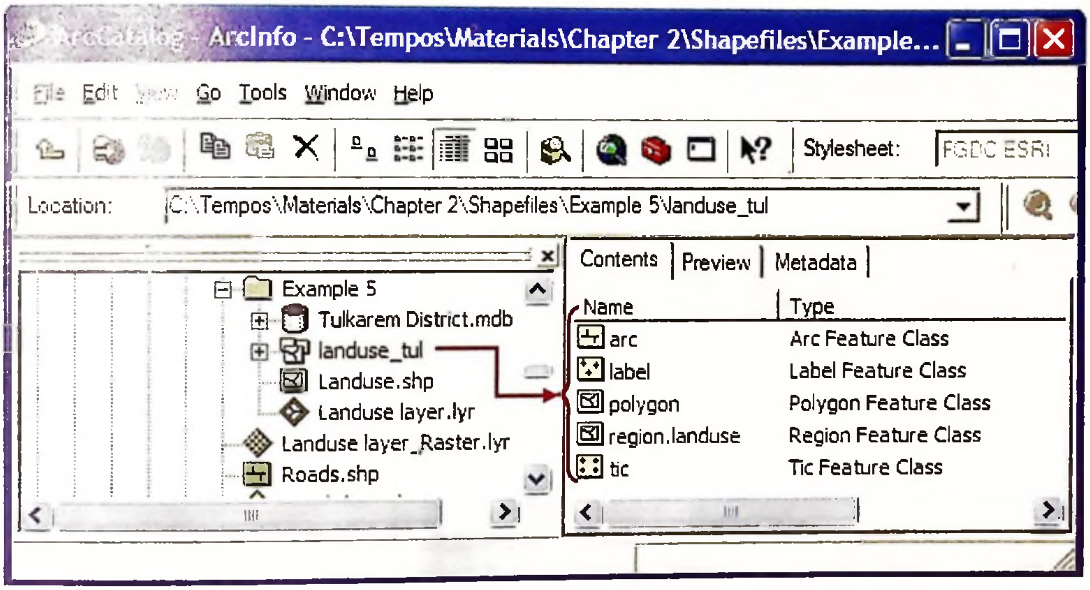


Figure 2.15: Structure of GIS coverage

2.2.4 Personal GeoDatabases

Personal GeoDatabases (PGDs) are a new format used by ArcGIS. They are an independent equivalent to running a large geodatabase via software such as ArcSDE, and structure more like an Access database, but in this case with the addition of geographical features. PGDs can store rasters and tables as well as features.

Within a PGD, data is stored in feature classes, which is basically an individual dataset. The PGD is appropriate to store a set of related features e.g. related to specific a governorate, Figure 2.16.

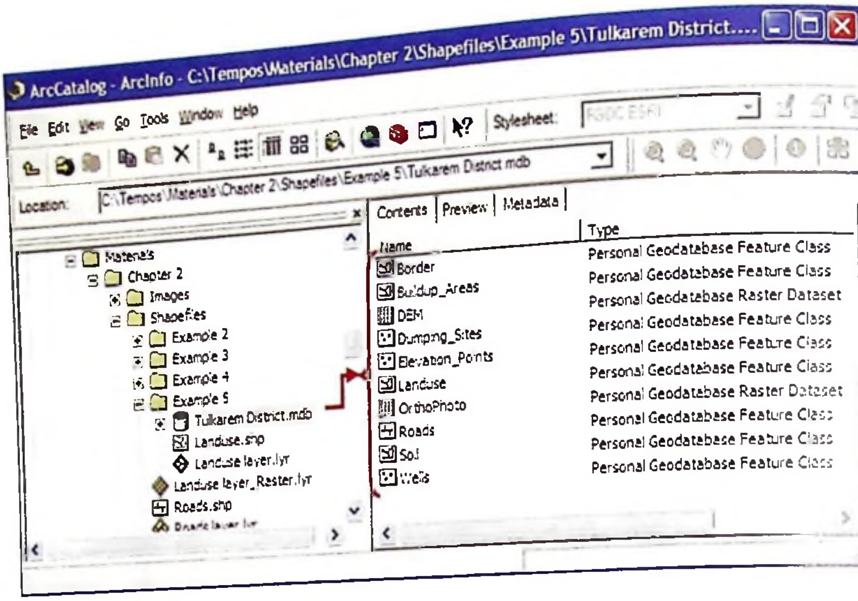


Figure 2.16: Structure of a PGD

2.2.5 Geodatabase

A geodatabase is the common data storage and management framework for ArcGIS and can be utilized wherever it is needed; on desktops, in servers (including the Web), or in mobile devices. Like PGDs, it supports all the different types of data that can be used by ArcGIS (e.g. attribute tables, geographic features, satellite and aerial imagery, etc), Figure 2.17.

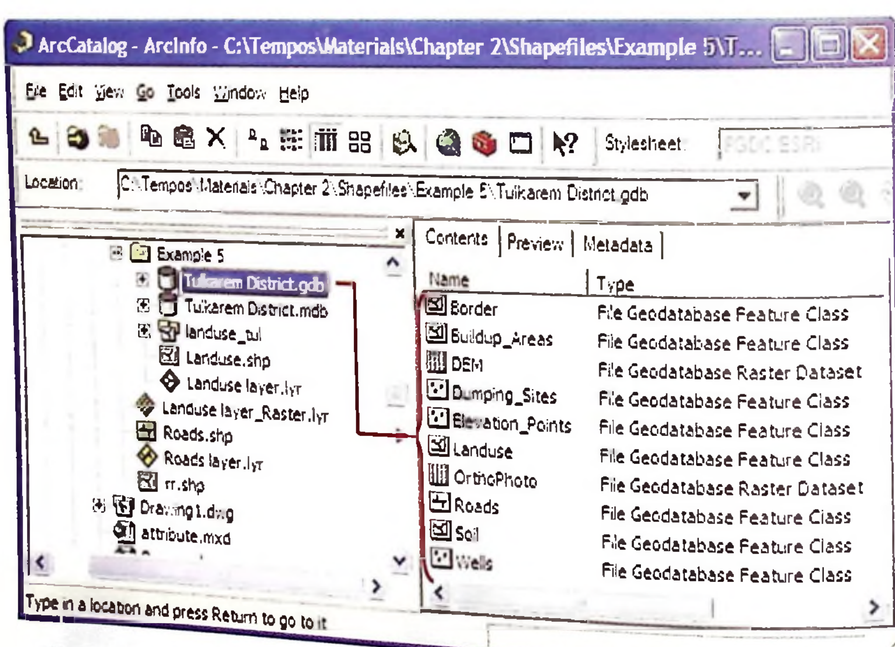


Figure 2.17: Structure of a geodatabase

2.2.6 Text Files and XY Data

Tables can be added to ArcGIS either in the form of Dbase (*.dbf), comma delimited (*.csv), tab delimited (*.txt) text or Microsoft Excel sheets (*.xls). Note that there are a number of conventions that should be considered when using these files with GIS datasets, such as no missing in field headings or even in the data values, no use of formulas, etc. Figure 2.18 shows a standard structure of an XY data file.

Using a text file to display XY data is possible for a limited number of purposes, however the user will need to export it to either a PGD feature class or shapefile before full functionality is available for this type of dataset.

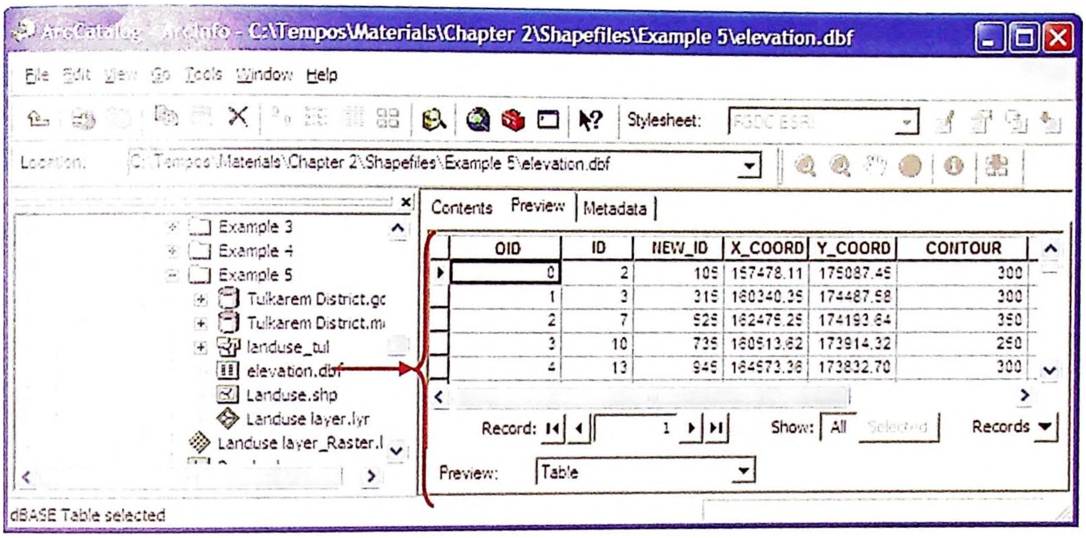


Figure 2.18: XY data file used by ArcGIS

2.2.7 Image Files

There are a number of image formats compatible with ArcGIS of which the most commonly used are JPEG, BMP and TIFF. These are suitable for providing background context, however, don't contain any attributes that can be used for analysis. Most image files come with a separate text file which contains the georeferencing information for the image e.g. *.jgw , *.bpw or *.tfw, these files need to maintain the same prefix and directory location as the image itself in order to store the georeferencing information associated with the image.

2.2.8 ASCII Grids

This is a text based format commonly used for gridded data. ASCII files can be imported into ArcGIS as long as the relevant header information is present in the file, Figure 2.19.

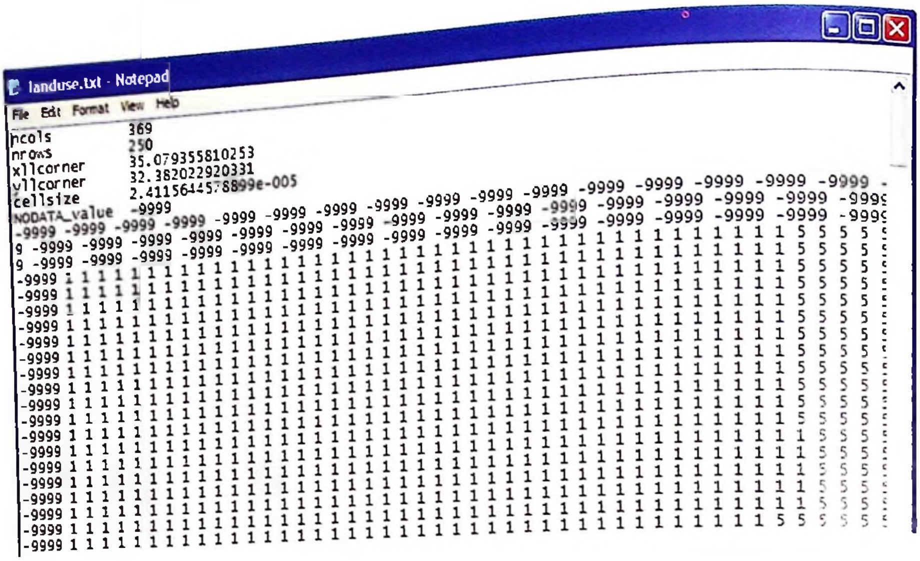


Figure 2.19: Structure of an ASCII grid file.

2.2.9 CAD Files

AutoCAD Drawing Files (DWG) and Autodesk's Data Interchange File (DXF) are probably the most widely used vector data transfer format. The DXF format offers some very important advantages. It contains very complete display information, and almost every graphics program can read it. However, there are several different ways to store attribute information in DXF but still there are no attribute standards, many programs that claim to read DXF files do not import attribute information properly.

2.3 GIS Data Sources

Normally data is stored in the form of tables, hard copy maps or digital maps which are mainly derived from remote sensing or aerial photographs. These data could be divided into two types of datasets as described in Section One of this Chapter; spatial data which has a geographic reference and attribute data (non-spatial) which most of the time describes specific spatial data.

The creation of a clean digital database is the most important and time consuming task upon which the usefulness of GIS depends. The establishment and maintenance of a robust spatial database is the cornerstone of successful GIS application. In addition to that building a GIS database may be the most expensive part of a GIS application. The general consensus among the GIS community is that 60 to 80 % of the cost incurred during implementation of GIS technology lies in data acquisition, data compilation and development of a database.

A wide variety of data sources exist for both spatial and attribute data. The most common general sources for spatial data are:

1. Point data samples from the field
2. Existing digital data files
3. Hard copy maps: sometimes referred to as analogue maps which provide the most popular source for any GIS data.

4. Tabular data: attribute data has an even wider variety of data sources. Any textual or tabular data can be referenced to a geographic feature, e.g. a point, line, or area. Attribute data is usually entered by manual keying.
5. Surveying
6. The Global Positioning System (GPS)
7. Photogrammetry
8. Remotely-sensed imagery

Converting these different types of data sources into a GIS format is considered the basic job for developing a GIS system. By using the GIS standards and algorithms, the user can derive new data that provides the ability to interpret the base data. For example, the elevation map for a particular location is basic data, by using some of the GIS algorithms the user could derive a slope map for this location.

There are many ways that could be used to convert data into GIS format based on the existing format of the available data including:

2.3.1 Manual Input Data

Commonly, there are many thousands of records kept in paper archives that contain valuable information. This may be historical data or data collected based on specific monitoring programs. For example, water levels and quality are usually measured every three months for most of the groundwater wells in the West Bank. These measured data are manually entered in the form of text files or Excel worksheets without geographical position details. If, for example, the well locations are recorded on a digital map with well name or code and the records (table) also have the same name or code, a link can be developed between these records and the digital map, (see Section 2.6.2).

2.3.2 Conversion of Existing Digital Data

A second technique that is becoming increasingly popular for data input is the conversion of existing digital data. A variety of spatial data, including digital maps, are openly available from a wide range of governmental, non-governmental and private sources. The most common digital data to be used in GIS is data from CAD systems. A number of data conversion programs exist, mostly from GIS software vendors, to transform data from CAD formats to a raster or topological GIS data format. Several ad hoc standards for data exchange have been established in the market.

2.3.3 Capturing Data from Maps

Paper maps have been used in geography for centuries. Capturing this type of information into a digital form makes it much easier to store and reproduce. It also enables the power of computers to be used in manipulating, updating and analyzing the information in many different ways. There are two main methods used for converting paper maps into electronic form; scanning and digitizing.

2.3.3.1 Scanning

Nowadays, scanning technology is widely used in most offices. A scanner will copy any printed image. By capturing the image in digital form it can be stored on the computer and displayed on screen. Scanning a map is a straightforward process and generally fast, but does not provide or capture any attribute information for features, such as the address of a building. Raster data uses up a lot of disk space, so rasterisation of maps by scanning is not always the most efficient method.

Some very specialized computer systems are able to convert raster datasets to vector datasets by recognizing patterns in the image. For instance, it can guess that sequences of colored pixels which seem to form a line across the image are showing a linear feature of some kind. Section 2.6.1.3 will show how a raster dataset could be converted to a vector dataset.

The vectorisation of raster datasets can be a fast way to capture data because it can be automated, but is usually less accurate than manual digitizing.

2.3.3.2 Digitizing

Digitizing is the transformation of information from an analog format (paper map) to a digital format that can be stored and displayed with a computer. Digitizing is performed on a digitizing table or tablet but may also be done on a computer screen (heads up digitizing). The digitizing table has a fine grid of wires embedded in it that acts as a Cartesian coordinate system, Figure 2. 19. The source map is laid flat on the digitizing table and an electronic cursor is passed over the features of the map. In this way, each of the coordinate points which make up the different shapes can be identified. By clicking the cursor when it is held over a point, digitizing captures map data in vector form.

Digitizing can be very time consuming because every single point or vertex must be captured individually. However, a digitized map is different from a scanned one in that the result of digitizing is in vector data form, so, it is possible to attach attribute information to features.

Figure 2.19: Digitizing maps using a digitizer

2.3.4 Surveying

The size, shape and relative location of physical objects in the field could be measured by a surveyor with many types of surveying instruments.

The accuracy and type of survey are the main issues to be determined for building up a series of points that can either be independent in location or trace points along a linear feature or demarcate an area with a similar attribute that can be built up by a surveyor. For example, using a total station, Figure 2.20, a highly accurate location and elevation map can be achieved. The total station can record its own coordinate system that can be transformed later, but it is common practice to set up the station on a known point (a reference point). Then all subsequent measurements will be relative to that reference point. It is good practice to return to the reference point or to cross other independent referencing points so that the survey can be checked for accuracy.

Figure 2.20: A digital total station

In many cases within the water environment, the high degree of accuracy provided by a digital total station is not needed. Relatively accurate surveys can be carried out using a tape measure and a compass.

Another type of survey is to use a pair of digital binoculars to estimate the distance and angle of an object from a current position. By just sighting the binoculars onto an object, a single set of values for that object will be returned. Tape measures and binoculars can be used in tandem with a total station or with a Global Positioning System (GPS).

2.3.5 The Global Positioning System (GPS)

The Global Positioning System (GPS), Figure 2.21, is basically a surveying technique that relies on a series of orbiting satellites. It gives an excellent position and height reading (to the order of 1 cm or less). The only constraint is that the satellite receiving equipment must be able to make contact with three to four satellites.

Figure 2.21: Global Positioning System (GPS)

GPS systems can be used for the accurate navigation to a point. For example a dual frequency system will provide very accurate measurements, Figure 2.22. This system is composed of two sets of equipment; one set of equipment acts as a referencing base station, and the second will be the roving station that records all the points in the survey. By comparing the base station and the roving station data together, an accurate map is determined: this is called a differential GPS.

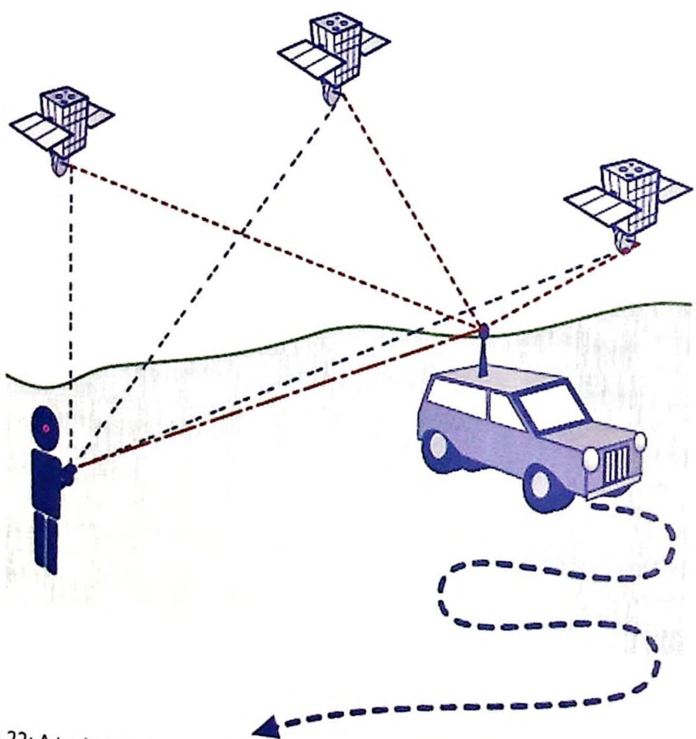


Figure 2.22: A typical set-up for a base and roving differential GPS.

2.3.6 Photogrammetry

Photogrammetry is defined as the science or art of obtaining reliable measurements by means of photography. Although the term can apply to measurement from ground photographs, modern photogrammetric techniques are most often applied to aerial and satellite images. One of the most common uses of photogrammetry is the analysis of aerial photography, Figure 2.23, to extract ground features for the production of location maps. Aerial photogrammetry is one type of photogrammetry where the camera is mounted in an aircraft and is usually pointed vertically towards the ground. Multiple overlapping photos of the ground are taken as the aircraft flies along a flight path. The major problem of aerial photos is caused by distortion of the image by the lens, the angle of the airplane and the curvature of the land.

Figure 2.23: Aerial photograph map

2.3.7 Remote Sensing

Remote sensing may be defined as the technique of obtaining information about the Earth's surface and environment by airplanes and satellites. All forms of remote sensing use electromagnetic radiation, coming from the Earth's surface received by specialized sensors on the satellite or airplane platform. Visible light is one form of radiation that is very useful in remote sensing because humans can see it. However, there are many other forms covering a whole range of different wavelengths or frequencies, Figure 2.24, which humans cannot see without special instruments; these wavelengths make up the electromagnetic spectrum.

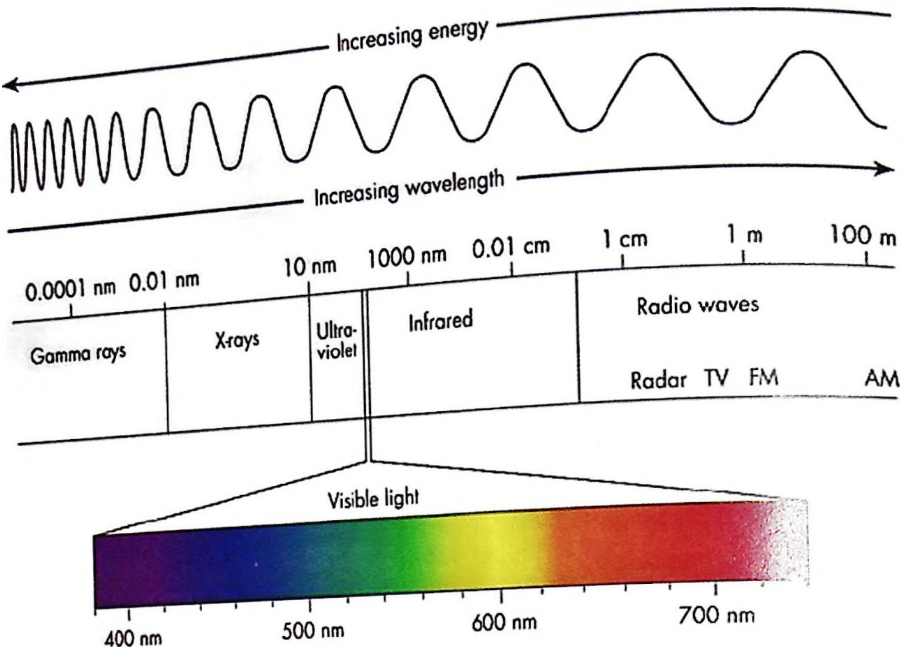


Figure 2.24: The electromagnetic spectrum

2.4 GIS Data Models

GIS stores information about the world as a collection of thematic layers that can be linked together by geography. This is a simple, but extremely powerful and versatile concept that has proven to be invaluable for solving many real-world problems. The thematic layer approach allows GIS users to organize the complexity of the real world into a simple representation and help them facilitate their understanding of natural relationships. In this context, there are five database models that could be used in GIS:

2.4.1 Tabular Model

The simple tabular model stores attribute data as sequential data files with fixed formats (e.g. comma delimited for ASCII data), Figure 2.25. This type of data model is outdated in the GIS arena. It lacks any method of checking data integrity, as well as being inefficient with respect to data storage, e.g. limited indexing capability for attributes or records, etc.

Well_ID	Elev_m	Owner	Locality	Depth_m	Usage	Aquifer	Formation
15-18/C06	145	MUHAMMAD 'ABED AL HALEEM	FAR'UN	165	Agricultural	UC	Bet/Heb
15-18/012	180	MUHAMMAD KHADER 'ABDALLAH	KUFUR JAMMAL	163	Agricultural	UC	Bet/Heb
15-18/015	270	KAMEL AL SALEM & PARTNERS	KUFUR ZEEBAD	404	Domestic	LC	UBK/LBK
15-18/020	90	WASFI 'ABED AL KAREEM	FAR'UN	110	Agricultural	UC	Bet/Heb
15-18/C21	218	'AREF 'ABED AL QADER	AL RAS	0	Abandoned	UC	Bet/Heb
15-18/024	100	SHUFA WATER COOPERATIVE COMMITTEE	SHUFAH	151	Domestic	UC	Jer/Bet/Heb
15-18/C25	164	SAL'EET	KUFR SOUR	0	Mekoroth	UC	Bet/Heb
15-19/C06	95	RA'FAT AL QUBBAJ	NUR SHAMS	96	Agricultural	UC	Bet/Heb
15-19/C10	100	ZAITA VILLAGE COUNCIL	ZAITA	262	Domestic	UC	Jer/Bet/Heb
15-19/C12	135	ZUBAYDAH AL SA'EED	DHINNABAH	154	Agricultural	UC	Bet/Heb
15-19/C17	75	TULKARM MUNICIPALITY	TULKARM	100	Domestic	UC	Jer/Bet/Heb
15-19/C21	73	HASEEB IMUS	'ATTEEL	152	Agricultural	UC	Jer/Bet/Heb
15-19/C25	110	'ABED AL RAHEEM MER'IB	SHWAIKAH	132	Agricultural	UC	Jen
15-19/C28	140	HASAN MAHMUD KHALEEL	KUFUR AL LABAD	175	Agricultural	UC	Bet/Heb
15-19/C42	100	MUHAMMAD 'ABED AL RAZEQ & PARTNERS	'ALLAR	200	Agricultural	UC	Jer/Bet/Heb
15-19/C47	195	DAIR AL GHSUN VILLAGE COUNCIL	DAIR AL GHSUN	185	Domestic	UC	Bet/Heb
15-19/C48	210	BAL'A VILLAGE COUNCIL	BAL'A	295	Domestic	UC	Jer/Bet/Heb
[illegible]	[illegible]	MUHAMMAD ABU SHAMS	BAQAH AL SHARQIYYAH	0	Agricultural	UC	Jer/Bet/Heb
15-20/C02A	65	MUHAMMAD ABU SHAMS	BAQAH AL SHARQIYYAH	140	Agricultural	UC	Jer/Bet/Heb
[illegible]	[illegible]	MUHAMMAD AL TAHER & PARTNERS	NAZLET 'ISA	160	Agricultural	UC	Bet/Heb
[illegible]	[illegible]	QAFFEEN VILLAGE COUNCIL	QAFFEEN	176	Domestic	UC-T	Jer/Bet/Heb
[illegible]	[illegible]	'ANABTA MUNICIPALITY	'ANABTA	150	Domestic	UC	Jer/Bet/Heb
[illegible]	[illegible]	[illegible] 'AWARTANI	'ANABTA	160	Agricultural	UC	Bet/Heb

Figure 2.25: Example of a simple tabular model

2.4.2 Hierarchical Model

In a hierarchical data model, data are organized into a tree-like structure. The structure allows repetition of information using parent/child relationships meaning that each parent can have many children but each child only has one parent, Figure 2.26. All attributes of a specific record are listed under an entity type. In a database, an entity type is the equivalent of a table; each individual record in a table is represented as a row and each attribute as a column. Entity types may be related to each other using 1:N mapping, also known as one-to-many relationships, Figure 2.27.

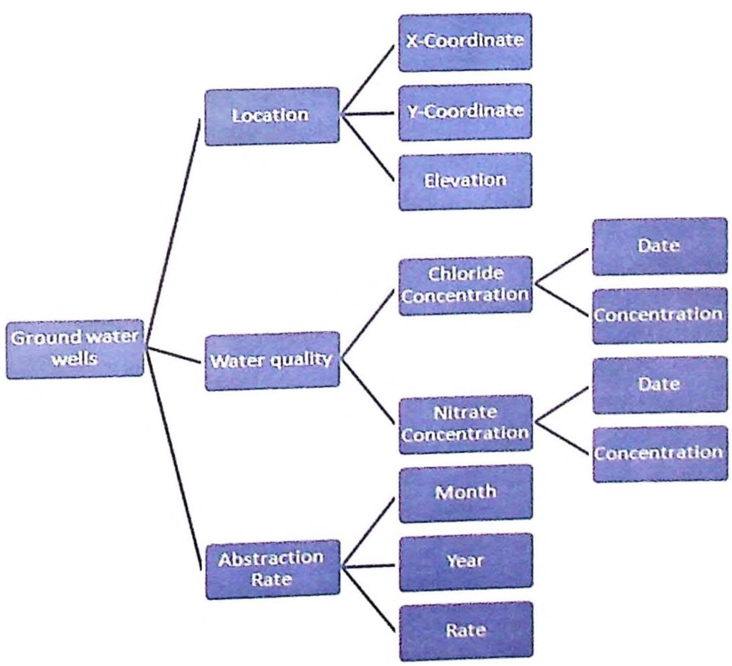
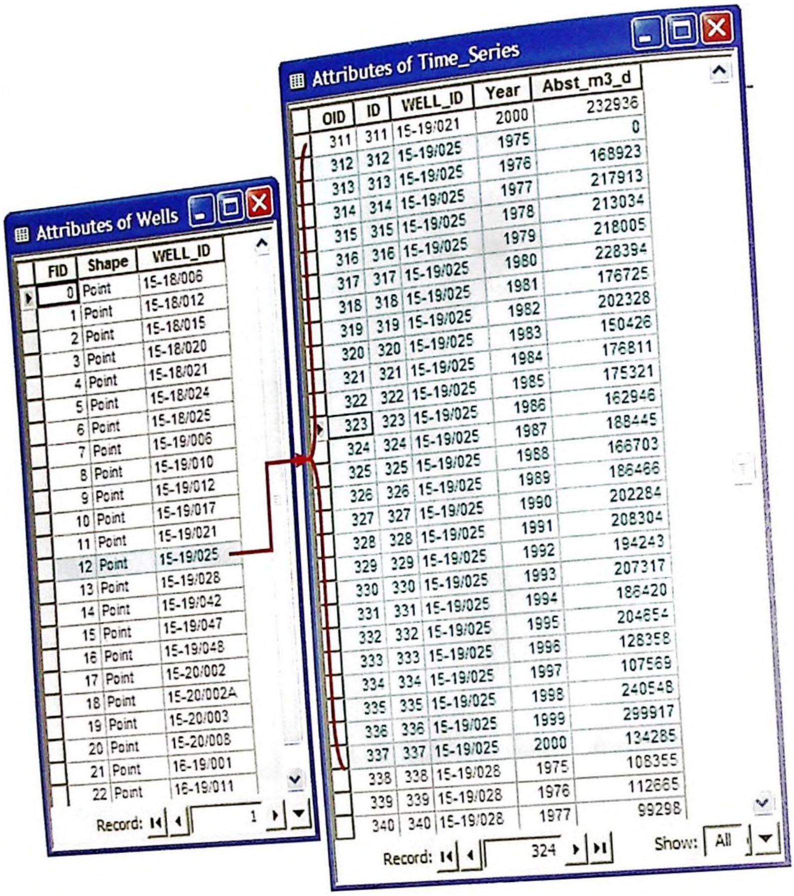


Figure 2.26: Example of a sample hierarchical database



Attributes of Wells

FID	Shape	WELL_ID
0	Point	15-18/006
1	Point	15-18/012
2	Point	15-18/015
3	Point	15-18/020
4	Point	15-18/021
5	Point	15-18/024
6	Point	15-18/025
7	Point	15-19/006
8	Point	15-19/010
9	Point	15-19/012
10	Point	15-19/017
11	Point	15-19/021
12	Point	15-19/025
13	Point	15-19/028
14	Point	15-19/042
15	Point	15-19/047
16	Point	15-19/048
17	Point	15-20/002
18	Point	15-20/002A
19	Point	15-20/003
20	Point	15-20/008
21	Point	16-19/001
22	Point	16-19/011

Record: 1

Attributes of Time_Series

OID	ID	WELL_ID	Year	Abst_m3_d
311	311	15-19/021	2000	232936
312	312	15-19/025	1975	0
313	313	15-19/025	1976	168923
314	314	15-19/025	1977	217913
315	315	15-19/025	1978	213034
316	316	15-19/025	1979	218005
317	317	15-19/025	1980	228394
318	318	15-19/025	1981	176725
319	319	15-19/025	1982	202328
320	320	15-19/025	1983	150426
321	321	15-19/025	1984	176811
322	322	15-19/025	1985	175321
323	323	15-19/025	1986	162946
324	324	15-19/025	1987	188445
325	325	15-19/025	1988	166703
326	326	15-19/025	1989	186466
327	327	15-19/025	1990	202284
328	328	15-19/025	1991	208304
329	329	15-19/025	1992	194243
330	330	15-19/025	1993	207317
331	331	15-19/025	1994	186420
332	332	15-19/025	1995	204654
333	333	15-19/025	1996	128358
334	334	15-19/025	1997	107569
335	335	15-19/025	1998	240548
336	336	15-19/025	1999	299917
337	337	15-19/025	2000	134285
338	338	15-19/028	1975	108355
339	339	15-19/028	1976	112665
340	340	15-19/028	1977	99298

Record: 324 Show: All

Figure 2.27: Example of a one-to-many relationship

An example of a hierarchical data model would be if groundwater wells had descriptive records in a table (entity type) called "Wells". In this table attributes/columns such as well name, depth, tapped aquifer, etc could be found. Abstraction rates are also listed in a separate table called "Wells Abstractions" with attributes such as average monthly abstraction, year, percentage of water use for agricultural purposes, etc. The Wells table represents a parent segment and the "Wells Abstractions" table is a child segment. These two segments form a hierarchy where Wells may have many children such as abstraction rates, water qualities, but each child may only have one parent.

2.4.3 Network Model

The network database organizes data in a network structure. Any column in a network structure can be linked to any other. Like a tree structure, a network structure can be described in terms of parents and children. This model allows for children to have more than one parent.

Network databases have not found much more acceptance in GIS than the hierarchical databases. They have the same flexibility limitations as hierarchical databases; however, the more powerful structure for representing data relationships allows more realistic modeling of geographic phenomenon. However, network databases tend to become overly complex too easily. In this regards, it is easy to lose control and understanding of the relationships between elements.

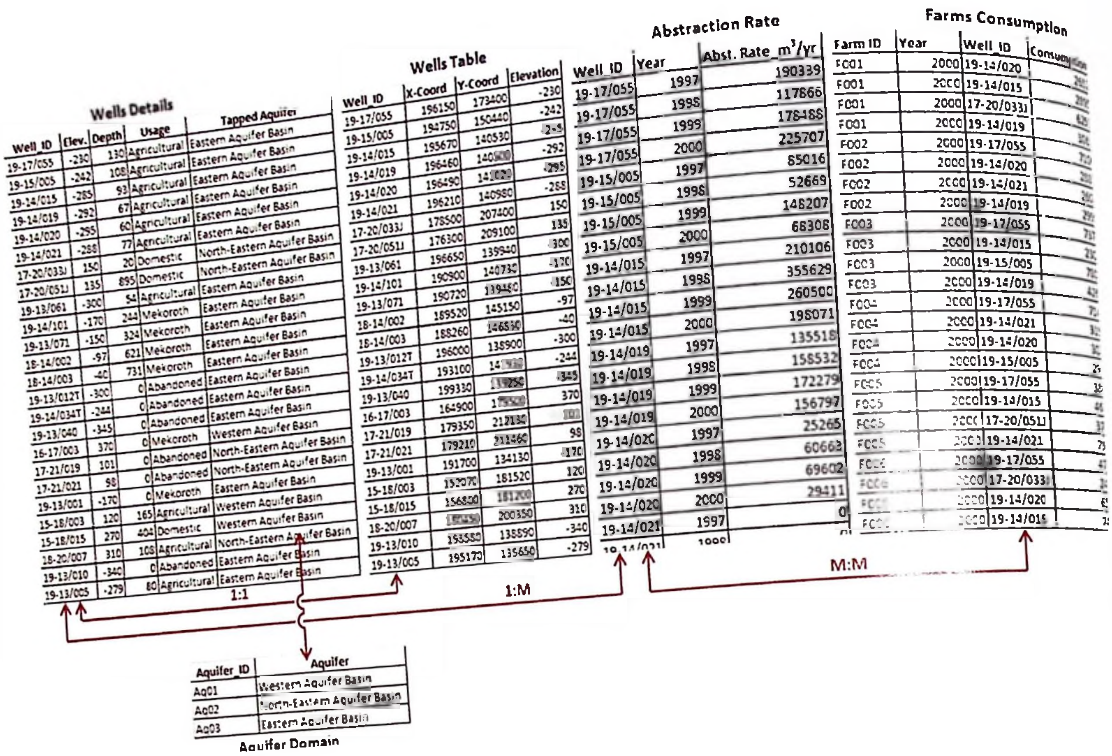
2.4.4 Relational Model

Three key terms are used extensively in relational database models: relations, attributes, and domains. A relation is a table with columns and rows. The named columns of the relation are called attributes, and the domain is the set of values the attributes are allowed to take.

The basic data structure of the relational model is the table, where information about a particular entity, i.e. groundwater wells, is represented in columns and rows. Thus, the "relation" in a "relational database" refers to the various tables in the database; a relation is a set of rows. The columns enumerate the various attributes of the entity (e.g. the well's name, and owner), and a row is an actual instance of the entity (a specific well) that is represented by the relation. As a result, each row of the Wells table represents various attributes of a single well.

All relations (and, thus, tables) in a relational database have to adhere to some basic rules to qualify as relations. First, the ordering of columns is immaterial in a table. Second, there can't be identical rows in a table. And third, each row will contain a single value for each of its attributes i.e. each row has a well name.

A relational database contains multiple tables, each similar to the one in the "Hierarchical" database model. One of the strengths of the relational model is that, in principle, any value occurring in two different records (belonging to the same table or to different tables), implies a relationship among those two records. Yet, in order to enforce explicit integrity constraints, relationships between records in tables can also be defined explicitly, by identifying or non-identifying parent-child relationships characterized by assigning cardinality (1:1, 1:M, M:M), Figure 2.28. Tables can also have a designated single attribute or a set of attributes that can act as a "key", which can be used to uniquely identify each row in the table (e.g. Well ID could be used as a primary key).



Wells Details

Well_ID	Elev.	Depth	Usage	Tapped Aquifer
19-17/055	-230	130	Agricultural	Eastern Aquifer Basin
19-15/005	-242	108	Agricultural	Eastern Aquifer Basin
19-14/015	-285	93	Agricultural	Eastern Aquifer Basin
19-14/019	-292	67	Agricultural	Eastern Aquifer Basin
19-14/020	-295	60	Agricultural	Eastern Aquifer Basin
19-14/021	-288	77	Agricultural	Eastern Aquifer Basin
17-20/033J	150	20	Domestic	North-Eastern Aquifer Basin
17-20/051J	135	895	Domestic	North-Eastern Aquifer Basin
19-13/061	-300	54	Agricultural	Eastern Aquifer Basin
19-14/101	-170	244	Mekoroth	Eastern Aquifer Basin
19-13/071	-150	324	Mekoroth	Eastern Aquifer Basin
18-14/002	-97	621	Mekoroth	Eastern Aquifer Basin
18-14/003	-40	731	Mekoroth	Eastern Aquifer Basin
19-13/012T	-300	0	Abandoned	Eastern Aquifer Basin
19-14/034T	-244	0	Abandoned	Eastern Aquifer Basin
19-13/040	-345	0	Abandoned	Eastern Aquifer Basin
16-17/003	370	0	Mekoroth	Western Aquifer Basin
17-21/019	101	0	Abandoned	North-Eastern Aquifer Basin
17-21/021	98	0	Abandoned	North-Eastern Aquifer Basin
19-13/001	-170	0	Mekoroth	Eastern Aquifer Basin
15-18/003	120	165	Agricultural	Western Aquifer Basin
15-18/015	270	404	Domestic	Western Aquifer Basin
18-20/007	310	108	Agricultural	North-Eastern Aquifer Basin
19-13/010	-340	0	Abandoned	Eastern Aquifer Basin
19-13/005	-279	80	Agricultural	Eastern Aquifer Basin

Wells Table

Well_ID	X-Coord	Y-Coord	Elevation
19-17/055	196150	173400	-230
19-15/005	194750	150440	-242
19-14/015	195670	140530	[illegible]
19-14/019	196460	140[illegible]	-292
19-14/020	196490	14[illegible]	-295
19-14/021	196210	140980	-288
17-20/033J	178500	207400	150
17-20/051J	176300	209100	135
19-13/061	196650	139940	-300
19-14/101	190900	140730	-170
19-13/071	190720	139[illegible]	-150
18-14/002	189520	145150	-97
18-14/003	188260	146[illegible]	-40
19-13/012T	196000	138900	-300
19-14/034T	193100	14[illegible]	-244
19-13/040	199330	[illegible]	-345
16-17/003	164900	1[illegible]	370
17-21/019	179350	212130	[illegible]
17-21/021	179210	211460	98
19-13/001	191700	134130	-170
15-18/003	152070	181520	120
15-18/015	156800	[illegible]	270
18-20/007	[illegible]	200350	310
19-13/010	193550	138890	-340
19-13/005	195170	135650	-279

Abstraction Rate

Well_ID	Year	Abst. Rate_m³/yr
19-17/055	1997	190339
19-17/055	1998	117866
19-17/055	1999	178488
19-17/055	2000	225707
19-15/005	1997	85016
19-15/005	1998	52669
19-15/005	1999	148207
19-15/005	2000	68308
19-14/015	1997	210106
19-14/015	1998	355629
19-14/015	1999	260500
19-14/015	2000	198071
19-14/019	1997	135518
19-14/019	1998	158532
19-14/019	1999	172279
19-14/019	2000	156797
19-14/020	1997	25265
19-14/020	1998	60663
19-14/020	1999	69602
19-14/020	2000	29411
19-14/021	1997	0
[illegible]	[illegible]	[illegible]

Farms Consumption

Farm ID	Year	Well_ID	Consumption
F001	2000	19-14/020	[illegible]
F001	2000	19-14/015	[illegible]
F001	2000	17-20/033J	[illegible]
F001	2000	19-14/019	[illegible]
F002	2000	19-17/055	[illegible]
F002	2000	19-14/020	[illegible]
F002	2000	19-14/021	[illegible]
F002	2000	19-14/019	[illegible]
F003	2000	19-17/055	[illegible]
F003	2000	19-14/015	[illegible]
F003	2000	19-15/005	[illegible]
F003	2000	19-14/019	[illegible]
F004	2000	19-17/055	[illegible]
F004	2000	19-14/021	[illegible]
F004	2000	19-14/020	[illegible]
F004	2000	19-15/005	[illegible]
F005	2000	19-17/055	[illegible]
F005	2000	19-14/015	[illegible]
F005	2000	17-20/051J	[illegible]
F005	2000	19-14/021	[illegible]
[illegible]	2000	19-17/055	[illegible]
[illegible]	2000	17-20/033J	[illegible]
[illegible]	2000	19-14/020	[illegible]
[illegible]	2000	19-14/015	[illegible]

Aquifer_ID	Aquifer
Aq01	Western Aquifer Basin
Aq02	North-Eastern Aquifer Basin
Aq03	Eastern Aquifer Basin

Aquifer Domain

Figure 2.28: Example of a relational database

2.5 Data Quality

2.5.1 Definitions

There are three main parameters related to data quality: accuracy, precision and error. The definitions of these indicators are:

2.5.1.1 Accuracy

Defined as the closeness of results, computations or estimates to true values (or values accepted to be true) since spatial data is usually a generalization of the real world, it is often difficult to identify a true value, but work instead with values which are accepted to be true for example when measuring the accuracy of a contour in a digital database, we compare to the contour as drawn on the source map, since the contour does not exist as a real line on the surface of the Earth.

It could be said that the data is accurate if the observed measurements are very close to the true values or the accepted ones.

2.5.1.2 Precision

Defined as the number of decimal places or significant digits in a measurement precision is not the same as accuracy; a large number of significant digits does not necessarily indicate that the measurement is accurate

It could be said that the data is precise if the observed measurements are very close to each other. This one is called statistical precision. Numerical precision is the number of significant digits that an observation is recorded in. A value recorded to 4 decimal places is more precise than one to 2 decimal places.

The difference between accuracy and precision is clarified in the following example: consider Figure 2.29 that illustrates the trials to locate the green point using a device. The device recorded the red points for that purpose. Compare between these trials.

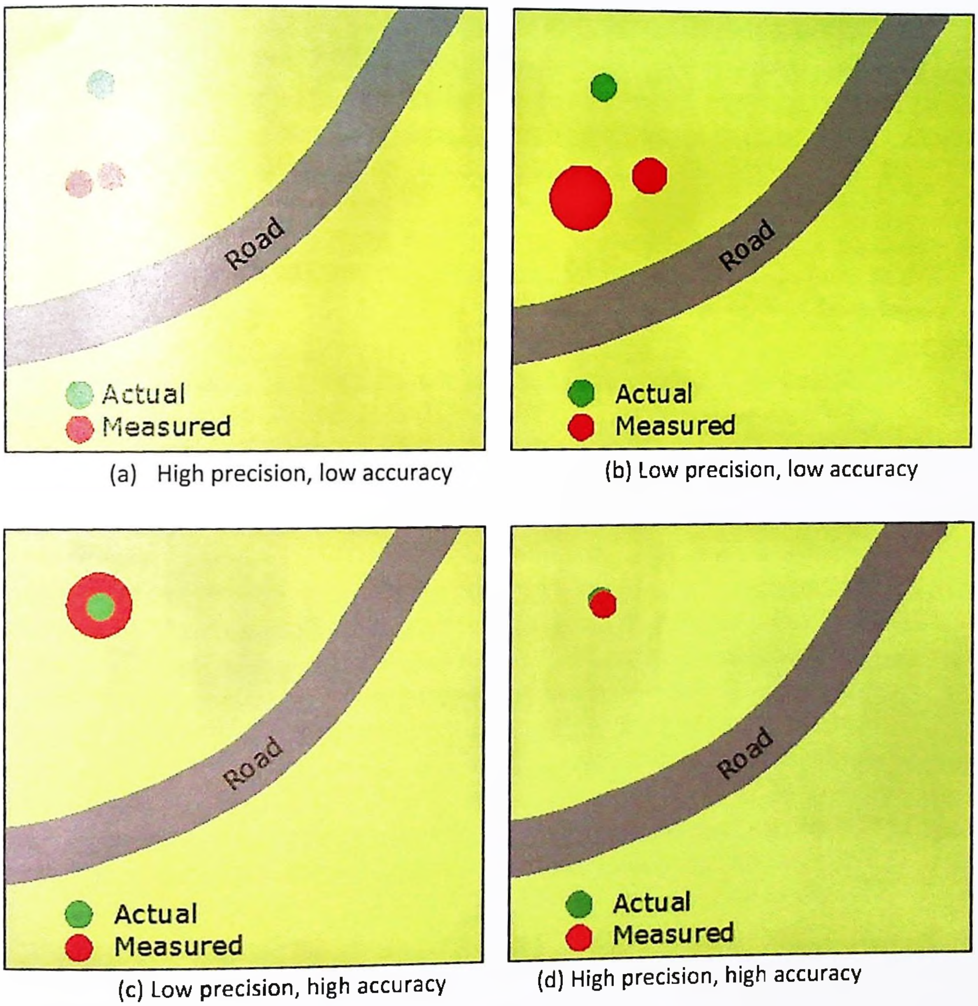


Figure 2.29: The differences between accuracy and precision

2.5.1.3 Error

An error is defined as the difference between the true value and the obtained value when considering the presentation of reality using GIS.

2.5.2 GIS Data Quality

Understanding the concept of data quality is very important for establishing a reliable GIS database. The accuracy of GIS data depends on the quality of the original input data and on the precision with which input data are processed. Higher data accuracy implies higher initial data quality and more precise processing, and as a result high system costs. Therefore, selecting the degree of GIS data accuracy is a function of four criteria:

1. Needs: This criterion may be determined by a set of questions: What is the GIS database needed for? What is expected from the GIS database? What is the complexity of the problem that needs to be solved, etc.
2. Costs: which is related to how much money we want to spend, what is the available fund, etc.
3. Accessibility: Depending on the availability of the initial data in the market, the possibility to measure the data from the field, etc.
4. Time frame: which could be measured by the time allocated for establishing the GIS database.

The International Organization for Standardization (ISO, 2001) has proposed that the following elements should be used to describe the quality of the dataset:

- **Positional Accuracy:** is defined as the closeness of a location to its true position. In ordinary mapping, accuracy is inversely proportional to map scale. For example, a map to scale 1:1,000 is more accurate than one to scale 1: 100,000.

  There are two components to positional accuracy: relative and absolute accuracy. Absolute accuracy is concerned with the accuracy of data elements with respect to a coordinate scheme. That is how close the location on the map or data representation is to its real location on Earth. For example, 95% of the well locations are within 50 meters of their surveyed locations. Often relative accuracy is of greater concern than absolute accuracy. That is how similar a shape on the map or data representation is to the shape of the object on Earth. For example, the boundaries of an area do not vary by more than 10 meters from their actual shape.

- **Attribute Accuracy:** is equally as important as positional accuracy. It is an assessment of the reliability of values assigned to features in the dataset in relation to their true real world values.

- **Temporal accuracy:** is concerned with the appropriateness of using a particular period of time for GIS datasets, i.e. have data from different time frames been combined into one dataset?

- **Logical consistency:** is the degree to which there may be contradictory relations in the underlying database. It is an indication of topological problems, such as overshoots, undershoots, unwanted intersections, unclosed polygons, missing or duplicate labels, etc.

- **Completeness:** is the degree to which data is missing in addition to the method of handling missing data. For example, the ability to estimate rainfall rates in specific areas may be compromised if data is not available for specific areas.

- **Lineage:** is the degree to which there is a chronological set of similar data developed using the modeling and processing methods. For example, population estimates may not be available for all years; may be estimated on different days of the year; or may be estimated using different estimation techniques and data sources.

2.5.3 Common Errors Found in a GIS Dataset

Data editing and verification is in response to the errors that arise during the encoding of spatial and non-spatial data. The editing of spatial data is a time consuming, interactive process that can take as long, if not longer, than the data input process itself. Several kinds of errors can occur during data input. They can be classified as:

- **Incompleteness of the spatial data:** This includes missing points, line segments, and/or polygons.

- **Location placement errors of spatial data:** These types of errors usually are the result of careless digitizing or poor quality of the original data source.

- **Distortion of the spatial data:** This kind of error is usually caused by base maps that do not have a unique scale over the whole image, e.g. as a result of stretching aerial photographs.

- **Incorrect linkages between spatial and attribute data:** This type of error is commonly the result of incorrect unique identifiers (codes) being assigned during manual key in or digitizing. This may involve assigning an entirely incorrect code to a feature, or more than one code being assigned to a feature.

- **Attribute data Errors:** Often the attribute data does not exactly match the spatial data. This is because they are frequently from independent sources and often different time periods. Missing data records or too many data records are the most common problems.

2.6 Practical Exercises

2.6.1 Vector Model versus Raster Model

This exercise aims to practice GIS data simulation; a comparison between vector and raster data representation, converting vector data into raster data with different cell sizes and vice versa.

2.6.1.1 Import Data into a New ArcMap Project

1. Open the Ex1_1.mxd project from "C:\GIS_Tutorial\Chapter2\Exercise1\" or by opening a new ArcGIS project and then adding Illar.bmb, Roads_layer.lyr and Landuse_layer.lyr using the Add Data button or by dragging them from ArcCatalog.
2. Double-click on the Layers dataset (or right-click and then select Properties), select the Coordinate System tab.
3. From the Select Coordinate System box, click Predefined then Geographic Coordinate System then select World and finally select WGS 1984 as the coordinate system to be used for the map.
4. Arrange the map as shown in Figure 2.30. Turn on and then off both Roads and Landuse layers by clicking on the box left to the layer in the table of contents. Notice how the real world picture is presented by vector dataset models.

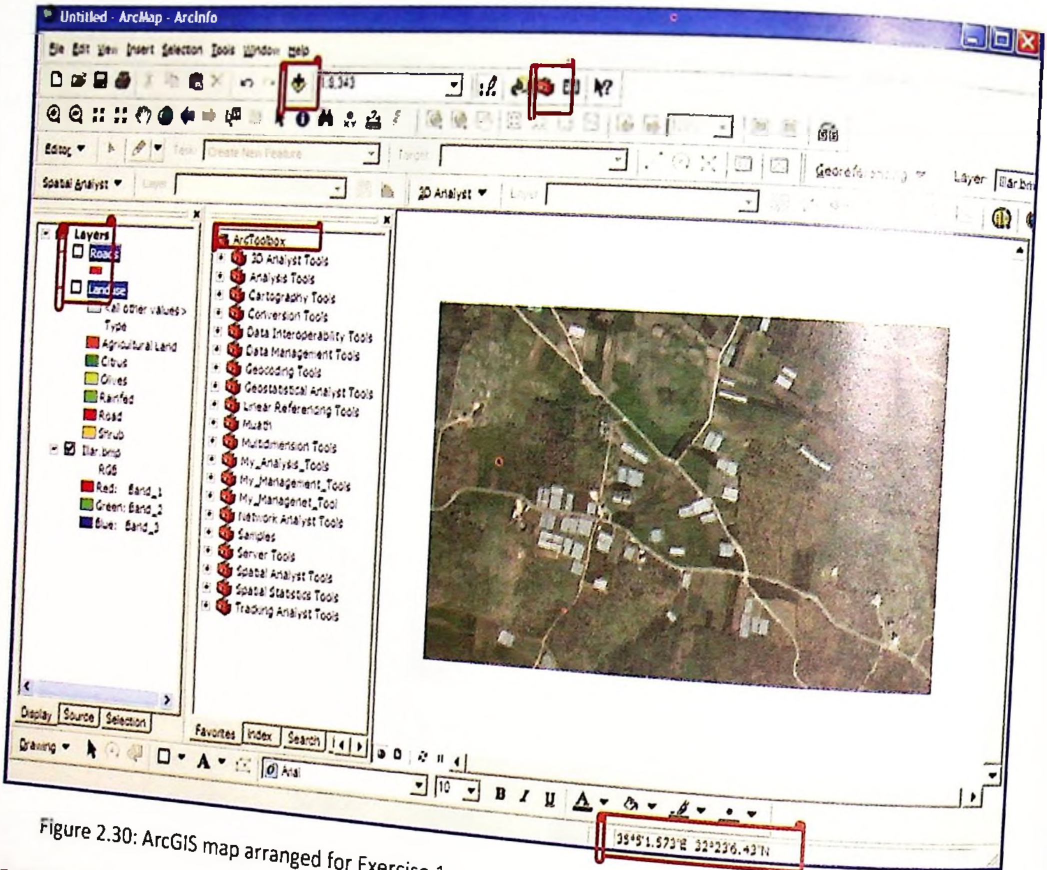


Figure 2.30: ArcGIS map arranged for Exercise 1.

2.6.1.2 Convert a Vector Model to a Raster Model

1. Open a new ArcGIS project, Save it as "Ex1_2.mxd" on "C:\GIS_Tutorial\Chapter2\Exercise1\".
2. Add Soil.shp using the Add Data button or by dragging it from ArcCatalog.
3. Double-click on the Layers dataset (or right-click and then select Properties), select the Coordinate System tab.
4. From the Select Coordinate System box, click Predefined then Projected Coordinate System then select National Grids and finally select Palestine 1923 Palestine Grid as the coordinate system for the map.

5. Double-click on Soil.shp in the table of contents window (or right-click on it then select Properties), select the Symbology tab.
6. Select Categories from the Show; window, click on Unique values. In the Value Field select Formula as a field for classification. Click on Add All Values then press OK, Figure 2.31.

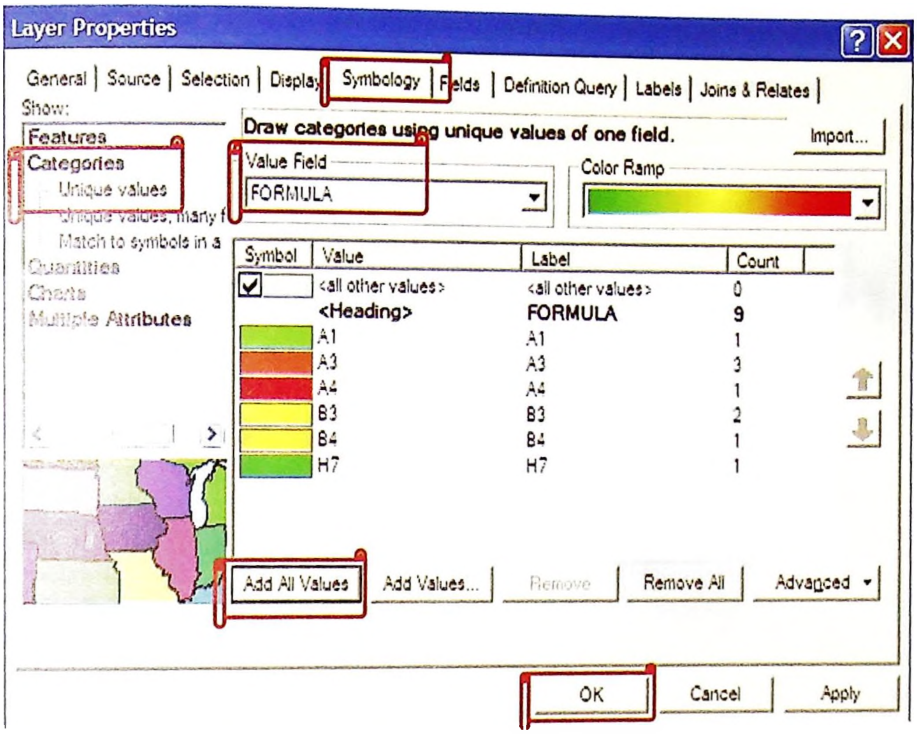


Figure 2.31: Symbology of the Soil dataset

7. In the ArcToolbox window, click on the Conversion Tools, then on To Raster, double-click on the Polygon to Raster tool.
8. In the Polygon to Raster window, select the Soil shapefile to convert it to a raster or you can drag it from the table of contents to the Input feature box. Use the soil Formula for the Value field. The tool will convert the shapefile to a raster file based on the soil formula. Enter 10 as the value for the cell size (this means that the cell size is 10 meters).
9. Save the output file on the same folder, naming it "Soil_10m", Figure 2.32.
10. Repeat step 8 with a cell size of 50 and then compare the two results, Figure 2.33.

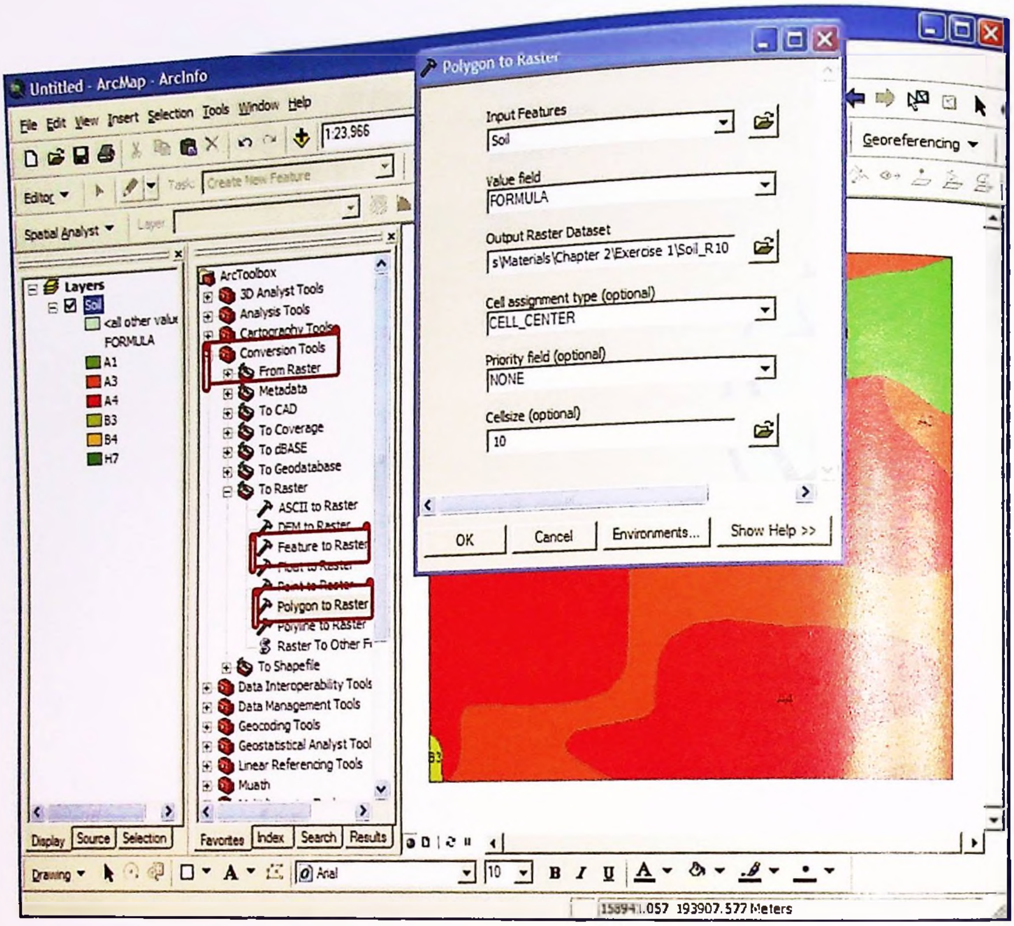
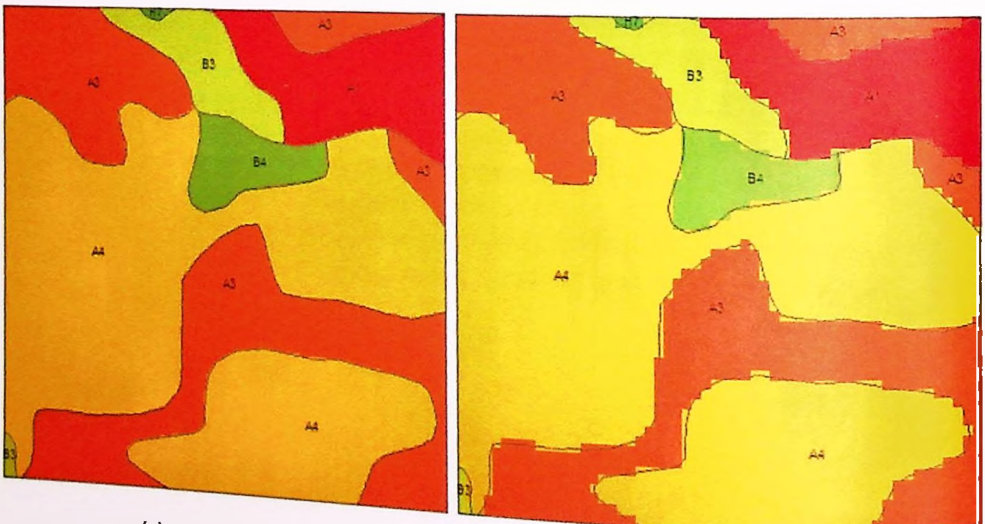


Figure 2.32: Polygon to raster conversion tool



(a) 10 meter cell size

(b) 50 meter cell size

Figure 2.33: Comparison between two raster datasets having two different cell sizes

2.6.1.3 Convert a Raster Model to a Vector Model

In this exercise, you will convert the raster you created in the previous section back to a vector data model.

1. Click on the Conversion Tools in the ArcToolbox window, next on From Raster then double-click the Raster to Polygon tool.
2. In the Raster to Polygon window, select the soil_R10 raster file to convert it to a shapefile or you can drag it from the table of contents to the Input feature box. Use the soil Formula for the Value field.
3. Save the output file on the same folder, naming it "Soil_R_to_V_10", then press OK, Figure 2.34.

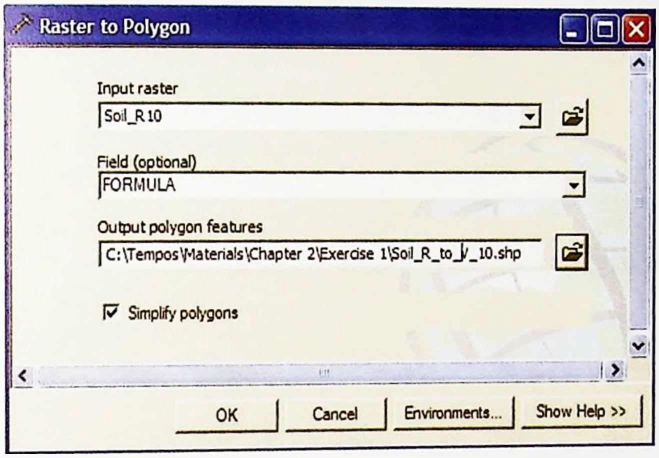
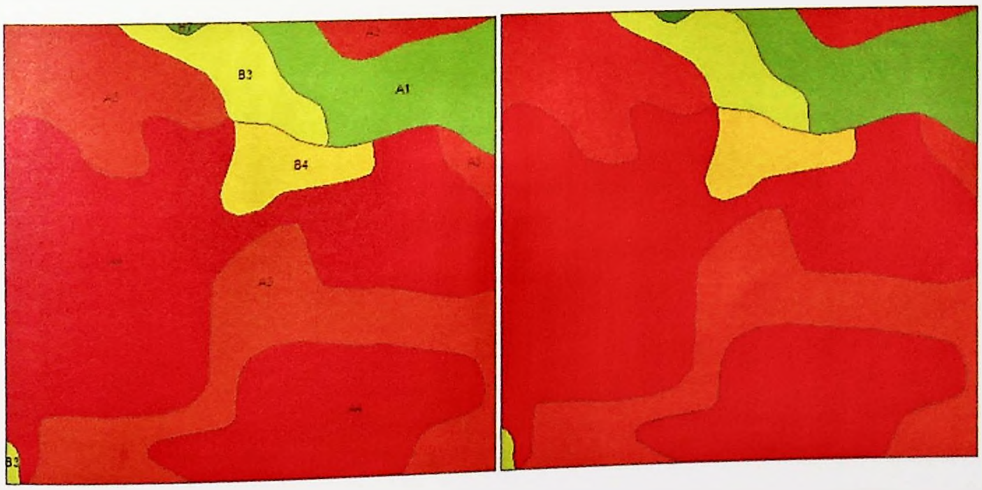


Figure 2.34: Raster to polygon toolbox

4. Repeat step 2 for the Soil_R50 raster, then compare the two results shown in Figure 2.35 with the original Soil shapefile.



(a) Original vector shapefile

(b) Shapefile created from a raster (10 m cell size)

(c) Original vector shapefile

(b) Shapefile created from a raster (50 m cell size)

Figure 2.35: Comparison between vector datasets originating from different cell size raster datasets

2.6.2 Joining Spatial and Non-Spatial Datasets

This exercise illustrates how non-spatial data (i.e. descriptive or time series datasets) could be linked with spatial data. In this exercise, there are three types of datasets:

1. Location of wells (wells.shp): this is a shapefile representing the location of groundwater wells in Tulkarem Governorate. The attribute table of this shapefile contains the wells ID (Primary Key).
2. Well description (Description. dbf): this is a database containing descriptive information about the groundwater wells in Tulkarem Governorate. It includes information about well code, depth, elevation, owner, usage, tapped aquifer and formation. The well code in this dbase is unique; this means that each well is presented by only one row. In this case One-to-One relation could be developed between the wells shapefile (spatial dataset) and the Description.dpf table.
3. Time series of well abstraction rate (Time_Series.dbf): which contains the annual abstraction rate for the same wells from 1975 to 2000. This table also contains the Wells ID (in this table the Well ID is not unique, i.e. many rows represent the same well). In this case the relation between the Wells shapefile (spatial dataset) and this table is called a one-to-many relationship.

In this exercise, two types of connections will be tested; One-to-One and One-to-Many relationships.

2.6.2.1 One-to-One Relation

1. Open a new ArcGIS project, save it as "Ex2_1" in: "\GIS_Tutorial\Chapter2\Exercise2\".
2. From "C:\GIS_Tutorial\Chapter2\Exercise2" add the Wells.shp, Description.dbf, Time_series.dbf and Tulkarem.shp datasets.

3. Click on the Identify tool then on any well in the map window to see the attribute data attached with the wells.
4. Right-click on Wells.shp then select Open Attribute Table to open the attribute table, Figure 2.36.

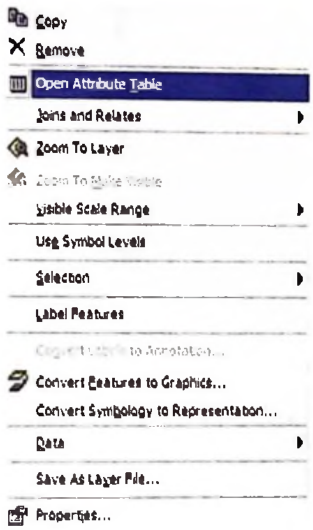


Figure 2.36: Opening an attributes table of a GIS dataset

5. Do the same for Description.dbf and Time_series.dbf tables.
6. Arrange the three tables, so that you can see the complete table of contents as shown in Figure 2.37.

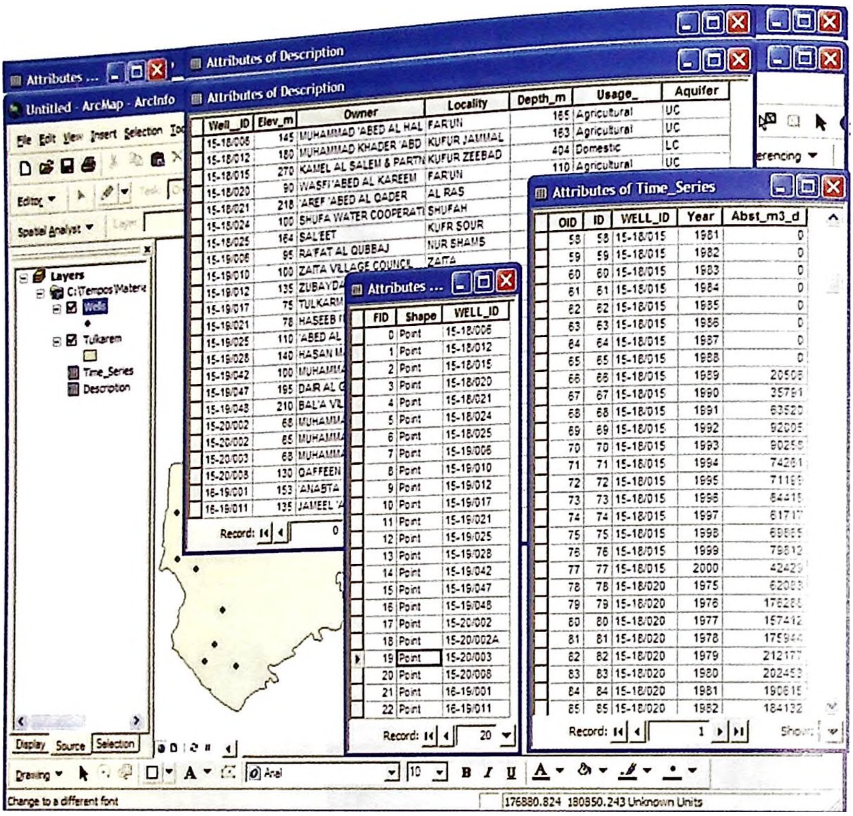


Figure 2.37: Tables arranged for joining

7. From the table of contents, right-click on Wells.shp, click on Joins and Relates then select Join. The Join Data dialog box will appear.
8. Joining the two tables (wells and description tables) will be established by using the Well_ID field. Note that in both tables this field is unique and could be considered as a primary key field; fill out the Join Data dialog box as shown in Figure 2.38 and then press OK to continue the join process.

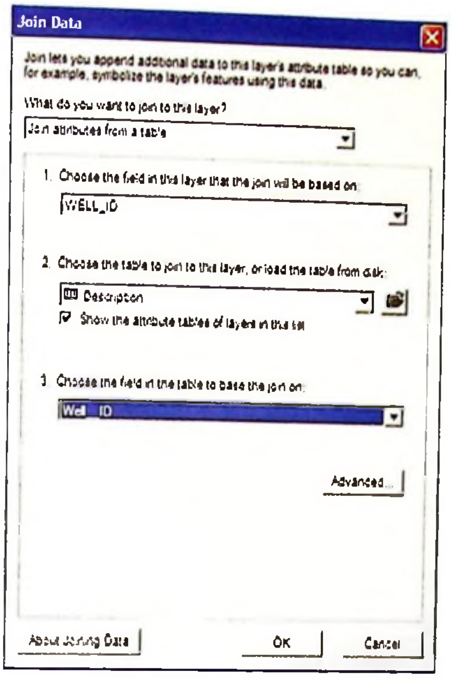


Figure 2.38: Join Data toolbox

9. Repeat step 3 and compare the differences. You will find many attributes attached to the Wells shapefile such as well owner, depth, etc. from the description table.
10. Expand the Attributes of Wells table and notice how the Description table is appended to the Wells attribute table, Figure 2.39.

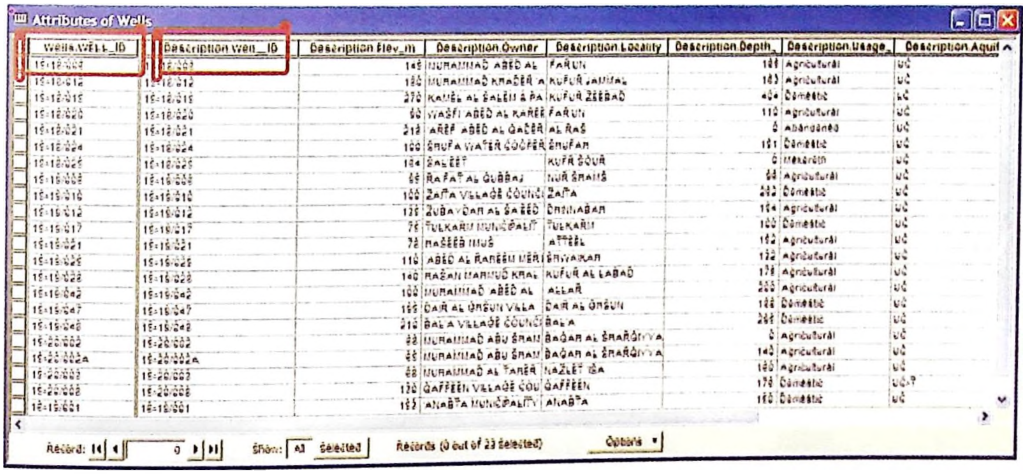


Figure 2.39: Attributes of the Wells after being joined with the Description table

11. At this point, the joint table is temporary. This means that you can cancel the join any time. To save; you have to export the Wells.shp to a new shapefile. To do this, right-click on Wells.shp, select Data and then click on Export Data, Figure 2.40. The Export Data window will appear, browse to the location where you want to save the exported

shapefile, name it "Wells_Details.shp", keep other fields as its default values and then press OK twice to accept adding this new shapefile to the map.

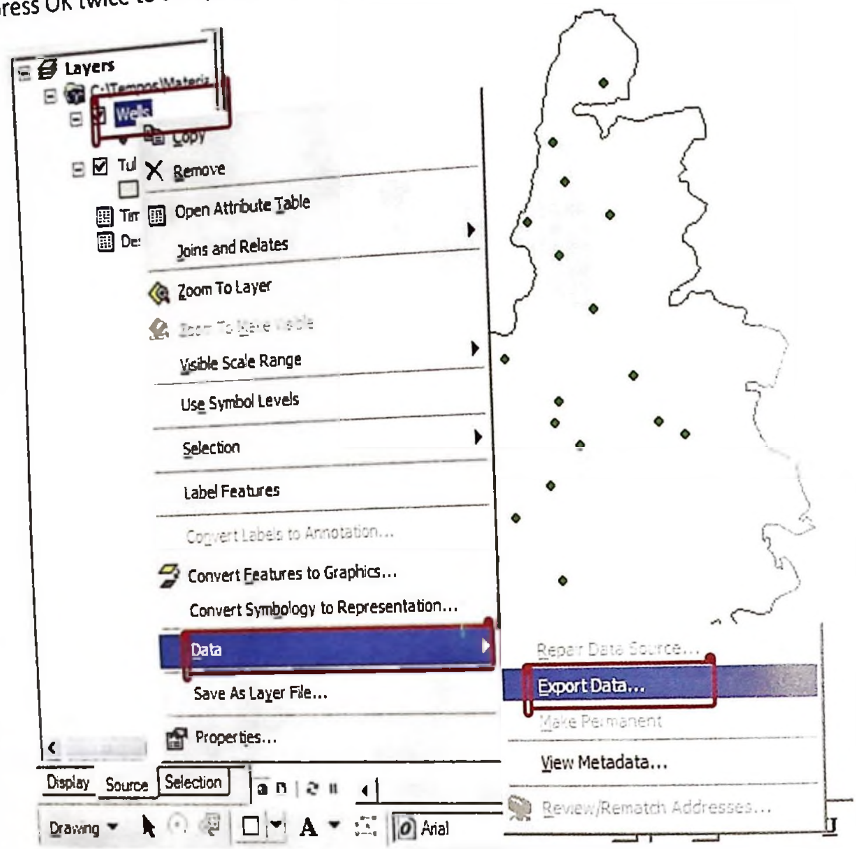


Figure 2.40: Exporting data to a new shapefie

12. Open the attribute table of the Wells_Details shapefile. Compare this attribute table with the attribute tables of the Wells.shp shapefile.
13. To remove the duplicated fields; right-click on the name of the field you want to remove and then click on the Delete Field icon, Figure 2.41.

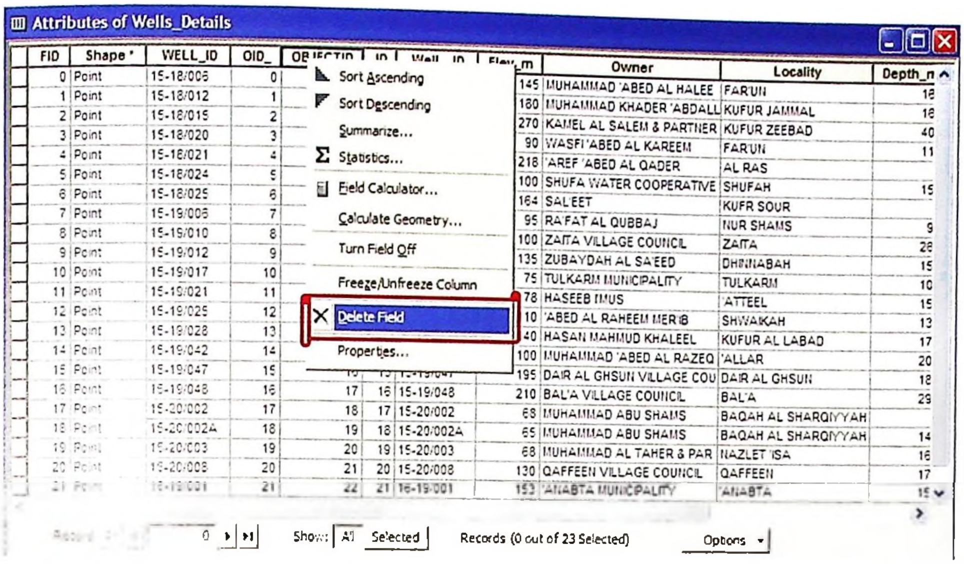


Figure 2.41: Deleting fields from a table

2.6.2.2 Remove Join Tables

1. To remove the join between Wells.shp and Description.dbf, right-click on Wells.shp, select Joins and Relates then select Remove Joins. A list of all join relations will appear. In this exercise there is only one join relation called Description which was established in the previous section. Click on it to remove, Figure 2.42.

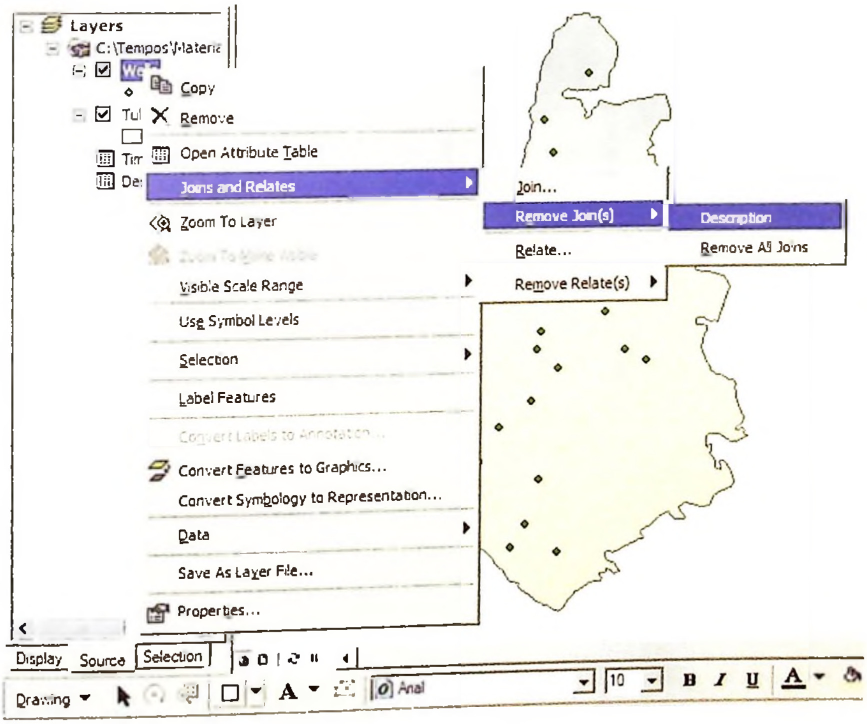


Figure 2.42: Remove the descriptive join

2. Open the attribute table of Wells.shp, you will find that it has been stored in its original form.

2.6.2.3 One-to-Many Relation (Relate Tables)

In this section, you will link (relate) the Wells shapefile with its time series of abstraction rates. The Well_ID field will be used for this purpose.

1. Open the Attributes of Wells table.
2. Right-click on Wells.shp, click on Joins and Relates then select Relate. The Relate dialog box will appear.
3. Fill out the Relate dialog box as shown in Figure 2.43 and then press OK to continue the relate process.

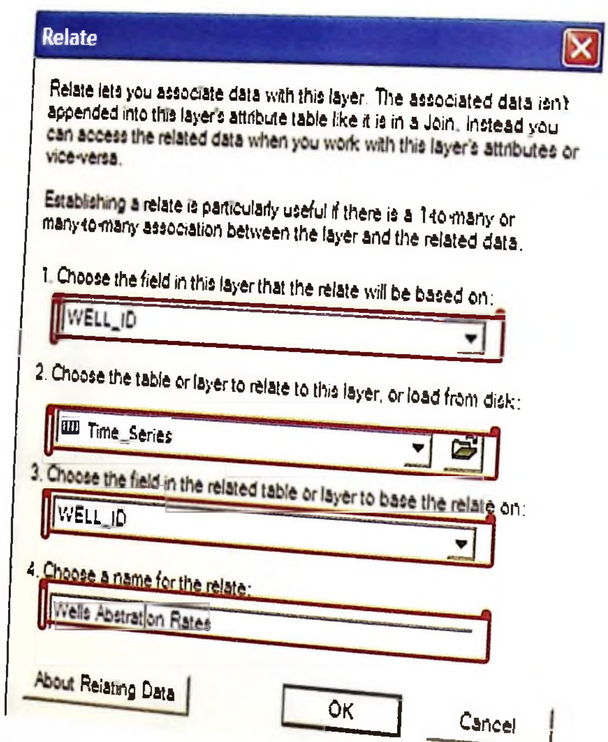


Figure 2.43: Relate data tool box

4. Click on row 11 in the Attributes of Wells table to select Well_ID: 15-19/021.
5. Click on the Options button, select Related Tables then click on Wells Abstraction rates: Time_series, Figure 2.44.

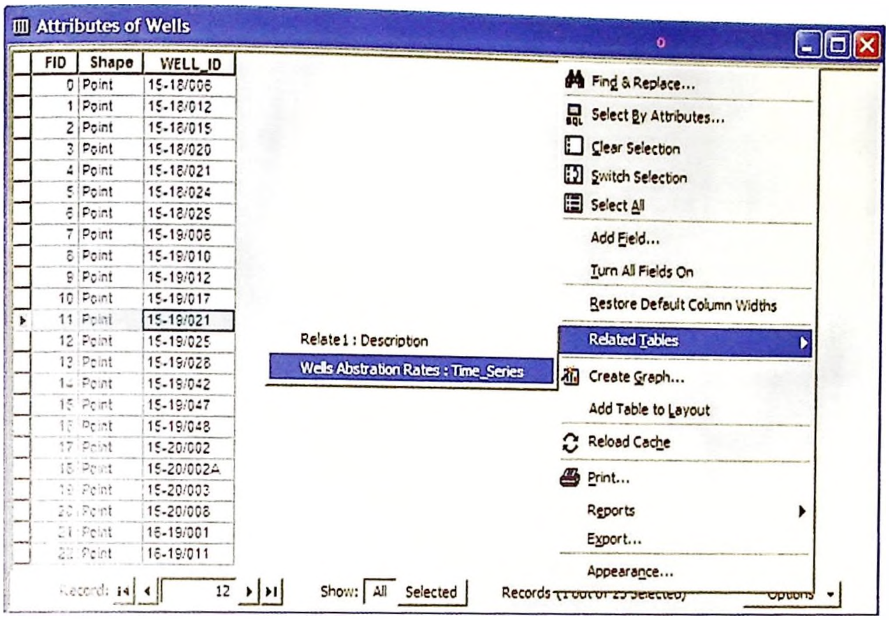


Figure 2.44: Open defined relation

6. Open the Time_Series.dbf table, then click on the Selected button, Figure 2.45, to preview all records (rows) related to Well_ID: 15-19/021.
7. Repeat steps 4, 5 and 6 for Well_ID: 15-20/002.
8. You can remove a link the same way as removing a join relation descried in the Join Tables section.

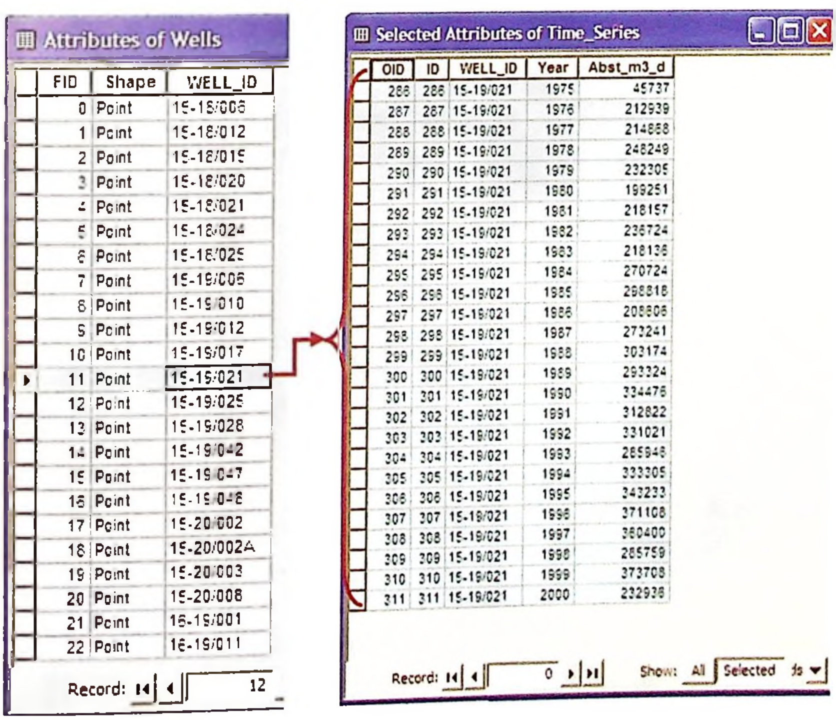


Figure 2.45: A defined relation

2.6.3 Working within GIS File Formats

Section 2.6.1 shows how data can be converted from a vector data model to a raster data model. Here, you will convert different GIS dataset formats to other formats.

2.6.3.1 Creating a Layer File

1. Create a new ArcGIS project, save it as "Ex2_3" on: "C:\GIS_Tutorial\Chapter2\Exercise3\".
2. From "C:\GIS_Tutorial\Chapte 2\Exercise3" add the Geology.shp shapefile.
3. Double-click on Geology.shp (or right-click and select Properties). When the Layer Properties window appears, select the Symbology tab.
4. In the Show window select Categories then select Unique value.
5. In the Value Field select Formation which is to be used for classification.
6. In the Color Ramp, select the green to red spectrum from the list of colors.
7. Click on the Add All Values button, and then click on the Labels tab in order to label the geological features, Figure 2.46.

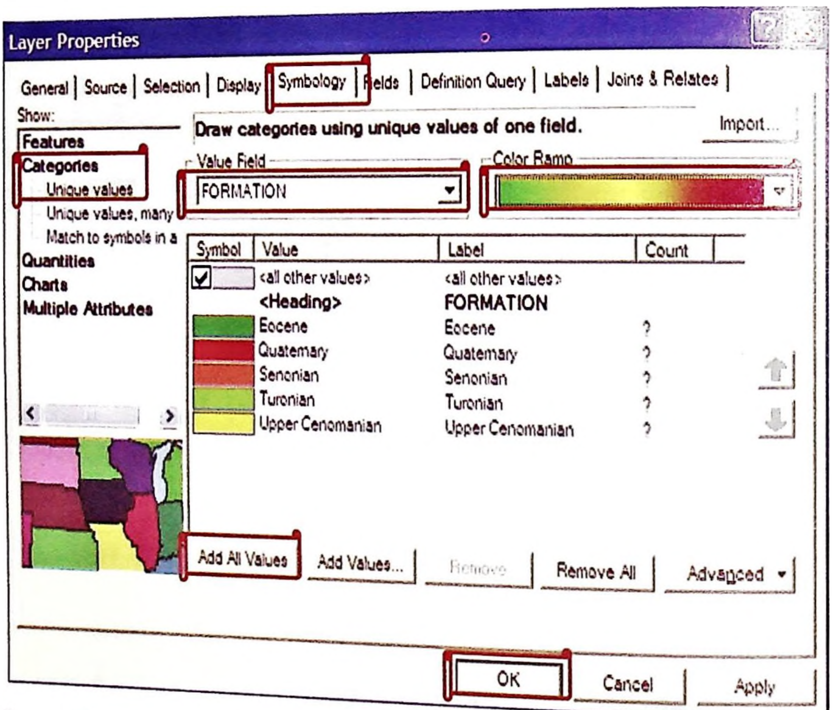


Figure 2.46: Symbology window

8. In the Labels window, check the box at the left-top corner to view labels on the map. Select Code as a labeled field. Select 6 as the font size. Keep other fields as default values then press OK to finish, Figure 2.47.

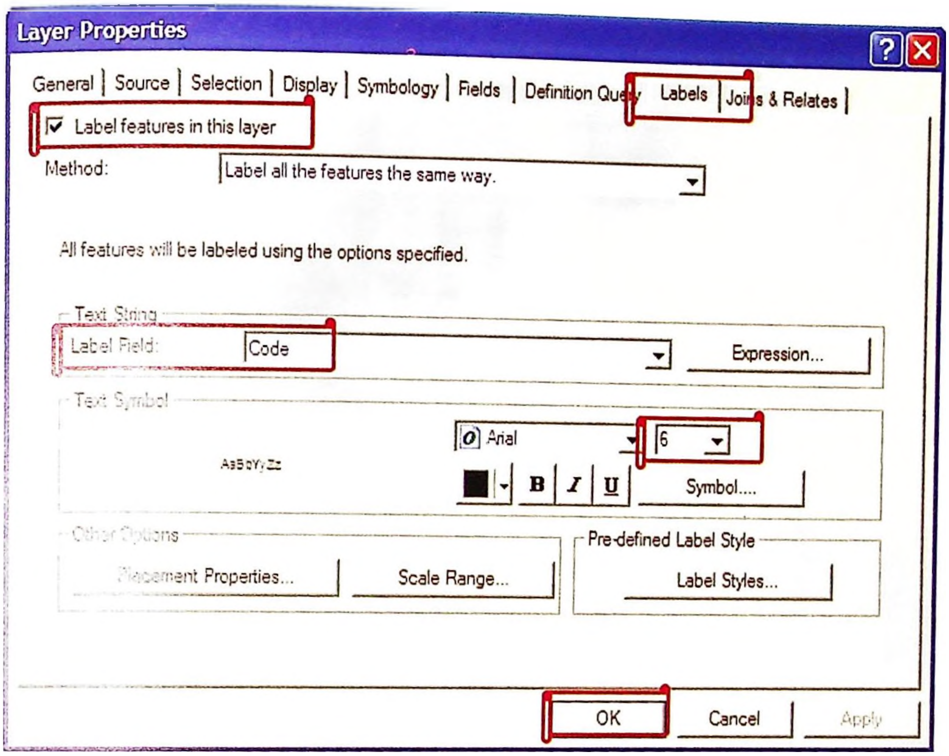


Figure 2.47: Labels window

At this stage, you have classified the geological map into five categories; each category has a specific color and label features on the map. Since the type of geology is a shapefile, then the classification and labeling of this shapefile will not be saved within the structure. To save the symbology and labels within the dataset, you can convert it to a layer form.

9. Right-click on the geology shapefile, and then click on Save As Layer File. The Save Layer dialog box will appear, save it as "Geology_layer" on the same location of the Geology shapefile. To check your work, you can open a new ArcGIS project and add both the Geology shapefile and the Geology_Layer to the map window. Then compare the difference between the two datasets, Figure 2.48.
10. Step 9 can be also be done from ArcCatalog; browse to the Geology shapefile, right-click on it, then select Create layer to open the Save layer dialog box, Figure 2.49. In this case the labeling and the symbology of the dataset will be saved after creating the layer in the same way described in steps 2 to 8. Try to convert the Land use shapefile into a layer.

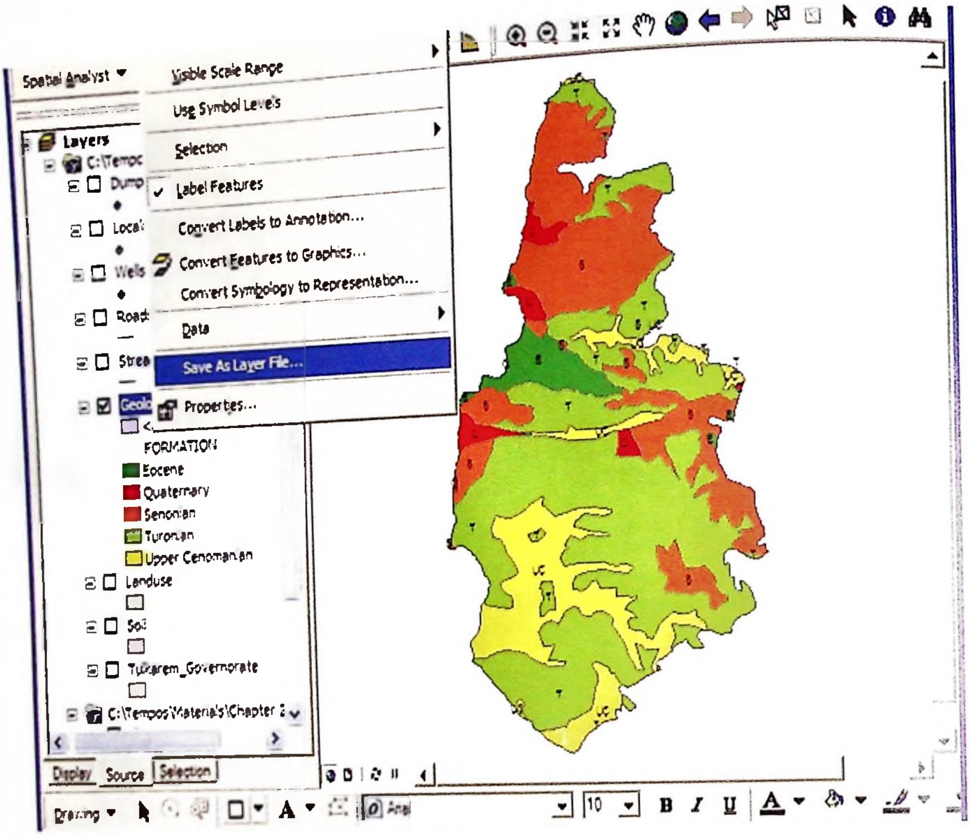


Figure 2.48: Creating a layer using ArcMap

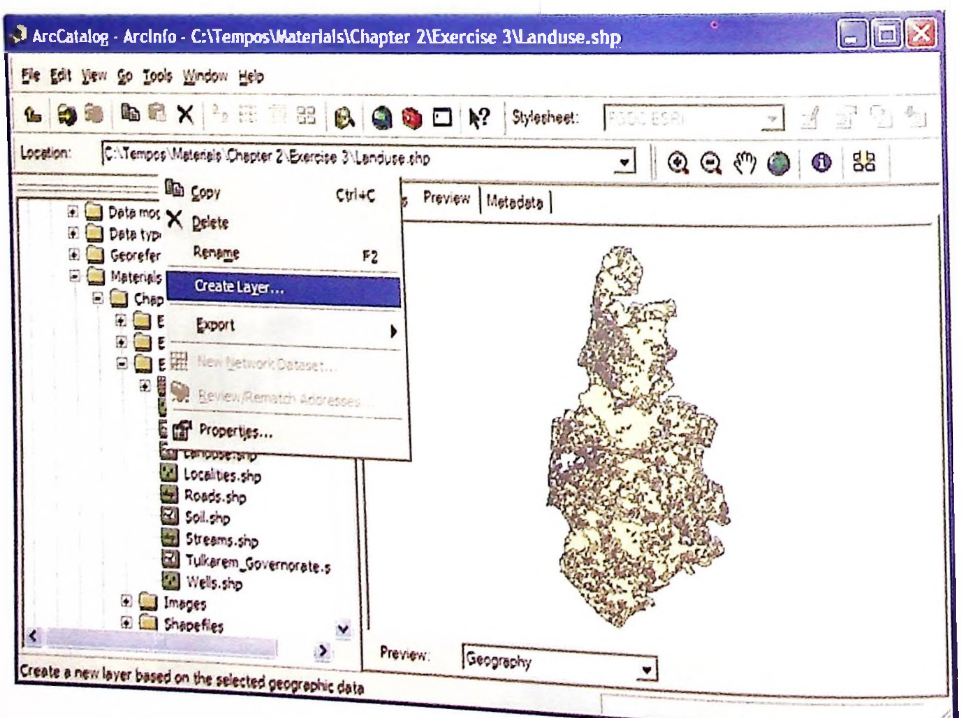


Figure 2.49: Creating a layer using ArcCatalog

2.6.3.2 Working with a GeoDatabase/Personal Geodatabase

The Exercise 3 folder contains different types of datasets for the Tulkarem Governorate; boundary, soil, land use, geology, roads system, wells, location of solid waste dump sites, DEMs, streams and localities. Since these data files are related to the same geographic location, it is recommended to store them in a Personal Geodatabase or Geodatabase depending on the size and the purpose of these datasets.

1. Open ArcCatalog, browse to folder "C:\GIS_Tutorial\Chapter2\Exercise3\".
2. Right-click on Exercise 3, select New then click on File Geodatabase, Figure 2.50. A new Geodatabase will be created under the Exercise 3 folder, rename it as "Tulkarem_Governorate". At this stage, you have created an empty geodatabase without any data. In the same way, you can also create any new "empty" type of GIS data form; shapefile, layer, coverage, personal geodatabase, etc.

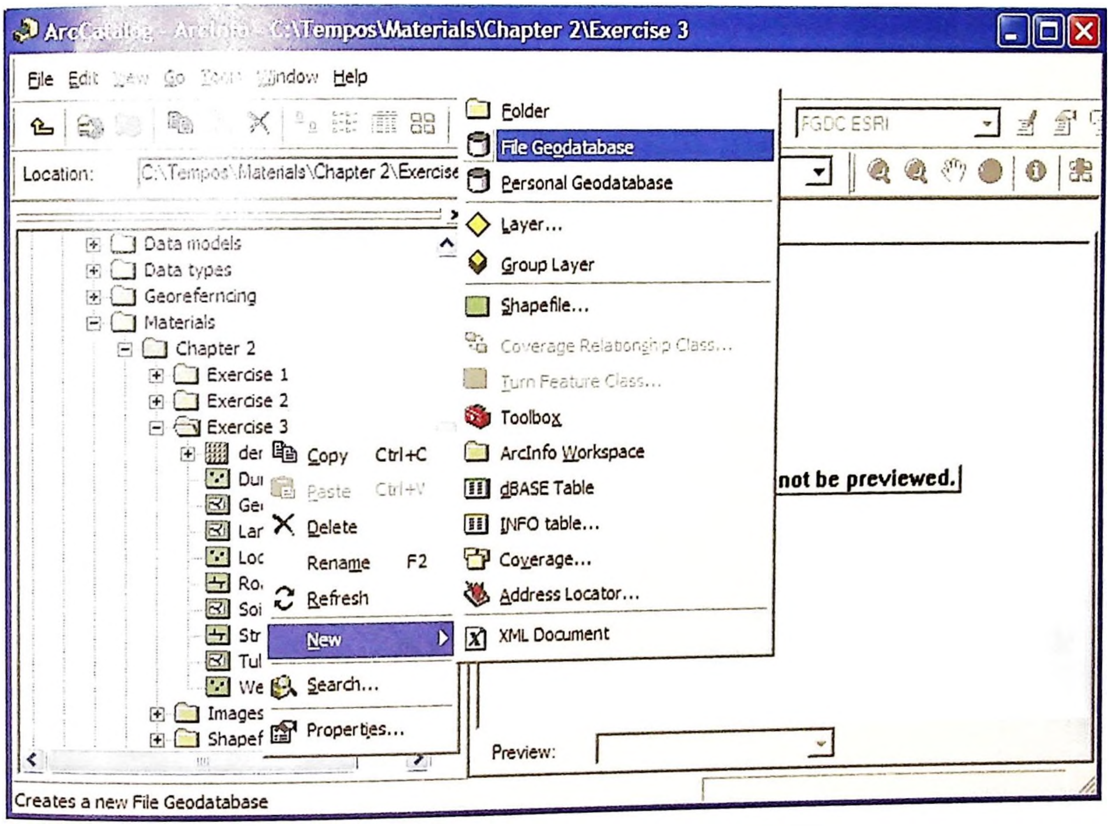


Figure 2.50: Creating a new geodatabase

3. To store data in the geodatabase, right-click on the Tulkarem_Governorate geodatabase, you can import existing datasets (feature datasets, table, or raster) or you can create new types of datasets, Figure 2.51. To import datasets, you have two options; you can import each type of datasets in one step, (Feature Class (Multiple ..)), or you can import them one by one (Feature Class (Single ..)).

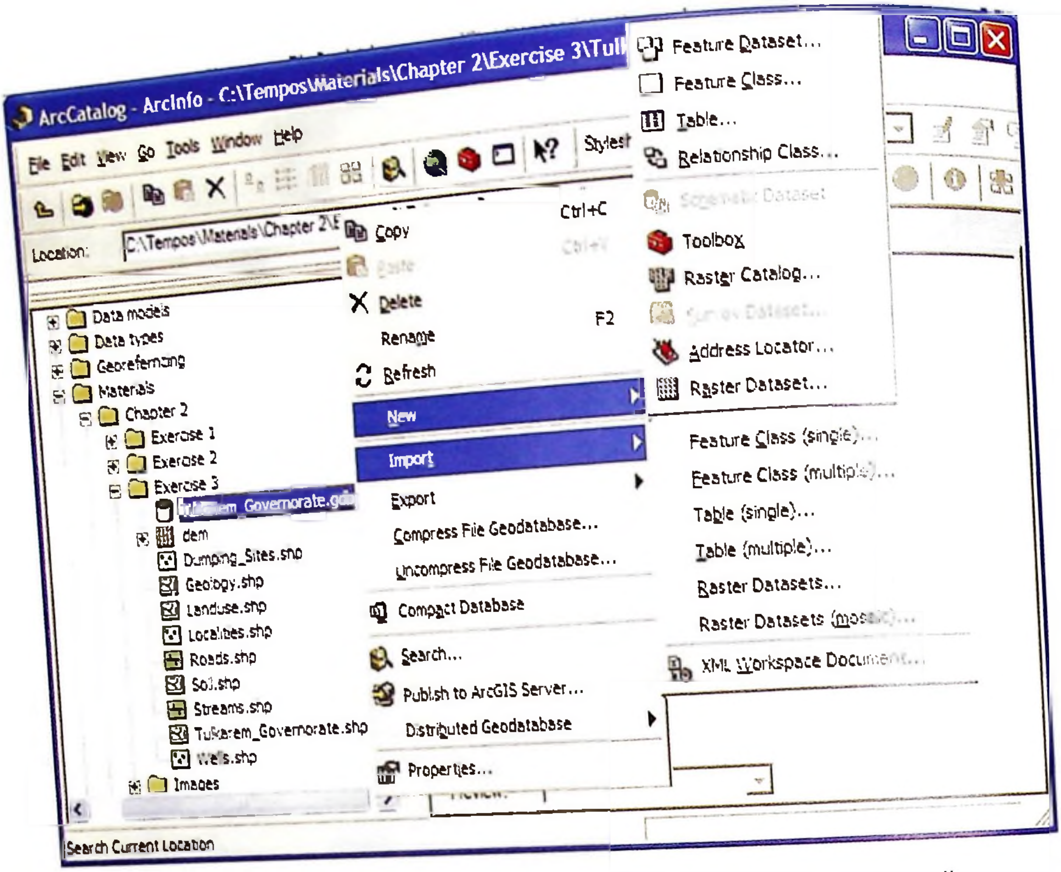


Figure 2.51: Create new/Import different GIS datasets into Tulkarem_Governorate.gdb

4. Select Feature Class (Multiple ..), the Feature Class to GeoDataBase dialog box will appear, Figure 2.52.
5. Click the Open Folder button, and then browse to Exercise 3. Select all shapefiles in this folder to be added into the Tulkarem_Governorate geodatabase, then click OK to finish.
6. Do the same to import DEM into the geodatabase.
7. Click on the plus sign on the left to the Tulkarem_Governorate geodatabase to expand, check the contents of this geodatabase.
8. Create a Personal GeoDatabase for Tulkarem Governorate.

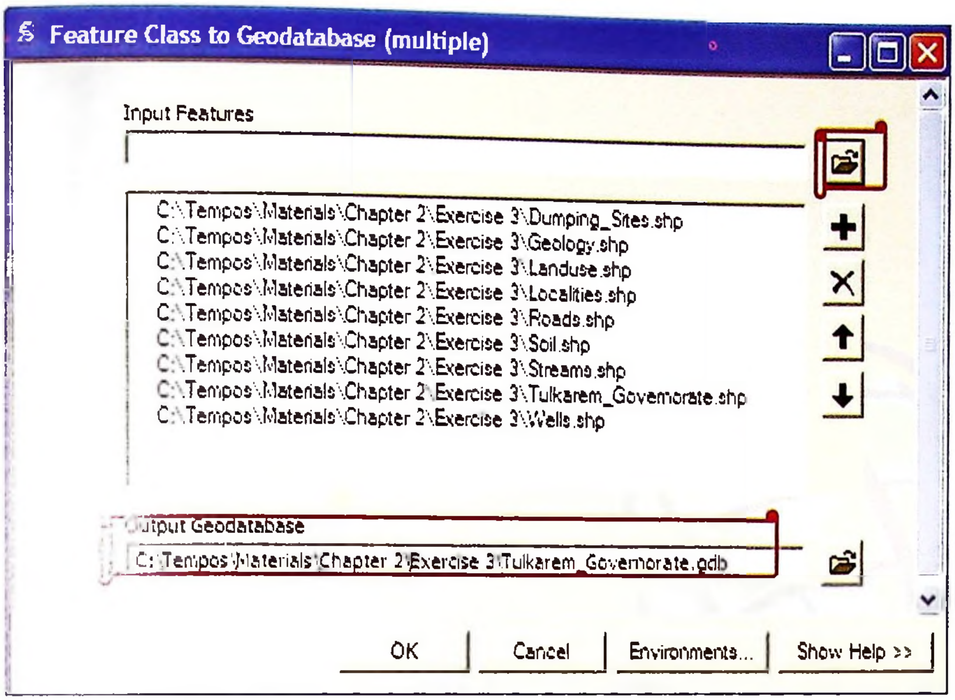


Figure 2.52: Import multi features to Tulkarem_Governorate.gdb

2.6.3.3 Exporting Data to CAD Format

CAD is a very important technology used in engineering. ArcGIS includes tools to interact with CAD software. In this exercise, you will save a copy of the road system in Tulkarem Governorate inCAD drawing format (*.dwg or *.dxf).

1. If the ArcToolbox window does not appear in the ArcCatalog interface, you can add it by clicking on the ArcToolbox button. AcrToolbox will then be added to ArcCatalog.
2. Browse to the Tulkarem_Governorate geodatabase, click on the positive sign to expand.
3. In the ArcToolbox window, click on Conversion Tools, then expand the To CAD tools.
4. Since you want to export the Roads dataset, click on Expand to CAD. The export dialog box will open.
5. Drag the Roads dataset from the Tulkarem_Governorate geodatabase to the Input features box.
6. Select the CAD type you want, also, save the exported file on Exercise 3. Click OK to finish, Figure 2.53.
7. Open the exported file by using any CAD software you have.

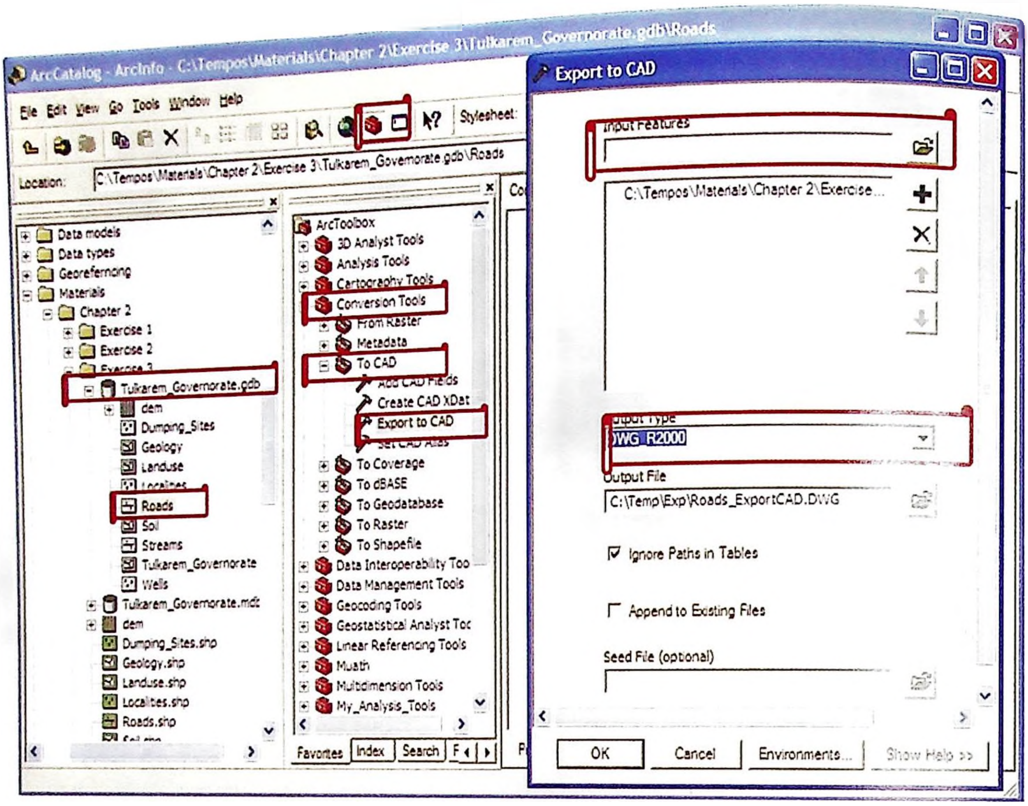


Figure 2.53: Export a GIS feature to a CAD file

ArcGIS has a very wide range of conversion tools that could be used to convert from one type to another. You can open ArcToolbox and check the available conversion tools, Figure 2.54. Try to test some of them.

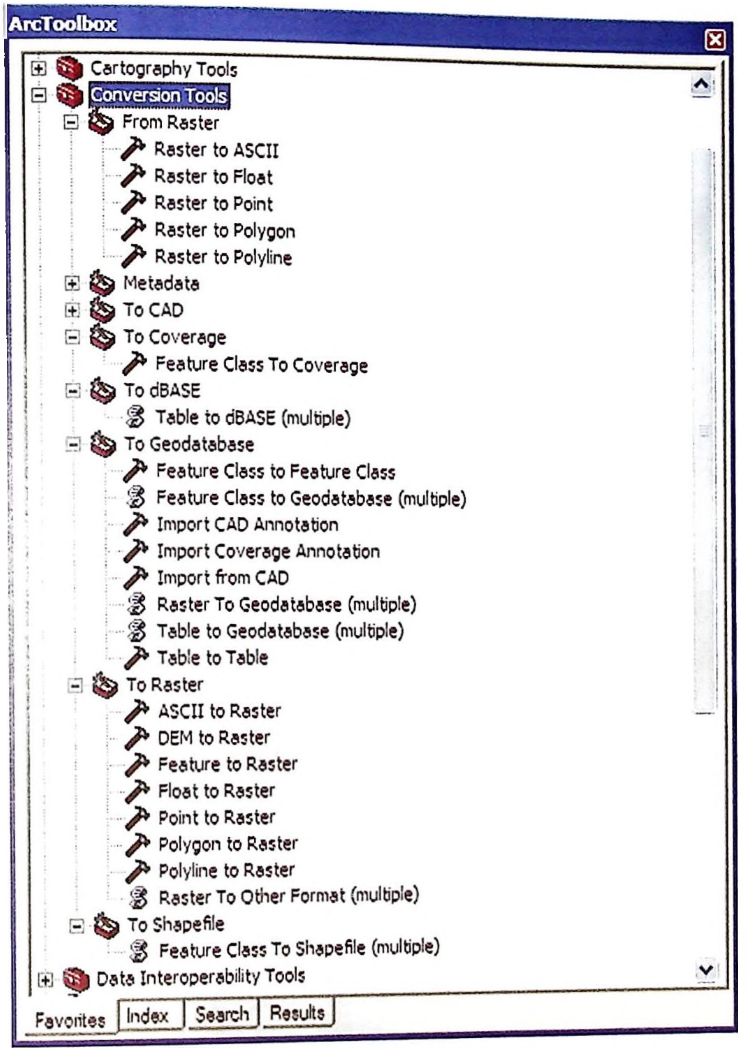
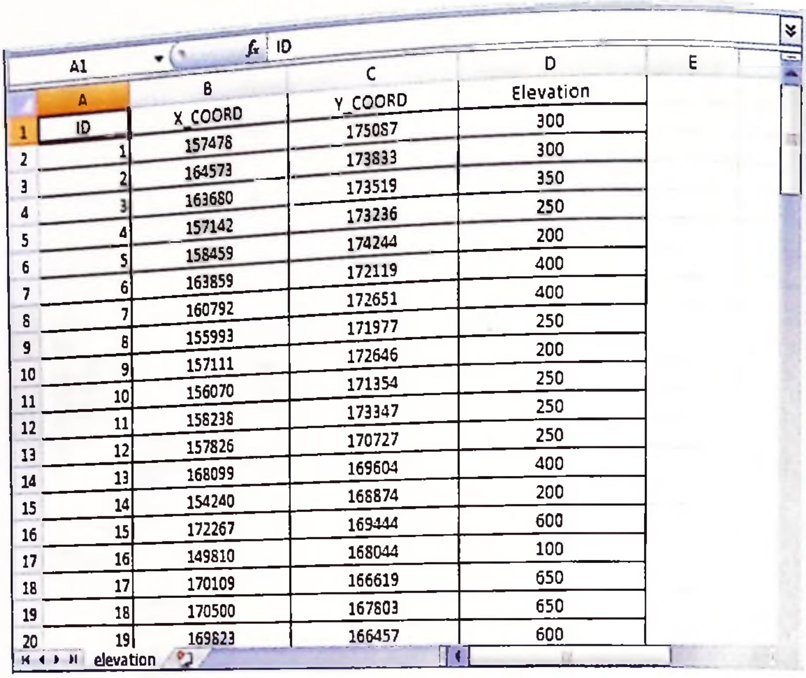


Figure 2.54: Conversion tools in ArcToolbox

2.6.4 Converting Surveyed Data to a GIS Feature

Suppose you have a set of elevation points that have been collected using a GPS for Salfit Governorate. The data was stored in a Microsoft Excel file including X-coordinates, Y-coordinates and elevations. Now you want to convert this Excel file into a shapefile.

1. Open Elevation_Salfit.xls from "C:\GIS_Tutorial\ Chapter2 \ Exercise4". Check the structure of the Excel sheet, the sheet should be in the form of a database; the first row contains the titles of columns while the other rows contain the data (values) with no formulas, empty fields or merged cells, Figure 2.55.



ID	X_COORD	Y_COORD	Elevation
1	157478	175057	300
2	164573	173833	300
3	163680	173519	350
4	157142	173236	250
5	158459	174244	200
6	163859	172119	400
7	160792	172651	400
8	155993	171977	250
9	157111	172646	200
10	156070	171354	250
11	158238	173347	250
12	157826	170727	250
13	168099	169604	400
14	154240	168874	200
15	172267	169444	600
16	149810	168044	100
17	170109	166619	650
18	170500	167803	650
19	169823	166457	600

Figure 2.55: Elevation points stored in a Microsoft Excel file

2. Create a new ArcGIS project, save it as "Ex2_4" on the folder: "C:\GIS_Tutorial\Chapter2\Exercise4\".
3. From "C:\GIS_Tutorial\Chapter 2\Exercise 4", double-click the Elevation Points _salfit.xls icon. All sheets within the Excel file will be listed, Figure 2.56. Click on the elevations$ sheet then click Add. This sheet will be added to the Map view.

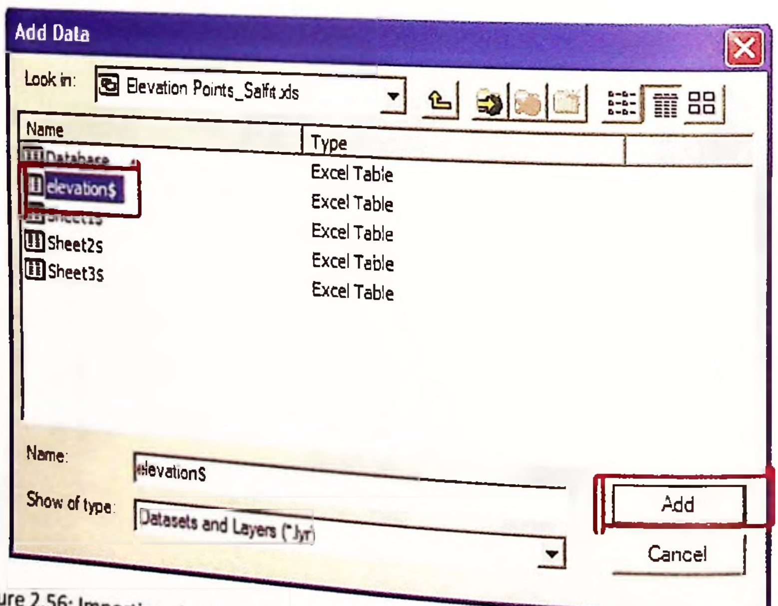


Figure 2.56: Importing elevation points from a Microsoft Excel file to ArcMap

4. From the same folder add the Salfit_Governorate.shp shapefile.
5. The Microsoft Excel file is inserted to the table of contents of ArcMap in the form of a table. To convert it to a spatial file (geographic file), right-click on the elevation$ file in the table of contents, then select Display XY Data, Figure 2.57. The New dialog box will appear.

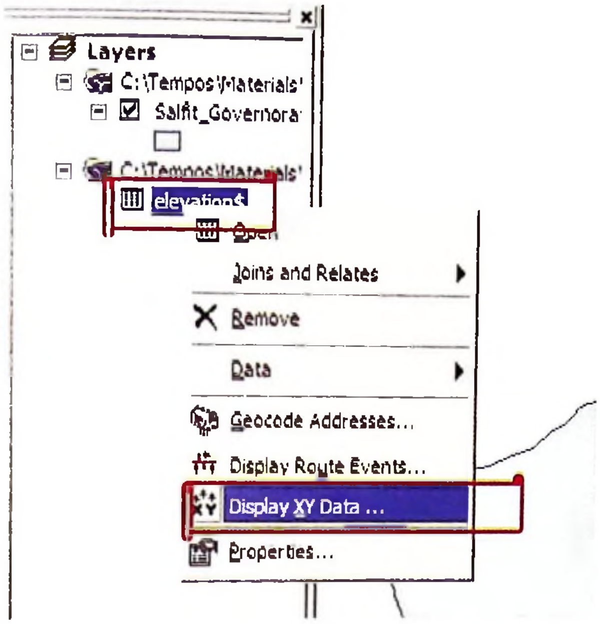


Figure 2.57: Converting elevation points to spatial dataset

6. In the dialog box select the fields that represent the X and Y values.
7. Click on the Edit button to define the coordinate system of the XY data, click on the Select button then double-click Predefined. Double-click on Projected Coordinate System then select National Grids, Palestine 1923 Palestine Grid system. Click OK twice to finish defining the grid system.
8. The Display XY data form will be similar to Figure 2.58. Click OK to finish.

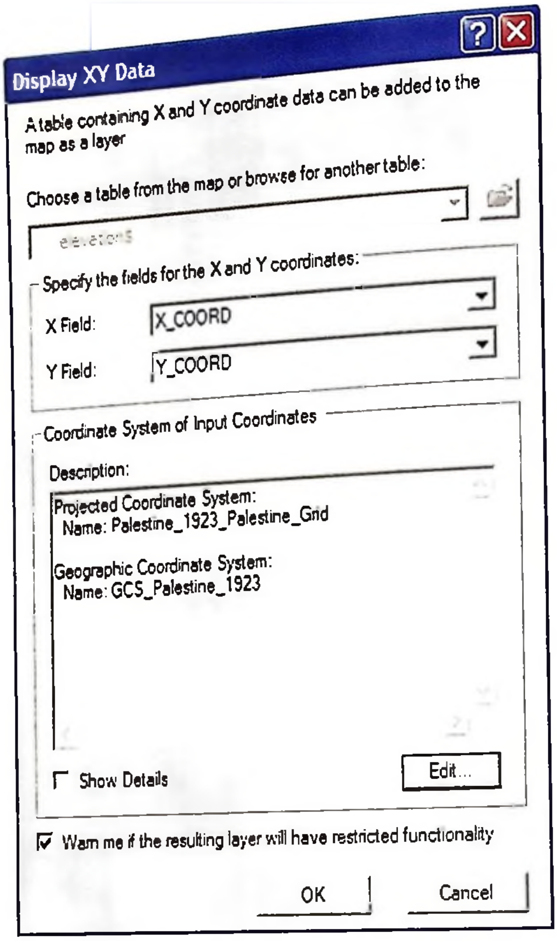


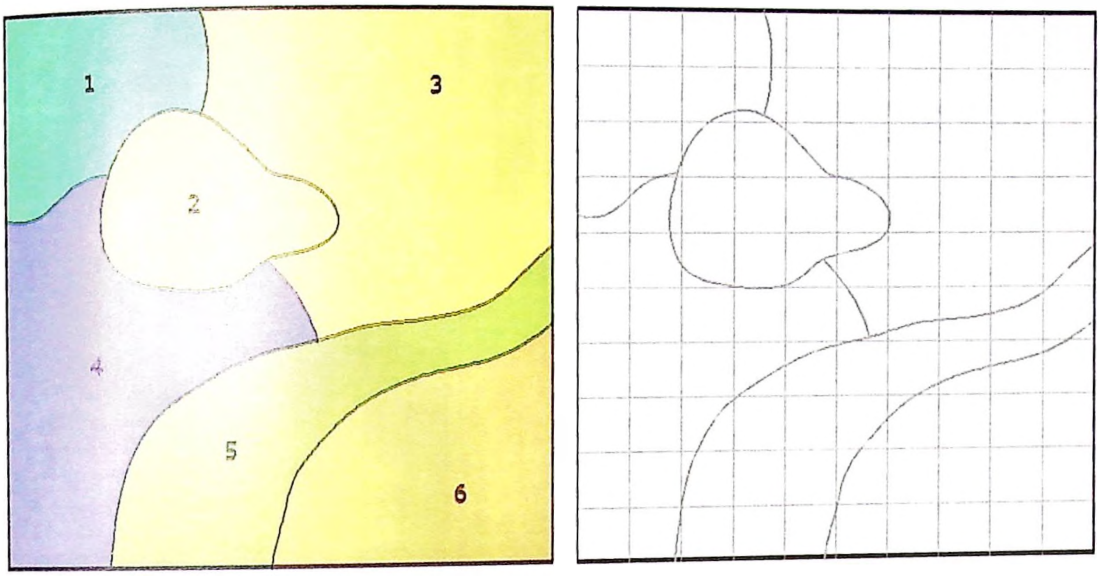
Figure 2.58: Display XY Data definition window

9. A new spatial GIS file will appear in the table of contents named elevation$_Events. This file is called an event shapefile. To convert this file into a permanent shapefile, right-click on this event shapefile, click Data then Export Data to save this file as a shapefile.

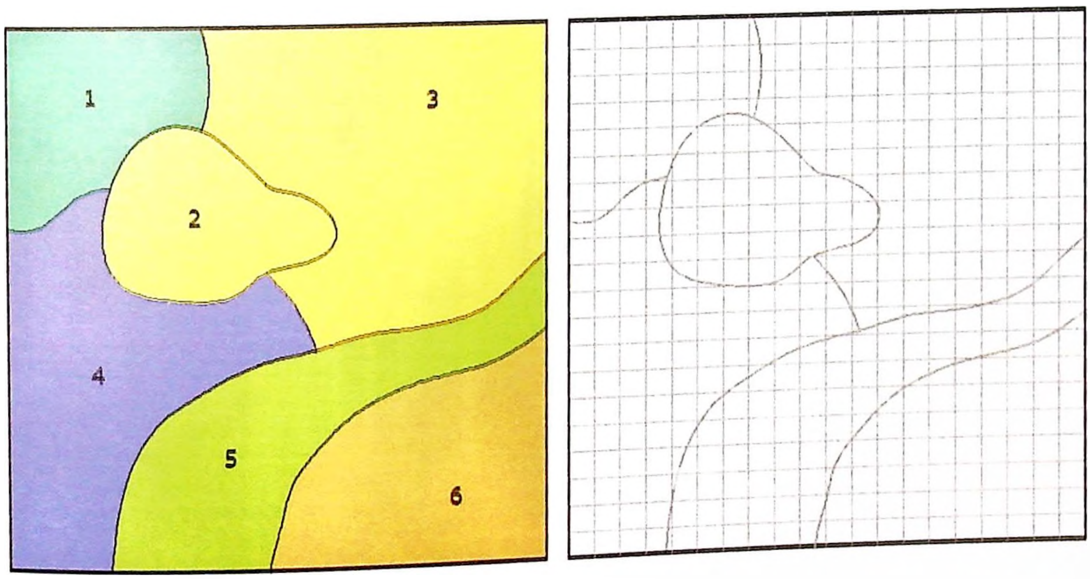
2.7 Discussion

1. Convert the following vector datasets to raster datasets (use the given cell sizes), then comment on the output results:

(a)

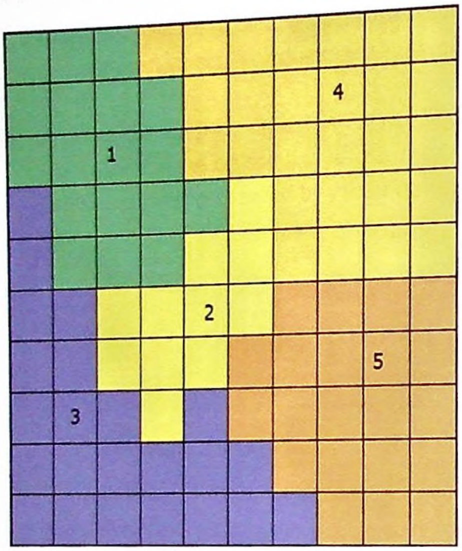


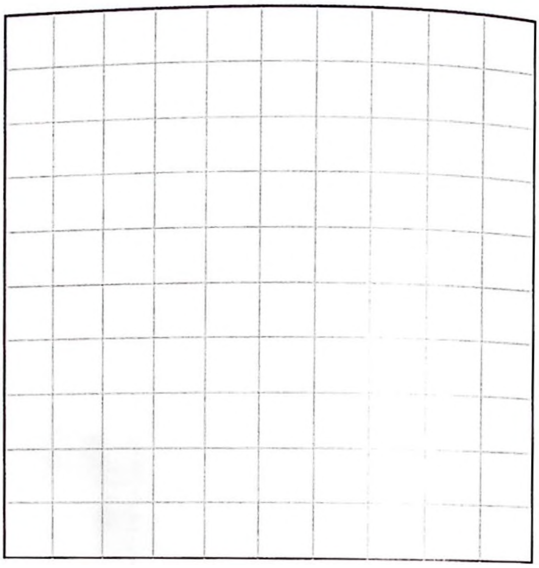
(b)



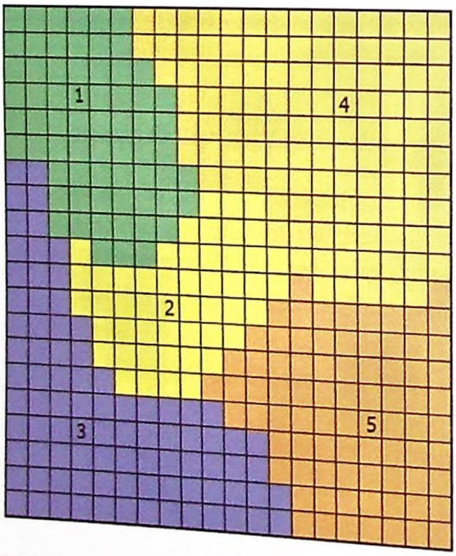
2. Convert the following raster datasets to vector datasets, then comment:

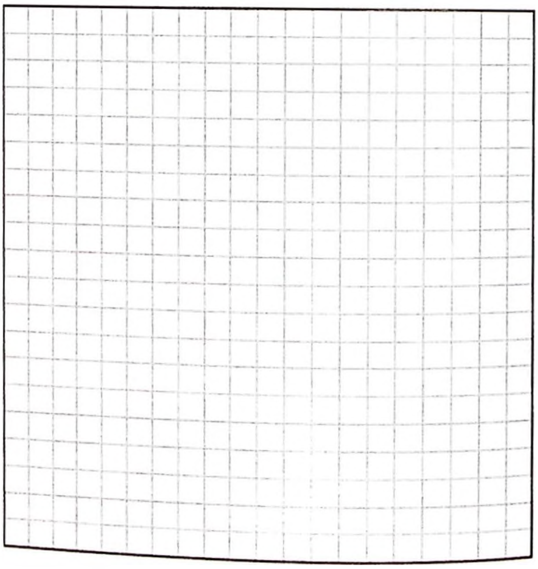
(a)





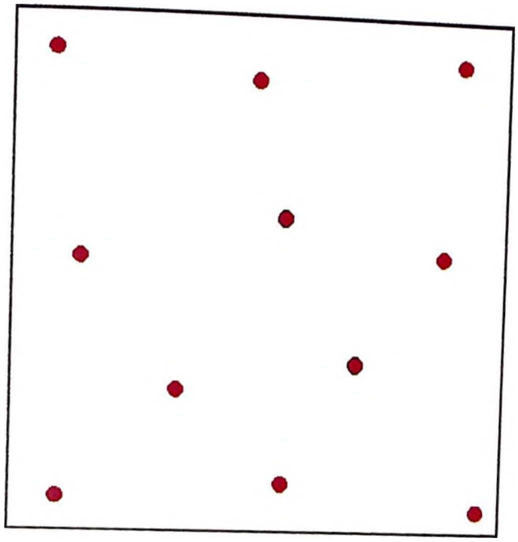
(b)





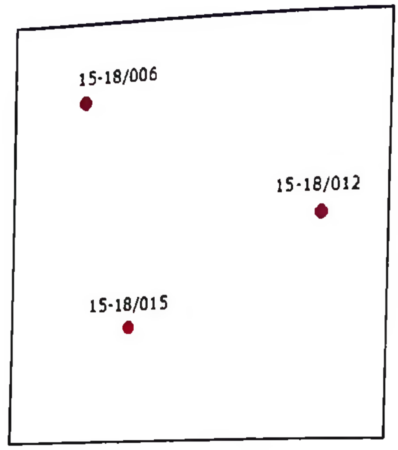
3. Give an example of how a continuous phenomenon can be represented using a vector data model.

4. Use the elevation points in the figure below to establish a TIN (use different colors).



5. Re-arrange the table below in order to be linked to the map in both One-to-One and One-to-Many relations.

Groundwater Wells				
Well_ID		15-18/006	15-18/012	15-18/015
Elev_m		145	180	270
Owner		MUHAMMAD 'ABED AL HALEEM	MUHAMMAD KHADER 'ABDALLAH	KAMEL AL SALEM & PARTNERS
Locality		FAR'UN	KUFUR JAMMAL	KUFUR ZEEBAD
Depth_m		165	163	404
Usage_		Agricultural	Agricultural	Domestic
Aquifer		UC	UC	LC
Abstraction Rates	2000	217549	363182	222318
	2001	324255	327385	230760
	2002	344051	360601	309423
	2003	264291	317495	206940
	2004	342711	337625	344767
	2005	299549	259139	388705
	Average	298734	327571	283819



6. Which data models can be stored in a Geodatabase?
7. Use the same approach in Section 2.6.3 to create coverage for the Landuse, Wells and Roads datasets, compare between these coverages and their corresponding shapefiles.
8. Suppose you want to establish new GIS datasets, what are the strategic issues to be considered before you start?

Coordinate Systems and Map Projections

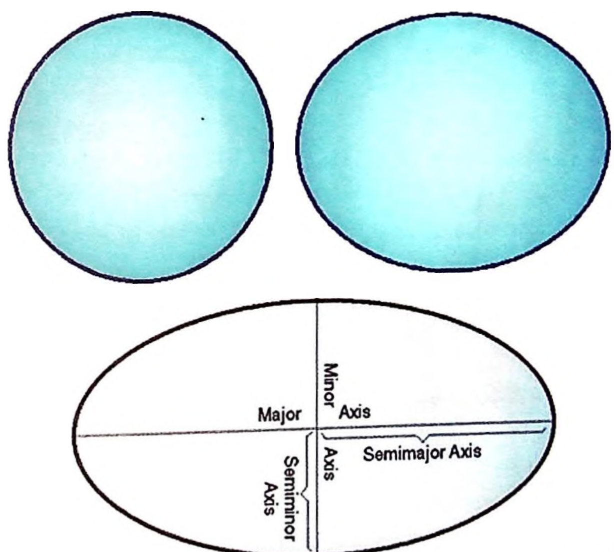
Chapter 3

Coordinate Systems and Map Projections

3.1 Modeling the Earth

3.1.1 Introduction

The geometry of the Earth was discussed, studied, and imagined thousands of years ago. Around 300 B.C., scientists concluded that the Earth was round and very closely to a spherical shape, Figure 3.1(a). In a mathematician's language, the Earth's shape is very close to an ellipsoid, Figure 3.1 (b). An ellipsoid is defined as a three dimensional solid object formed by rotating an ellipse, a two dimensional object, about one of its axes, Figure 3.1c. In the case of the Earth, the ellipse is rotated about its minor axes producing an oblate ellipsoid. An oblate ellipsoid is flattened at the poles, Figure 3.2. Thus, the term oblate applies only to an object which rotates as the Earth, since the term pole would have no meaning otherwise. A prolate ellipsoid would apply to an ellipsoid which is expanded at the poles produced by rotating an ellipse around its major axes, Figure 3.3.



(a) Sphere (b) Ellipsoid (c) Ellipse

Figure 3.1: Geometrical shapes of a sphere, ellipsoid and ellipse

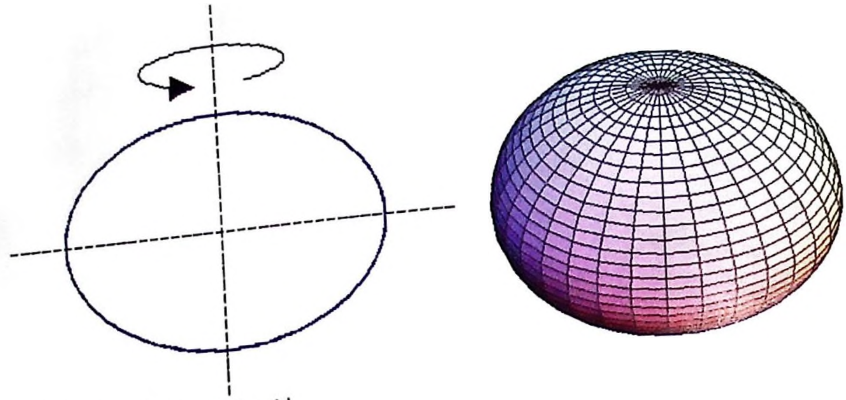


Figure 3.2: Shape of oblate ellipsoid

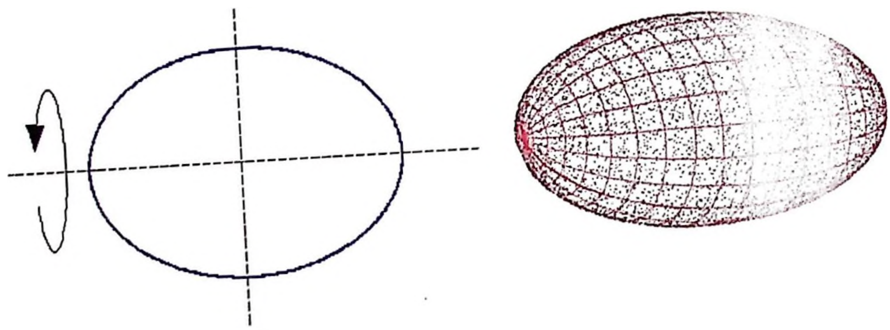


Figure 3.3: Shape of prolate ellipsoid

In the Earth's case, the major, or semi-major, radius is defined by the radius of the equator; the equatorial radius. The minor axis, or semi-minor axis, is defined by the distance from the center of the Earth to either pole, and is referred to as the polar radius. Being an oblate ellipsoid, the polar radius is required to be somewhat less than the equatorial radius. The distance around the Earth's equator is 24,901.55 miles (40075.16 km) and 24,859.82 miles (40008.00 km) between the North and South Poles. The difference between the two is 41.73 miles (67.16km).

3.1.2 Projecting the Earth

The Earth has irregularities, Figure 3.4, that keep it from being a simple geometric solid. Therefore, a spherical globe is not quite accurate in representing the Earth. To solve this problem, projection methods are required to illustrate the Earth (or part of it) on flat maps with minimum distortions.

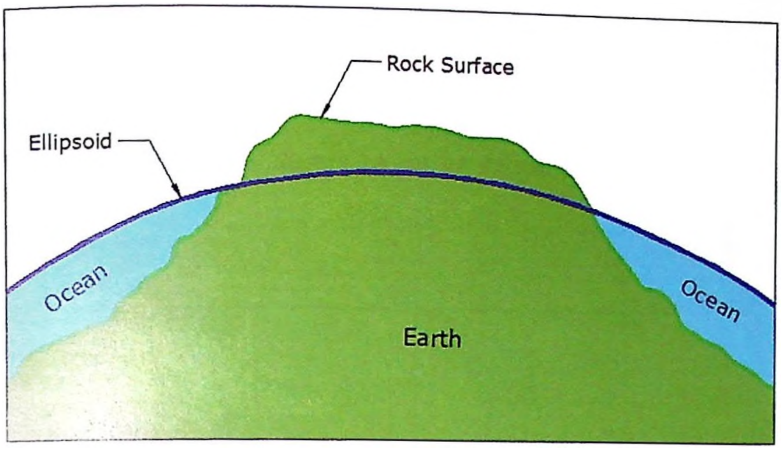


Figure 3.4: Irregularities of the Earth.

Projection is a method used to represent the curved surface of the Earth on the flat surface of a map. There are many map projection methods used in projecting the Earth. Each map projection has advantages and disadvantages; the appropriate projection for a map depends on the scale of the map, and on the purposes for which it will be used. The process of transferring information from the Earth to a map causes every projection to distort at least one aspect of the real world; either shape, area, distance, or direction. For example, a projection may have unacceptable distortions if used for a large area on the Earth (e.g. Russia), but may be an excellent choice for smaller areas like Palestine. The properties of a map projection may also influence some of the design features of the map; some projections are good for small areas, some are good for mapping areas with a large east-west extent, and some are better for mapping areas with a large north-south extent.

To understand how the Earth is projected, it is necessary to be familiar with the terms and parameters which are used for this purpose. Some of these terms are described in the following sections.

3.1.2.1 Latitude & Longitude

The Earth, as an ellipsoid, is divided into a network of vertical and horizontal lines. The horizontal lines are called latitudinal lines which are parallel to the equator, while the vertical lines are called longitudinal lines or meridians which converge on each pole. The equator divides the Earth into the Northern Hemisphere and Southern Hemisphere. The angle between the equator and the poles is 90 degrees. The longitudinal line that passes though Greenwich, England, divides the Earth into two halves of 180 degrees east and west. This line is called Greenwich Meridian or Prime Meridian, Figure 3.5.

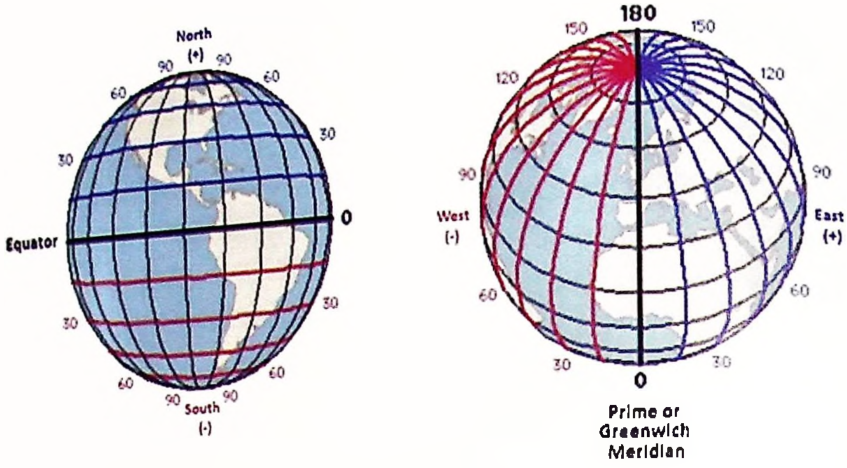


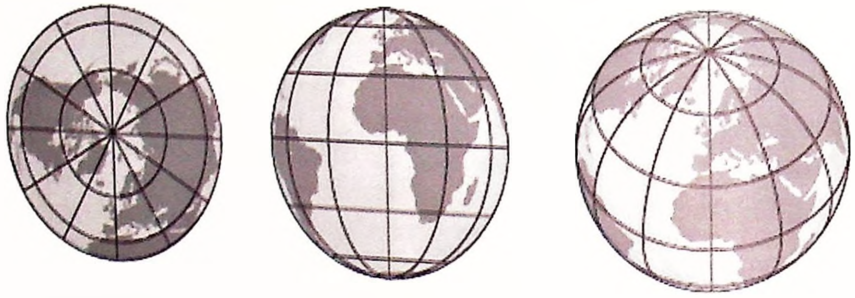
Figure 3.5: Latitudinal and longitudinal lines

3.1.2.2 Scale

The relationship between a distance on a map, chart, or photograph and the corresponding distance on the Earth is a scale. The scale is usually given as a fraction or ratio such as 1:2,000,000, or 1/2,000,000.

3.1.2.3 Aspect

An aspect is the position from which the Earth is viewed when it is projected. A polar aspect is tangent at the pole, an equatorial aspect is tangent at the equator, and an oblique aspect is tangent anywhere else, Figure 3.6.

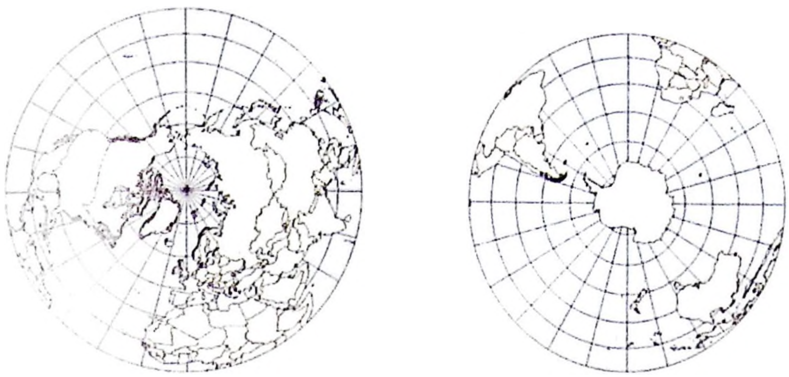


(a) Polar aspect (b) Equatorial aspect (c) Oblique aspect

Figure 3.6: Types of aspects

3.1.2.4 Hemisphere

The largest part of a globe that you can see at one time is a hemisphere. Any half of the globe is a hemisphere. The Northern Hemisphere includes all the areas to the north of the equator and the Southern Hemisphere all areas to the south, Figure 3.7.



(a) Northern hemisphere (b) Southern hemisphere

Figure 3.7: The Northern and Southern Hemispheres

3.1.2.5 Coordinates

Every point on the globe has a meridian (longitude) running through it from north to south and a parallel (latitude) running through it from east to west. Maps and globes only show some of the meridians and parallels because if they were all showed the map would be covered with lines and not very useful. Longitude and latitude are measured in degrees and marked with the ° symbol. There are 360 degrees of longitude; measured 180 degrees east and west of the prime meridian, and 180 degrees of latitude, measured 90 degrees north and south of the equator as shown in Figure 3.5 above.

Considering the Earth to be perfectly spherical, one degree of latitude along a meridian (from one parallel to the next one (1° away) always measures the same distance because latitude measures distance. That distance amounts to about 69.1 mile (111.1 km).

One degree of longitude on the other hand, measures an angle, so the distance covered by 1° of longitude is a different distance at every latitude. Again assuming the Earth to be perfectly spherical, then at the equator 1° of longitude is the same as 1° of latitude; at 60° north or south the distance is 34.5 mile (55.6 km); and at either pole the distance is zero.

Minutes and seconds are used to measure smaller parts of a degree. Minutes are marked with ' and seconds with ". One minute is 1/60 of a degree and one second is 1/60 of a minute, so on the equator 1' is about 1.15 mile (1.85 km) and 1" is about 101 feet (0.0309 km or 30.9 m).

The coordinate of a location is given by the intersection of the parallel and meridian that pass through that location, along with a direction stating north or south for latitudes, or east or west for longitudes. Typically the latitude is given first. For example the coordinate of Al Aqsa Mosque (Jerusalem, Palestine) is 31°46'35"N (latitude) and 35°14'8"E (longitude).

3.1.2.6 Distortion

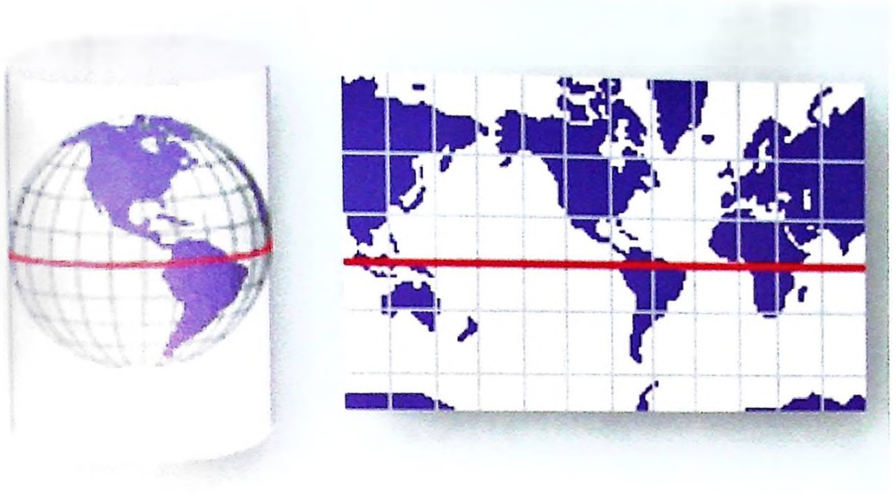
Maps always show a distorted view of the Earth because they are not curved in three dimensions. The cartographer (mapmaker) usually tries to make as accurate a map as possible, and that is why there are so many different projection classes; each distorting the Earth in a different way.

These distortions come in two principal varieties. Areal distortion causes different regions on the map to have disproportionate sizes with respect to each other. For example, many maps show areas smaller or larger than their actual size. Distortion of shape is technically called angular distortion which usually manifests itself as shearing, meaning that map features are twisted or bent. Since globes have many properties and any of those properties can be changed by projection, there are many other possible kinds of distortion. Some of these are scale distortion, which means that distances are not shown correctly with respect to each other; direction distortion, which means that directions are not shown correctly; and interruption, which means that two points next to each other on the globe are separated on the map.

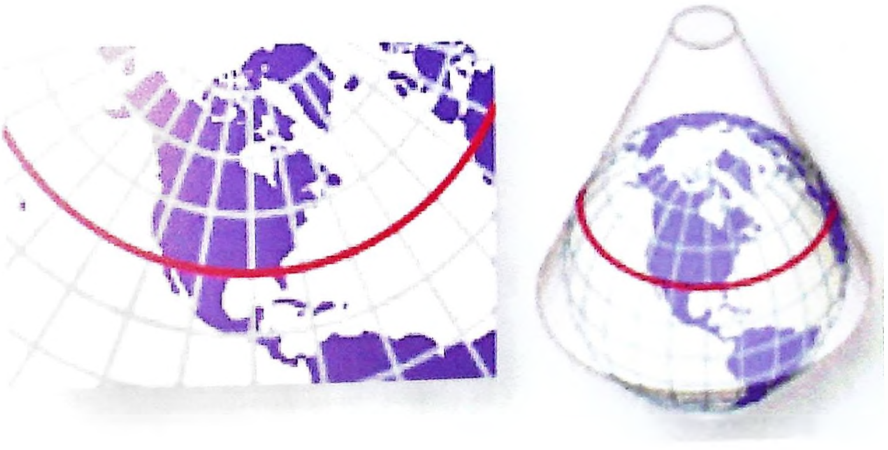
Areal distortion and angular distortion can exist independently of each other, so a given projection might have only one of those two kinds of distortion. However all projections have scale distortion often used as a convenient measure for the accuracy of a map. The amount of scale distortion is indirectly related to the amounts of angular and areal distortion. A map has a stated scale called the nominal scale or principal scale, which is somewhat arbitrary but usually equals the scale of the center of the map. At any point on the map the scale may vary from the nominal scale, and the ratio of the two is called the scale factor at that point. Unless the projection has no angular distortion at the point being measured, the scale factor at that point will vary according to direction, and in that case the scale distortion could be defined in many different ways.

3.1.3 Natural Projection Class

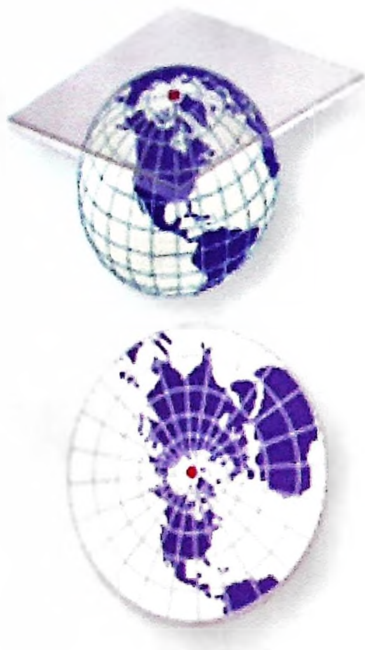
There are three main natural projection classes used to project the Earth with minimum distortion. These classes are called cylindrical, conic and planar, Figure 3.8. To understand these classes, imagine that a light source is projected through a transparent globe onto a developable surface used as a screen. This representation of the globe or part of the globe on a flat surface, such as a sheet of paper, can be called a projection.



(a) Cylindrical class



(b) Conic class

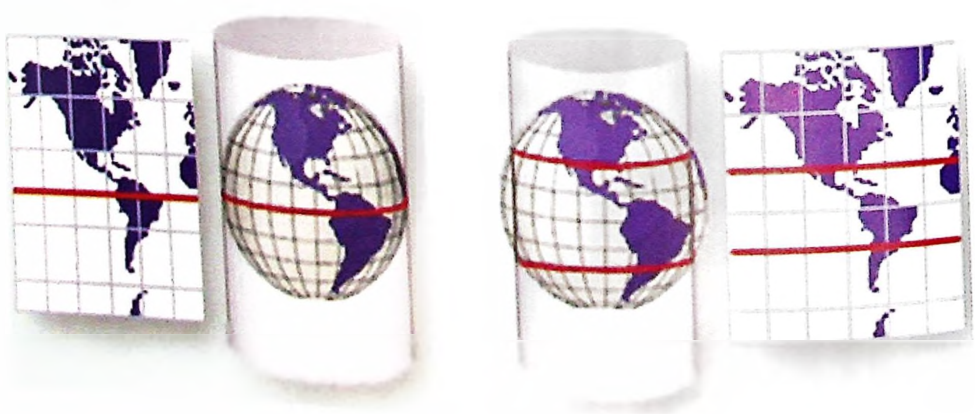


(c) Planar class

Figure 3.8: Natural projection classes

3.1.3.1 Cylindrical Projection Class

A cylindrical projection projects information from the spherical Earth to a cylinder. The cylinder may be either tangent to the Earth along a selected line or may be secant (intersect the Earth) along two lines, Figure 3.9. Imagine that once the Earth's surface is projected, the cylinder is unwrapped to form a flat surface. The lines where the cylinder is tangent or secant are the places with the least distortion.



(a) Tangent at selected line

(b) Secant along two lines

Figure 3.9: Tangent and secant lines used for projection

There are two main types of cylindrical projection; Mercator and Transverse projections. A Mercator projection is created using a cylinder tangent at the equator, Figure 3.10. A Transverse Mercator projection is created using a cylinder that is tangent at a selected meridian, Figure 3.11.

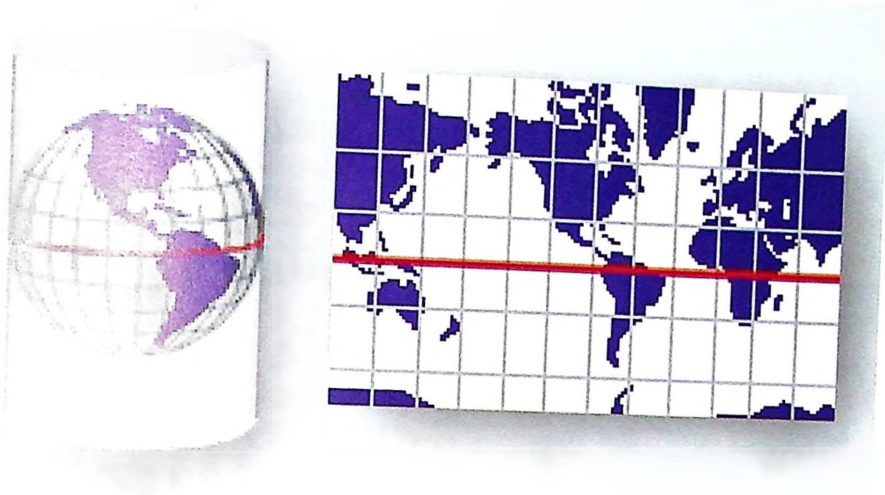


Figure 3.10: Mercator projection

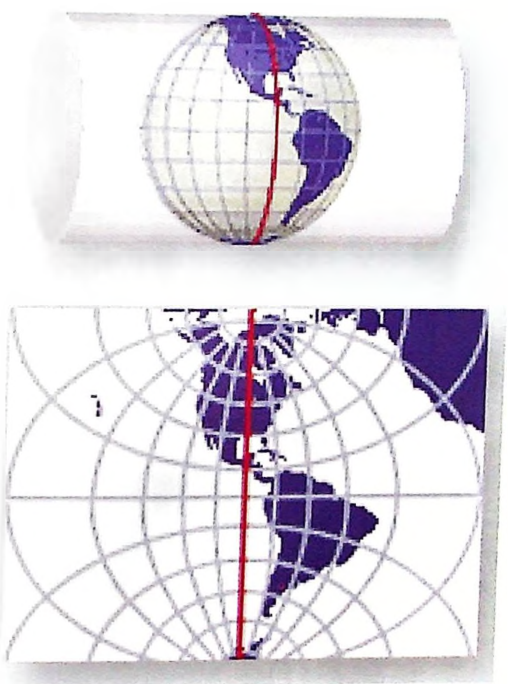
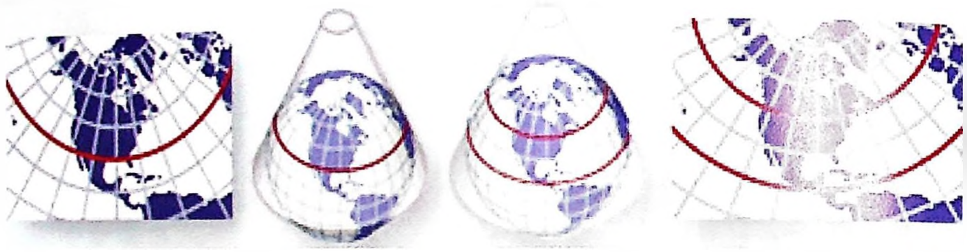


Figure 3.11: Transverse Mercator projection

3.1.3.2 Conic Projection Class

The main problem with cylindrical projections is that they do a poor job minimizing distortion except at points very close to the line of tangency. They are a poor choice for mapping large countries (such as the US or Russia) that have great east-west extents.

A better choice for mapping such regions is a conic projection, which projects shapes from the Earth's sphere onto a cone. Cones, of course, can be unrolled into a flat sheet without any deformation. Locations near the line where the cone is tangent to the Earth will be relatively free of distortion. By using taller cones, the line of tangency is moved nearer to the equator and by using fatter, more open cones; the line of tangency is moved closer to the pole, Figures 3.12 and 3.13.



(a) Tangent at a single parallel (b) Secant at two parallels

Figure 3.12: Tangent and secant parallels

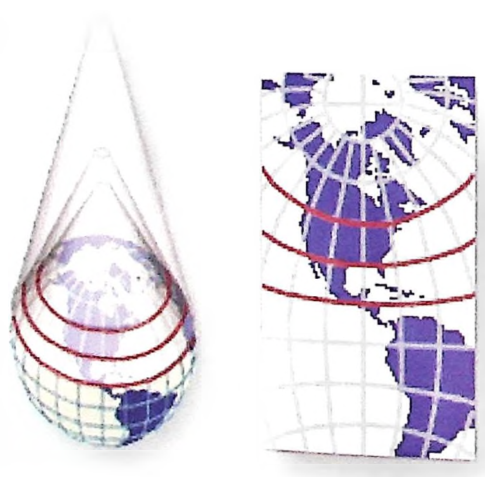
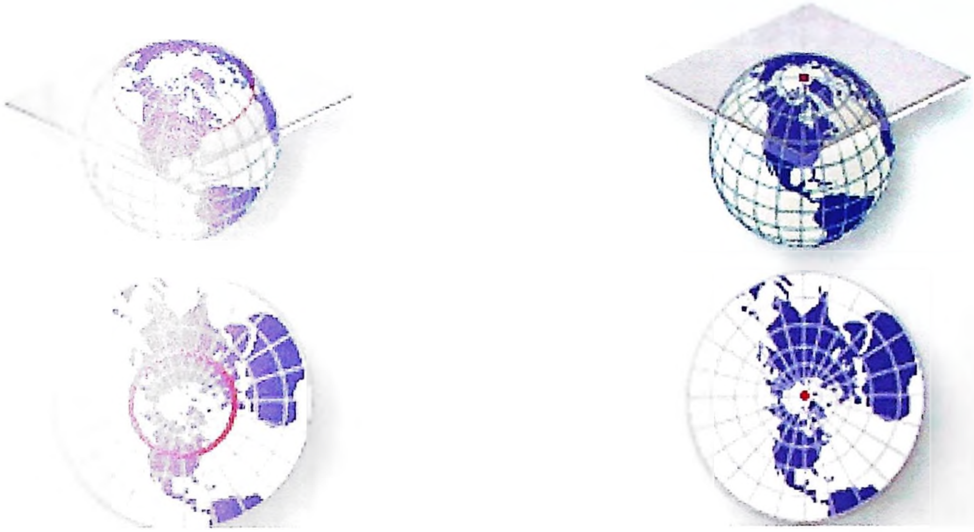


Figure 3.13: Conic projection

3.1.3.3 Planar Projection Class

A planar projection is a type of map in which the details of the globe are projected onto a plane (a flat surface) yielding a rectangular-shaped map. With a planar projection, a portion of the

Earth's surface is transformed from a perspective point to a flat surface. In the polar case, the parallels are represented by a system of concentric circles sharing a common point of origin from which radiate the meridians, spaced at true angles, Figure 3.14. This projection shows true direction only between the center point and other locations on the map. Although these projections are most often used to map Polar Regions, they may be centered anywhere on the Earth's surface.



(a) Secant (b) Tangent

Figure 3.14: Planar projection

3.1.4 Projections and Projection Parameters

Virtually all projections in common use fall into one of the above three categories. They are either cylindrical (regular or transverse), conic or planar projections as customized by slightly different projection parameters. Projection parameters are options of how the projection can be arranged. For example, a planar projection can be centered on any point on Earth by specifying the latitude and longitude of the desired central point. Conic projections may be customized by specifying the parallel of latitude at which the cone should be tangent. Specifying a projection together with various optional parameters will drive the mathematical conversion of longitude, latitude degree coordinates into the numbers used within the projected coordinate system.

Some GIS formats automatically save the projection parameters in use together with the data, Figure 3.15. While importing drawings from such formats, Manifold will automatically fetch all necessary parameters from such "smart" formats and will load the coordinates for that drawing with the correct parameters necessary to use the data.

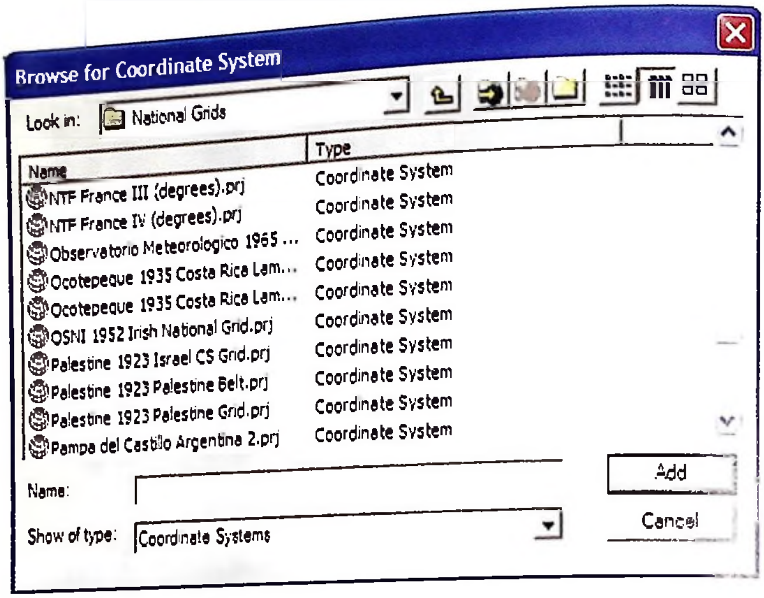


Figure 3.15: Example of some projections stored in ArcGIS

When importing projected drawings from legacy GIS formats that do not save the projection information with the data, the user will need to know what parameters should be used with that drawing. The user will then have to enter this information manually into that drawing's coordinate properties so Manifold can use the data as intended.

Once a map is constructed using a given projection, the map is a flat surface. Distances on that flat surface may be measured as X and Y rectangular coordinates, with the X coordinate being the distance to the right of the vertical line passing through the origin or the center of a projection. A negative X coordinate represents the distance to the left. In practice a false X or false easting is frequently added to all values of X to eliminate negative numbers. Likewise, the Y rectangular coordinate is the distance above the horizontal line passing through the origin or center of a projection, with negative Y being the distance below. In practice, a false Y or false northing is frequently added to all values of Y to eliminate negative numbers.

3.1.5 Geographic Coordinate System

A geographic coordinate system is one of the most common coordinate systems. It 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 longitudinal and latitudinal coordinates. For example, Figure 3.16 shows a geographic coordinate system where a location is represented by the coordinates of 80 degrees east and 55 degrees north.

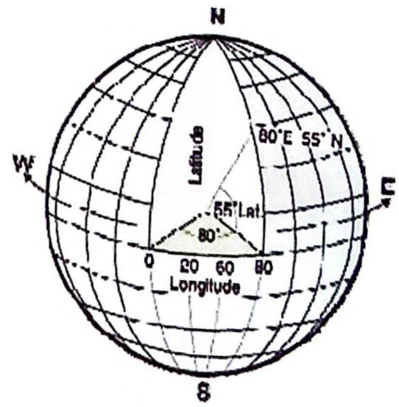


Figure 3.16: A geographic coordinate system

To make the geographic coordinate system useful, a map grid must be divided into small enough sections that can be used to describe, with an acceptable level of accuracy, the location of a point on the map, Figure 3.17.

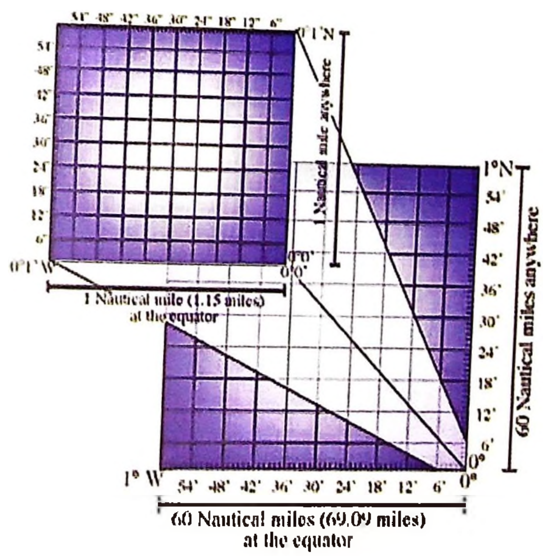


Figure 3.17: Dividing a map into smaller grids

An alternative method of notation in the geographic coordinate system, often used for many GIS applications is the decimal degree system. In the decimal degree system the major (degree) units are the same, but rather than using minutes and seconds, smaller increments are represented as a percentage (decimal) of a degree.

The decimals can be reported to four places, resulting in a notation of DD.XXXX°N, DD.XXXX°E. When using four decimal places, the decimal degree system is accurate to within ± 36.5 feet (11.12 m). However, because the accuracy of the fourth decimal place is often uncertain, decimal degree coordinates are often rounded to three decimal places. This results in an accuracy of ± 364.8 feet (111.2 m).

For example, the location of Al Aqsa Mosque in Jerusalem, Palestine when expressed using minutes and seconds is 31°46'35"N and 35°14'8"E but when using the decimal degree notation this same location is written as 31.7764°N and 35.2356°E.

Mapping Palestine using the geographical coordinate system is shown in Figure 3.18. It approximately lies between the longitudinal lines 34° 12′ 40″E and 35° 40′ 00″E and between the latitudinal lines 29° 30′ 00″N and 33° 16′ 00″N.

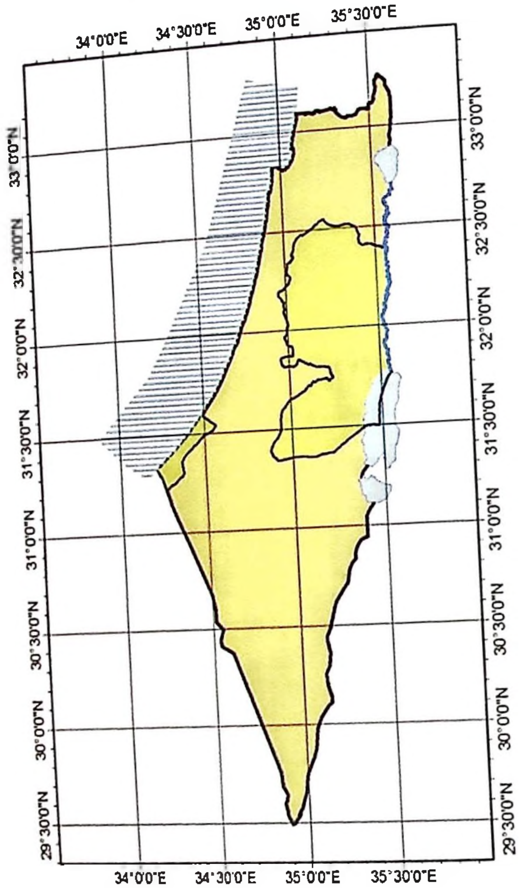
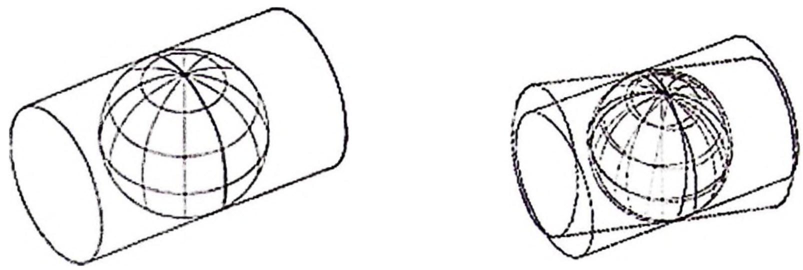


Figure 3.18: Map of Historical Palestine using the geographic coordinate system

3.1.6 Universal Transverse Mercator (UTM)

The Transverse Mercator Projection (UTM) system was an attempt to set up a universal worldwide system for mapping. UTM maps the Earth with a transverse cylinder projection using 60 different lines, each of which is a standard "UTM Zone". By rotating the cylinder in 60 steps (six degrees per step) UTM assures that all spots on the Earth will be within 3 degrees of the center, tangent line of one of the 60 cylindrical projections, Figure 3.19. This creates 60 zones around the world. The first zone begins at the International Date Line (180°, using the geographic coordinate system).



(a) Transverse Mercator (b) Universal Transverse Mercator

Figure 3.19: Transverse Mercator versus Universal Transverse Mercator projections

The zones are numbered from west to east, so zone 2 begins at 174°W and extends to 168°W. The last zone (zone 60) begins at 174°E and extends to the International Date Line. Figure 3.20, shows two UTM zones; Zone 10 and Zone 11, this Figure also shows how these two zones overlap.

Positions are measured using Eastings and Northings, measured in meters, instead of latitude and longitude. Eastings start at 500,000 on the center line of each zone. In the Northern Hemisphere, Northings are zero at the equator and increase northward. In the Southern Hemisphere, Northings start at 10 million at the equator, and decrease southward. The user must know his hemisphere and zone to interpret the location globally. Distortion of scale, distance, direction and area increase away from the central meridian of each zone.

The zones are then further subdivided into an eastern and western half by drawing a line, representing a Transverse Mercator Projection, down the middle of the zone. This line is known as the 'central meridian' and is the only line within the zone that can be drawn between the poles and is perpendicular to the equator (in other words, it is the new 'equator' for the projection and suffers the least amount of distortion). For this reason, vertical grid lines in the UTM system are oriented parallel to the central meridian. The central meridian is also used in setting up the origin for the grid system, Figure 3.21.

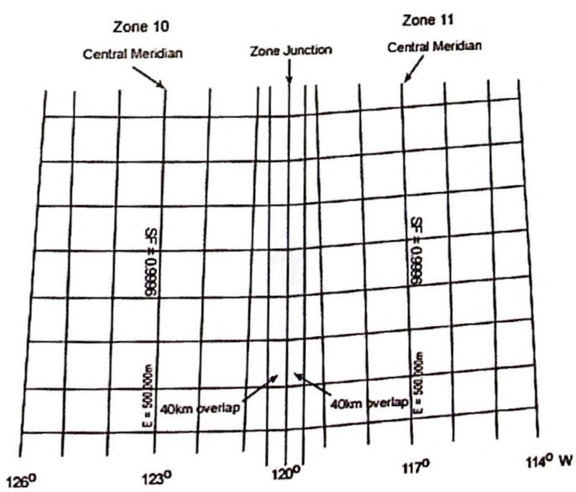


Figure 3.20: UTM zones, Zones 10 and 11

Any point can then be described by its distance east of the origin (its 'easting' value). By definition the Central Meridian is assigned a false easting of 500,000 meters in order to eliminate the necessity for using negative numbers. Any easting value greater than 500,000 meters indicates a point east of the central meridian. Any easting value less than 500,000 meters indicates a point west of the central meridian. Each UTM zone has its own origin for east-west measurements, Figure 3.21

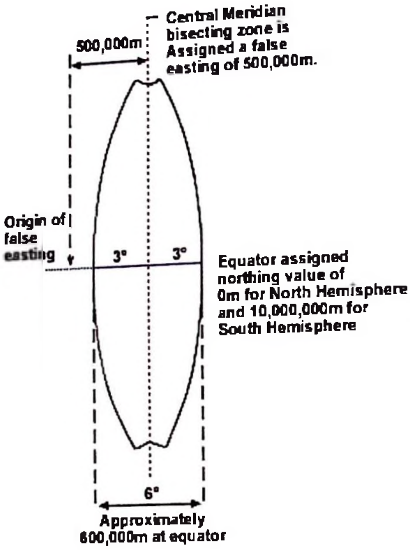


Figure 3.21: Details of the UTM zone

The zones are numbered from 1 to 60 eastward, beginning at the 180th meridian. Some software use negative zone numbers to indicate that the data is in the Southern Hemisphere, e.g. zone 19 is north of the equator, zone -19 is south of the equator, Figure 3.22. The Figure shows that Palestine is located in Zone 36 N.

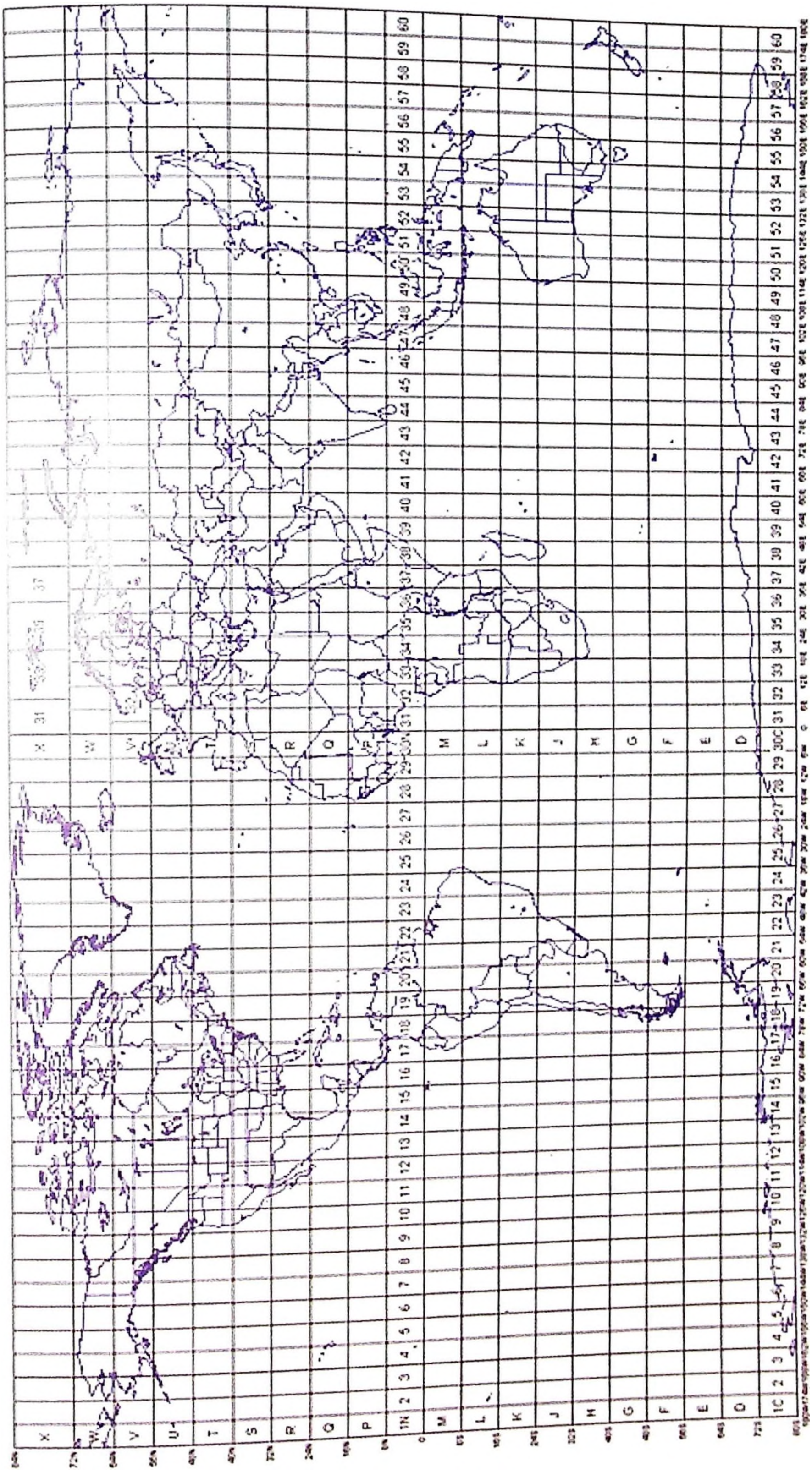


Figure 3.22: UTM zones and their numbers

3.1.7 Projected Coordinate Systems

A projected coordinate system is defined on a flat, two-dimensional surface. It is based on a geographic coordinate system that is based on a sphere or spheroid.

In a projected coordinate system, locations are identified by x, y coordinates on a grid, with the origin at the center of the grid. Each position has two values that reference it to that central location. One specifies its horizontal position and the other its vertical position. The two values are called the x-coordinate and y-coordinate. Using this notation, the coordinates at the origin are x = 0 and y = 0.

On a gridded network of equally spaced horizontal and vertical lines, the horizontal line in the center is called the x-axis and the central vertical line is called the y-axis. Units are consistent and equally spaced across the full range of x and y. Horizontal lines above the origin and vertical lines to the right of the origin have positive values; those below or to the left have negative values.

Palestine is located in Zone 36 N (UTM) as shown in Figure 3.22 above. Based on this location, Palestine is projected using a local Palestinian grid system which was developed during the British Mandate. The origin of this coordinate system is located in the Sinai Peninsula (Egypt) as shown in Figure 3.23. The parameters used to project Palestine in this local coordinate system are shown in Figure 3.24. These parameters are stored in ArcGIS and can be used to define the coordinate system for any feature as shown in the practical part of this chapter.

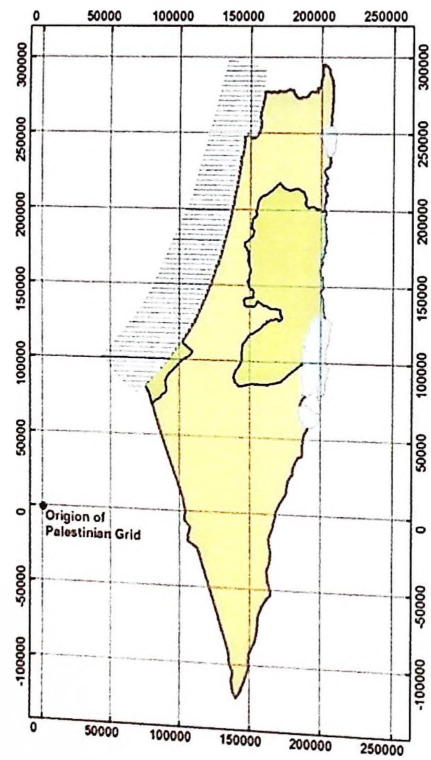


Figure 3.23: Historical Palestine using the Palestinian coordinate system

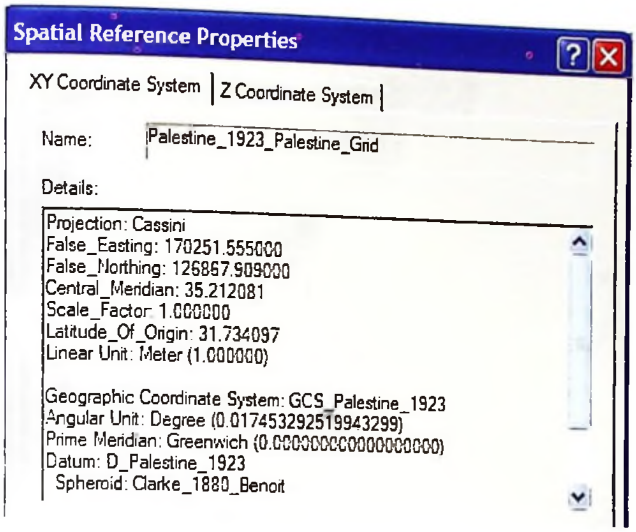


Figure 3.24: Projection parameters for the Palestinian grid

3.2 Georeferencing

Georeferencing is the method by which the geographic data (raster) is aligned to a known coordinate system. Georeferencing may involve shifting, rotating, scaling, skewing, wrapping, rubber sheeting and orthorectifying. This is usually done using control points.

Control points are points in the raster that have known coordinates. In the real world, the following could be used as control points: road intersections, the corner of a building or any other visible, small, stable, permanent, and well-defined landmarks. For example, Figure 3.25 shows control points that may be used to georeference the raster. Figure 3.26 shows the location of points with known coordinates and also illustrates the process of georeferencing the raster.

Figure 3.25: Different locations for control points

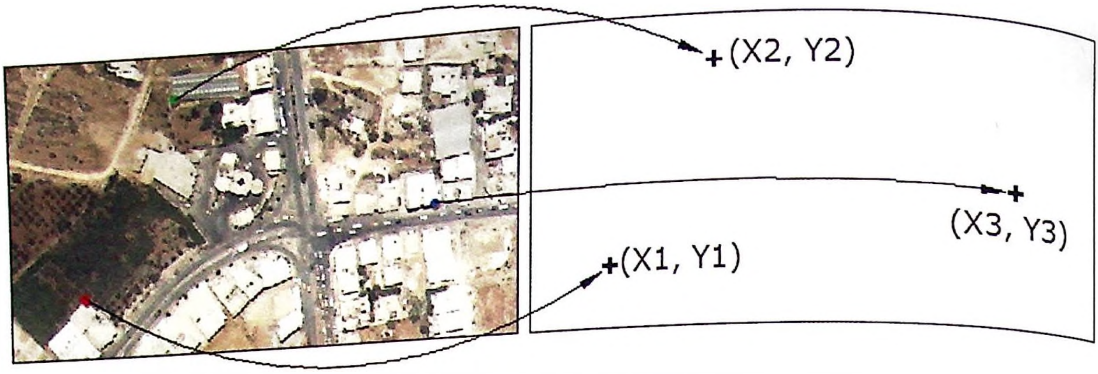


Figure 3.26: Location of control points in a known coordinate system

Normally, scanned maps don't contain spatial reference information (either embedded in the file or as a separate file). Sometimes aerial photography and satellite imagery have the locational information delivered with them but they are inadequate and the data does not align properly with other existing data. Thus, in order to use some raster in conjunction with other spatial data, it must first be georeferenced to a known coordinate system then it may be viewed, queried, and analyzed with other geographic data.

The number of control points needed to transform a raster dataset to permanently match the map coordinates of the target data depends on the quality of the original raster. The user has the choice of using a polynomial or spline to determine the correct map coordinate location for each cell in the raster. Use a first order, or affine transformation, to shift, scale, and rotate a raster dataset. This generally results in straight lines on the raster dataset mapped as straight lines in the warped raster dataset. Thus, squares and rectangles on the raster dataset are commonly changed into parallelograms of arbitrary scaling and angle orientation. With a minimum of three links, the mathematical equation used with a first-order transformation can map exactly each raster point to the target location. Any more than three links introduces errors, or residuals, that are distributed to all the other links. However, the user should add more than three links because if one link is incorrect, it will have a smaller impact on the transformation. Thus, even though the mathematical transformation error may increase as the user creates more links; the overall accuracy of the transformation will increase. The higher the transformation order, the more complex the distortion that can be corrected. However, transformations higher than the third order are rarely needed. Higher-order transformations require more links and, thus, will involve progressively more processing time. In general, if the raster dataset needs to be stretched, scaled, and rotated, use a first-order transformation. If, however, the raster dataset must be bent or curved, use a second- or third-order transformation. Table 3.1 shows examples of georeferencing methods needed for different input raster datasets.

In general, the Table below explains the different transformation methods, their uses and the minimum number of control points needed.

Table 3.1: Methods of georeferencing transformations

Method of Georeference	Used for	Minimum Control Points	Input Raster	Output
First order (Affine)	Stretched, scaled, and rotated	3 points		
Second order	Bent or curved.	6 points		
Third order	Bent or curved.	10 points		

3.3 Practices

3.3.1 Define a Projection for a Dataset

Suppose that you have a hard copy map of the West Bank Governorates. This map was created based using the Palestinian Coordinate System. To convert this map into a vector dataset, you should first georeference the map then digitize it into a shapefile. In this exercise you will define a coordinate system for this shapefile. Since the original map was developed using the Palestinian Coordinate System the digital shapefile should also have the same coordinate system.

1. Open a new ArcMap document, then add the West Bank_Governorate shapefile from "C:\GIS_Tutorial\Chapter3\Exercise1\Shapefiles\". Since the coordinate system is still not defined for this shapefile ArcMap will inform you that the georeference of the loaded shapefile is not defined, Figure 3.27. Click OK to finish loading the shapefile. If you want to check the coordinate system of this shapefile; you can right-click on the West Bank_Governorate shapefile from the table of contents, select Properties then select the Source tab in the Properties dialog box, you will find that the coordinate system for the shapefile is not defined, Figure 3.28.

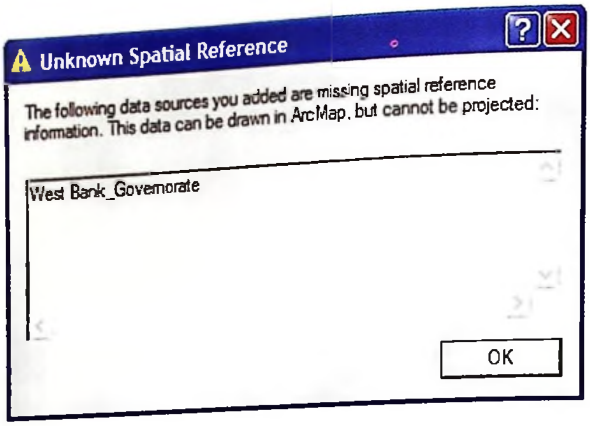


Figure 3.27: Spatial reference dialog box

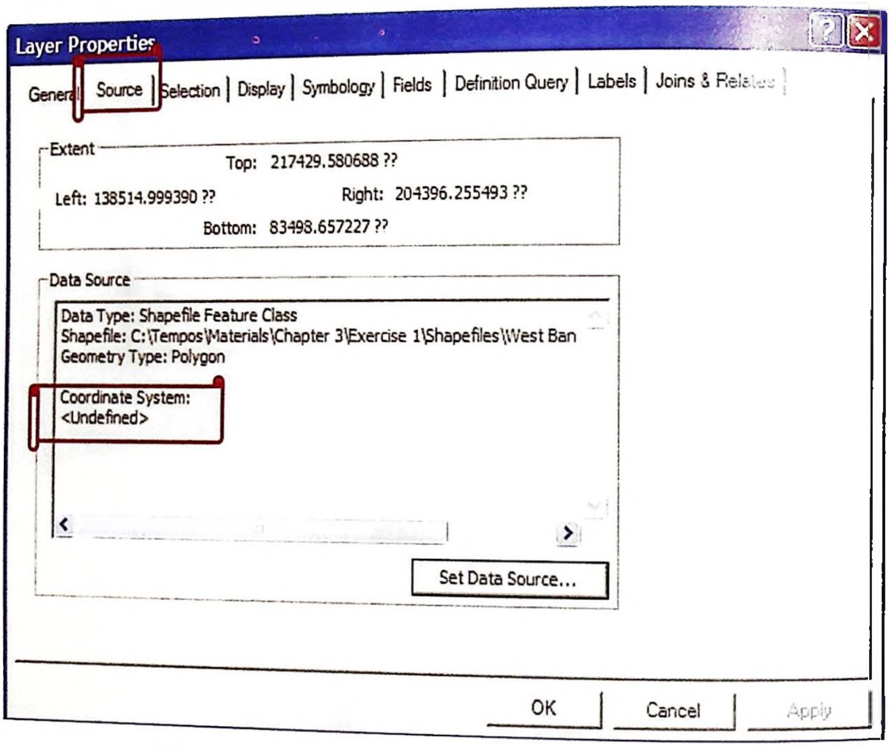


Figure 3.28: Layer Properties dialog box

2. To define the Projection system, expand the Data Management Tools item from ArcToolbox. Expand Projections and Transformations, then click on Define Projection, Figure 3.29, the Define Projection box will open.

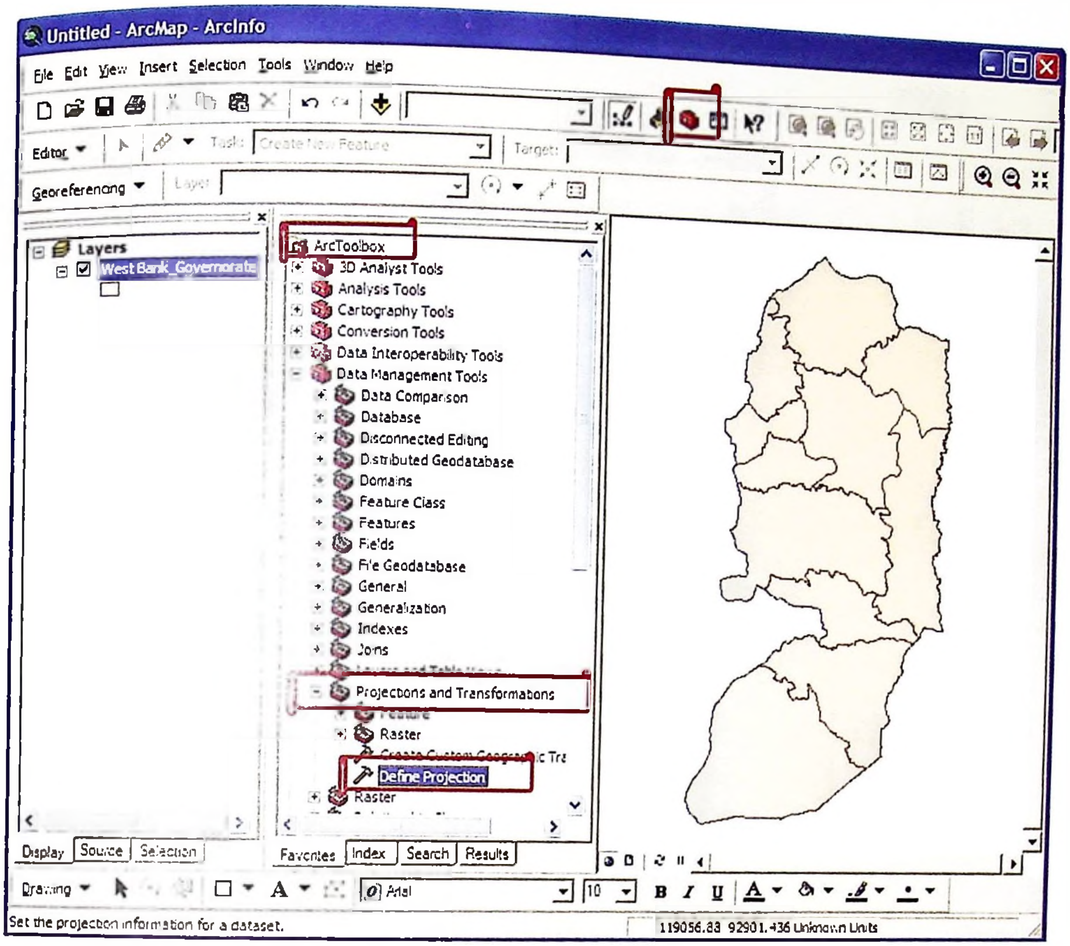


Figure 3.29: Location of the Define Projection tool

3. Drag the West Bank_ Governorate shapefile to the Input Dataset ... box, Figure 3.30.

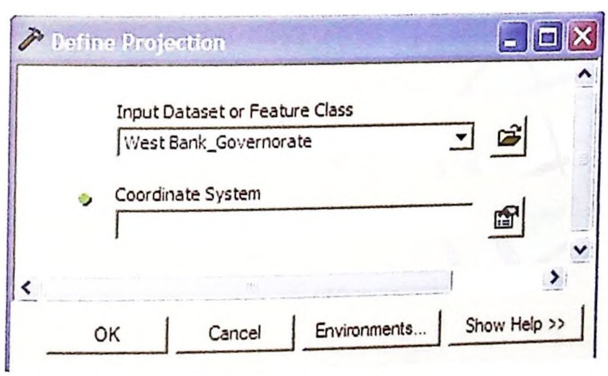


Figure 3.30: Define Projection dialog box

4. Click the button on the right side of the Coordinate System window, the Spatial Reference Properties window will open, Figure 3.31. In this dialog box, you will find six buttons; the first is the Select button which is used to select one of the projection

systems stored in ArcGIS. The second is the Import button. This button is used to copy the coordinate system from another dataset. The third button, New, is used to define a new coordinate system not stored in the ArcGIS package. The other three buttons are used to modify, clear and save the defined coordinate system.

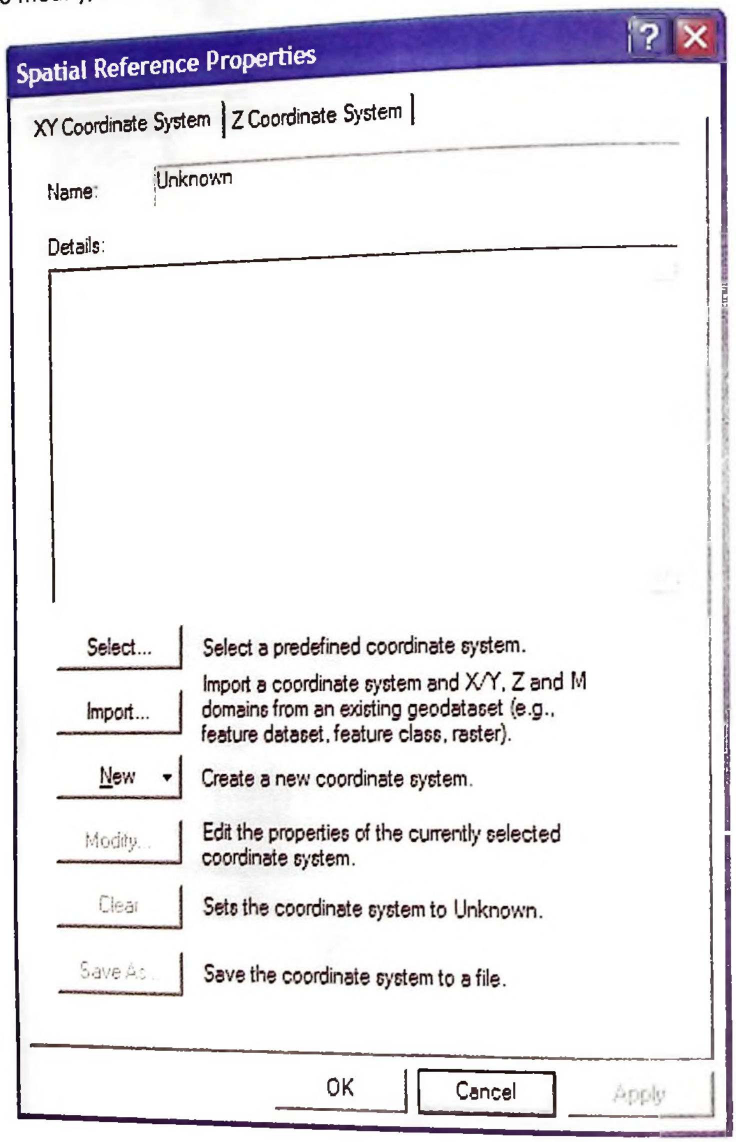


Figure 3.31: Spatial Reference Properties dialog box

5. Click the Select button, to select one of the projections stored within ArcGIS. Since the georeference of the source of the shapefile is the Palestinian Coordinate System, then you should select Projected Coordinate Systems. Now browse to Palestinian grid system. You can do this by one of the following two ways:
   a. Click on National Grids then browse to the Palestine 1923 Palestine Grid.prj, click Add, OK and OK once again to define the coordinate system, Figure 3.32.

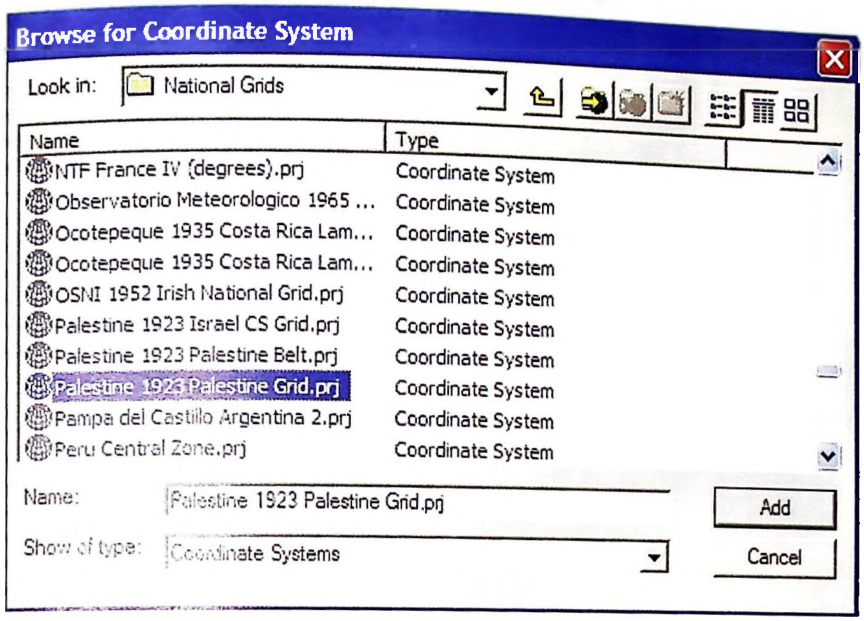


Figure 3.32: Define Palestinian grid system from National Grids

b. Click on the UTM folder, browse to WGS 1984 then select WGS 1984 UTM Zone 36N.Prj. Click Add, OK and OK once again to complete the definition of the coordinate system for the shapefile, Figure 3.33.

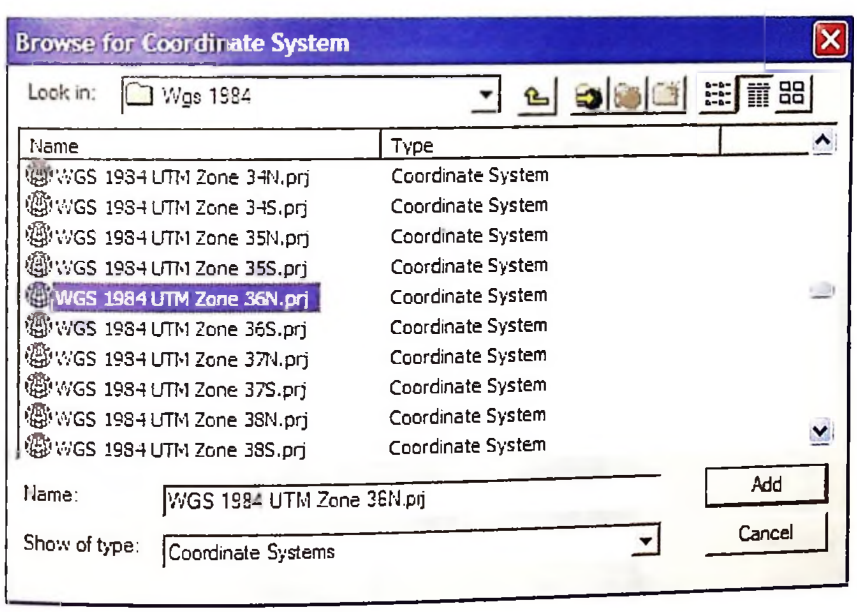


Figure 3.33: Defining the Palestinian grid system using UTM zones

3.3.2 Transfer Projections

In this exercise you will create a new shapefile from West Bank_Governorate with a different coordinate system; The Geographic Coordinate System.

1. Use the same map you created in Section 3.3.2.
2. From ArcToolBox click on Projections and Transformations, scroll down to Feature and click on Project, Figure 3.34.

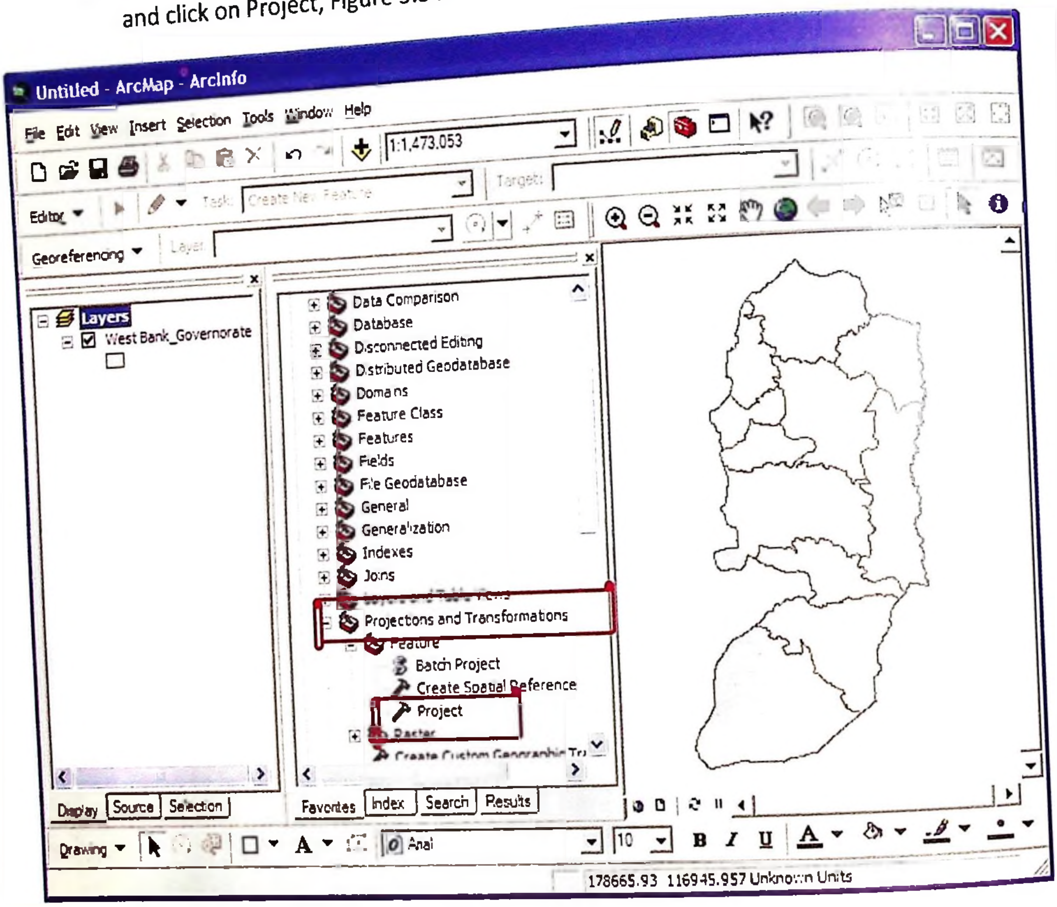


Figure 3.34: Opening the Project tool

3. By clicking on the Project tool, a new window will appear. Drag the West Bank_Governorate shapefile to the Input box. The Project tool will read the coordinate system of the loaded shapefile (Palestine 1923 Palestine Grid). In the output box browse to "C:\GIS_Tutorial\Chapter3\Exercise1\Shapefile\". Type "West Bank_Governorate_Geographic" as the name of the new shapefile.
4. Click the button on the right of the Output box to browse for the new coordinate system. From the Spatial Reference Properties window click on the Select button then select Geographic Coordinate Systems, click World then select WGS 1984.prj as the geographic system for the shapefile. Click Add then OK.

5. From the Geographic Transformation box, select Palestine 1923_to_WGS 1984_1. The Project window will look like Figure3.35.

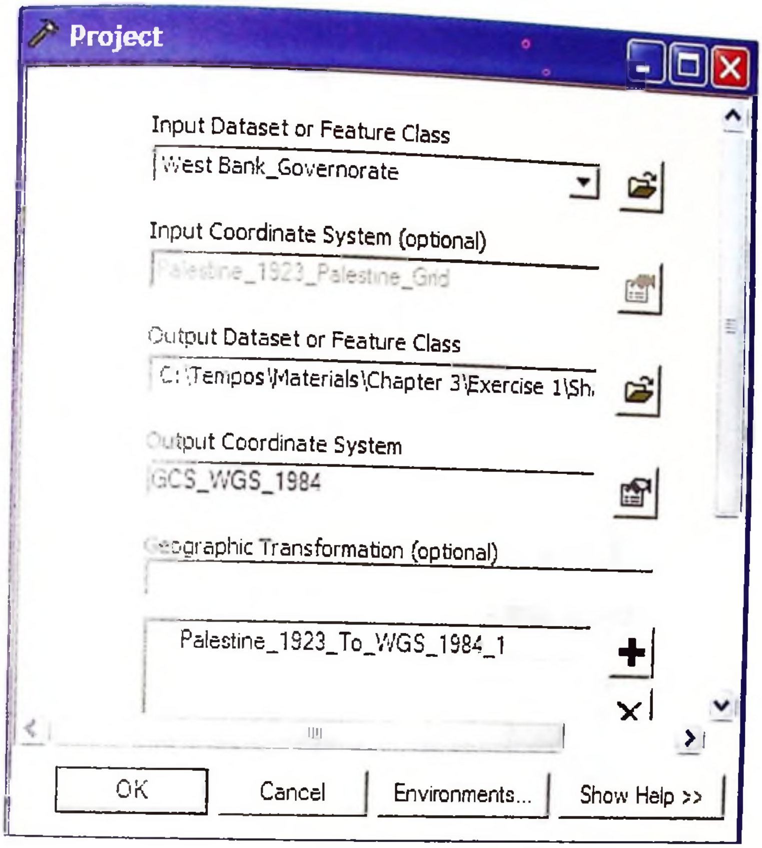


Figure 3.35: Defined parameters of the Project tool

6. Click OK. The system will create a new shapefile with a geographic coordinate system. Click OK to add this new shapefile to the map.
7. Save the map in the Exercise 1 folder. Keep it open for the next section.

3.3.3 Presenting a Map Using Different Projections

The map created in Section 3.3.2 has two shapefiles with different coordinate systems. You can check the coordinate system of the two shapefiles by reviewing their properties. The coordinate system of the map is not yet defined. On the bottom-right corner of the map, the map units are still unknown. Now, the map will be plotted using both the Palestinian and Geographic grid systems.

1. From the Table of Contents, double click on the Layers data frame. The properties of the data frame will then be illustrated.
2. Click on the Coordinate System tab. In the Select Coordinate System window, expand the Layer folder. Click on the West Bank_Governorate then click on the coordinate system below the name of the shapefile, Figure 3.36.

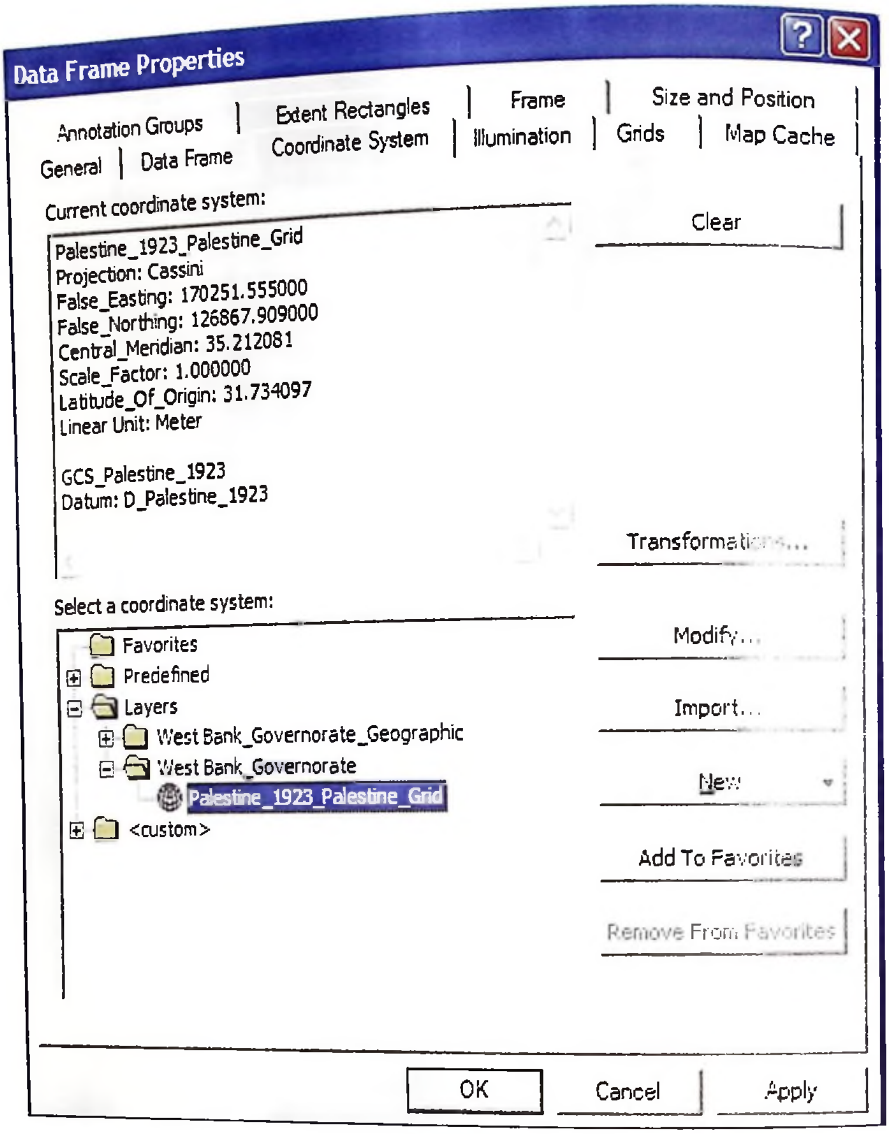


Figure 3.36: Defining the coordinate system for the map (Palestinian Grid)

3. Click OK to close the window. Then click Yes on the Warning window.
4. Notice the coordinate system for the map (bottom-right corner of the map), you will find that the map is plotted in meters, the unit of the Palestinian grid.
5. To plot the map using the Geographic Coordinate System, repeat steps 1 to 4. But select the coordinate system of the West Bank_Governorate_geographic shapefile instead of that for the West Bank_Governorate shapefile. The map's units will change from meters to degrees, Figure 3.37.

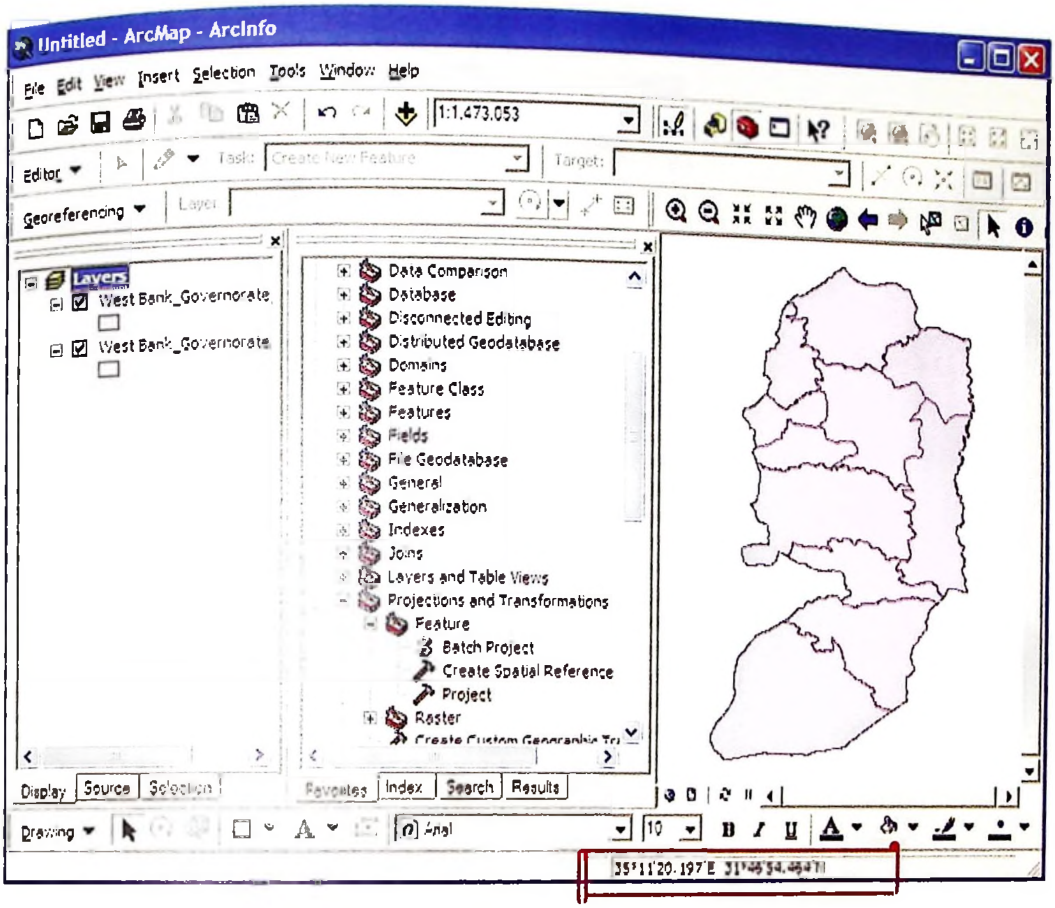


Figure 3.37: Map in Geographic Coordinate System.

3.3.4 Georeferencing Maps

Historical maps, satellite images and aerial photographs form the main sources of spatial data. In this section aerial photos taken from GoogleEarth will be georeferenced.

3.3.4.1 Turning on the Georeferencing Tool

1. Open a new ArcGIS map. Save it on "C:\GIS_Tutorial\Chapter3\Exercise2\Projects".
2. Click the View menu; then on Toolbars and tick the Georeferencing toolbar, Figure 3.38, the Georeferencing toolbar will open in the ArcMap interface, Figure 3.39.

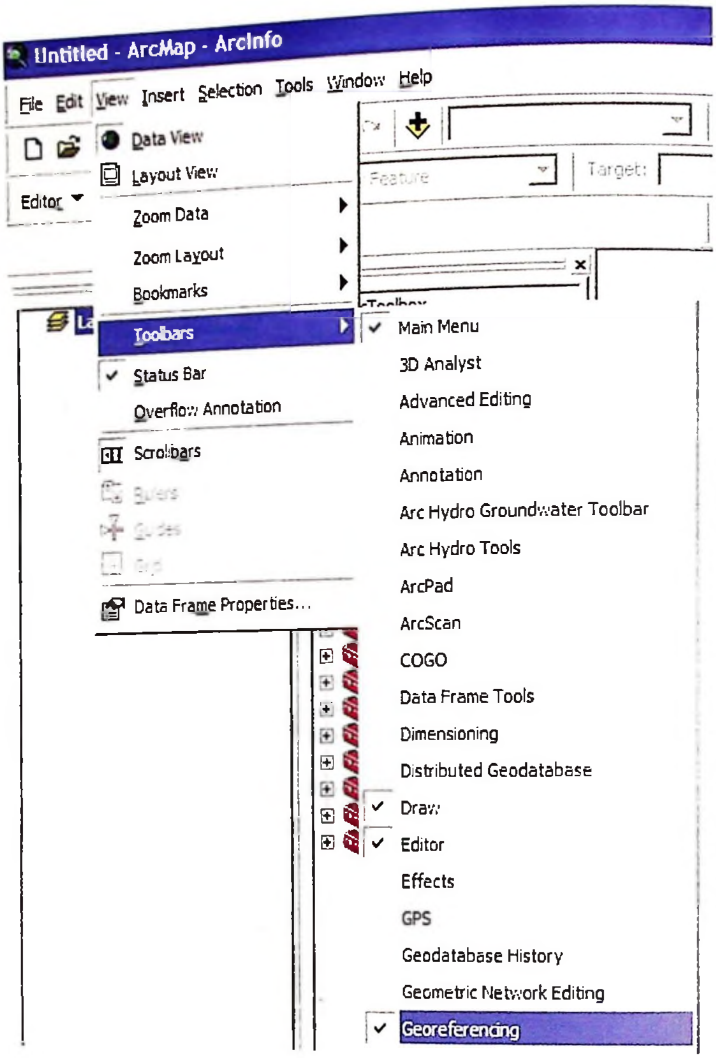


Figure 3.38: Adding the Georeferencing toolbar

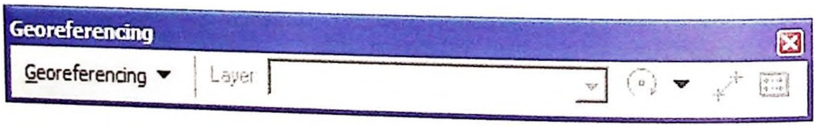


Figure 3.39: The Georeferencing toolbar

3.3.4.2 Adding an Image With Known Reference Points

1. From "C:\GIS_Tutorial\Chapter3\Exercise2\shapefiles" add the West Bank Governorate and Frush Beit Dajan area shapefiles and Frush Beit Dajan.bmp image. (Frush Beit Dajan is a Palestinian village located in northeast of the West Bank, Jericho Governorate).
2. Zoom in on the Frush Beit Dajan area shapefile.

3. In the Layer box on the Georeferencing toolbar, select Frush Beit Dajan.bmp.
4. Click on the Georeferencing button. Un-tick the Auto Adjust tool, then click on Fit to Display. The Frush Beit Dajan.bmp will overlay the ArcMap display as shown in Figure 3.40. This is the approximate location of this image.

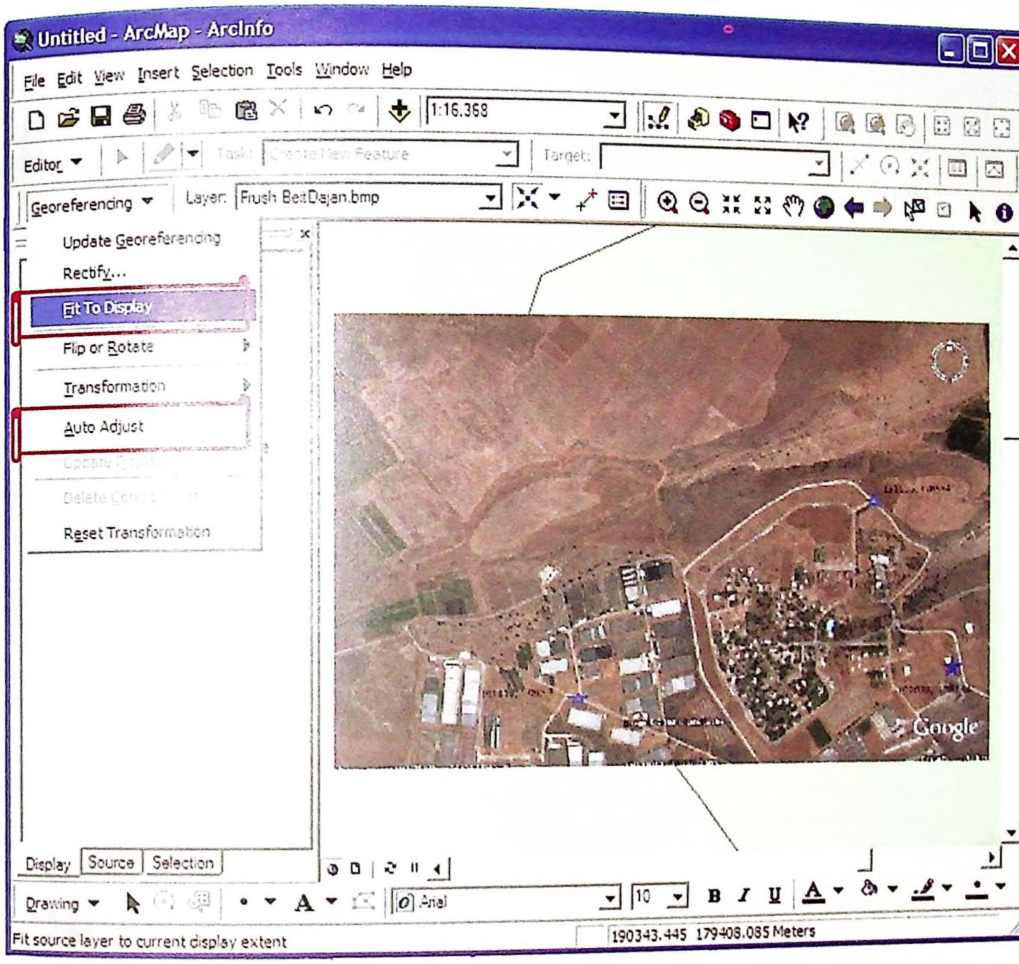


Figure 3.40: Positioning an image to its approximate location

5. You will find three blue points, these points are the control points which will be used to georeference this map. Zoom in to one of these three points in order to record its coordinates. From the Georeferencing toolbar, click Add Control Point. Tick on the center of the blue point, a green point will be created in the center of the blue point. Click anywhere on the screen to finish adding the first control point, Figure 3.41.

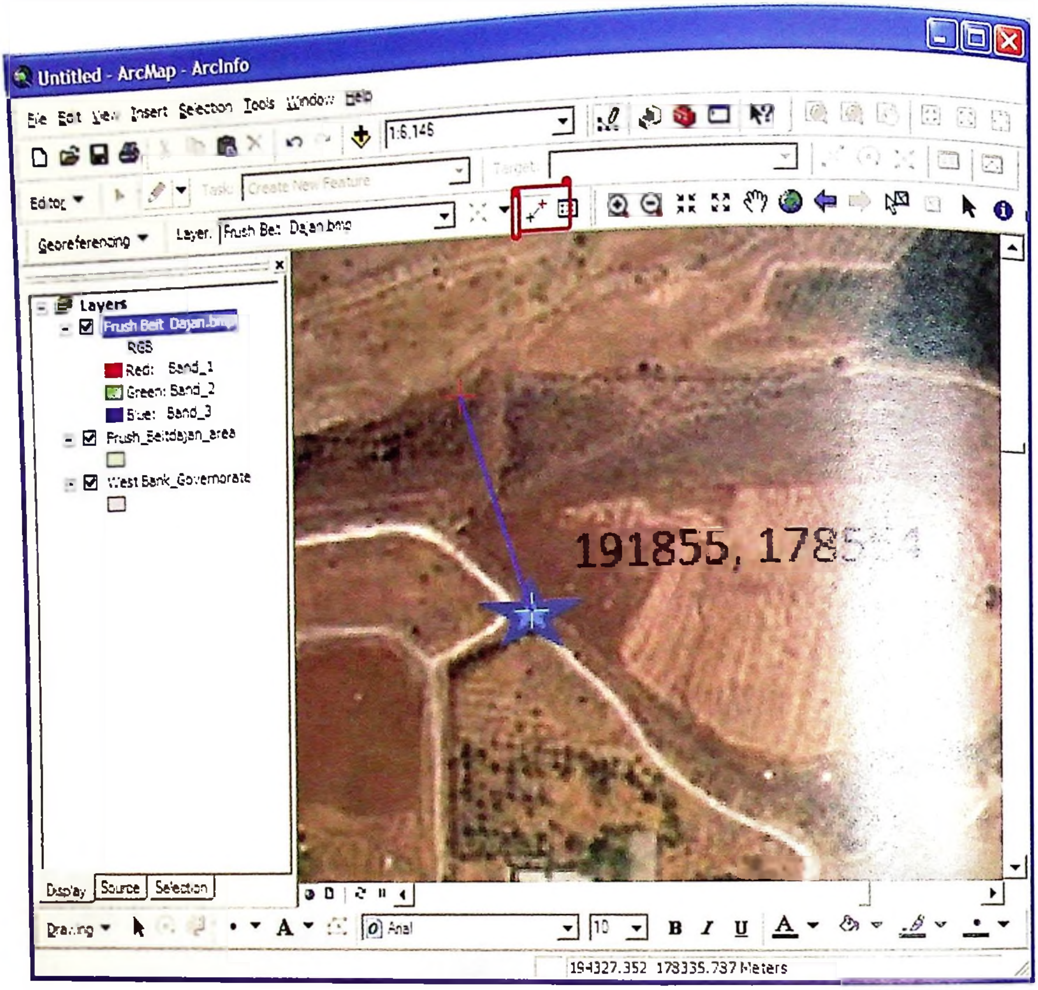


Figure 3.41: Adding a control point

6. Click on View Link Table on the right corner of the Georeferencing toolbar. The table of control points will open. You will find one row in the table. The values of the X Source and Y Source are the coordinates of the green cross, while the X Map and Y Map are the coordinate of the red cross. Now you will change the values of the X Map and Y Map as they appear on the map. Click on X Map and type "191855". Do the same for Y Map and type "178554" then click OK to complete the definition of the first control point, Figure 3.42.

Note 1: A residual error is the measure of compatibility between the true locations and the transformed locations of the output control points. If there is a link with a large error, consider deleting it by highlighting the point in the link table and clicking the delete icon.

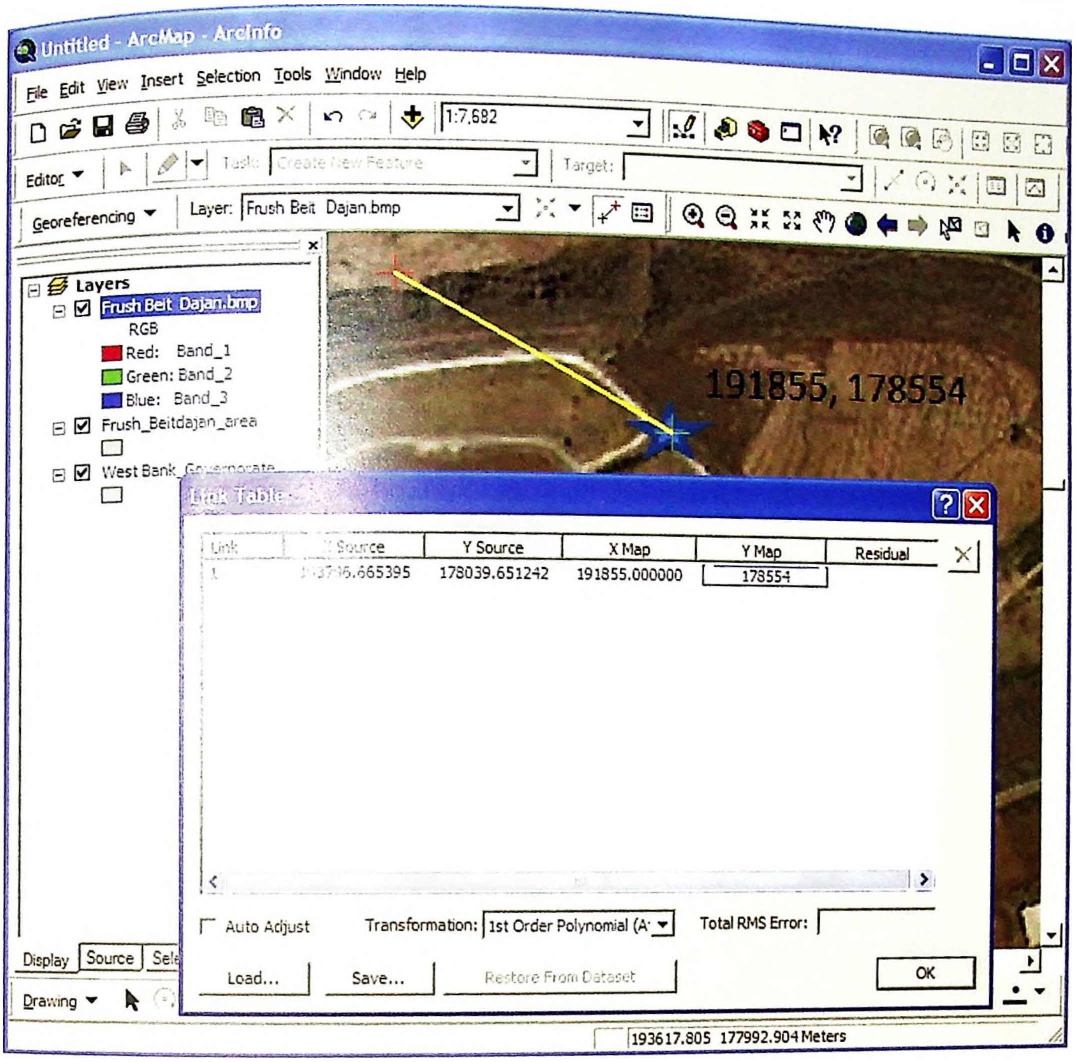


Figure 3.42: Editing the defined control point

7. Click Go Back to Previous Extend button on the Tools toolbar. Then repeat steps 4 and 5 for the other two control points after which the image will look like Figure 3.43.

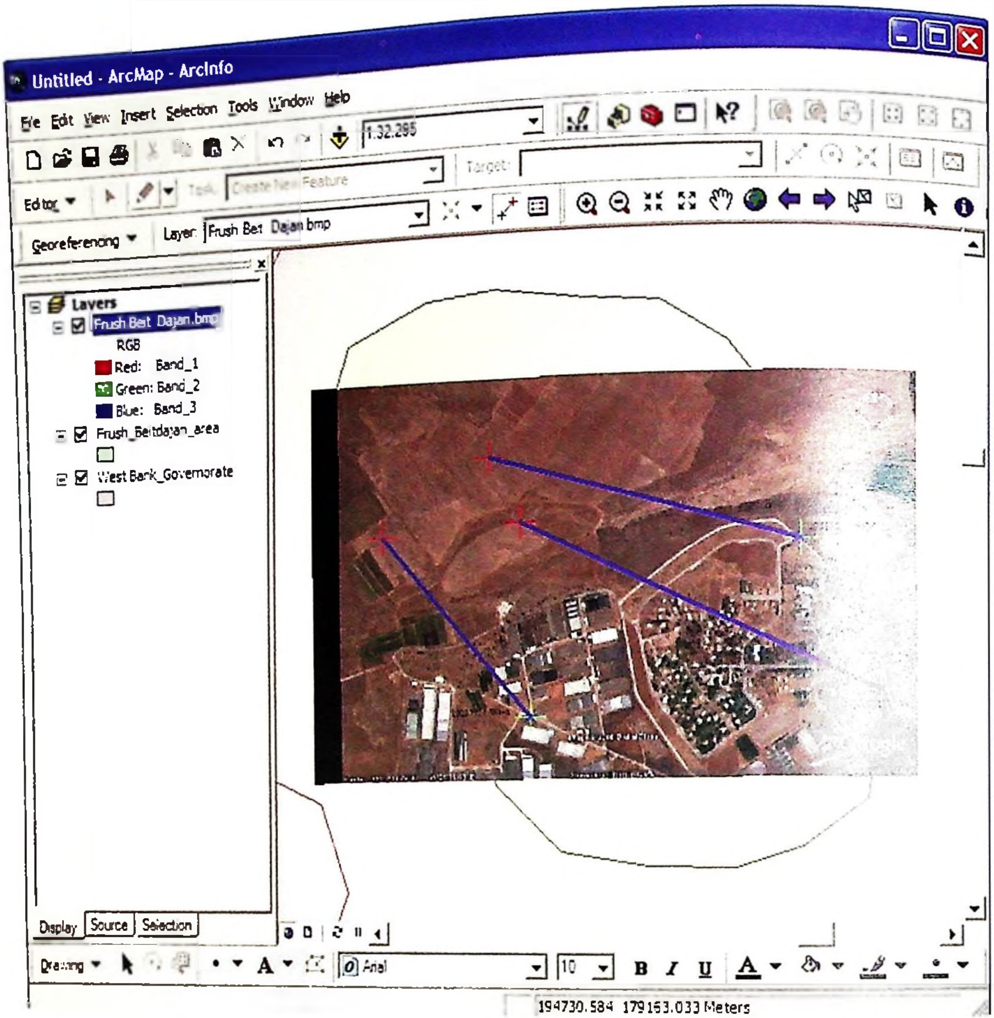


Figure 3.43: Location of the three defined control points

8. To transfer the three control points to their new locations, click on the Georeferencing button, and then use the Update Display tool. The three green crosses are then moved to the location of the red crosses, Figure 3.44.
9. To save the image, click on the Georeferencing button, then on Update Georeferencing. The control point will now disappear, two files with the image's name will be created in the same folder. One is a text file with the extension "bmw" which stores the coordinates of the image and the second with an extension ".aux" which saves the coordinates in a file readable by ESRI products.

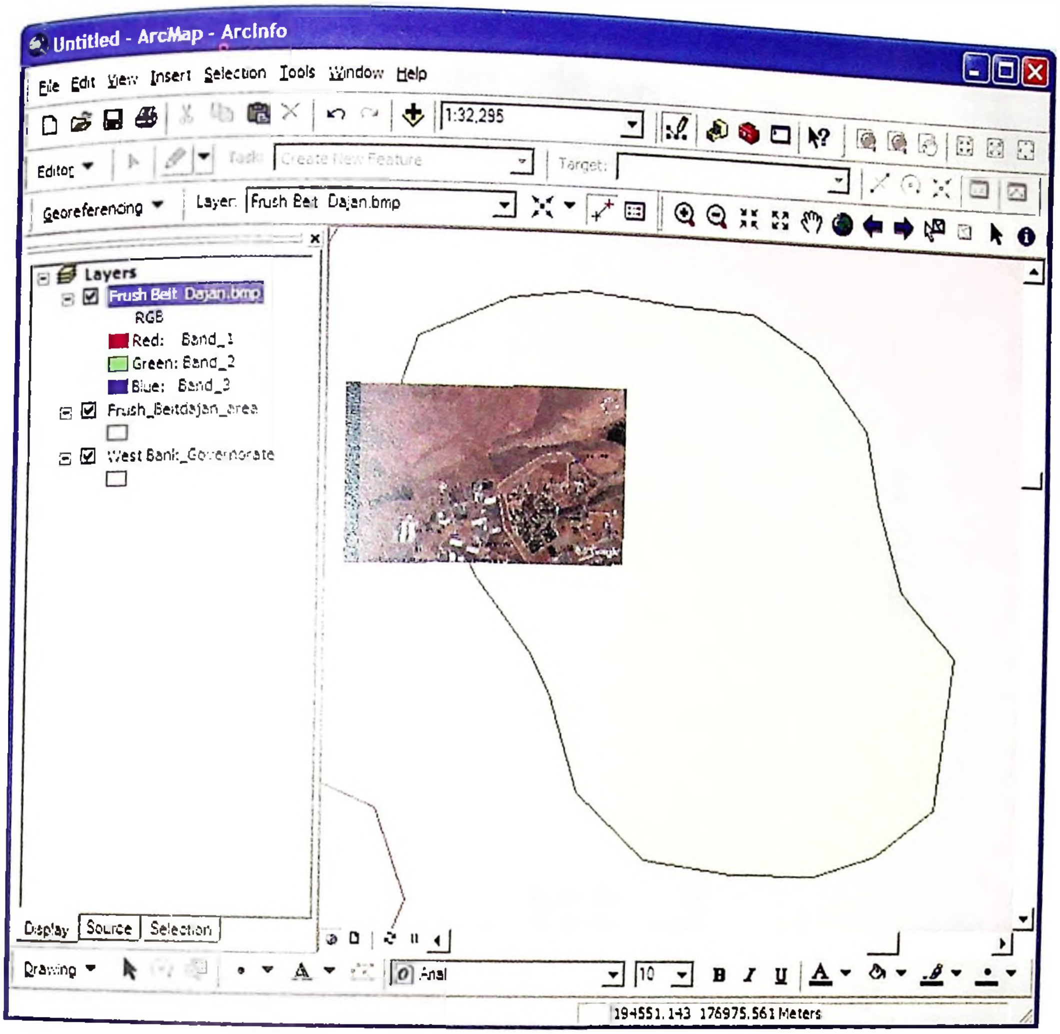


Figure 3.44: The georeferenced image

3.3.4.3 Georeferencing Images Based on Other Datasets

In this section, an image will be georeferenced based on the image georeferenced in the previous section. The two images complete each other; therefore, at least three control points located in both images can be identified.

1. Add Frush Beit Dajan2.jpg from the Exercise 2 folder, Figure 3.44.
2. From the Georeferencing toolbar, change the Layer to Frush Beit Dajan2.jpg.
3. Click on the Georeferencing button, then on the Fit to Display tool. The Frush Beit Dajan2.jpg will cover the overall ArcMap display. Use the Scale and Shift tools in the Georeferencing toolbar in order to view the two images in the same display, Figure 3.45.

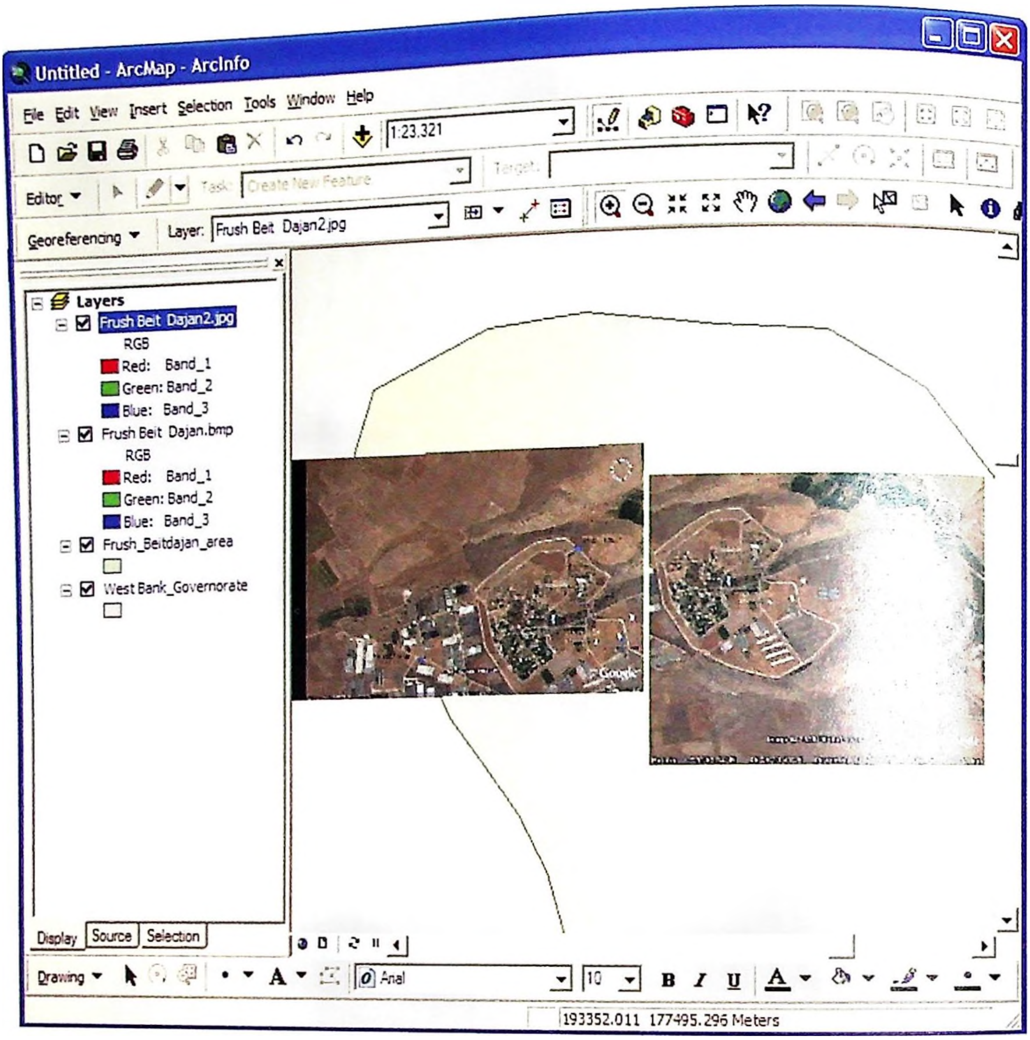


Figure 3.45: Preparing the images for georeferencing

4. Find at least three similar points in both images. Use these points to create control points as done in the previous section but without typing the coordinates. The map will look like Figure 3.46.

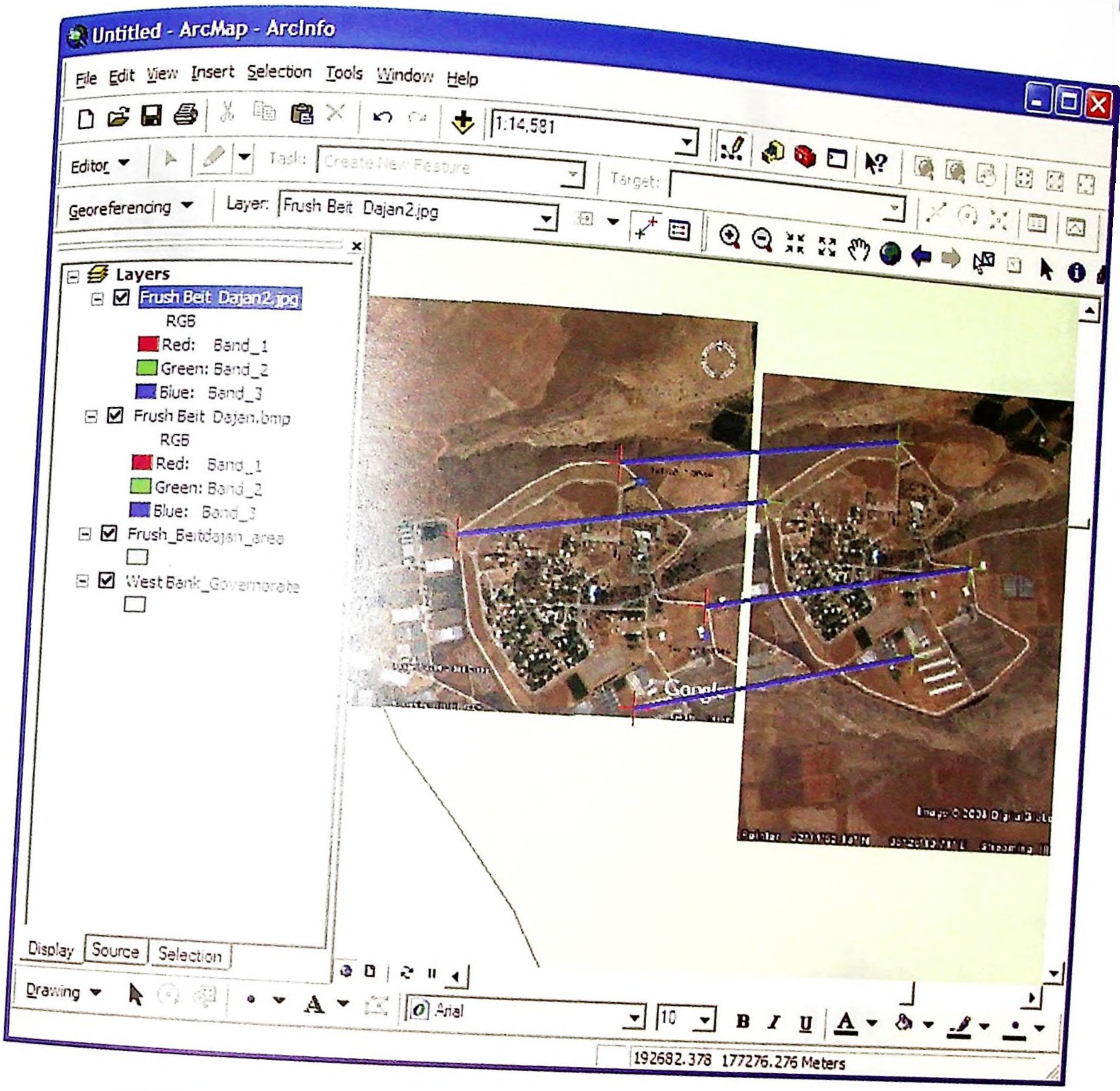


Figure 3.46: Adding control points

5. Repeat steps 8 and 9 in the previous section to finish georeferencing the second image, Figure 3.47.

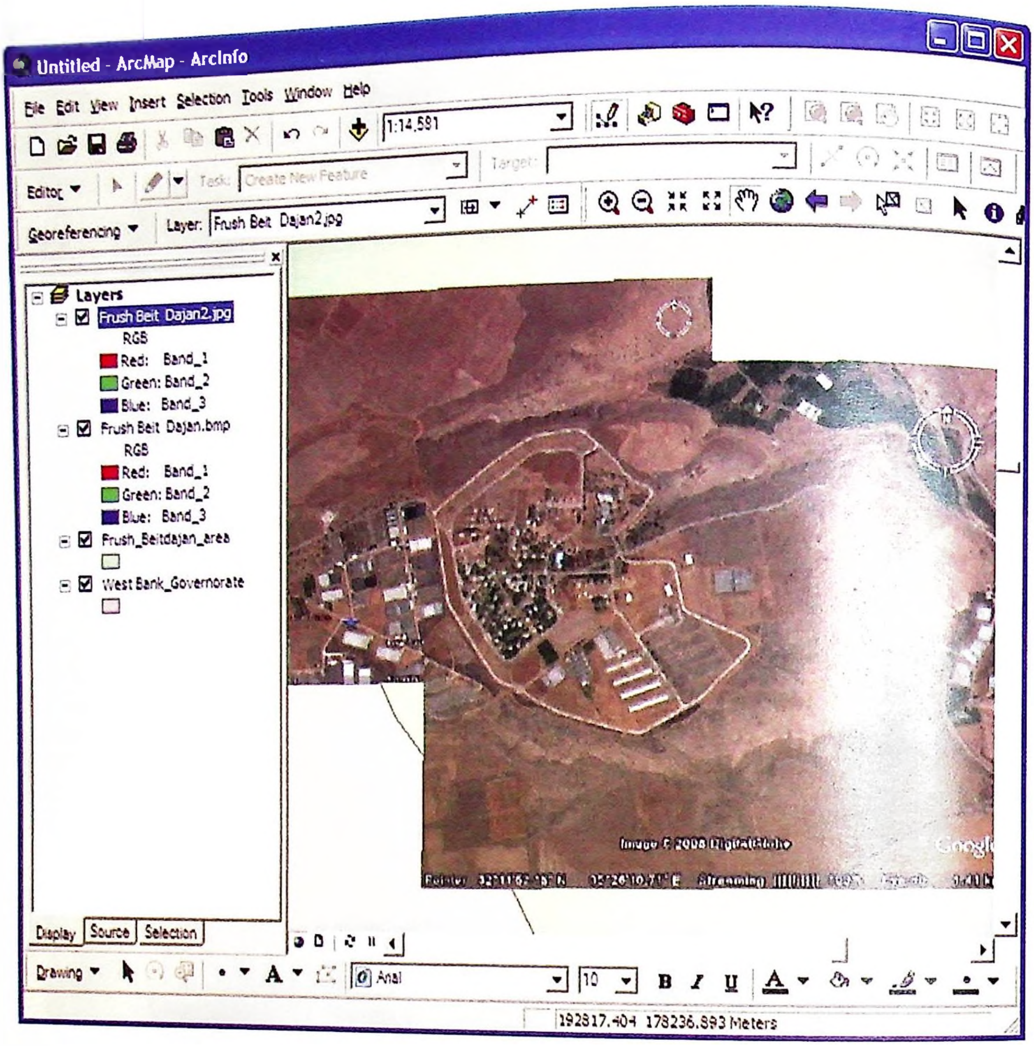


Figure 3.47: Map showing two referenced images

3.4 Discussion

1. What are the differences between a sphere and an ellipsoid?
2. What are the differences between Cylindrical, Conic and Planar Projection Classes?
3. What are the main distortions that may be generated as a result of projecting the Earth? Explain why these distortions occur?
4. What are the UTM zones used in the following countries: Egypt, Jordan, Brazil and India?
5. Convert the following points from DD° MM' SS" to DD.xxxx:

    a. 31° 22' 34"N 35 31' 55"E

    b. 32° 57' 00"N 35 30' 30"E

    c. 33° 00' 34"N 35 55' 15"E

6. Use the images and shapefiles in the "C:\GIS_Tutorial\Chapter3\Exercise3" folder to do the following:
    a. Check the coordinate systems used in all the datasets in the folder.
    b. You will find that the coordinate system of one of the images is defined. Use it to georeference the other images.

Visualization of Spatial Data and Map Cartography

4
Chapter

Visualization of Spatial Data and Map Cartography

4.1 Introduction

Maps are created to convey geographic information, highlight important geographic relationships, and present analysis results. Any GIS analyst will at some point end up with some results that need to be communicated. This GIS user can fulfill the purpose of his map by using proper placement elements and choosing symbols and cartographic elements that are tailored for the message that wants to be communicated.

Cartography is very much an art, with a long history and with much literature devoted to it. How a map is designed depends on the particular objectives of the mapmaker. One obvious objective for creating a map is to simply show where things are. Other map objectives may be to share information, guide people, or illustrate the results of an analysis. The primary objective is usually not to create a beautiful map but to create a product that communicates effectively, efficiently, and clearly.

Before maps can be designed the cartographer should get a feel for the nature of the information, since this determines the graphic options. This is done via cartographic information analysis. Based on this knowledge the cartographer can choose the correct symbols to represent information on the map. In most of the GIS software packages, the cartographer has a whole toolbox of visual variables available to match symbols to the nature of the data. These are applied according to the cartographic rules and guidelines.

Maps constructed using these basic cartographic guidelines are not necessarily appealing maps. Although well constructed, they could still look sterile. The design aspects required to create appealing maps also have to be included in the visualization process. Appealing in a communicative sense does not only mean having nice colors. One of the keywords here is contrast. Contrast will increase the communicative role of the map since it will create a kind of hierarchy in the map contents, assuming that not all information is of equal importance.

In general, a cartographer is required to pass through a set of stages in order to create a good map; starting with the selection of features in the real world to include, classification of the selected features, simplification of complex lines (e.g. roads), exaggeration of features that are too small to show at the scale of the map and finally symbolization of the different classes of the selected features. This Chapter will guide the user to create standard maps using most of the tools provided by the ArcGIS software packages.

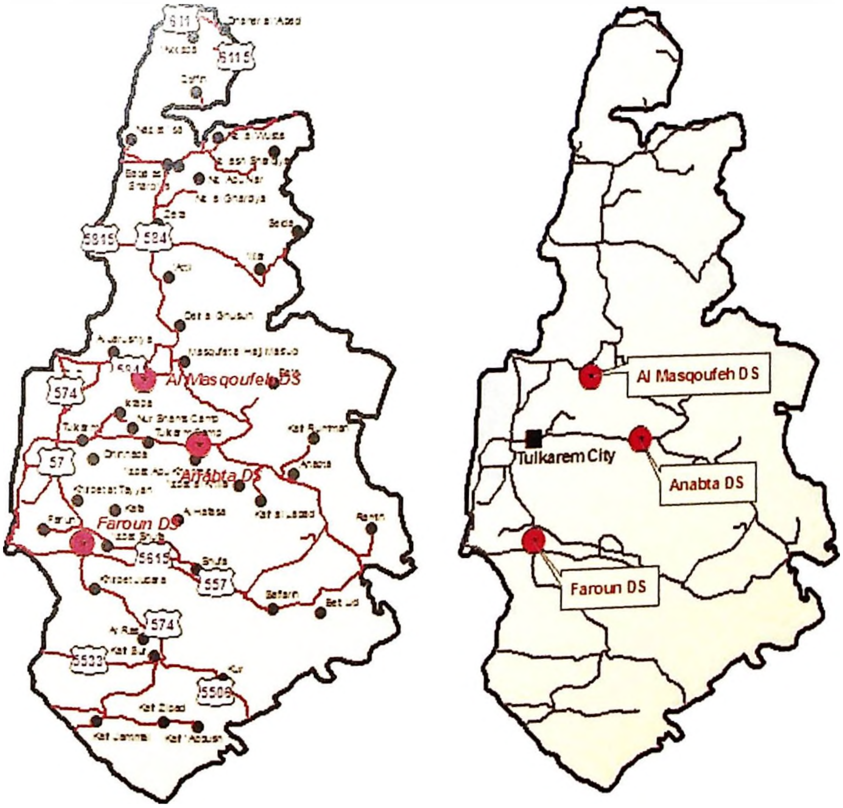
4.2 Cartography

Cartography is the art and science of map making, practiced by cartographers. The term comes from two Greek words, "chartis", meaning map, and "graphos", meaning to draw or write. In general, cartography can be described in the following points:

- The art and science of creating a map.
- A process of abstraction in which features of the real world are generalized or simplified to meet the demands of the theme and audience.
- Using systems that have advanced tools for map layout, placement of labels, large symbol and font libraries, and interfaces for expensive, high quality output devices.
- Form of visual communication; a special purpose language for describing spatial relationships.
- Use of visual resources such as color, shape and pattern to communicate information about spatial relationships.

4.3 Map Generalization

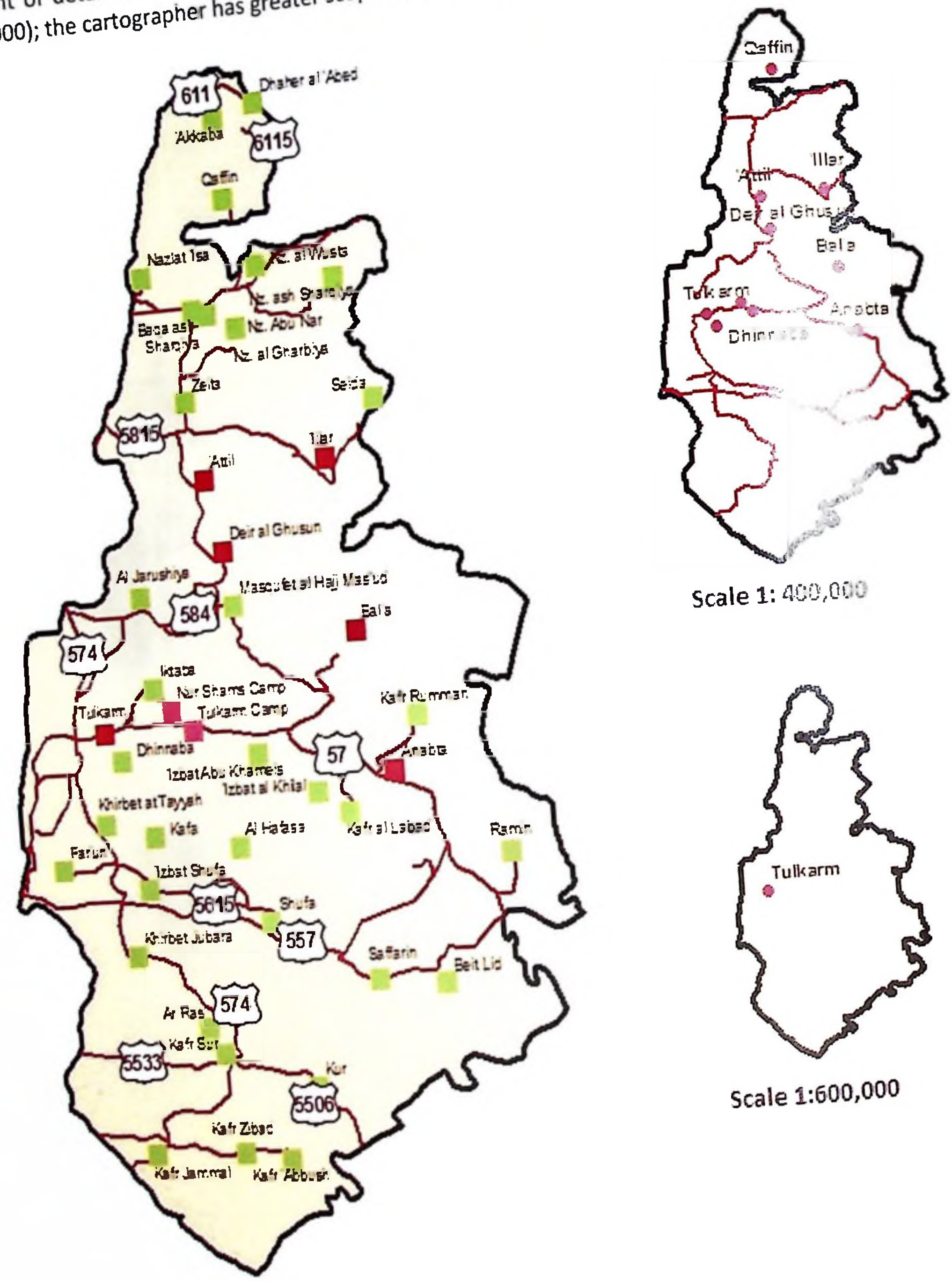
Generalization is one of the main issues needed in producing a map. It is a process of selection and simplified representation of map appropriated with the map scale. It is determined according to the purpose of the map. In GIS, it is possible to create a new map by reducing the amount of detail in the original one. Generalizing may or may not reduce the number of objects in the map. For example, in a map showing the location of dump sites in an area, it may not be necessary to keep the unneeded information such as local roads or/and location of small communities or even labels and annotations, Figure 4.1.



(a) Map with a lot of details (b) General Map (less details)

Figure 4.1: Tulkarem Governorate maps with different map details

The purpose of generalization is to produce a good map, balancing the requirements of accuracy, information content and legibility. The decision need to be taken regarding the amount of detail to be included depends on the scale of the map. At very large scales (e.g. 1:10,000); the cartographer has greater scope for including more details, Figure 4.2.



Scale 1:200,000

Scale 1: 400,000

Scale 1:600,000

Figure 4.2: Tulkarem Governorate map in different scales

4.4 Cartographic Symbology

Maps are symbolic representations of geographic features and the Earth's surface on a sheet of paper. Representing geographic features in their true size and with all details is only possible when the map has a 1:1 scale. However, using this scale is rarely practical, all features and thematic data shown on a map must undergo a process of simplification, generalization and finally symbolization. In effect, maps are complex tools for visualizing and communicating scaled-down geospatial data, and graphic symbology is their language of communication.

Cartographers and geographers use symbols on maps to represent various geographic phenomena involving location, distance, volume, movement, function, process, correlation, etc.

Once the purpose of a map has been established, it is necessary to select which geographical features are to be depicted on the map, and in what manner. Map scale is an important factor in determining which features can be shown and how. In general, there are two basic symbol designs that may be used to portray information on maps; pictorial and abstract.

4.4.1 Pictorial Symbols

Pictorial symbols, Figure 4.3, look like the features that they represent. These symbols tend to reflect the shape and color of the feature. For example, the symbol for an airport may be an airplane, or the symbol for a vegetated area may be a green polygon.

Figure 4.3: Sample of pictorial symbols

4.4.2 Abstract Symbols

Symbols described as abstract are geometric shapes assigned to represent a feature, Figure 4.4. For example, a series of graduated dots or squares could represent populated places on a reference map. On the other hand, colored or patterned polygons could represent varying concentrations of people, on a population density map.

Figure 4.4: Sample of abstract symbols

4.5 Data Classification

When a dataset is large, it is not practical to assign a unique symbol to each data record. Therefore, for mapping it is essential that data is classified or grouped. There are several methods of classifying data. In choosing the right method, the level of measurement and the underlying distribution of the dataset must both be considered. The classification method chosen should adequately describe the phenomenon being mapped, and at the same time facilitate the cartographic display of spatial patterns. All classification methods depend on exhaustive and mutually exclusive classes. Exhaustive classes contain all values in a given data range, no values are omitted. Mutually exclusive classes do not overlap; no value can fall into two classes.

4.5.1 Data Measurement Types

Data can also be described by the level of measurement which is usually divided into four levels including: nominal, ordinal, interval, and ratio.

4.5.1.1 Nominal Data

Nominal data are discrete and are classed according to type or quality. For example, a line could represent either a road or river, and a land use polygon could be residential, commercial, or a recreational area. Nominal data are often labeled with numbers or letters, but these labels do not imply ranking. A nominal datum can only be examined for its physical similarity to, or its difference from, other occurrences, or for the frequency of its occurrence, Figure 4.5.

Point	Airport	Capital	Groundwater Well	Town
Line	River	Road	Boundary	Pipe line
Area	Grassland	Water	Orchard	Treatment Plants

Figure 4.5: Sample of nominal data

4.5.1.2 Ordinal Data

Ordinal data provide information about ranks or hierarchy, in other words, relative values. Therefore, it is possible to describe one item as larger or smaller than another, or as low, medium, or high. However, it is not possible to measure the differences between ordinal data, because there are no specific numerical values attached to them. An example of ordinal data is the classification of roads ranked as highway, regional and local roads, Figure 4.6.

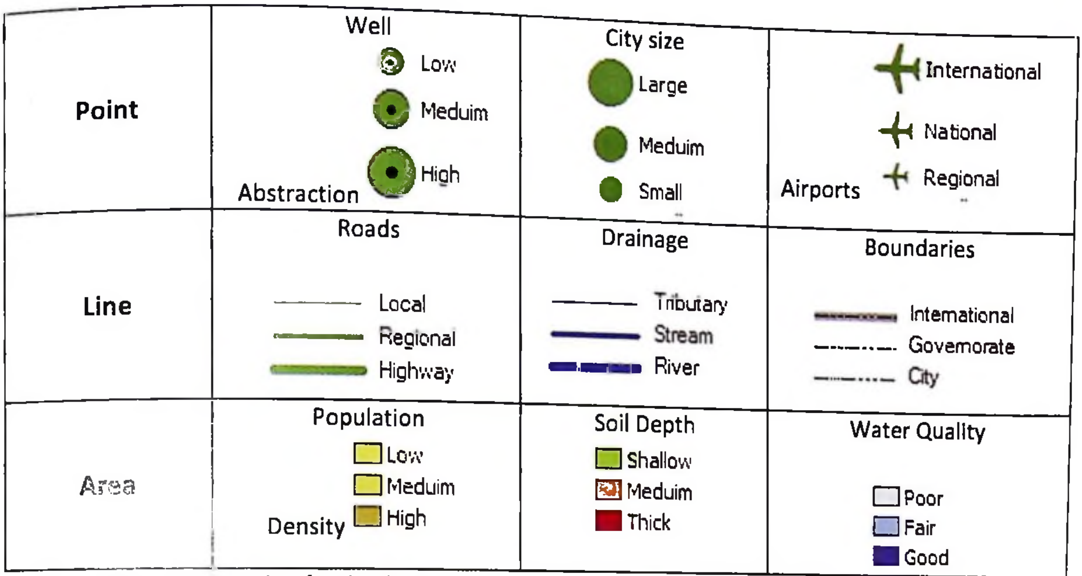


Figure 4.6: Sample of ordinal data

4.5.1.3 Interval Data

Interval data, in addition to being ranked, include numerical values. The information can be arranged along a scale using a standard unit. Therefore, it is possible to calculate the distance or difference between ranks, which must be expressed in terms of a standard unit, Figure 4.7.

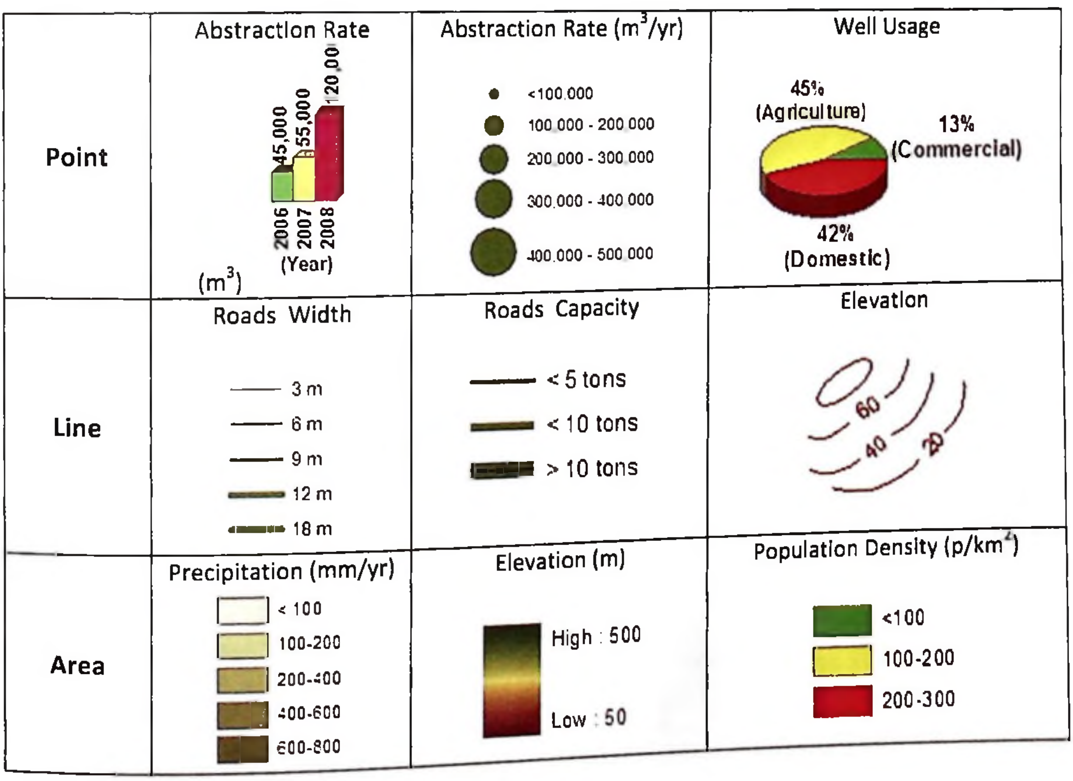


Figure 4.7: Sample of interval/ratio data

4.5.1.4 Ratio Data

Ratio data are the same as interval data, except that there is a natural zero; therefore, it is possible to express data as ratios. Physical measurements of height, weight, and length are examples of ratio variables. With this type of data it is meaningful to state that a measurement is twice that of another. This ratio remains true no matter what the unit of measurement is (e.g., meters or feet) because this type of data has a natural zero.

4.5.2 Data Types:

Before classifying or grouping data, it is necessary to determine whether the data are qualitative or quantitative and the level of measurement. This is important to know so that if required, the proper analyses may be applied to the dataset. Certain analyses can only be applied on particular types of data.

4.5.2.1 Qualitative Data

Qualitative data are data that are grouped in classes according to differences in type or quality. Qualitative data have no numerical values attached. Nominal data comes under this category (ordinal data may also be considered qualitative, if no numerical values are involved).

4.5.2.2 Quantitative Data

Quantitative data are data that contain attributes indicating differences in amount and can be expressed as numerical values. Included in this category are ordinal, interval, and ratio data.

4.5.3 Constructing Class Intervals

The assignment of classes, intervals or cut points for nominal and ordinal datasets is fairly straightforward. However, because of the more complex nature of interval/ratio data, more exploration of the dataset is required. First, it is necessary to understand the underlying distribution of the data. For thematic mapping, different classification (or ranging) methods are used to generalize different types of data distributions. Each method is suited to a particular shape of distribution. Plotting a scattergram or histogram that employs basic descriptive statistics (such as mean, mode, median, range, or standard deviation) will reveal the shape of the distribution. This shape will aid in the selection of the most appropriate classification method.

There are many statistical methods for the classification or ranging of interval/ratio data. In cartography, the four most common are: equal steps, quantiles, standard deviation, and natural breaks.

4.5.3.1 Equal Steps

The equal steps method divides the dataset into classes with equal intervals. The data may be arranged from high to low, or low to high values. In this method the difference between the high and low values of the distribution is divided into a number of equally spaced steps. This classification technique is useful for mapping rectangular distributions, when enumeration areas are of equal size.

4.5.3.2 Quantile Classifications

In quantile classifications the data are arranged in sequence from low to high values and the number of individual observations are counted. The observations are then divided into the selected number of classes, each class containing the same number of observations. The term quartile is used when the data are divided into four classes, quintiles for five, and sextiles for six, and so on. This method is useful for mapping rectangular distributions.

4.5.3.3 Standard Deviation

In the standard deviation method the mean or central point of the data distribution must first be calculated. The standard deviation is then used to set the classes. The observations are grouped based on how they are positioned on the plot in relation to the number of standard deviations from the mean. This method is useful if the data distribution is a normal curve.

4.5.3.4 Natural Breaks

The natural breaks method of classification is based on the subjective recognition of gaps in the distribution, where there are significantly fewer observations. Plotting a histogram of the data can identify these gaps. This method, developed by George Jenks, minimizes variation within classes and maximizes variation between classes. This technique is most useful when the dataset has more than one modal value.

4.5.4 Data Symbolization

Once geographic features and data have been selected, generalized and classified for the map, it is necessary to choose the appropriate graphic representation or symbols for the information. Symbols have characteristics that can be manipulated to suit the category of data being mapped. These characteristics are referred to as visual variables or visual resources. Visual variables include symbol size, shape, orientation, pattern (texture), hue (color), and color value (brightness and lightness), Figure 4.8.

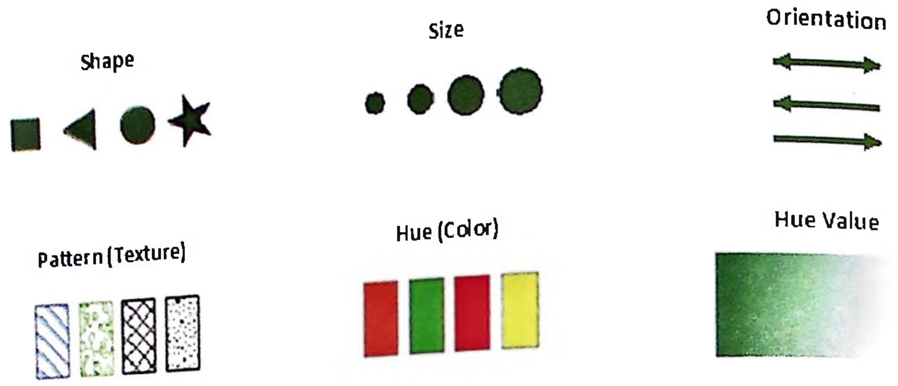


Figure 4.8: Sample of data symbolization

These variables, individually or in combination, may be applied to map symbol design. However, not all variables apply equally well to the symbolization of all types of geographic phenomena or datasets.

The symbolization of nominal or qualitative data is usually the least difficult. In this case, the symbol design should only indicate difference in class, and not imply ranking. The variables of shape, pattern, and hue may be used for qualitative data. The symbolization of quantitative data is more complex, and there is often a need to show data as a logical progression. Here, the variables of size and color value are more important.

4.5.4.1 Nominal Data

Point Dataset: The design of point symbology on maps depicting nominal data should use distinctly different shapes and/or hues, and not different sizes.

Line Dataset: Line symbols used to plot nominal data should vary only in pattern and/or hue, not in thickness. Line symbols can also be used to indicate connectivity (e.g., roads) and separation (e.g., boundaries).

Area Dataset: Area symbology on maps depicting nominal data, such as chorochromatic maps, different area hues or patterns should be used and not different values of selected hues.

4.5.4.2 Ordinal Data

Point Dataset: Point symbols on a map depicting ordinal data may use an abstract geometric shape or a pictorial symbol, classified according to size. Another method for depicting ordinal data is using the same point symbol in different color values. Size and color value may be combined for emphasis.

Line Dataset: Line symbols can rank data by line weight, style, or hue. Any combination of these methods is possible, and will help the user distinguish more readily the data classes on the map.

Area Dataset: Areas can show quantitative differences in data by different hue/color value, and pattern fills. For further emphasis, patterns can also be illustrated in different colors.

4.5.4.3 Interval and Ratio Data

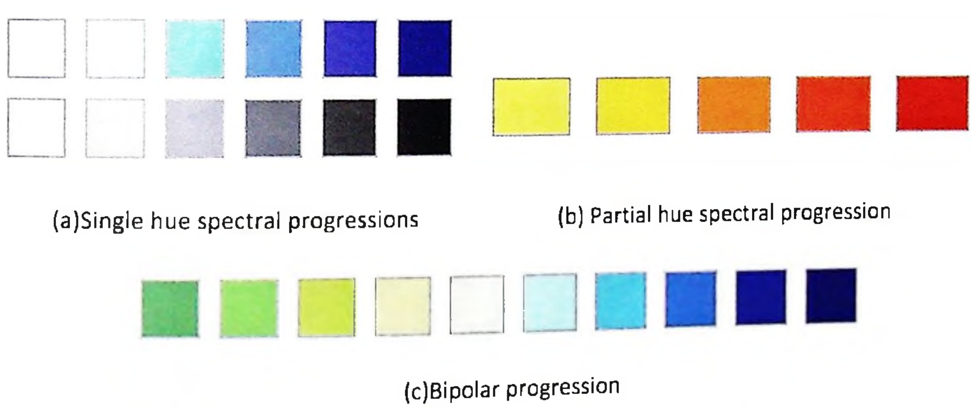
Point Dataset: Point symbols used to depict interval and ratio data can be designed in various colors, shapes and sizes; including graduated dots, circles, squares, bars, block piles, pie charts, etc.

Line Dataset: Line symbols depicting interval data can be graduated, as in the symbolization of commodity flows. An isopleth is a line symbol connecting points of equal value. Contours (lines joining points of equal elevation) are the most common form of this line symbol. Contours graphically indicate elevation value and position, and also allow for the calculation of slope data.

Area Dataset: Area symbology depicting interval and ratio data can use variations in color values and patterns to show a gradual progression of data.

4.5.5 Color Progressions

Color progressions in a single hue have data values increasing as the color value increases from white to the pure color, Figure 4.9 (a). This is particularly suited to monochrome maps, with data classes displayed as a gradual change, for example, from light to dark grey. Partial hue spectral progressions blend one color with another, Figure 4.9 (b). Bipolar progressions display data that range from positive to negative, Figure 4.9 (c). For example, hypsometric tints showing elevation above and below sea level.



(a)Single hue spectral progressions

(b) Partial hue spectral progression

(c)Bipolar progression

Figure 4.9: Color progression

4.6 Map Elements

Before a cartographer starts creating a map, there are a set of questions that should be taken into consideration: What is the goal of the map?, Who is the intended user?, Where and how will this map be used?, What data is available for the composition of the map?, and What resources are available (time, equipment, etc.)?.

In general and regardless of the cartographic style or content, most maps have common elements as shown in Figure 4.10 which shows a general map of Tulkarem Governorate.

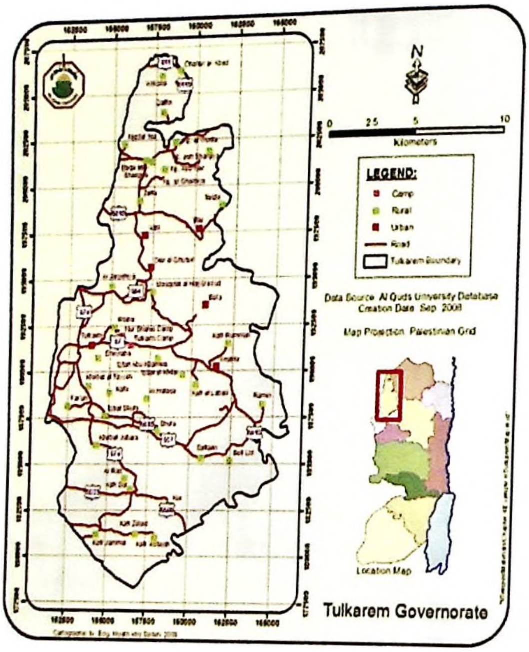


Figure 4.10: General map of Tulkarem Governorate

4.6.1 Map Scale

The scale of the map is defined as the ratio of a distance on the map to that same distance on the ground in the real world. The terms "small scale" and "large scale" are sometimes confused; large scale maps show great details, small features (large representative fraction: 1:10,000) while small scale maps show little detail, large features (small representative fraction: 1:250,000).

Virtually, most maps are smaller than the reality they represent. Map scales tell us how much smaller. Also, by knowing the scale the spatial extent of a map is better understood. In GIS, scale can be expressed in three ways:

- **Ratio scale:** it gives the ratio of map distance to earth distance. For example, if a map has a scale of 1:10,000 this means that one cm on the map represents 10,000 cm or 0.1 km on the ground. A small fraction in the ratio scale has a large denominator so 1:100,000 is a smaller scale than 1:25,000. Therefore, a large-scale map depicts a small area with great detail.
- **Verbal scale (nominal):** refers to data that are classified only into categories. It expresses the scale in words. For example: 1 centimeter represents 50 meters or one inch represents one mile which conveys more meaning than 1:63,630. This type of scale is not common in places where people use the metric system. People familiar with

centimeters and kilometers have little need for verbal scales to tell them that 1:100,000 means that one centimeter equals 1 kilometer or that 1:250,000 means that four centimeters represent one kilometer.

- Graphical scale: is usually drawn on the map to illustrate the distances represented on the computerized maps, and is often preferred because any changes are implemented quickly and interactively by the user. A graphic scale, also called a bar scale, is used on maps and drawings to represent length on paper with length units. In ArcGIS, there are many symbolic representation forms of graphical scales, the user can choose the desired shape and then modify it as required, Figure 4.11.

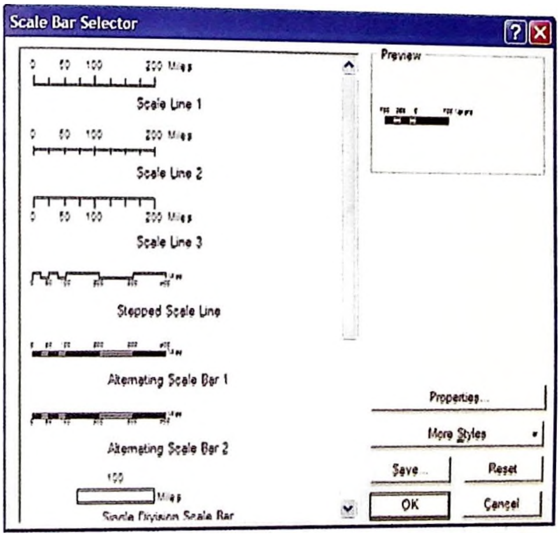


Figure 4.11: Scale Bar Selector window

4.6.2 Orientation

A map should indicate which way is north (and/or south, east and west). Commonly this is done by a north arrow or compass rose. Orientation may also be shown by graticule or grid marks (e.g. lines of latitude and longitude). By convention north is towards the top of the page (thus some maps do not have north arrows), but the orientation must still be given for a 'proper' map. North does not have to be at the top of the page and a north arrow is essential in maps where it is not.

4.6.3 Title

The title should be illustrated in a large font size, easily identifiable as the title of the map and should include descriptive text as of the location and purpose of the map. If the map is thematic, the theme should be included in the title. For example: Water Abstraction in the West Bank, 2008. The title is usually the largest font size of all lettering on the layout; however, it should not dominate the map graphic itself. The title may or may not be in a box and does not need to be at the top of the page (though it often is). For published materials (e.g., books or articles) the title may be included in a figure caption instead.

4.6.4 Border (or Neatline)

A border identifies exactly where the mapped area stops. The border is often the thickest line on the map and should be close to the edges of the mapped area. The distance between the map and the border should be the same on all sides (balanced). There can also be a border around the entire map layout (enclosing and grouping the title, legend, text boxes, etc.).

Both of these borders are sometimes referred to as a 'neatline.' In addition, there is sometimes a thin additional line just outside of a border (accentuating it and ideally making it more visually appealing) that may also be referred to as a neatline.

4.6.5 Legend

A legend defines the symbols or colors (including shades of gray and patterns) used on the map. Maps do not need legends if the symbology is common or simple as to be easily understood by the reader. However, it must be clear what each marker or line type, weight and pattern represents. The legend does not need to be labeled "Legend." The more complicated the symbology on a map the more important the legend becomes.

4.6.6 Map Credits

Map credits are text elements that give information about the map and its cartography such as source of data, date of the mapped data, name of the cartographer, date of the map creation, and date of the map publication and/or projection of the map.

4.6.7 Locator Map (Inset)

A locator map is needed if the area of the map is not easily recognizable or is of small scale. For example, if you map Tulkarem Governorate, there should be an inset map of the West Bank, showing the location of Tulkarem Governorate. Inset detail maps may also be used to show an area of the map in greater detail (larger scale).

4.7 Practicing Cartography in ArcGIS

4.7.1 Symbology in ArcGIS

4.7.1.1 Single Symbol

This type of classification is used as the default classification method of ArcGIS. In this type all features in any dataset will have the same shape and color. The user could change the size, color, thickness, hatch pattern of all features in one step.

1. Open a new ArcGIS map. Load the Roads, Tulkarem_Governorate and Communities shapefiles from “C:\GIS_Tutorial\Chapter4\Example1”.

2. Right-click on Tulkarem_Governorate in the table of contents. Click Properties to open the Layer Properties window.
3. Click on the Symbology tab. You will notice that the system selects Single Symbol by default, Figure 4.12.

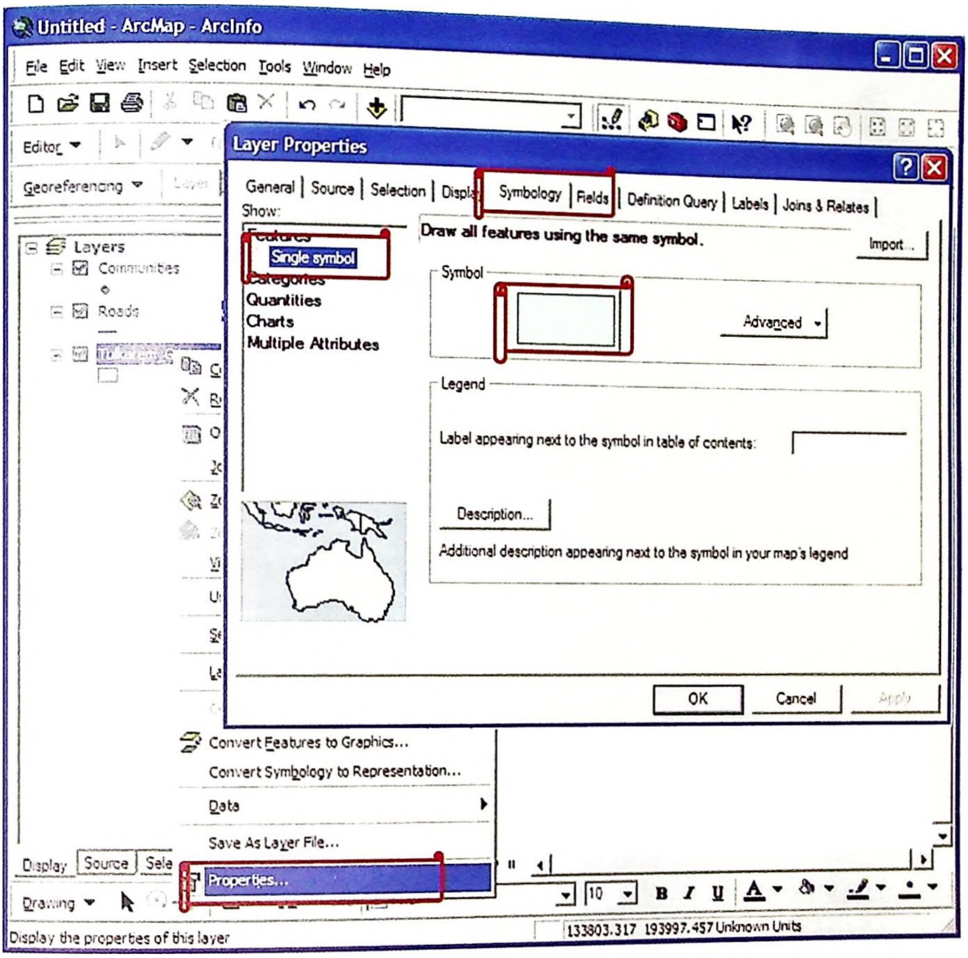


Figure 4.12: Opening the Symbology tab

4. To change the symbology of the Tulkarem_Governorate shapefile, click on the button in the middle of the Symbol box. The symbol selector will then open, Figure 4.13. The user may select any of the already defined colors or hatch patterns or go to the option window to select the fill out color, the outline width or outline color.

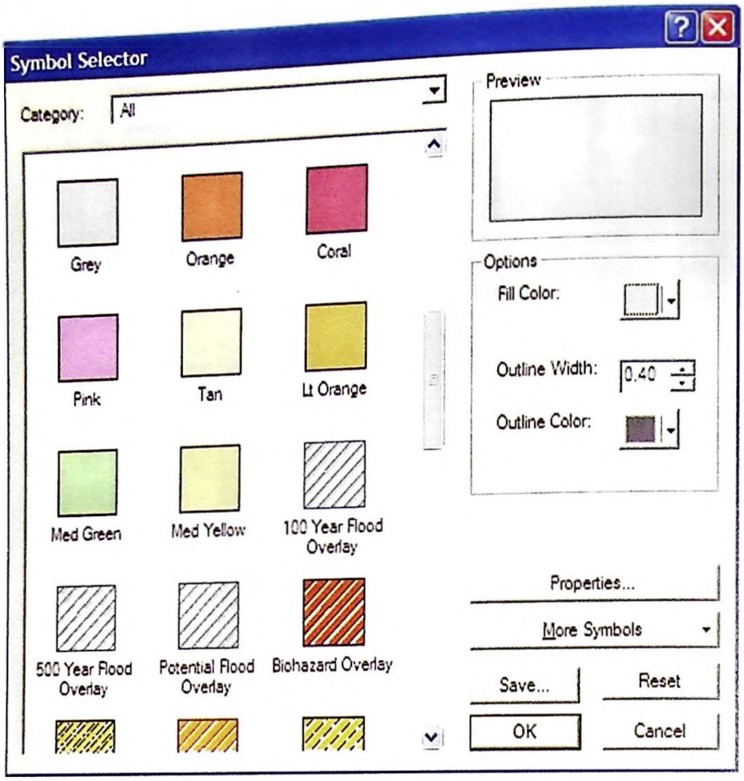


Figure 4.13: Symbol Selector window

5. Click the Fill Color button, and then select Light Apple from the colors window.
6. Type "2" in the Outline Width as the border width; change the color of the border to Grey 70%.
7. Click OK twice to finish.
8. Do the same for the other two shapefiles with the following details:
    a. Communities shapefile:
        i. Shape: Rectangular box
        ii. Color: Cherry Cola
        iii. Size: 8
        iv. Angle: 0
    b. Road shapefile:
        i. Shape : Continuous
        ii. Color: Seville Orange
        iii. Width: 2

The result will look like Figure 4.14.

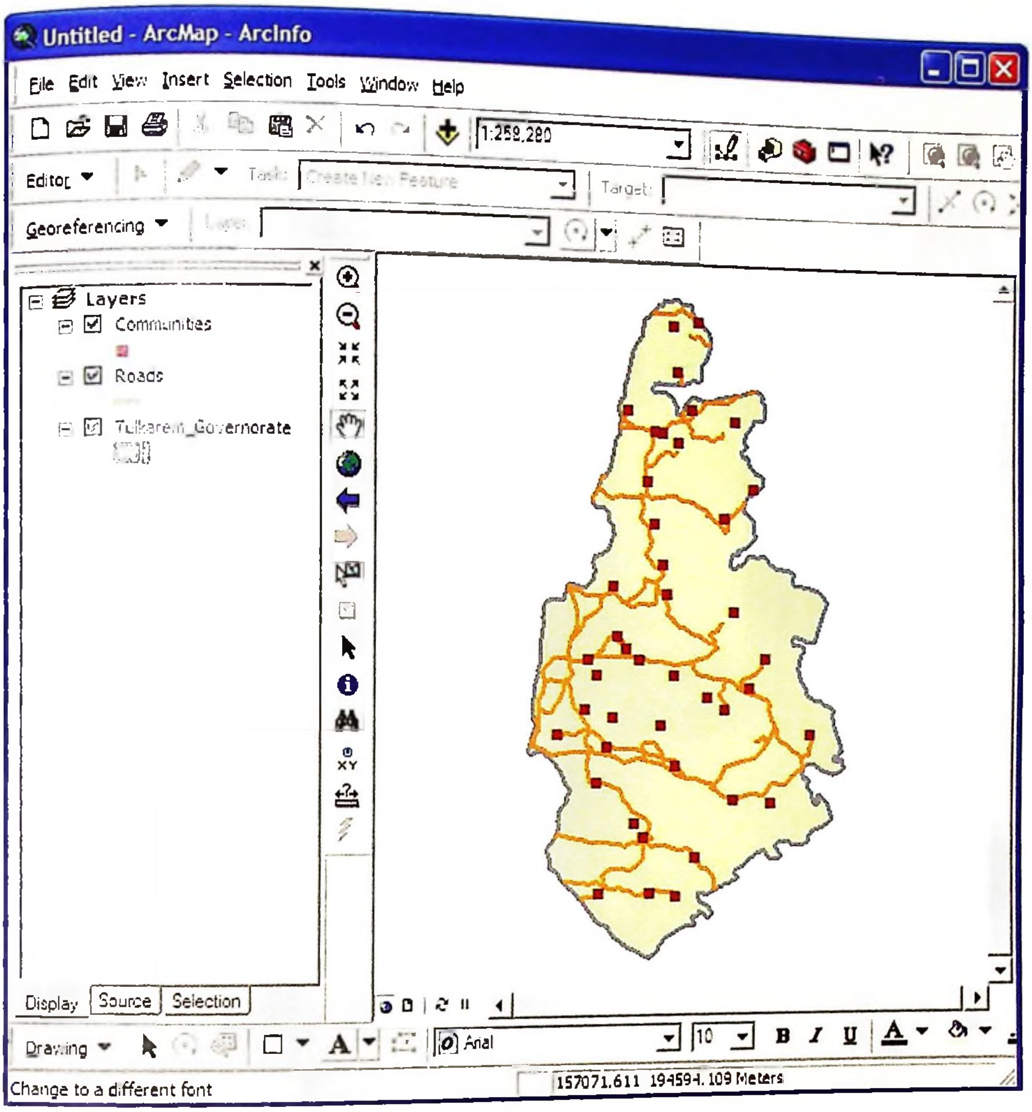


Figure 4.14: Using a single symbol for all shapefiles in the map

9. To change the background of Tulkarem Governorate from a solid color to a hatch fill, open the Layer Properties window once again.
10. From the Symbol Selector window, select 10% simple hatch. You can load more symbols by clicking on the More Symbols button to choose from additional styles of symbol stored in ArcMap.
11. Click on the Properties button to customize the symbol, Figure 4.15.

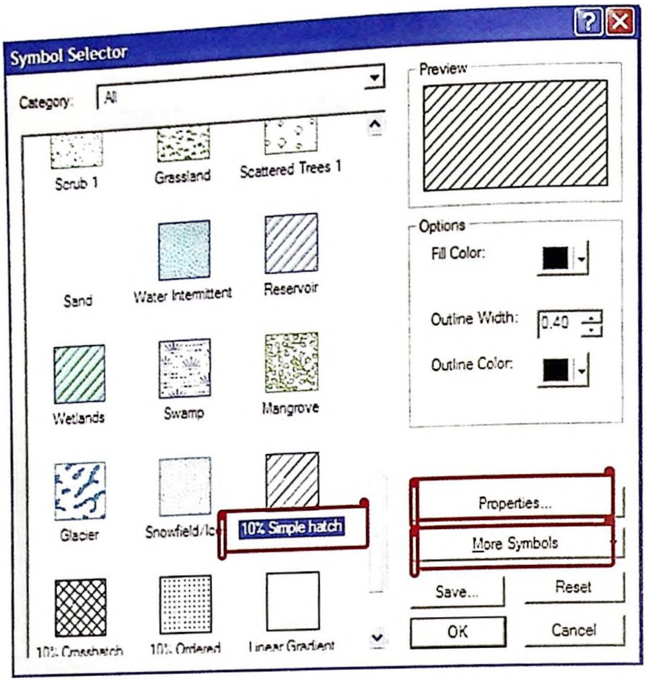


Figure 4.15: Changing symbol properties

12. In the Symbol Property Editor, Figure 4.16, select the type of fill as Line Fill Symbol for hatching.
13. Click on Line to customize the line fill, select the Boundary, City line from the symbol selector with a width of 1.
14. Click on Outline to customize the outline of the shape, select the continuous line with a width equal to 2 and color Gray 70%.
15. Click the Color button; choose Mongo.
16. Set the angle to 15, the offset to 1 and the separation to 5.

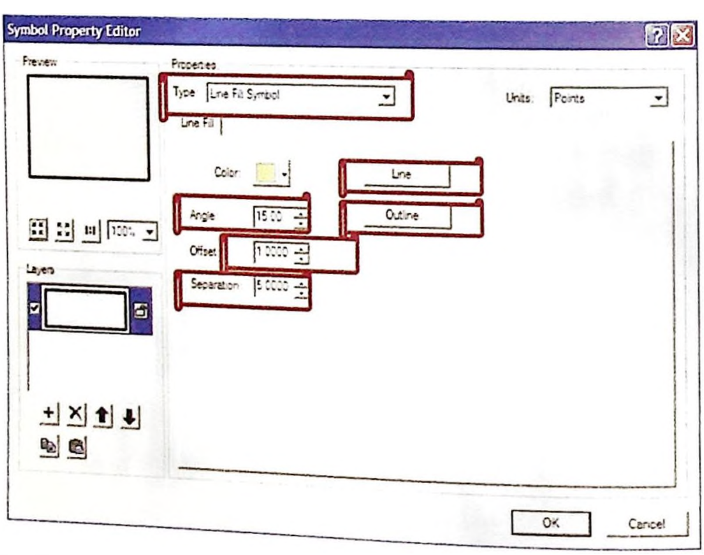


Figure 4.16: Customizing symbol properties

17. Click OK to close all windows. The output should resemble Figure 4.17.

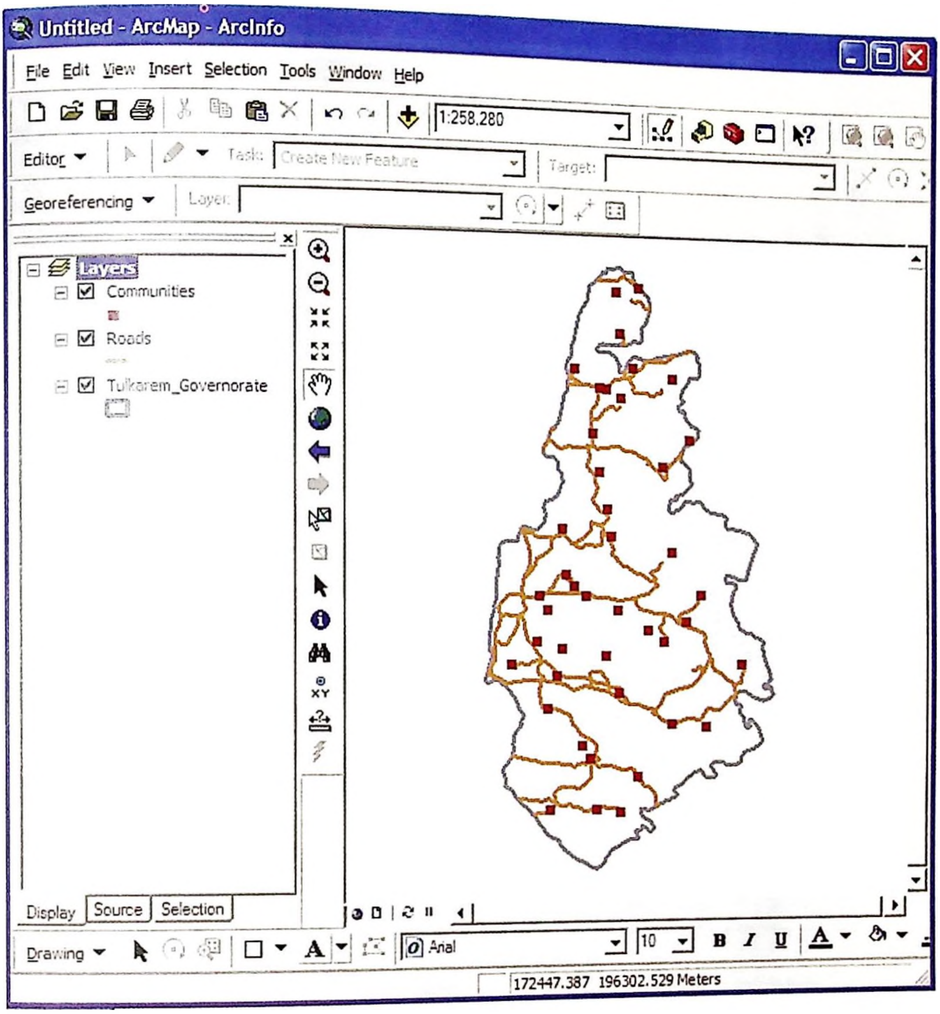


Figure 4.17: Using single symbology

4.7.1.2 Categories Classification

Categories classification is mainly used for classifying qualitative datasets. For example, the geology of an area may be classified using this type of classification. Each formation will be assigned one unique color or hatch pattern.

4.7.1.2.1 Unique Values Technique

1. Open a new ArcGIS map. Load the Geology and Tulkarem_Governorate shapefiles from "C:\GIS_Tutorial\Chapter4\Example2".
2. Right-click on Geology in the table of contents. Choose Properties to open the layer properties window.
3. Click on the Symbology tab then on Categories and choose Unique values.
4. Use the dropdown arrow to select the Value Field, choose Formation.

5. From the Color Ramp select any appropriate color scheme you want.
6. Click on Add All Values to include a unique color fill for each value found in the field.
7. Un-check the box beside *<all other values>* to exclude 'other' values (probably not needed since you just used the Add All Values option, Figure 4.18.
8. Use the up or down arrows to customize the order in which the different categories will be shown in the table of contents. Arrange them in the following order: Quaternary, Eocene, Senonian, Upper Cenomanian and Turonian.

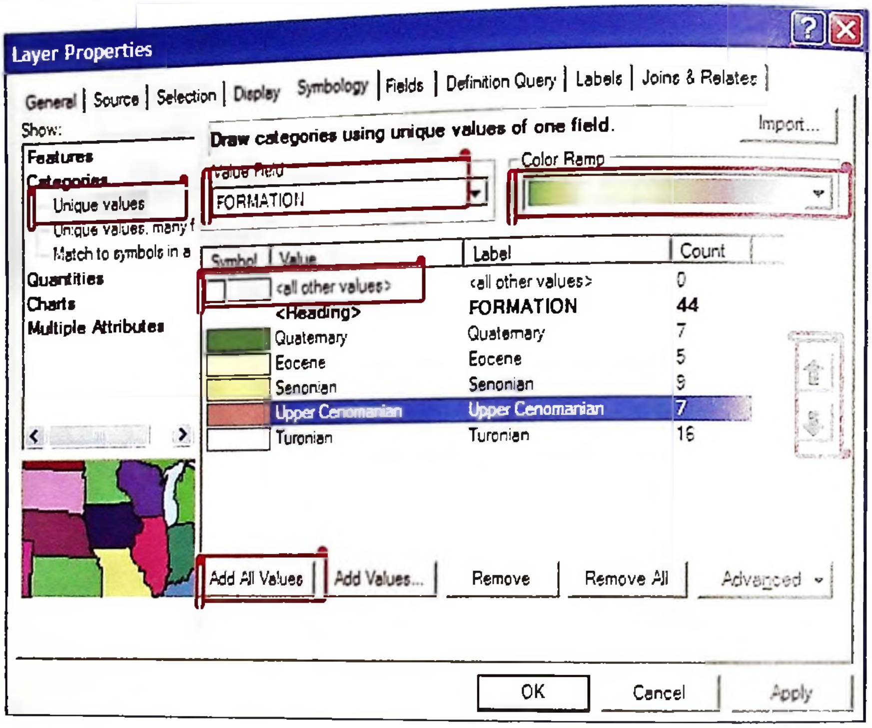


Figure 4.18: Defining categories symbology parameters using the unique values technique

9. Click Apply then OK to complete.
10. Arrange the shapefiles in the table of contents, so that the Tulkarem_Governorate is on top of the Geology shapefile.
11. Select the border of Tulkarem_Governorate to be solid with a width of 2. Choose the background to be empty (no color). The result of this example should look like Figure 4.19.

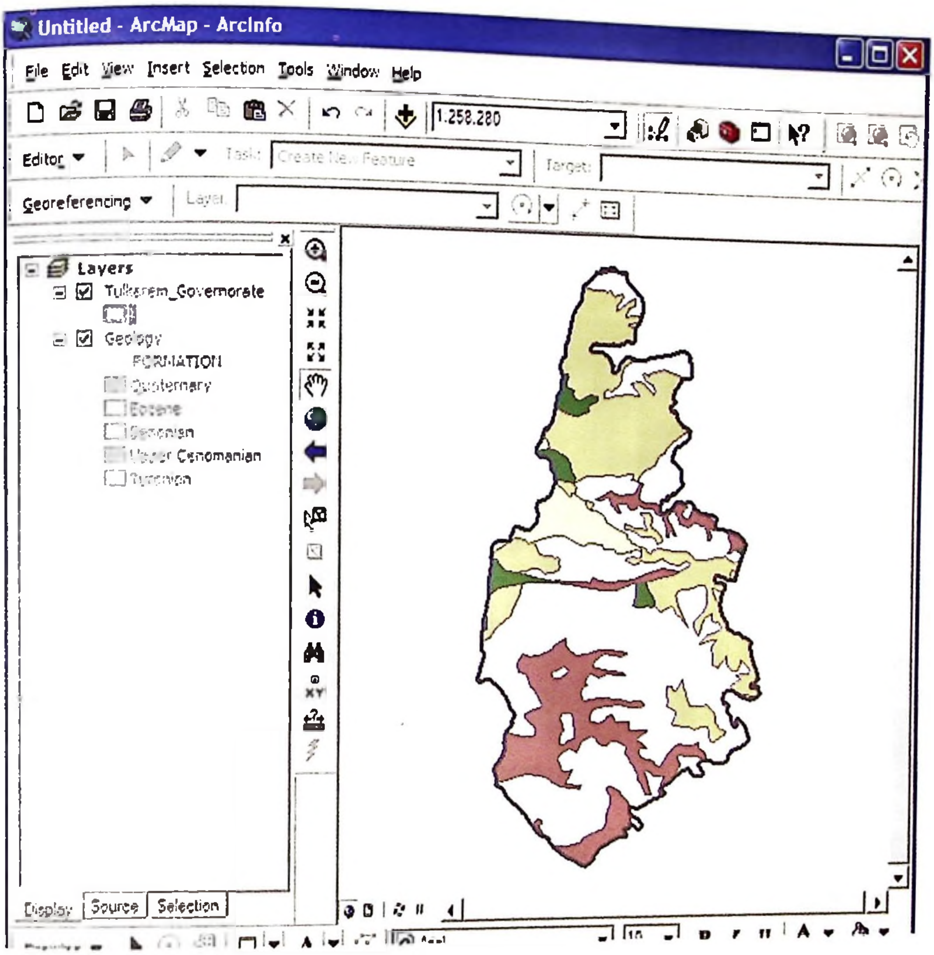


Figure 4.19: Symbology used to plot the geology of an area

4.7.1.2.2 Using Symbology from a Style File

1. Open a new ArcGIS map. Load the Landuse and Tulkarem_Governorate shapefiles from "C:\GIS_Tutorial\Chapter4\Example3".
2. Arrange the shapefiles in the table of contents, so that Tulkarem_Governorate proceeds the Landuse shapefile.
3. Select the border of Tulkarem_Governorate to be solid with a width of 2. Choose the background to be empty (no color).
4. Right-click Landuse in the table of contents and choose Properties. Click the Symbology tab.
5. Use the dropdown arrow to select the Value Field, choose Landuse.
6. Under Categories in the Show window, click Match to symbols in a style.
7. Click the Browse button and navigate to the "C:\GIS_Tutorial\Chapter4\Example3" folder.
8. Click the Landuse.style file then click Open.
9. Click Match Symbols, Figure 4.20.

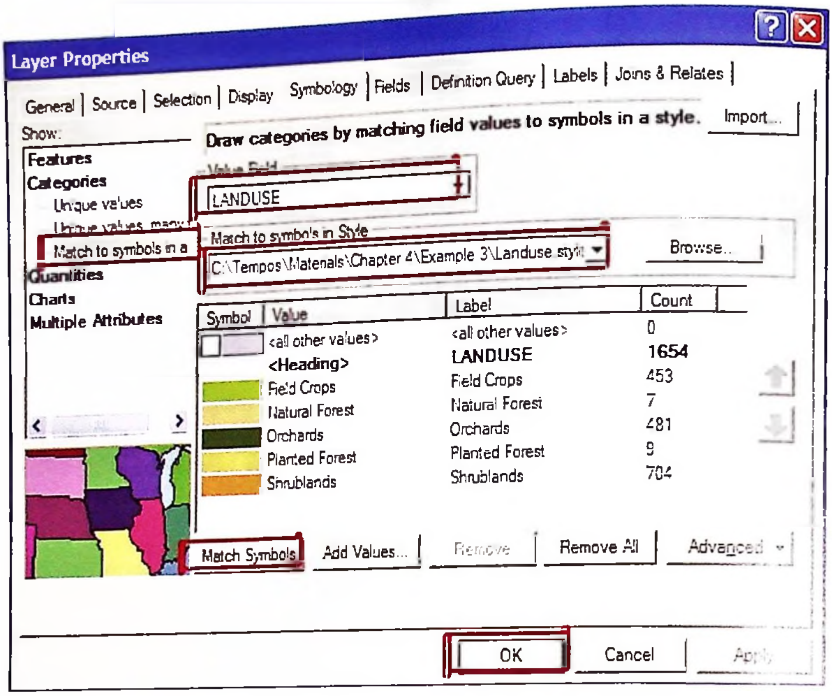


Figure 4.20: Defining categories symbology parameters using a previously defined style

10. Click OK. The land use will now be drawn using colors defined in the style file, Figure 4.21

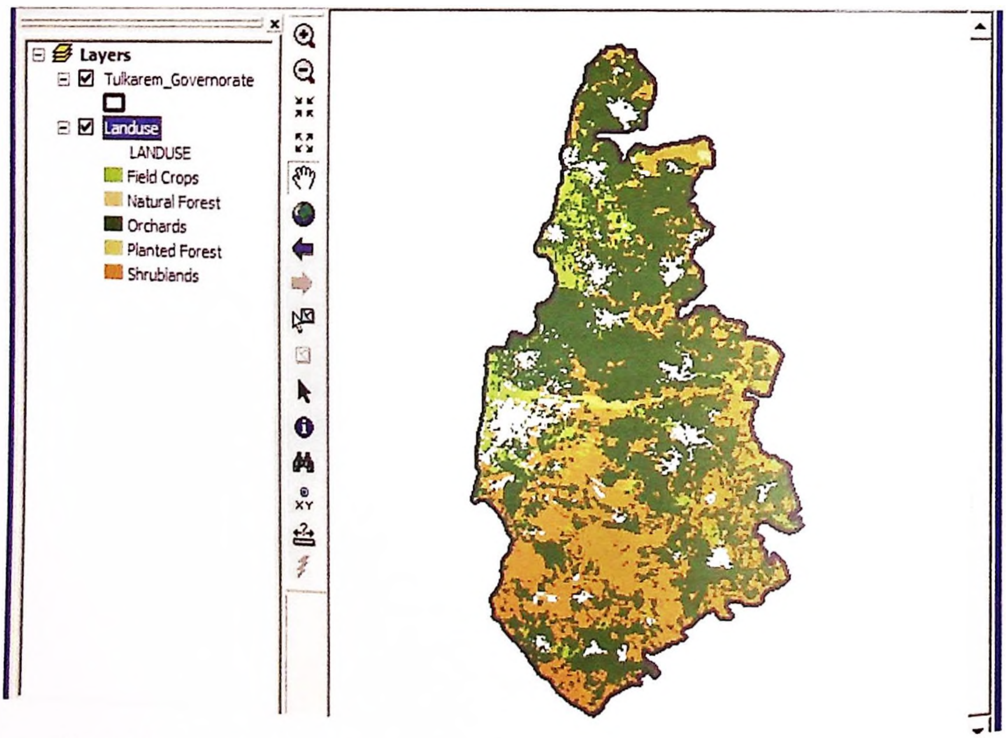


Figure 4.21: Symbology of land use using a previously defined style

4.7.1.2.3 Grouping Symbology

Categorical data often has more categories than desirable for a given map. For example, “Forests” in Tulkarem Governorate are classified into “Planted Forest” and “Natural Forest”. To produce a simpler map, these two types of forest categories can be combined (or grouped). This process is sometimes referred to as “collapsing” the range of categories.

1. Use the same classification in the example above, open the Layer Properties sheet, and then choose the Symbology tab. Select the items that are desired to be grouped (Planted and Natural forests) using the Ctrl key.
2. Right-click and choose Group Values, Figure 4.22.

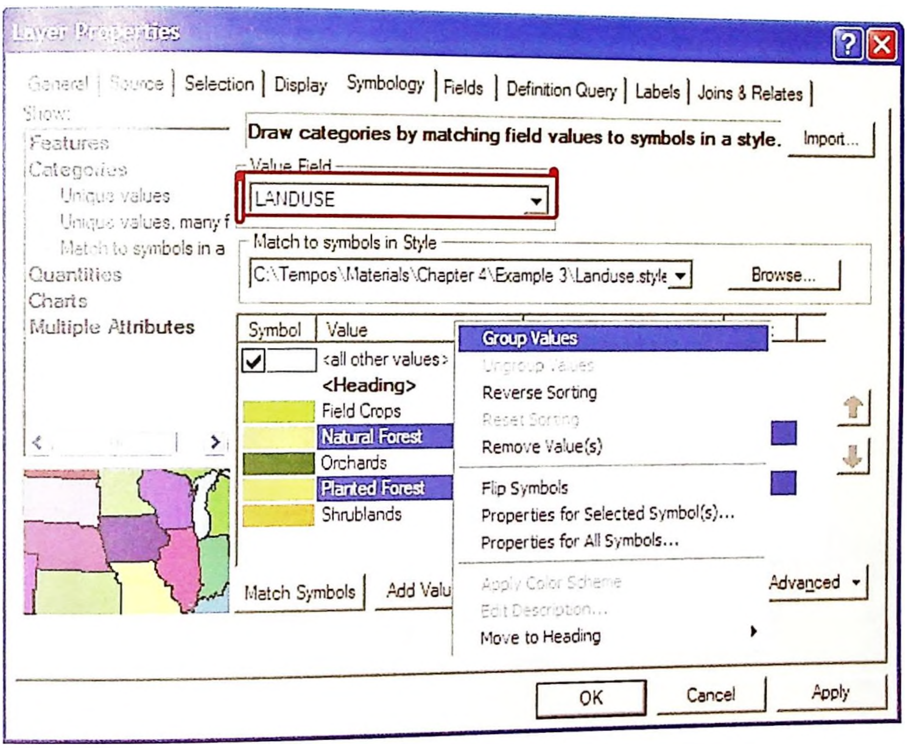


Figure 4.22: Grouping Symbols

3. Having grouped these categories, enter an appropriate Label for the group (e.g., Forest)

4.7.1.3 Quantities Classification

Quantities classification is mainly used for classifying quantitative datasets. There are several types of quantitative classification. For example, the use of “Graduate Colors” (a 'color ramp' or range of color values) is often used to depict an increase in some attribute of the data (e.g., population or rainfall). Other types of quantities classification will be illustrated in the following examples.

4.7.1.3.1 Graduate Color Fills and Classification Breaks

1. Open a new ArcGIS map. Load the Dead Sea, Jordan River and West Bank_Governorates shapefiles from "C:\GIS_Tutorial\Chapter4\Example4".
2. Use the Single Symbol to change the illustrative properties of the Dead Sea and Jordan River shapefiles as follows:
    a. Jordan River:
        i. Color: Light Blue
        ii. Width: 2 points
    b. Dead Sea:
        i. Background color: Light Blue
        ii. Outline color: Dark Blue
        iii. Outline width: 1 point
3. Open the Symbology tab for the West Bank_Governorates shapefile. Click on Quantities and choose Graduated Colors.
4. Use the dropdown arrow of the Value box to choose the Pop_den field. The default classification uses 5 classes and Natural Breaks, Figure 4.23. The same result can be chosen if the population field was normalized by the area. Choose any color ramp.

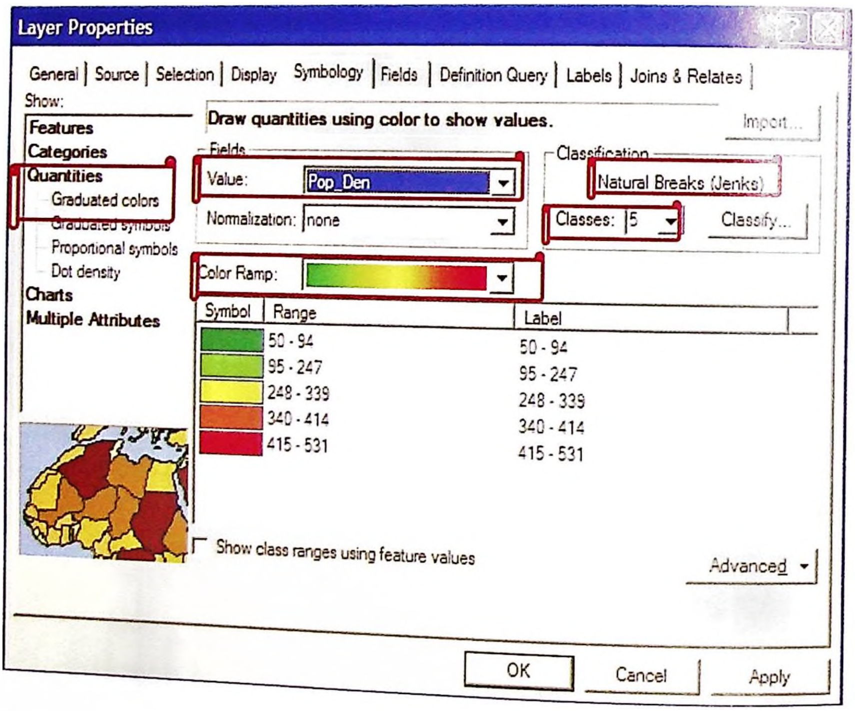


Figure 4.23: Defining quantities symbology parameters using the graduated colors technique

5. To customize the classification breaks you can change the number of classes by clicking on the Classify button.
6. Click on the Classify button. Try to choose different methods of classification.
7. Change the number of classes to 6.

8. Verify that the breaks (shown as blue lines in the graph) 'fit' with the data (shown as gray bars in the graph). Also verify that the break values are those desired. The Manual method can be chosen which allows the user to manually enter break values as shown in Figure2.24. Then click OK.

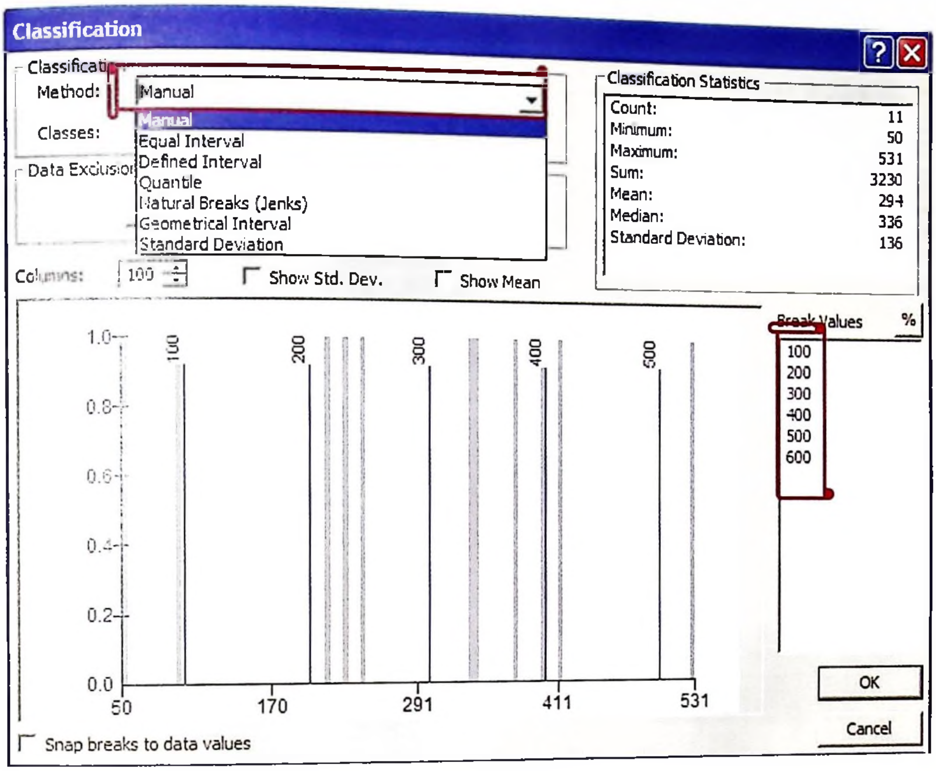


Figure 4.24: Setting breaks values for intervals

9. The class Labels can be manually edited, click on the first class label and type "Less than 100". Click OK or Apply to accept the settings, Figure 4.25.

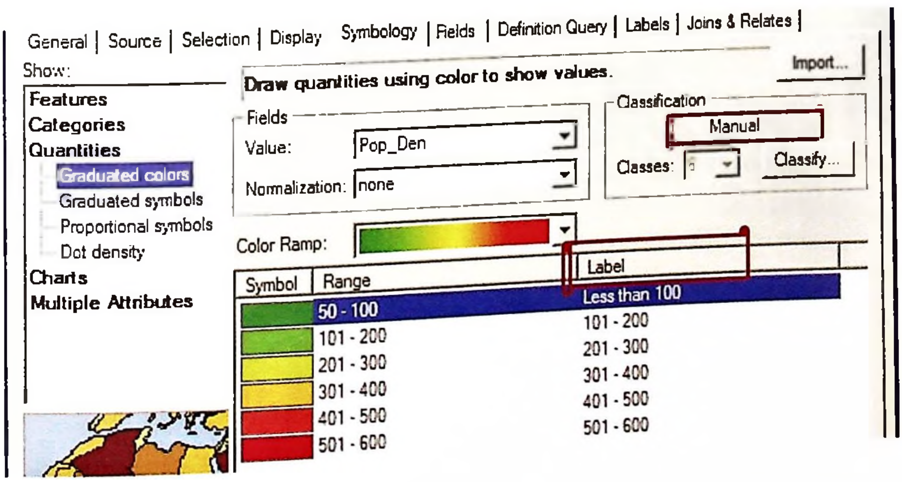


Figure 4.25: Editing intervals labels

10. Click OK to complete the classification process. A graduated color ramp based on the specified number and method of classes will be generated.
11. The name of the field being used for the classification can also be edited. Click on the name of the field in the table of contents and type "Population density (p/km2)", Figure 4.26.

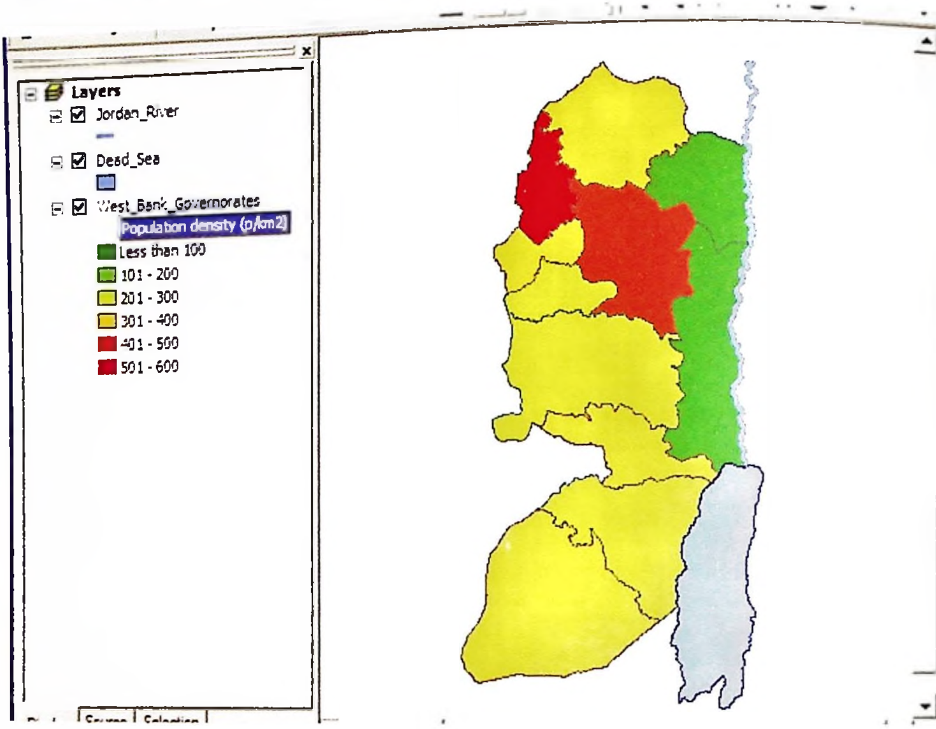


Figure 4.26: West Bank Governorates classified according to population density

4.7.1.4 Multiple Attributes Symbology

1. Use the map from the section above.
2. Open the Symbology tab for the West Bank_Governorates shapefile. Click on Multiple Attributes.
3. Use the dropdown arrow of the Value box to choose the DISTRICT field. Choose a color ramp (e.g. Green to Red). Then click on the Add All Values button to apply the classification to all Governorates.
4. Click on the Symbol Size... button to open the Symbols window, Figure 4.27.

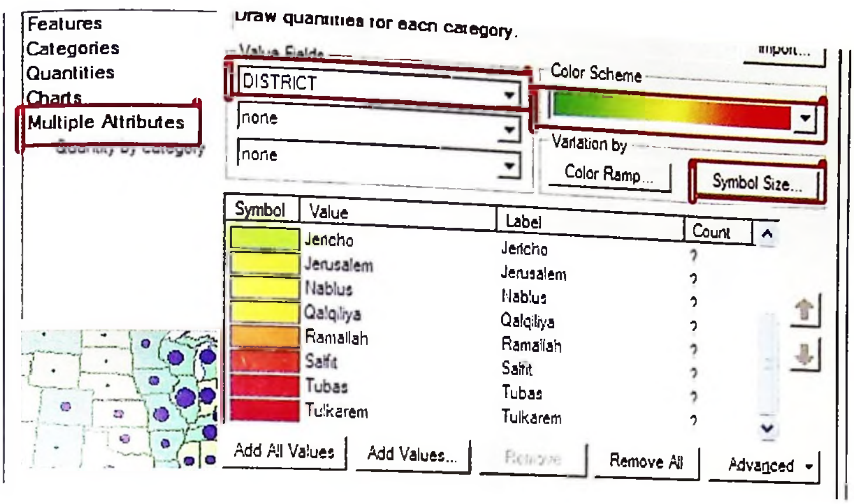


Figure 4.27: Defining parameters for multiple attributes symbology

5. Use the dropdown arrow of the Value box to choose the Population field.
6. Change the number of classes to 8. Use the manual method of classification with the break values of: 50000, 75000, 100000, 150000, 200000, 250000, 300000 and 400000.
7. Change the symbol size from 10 to 30.
8. Change the template to a star shape that is red; and with no background color, Figure 4.28.

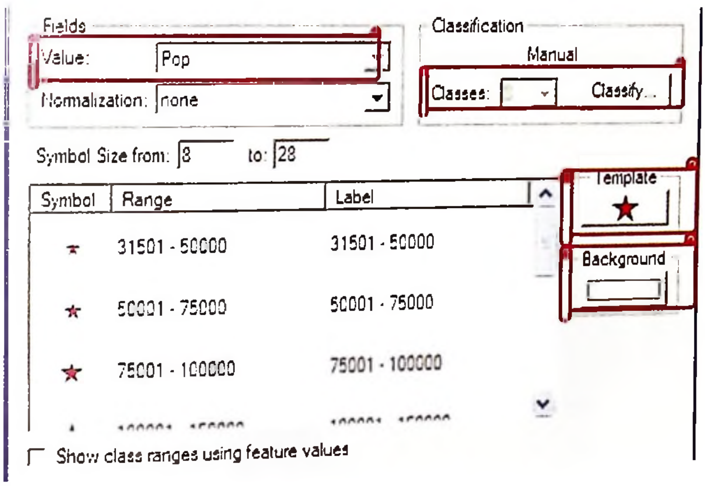


Figure 4.28: Customize the symbol shape and color

9. Click OK twice to complete. You will find that the West Bank_Governorates is classified according to both governorate name and population. The size of the star representing each Governorate reflects the size of its population, Figure 4.29.

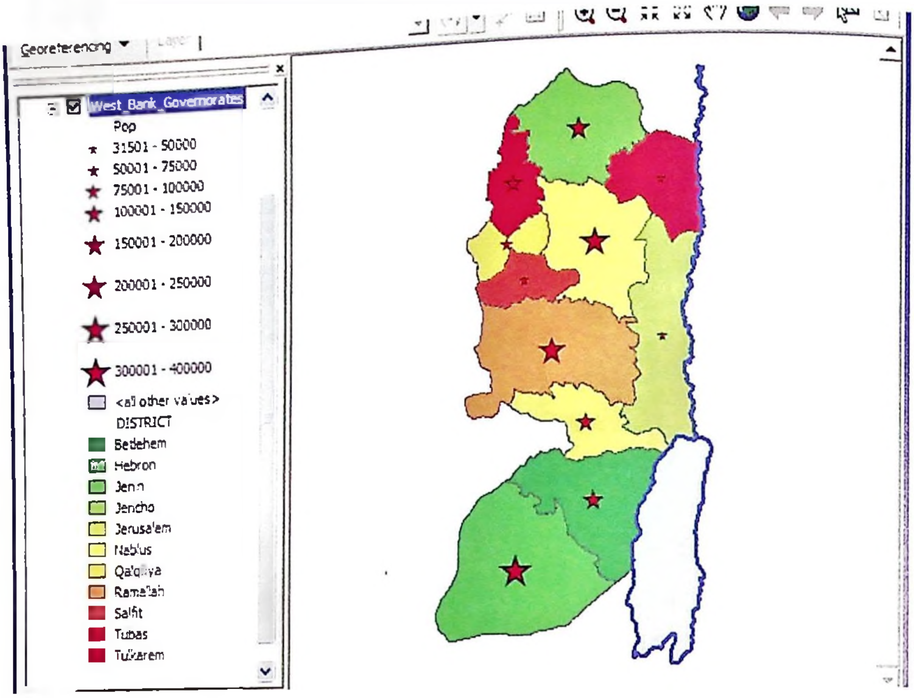


Figure 4.29: West Bank Governorates classified using multiple attributes (names and population)

4.7.1.5 Chart Symbology

In some cases, the data feature contains data which may be presented as a chart. For example, if the population of the West Bank Governorates is divided into four age categories (less than 16 years old, between 16-30 years, between 30-60 years and above 60 years old), then you can present these categories on the map using a chart as described in the following example.

1. Open a new ArcGIS map. Load the Dead Sea, Jordan River, Cities and West Bank_Governorates shapefiles from "C:\GIS_Tutorial\Chapter4\Example5".
2. Use the Single Symbol to change the illustrative properties of the Dead Sea, Jordan River and West Bank_Governorates shapefiles as follows:
    a. Jordan River:
        i. Color: Light Blue
        ii. Width: 2 points
    b. Dead Sea:
        i. Background color: Light Blue
        ii. Outline color: Dark Blue
        iii. Outline width: 1 point
3. Classify the West Bank_Governorates shapefile based on the District field using unique value symbology.
4. Open the Symbology tab for the Cities shapefile. Click on the Chart class, then chose Bar/Column.
5. From the Field Selection field, select the field as shown in Figure 4.30, select an appropriate color then click OK.

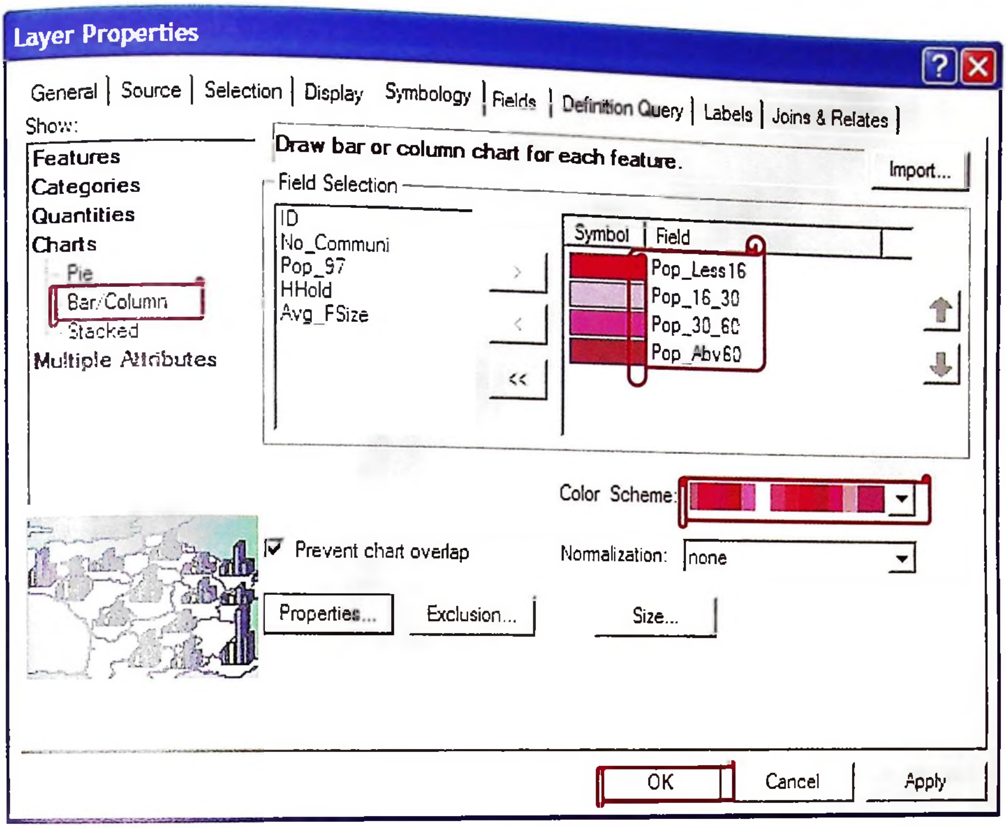


Figure 4.30: Defining symbology parameters using the chart technique

6. Repeat step 5 using a Pie chart, try to change the format of the charts by clicking on the Properties button.
7. The result, Figure 4.31, reflects the population within each Governorate as well as the percentage of each age class.

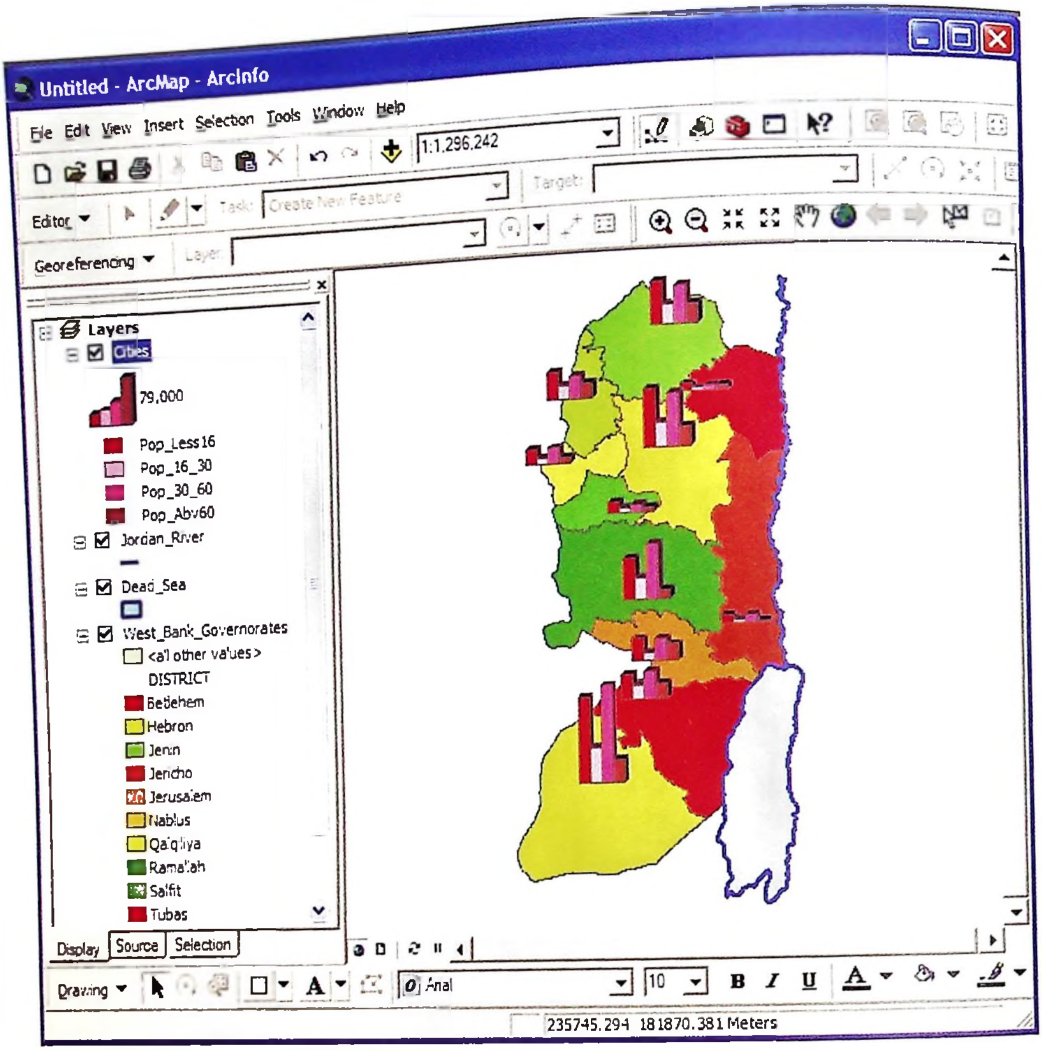


Figure 4.31: Classifying main cities according to population and age distribution

4.7.2 Labeling in ArcGIS

4.7.2.1 Adding Labels to a Shapefile

Labeling may be used to describe features such as names of roads, communities, groundwater wells, springs, etc. or to complement the symbology. For example, assume you have a map showing the distribution of groundwater wells in the West Bank; the wells are classified based on well use (e.g. domestic or agriculture). You can add labels to the map showing the annual average abstraction of each well. In this case you have presented two information sets within the same map; the well use and the average annual abstraction. ArcMap has the ability to automatically create "feature-linked" labels on the map based on values in the attribute table. These labels can be customized in font size, type, color, orientation, etc.

1. In this example you are going to label the communities in Tulkarem by their names. Open the map you have created in Example 1.

2. Right-click the Communities shapefile, click on Properties and then on the Labels tab.
3. Check the Label features in this layer box.
4. Choose Label all features in the same way from the Method dropdown list.
5. In the Label File, choose COMM_NAME.
6. In the Text Symbol box, set the following values, Figure 4.32:
   a. Font: Arial (Bold)
   b. Color: Dark Brown
   c. Font Size: 8

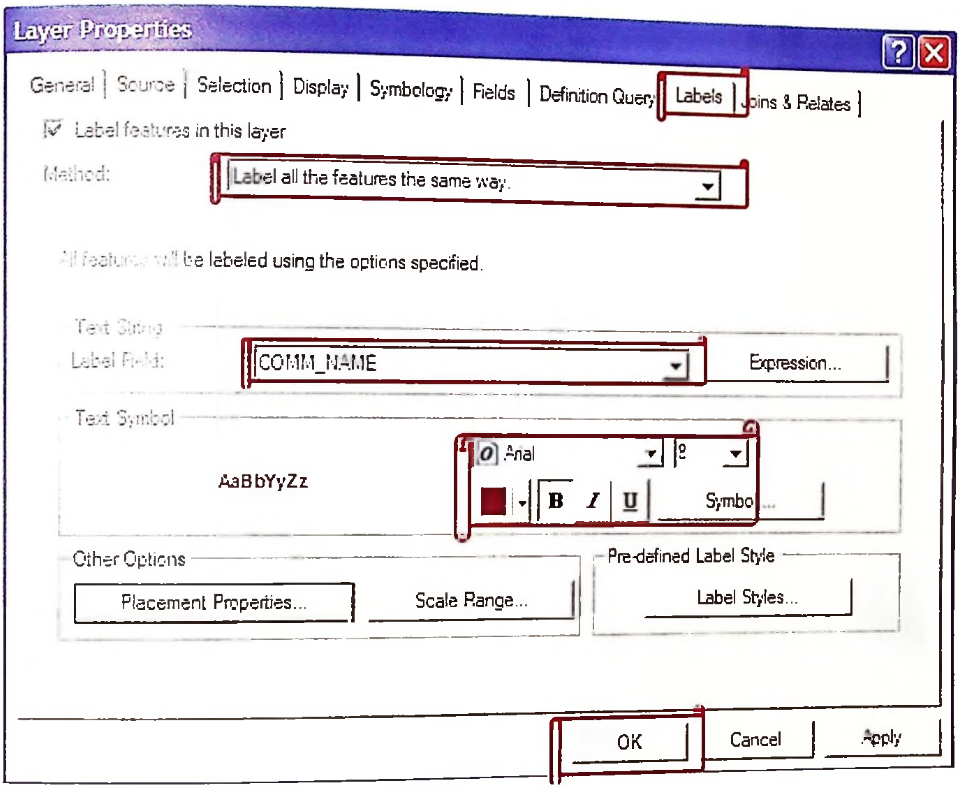


Figure 4.32: Defining label parameters for communities in Tulkarem Governorate

7. Click OK to close the label window. The map should be similar to Figure 4.33.

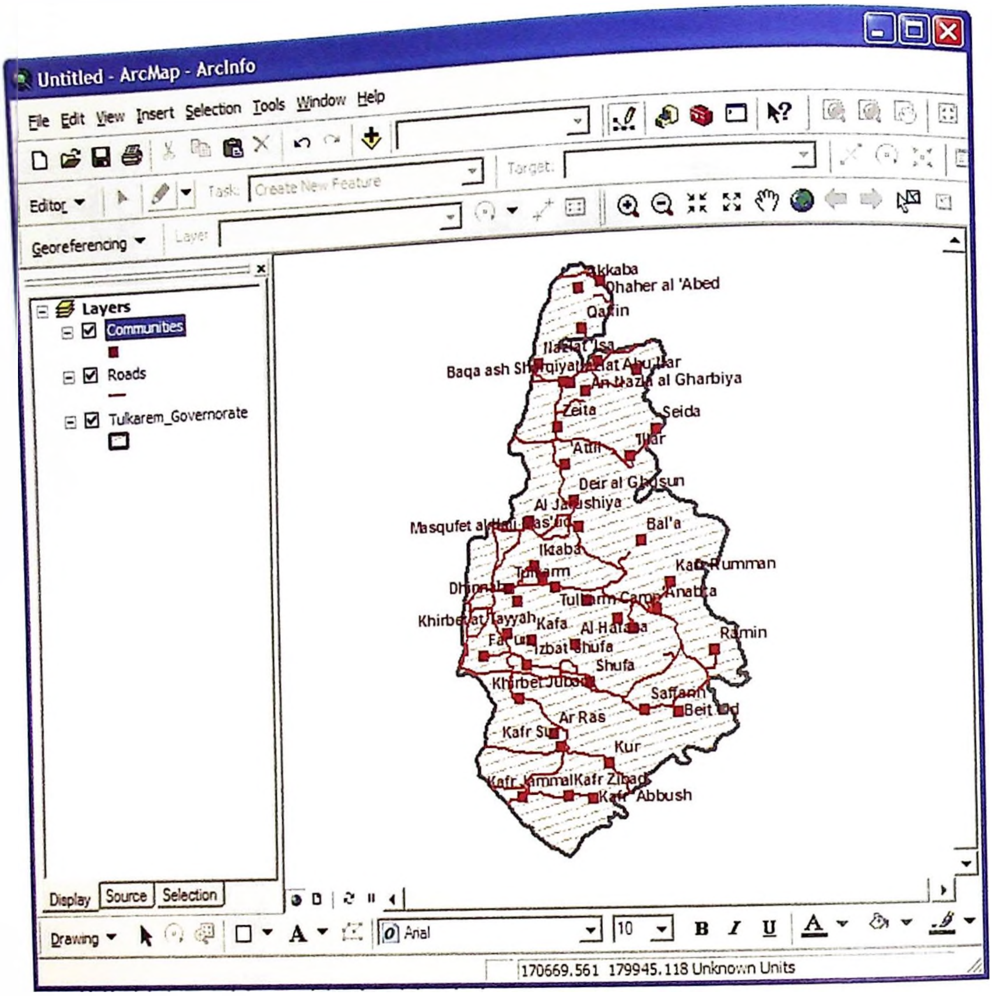


Figure 4.33: Adding labels for the Communities shapefile.

Figure 4.33 shows that some labels are overlapped. You can try to rearrange these labels by changing the label size and position.

8. Open the Labels window once again, and change the font size to 7.
9. Click the Placement Properties button to open the placement window. Click Change Location button, choose Prefer Bottom Left, all allowed, Figure 4.34.
10. Click OK three times to finish labeling the communities.

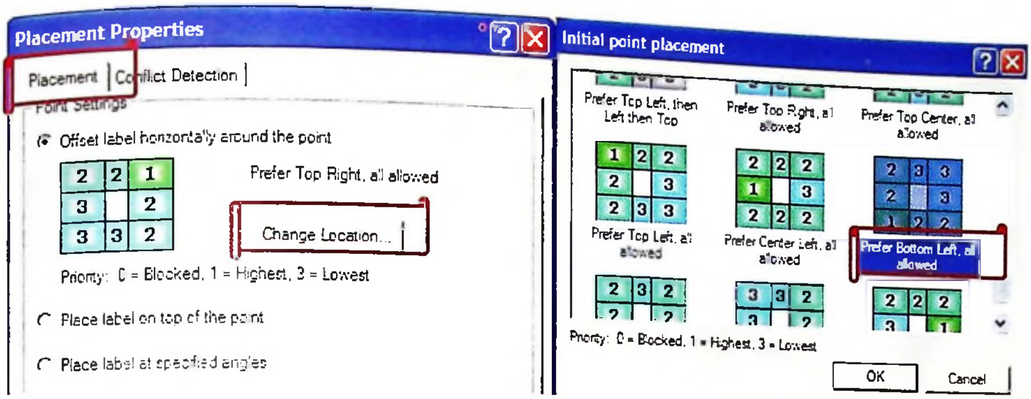


Figure 4.34: Modifying placement position of labels

11. The map in Figure 4.35 shows that the size and the location of the labels have changed. But many still overlap.

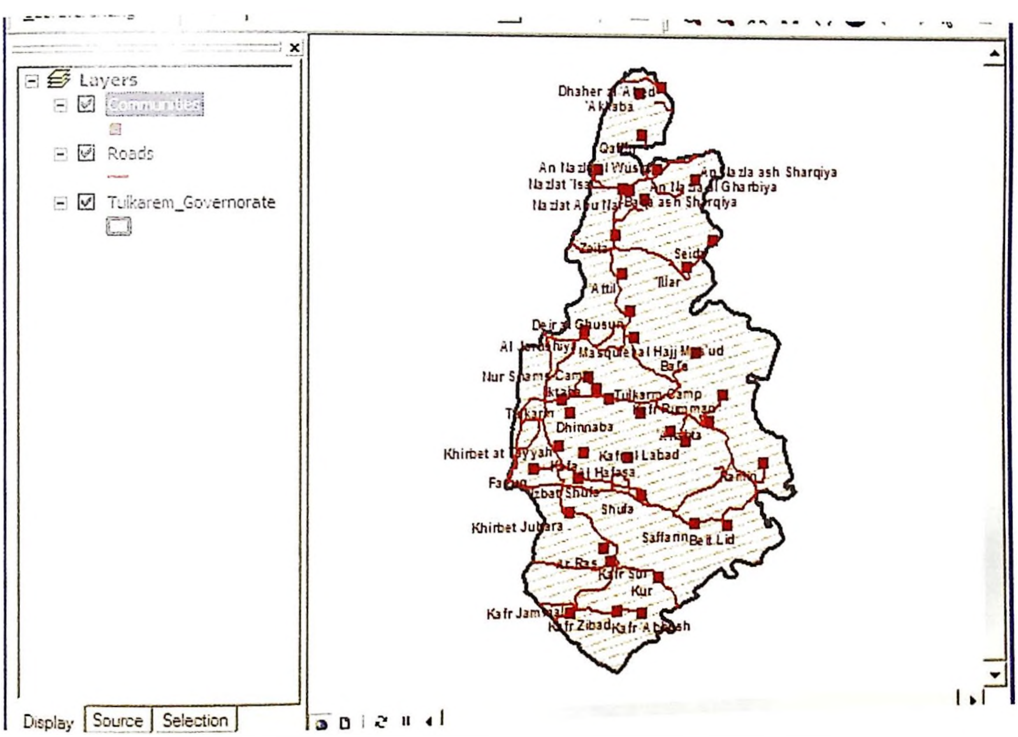


Figure 4.35: New locations of labels

4.7.2.2 Setting the Reference Scale for the Labels

To overcome the problem of the overlapped labels, a reference scale may be defined for the labels; in this case the label will be displayed for the specific scale in use. Labels in ArcGIS are dynamic, they are regenerated when you pan or zoom around the map. By default, they will be drawn using the same size symbol, regardless of the scale to which you zoom.

1. Open once again the Labels window for the Communities shapefile.
2. Click on the Scale range button. In the window, click on Don't show labels when zoomed
3. In the Out beyond box, choose 1:100,000 from the dropdown list as a minimum scale. Then click OK twice to finish, Figure 4.36.

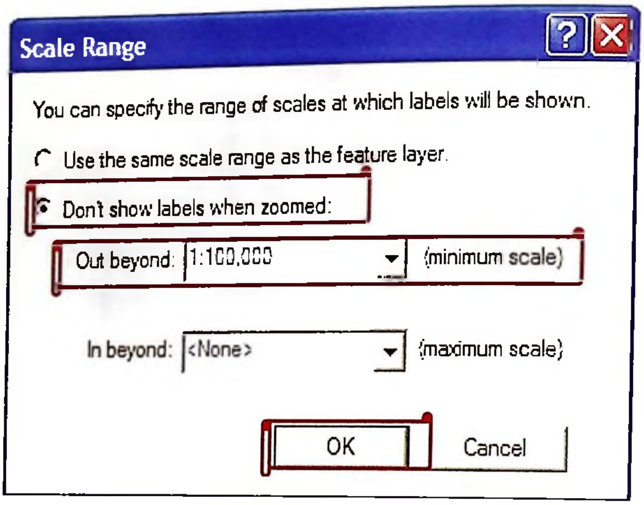


Figure 4.36: Defining a reference scale for viewing labels

4. Click on Zoom to Full Extend, you will notice that the labels have disappeared from the map since the scale of the map is beyond the defined reference scale.
5. In the Scale Box, select 1:100,000 from the dropdown list. You will find that the labels have reappeared but without any overlapping, Figure 4.37.

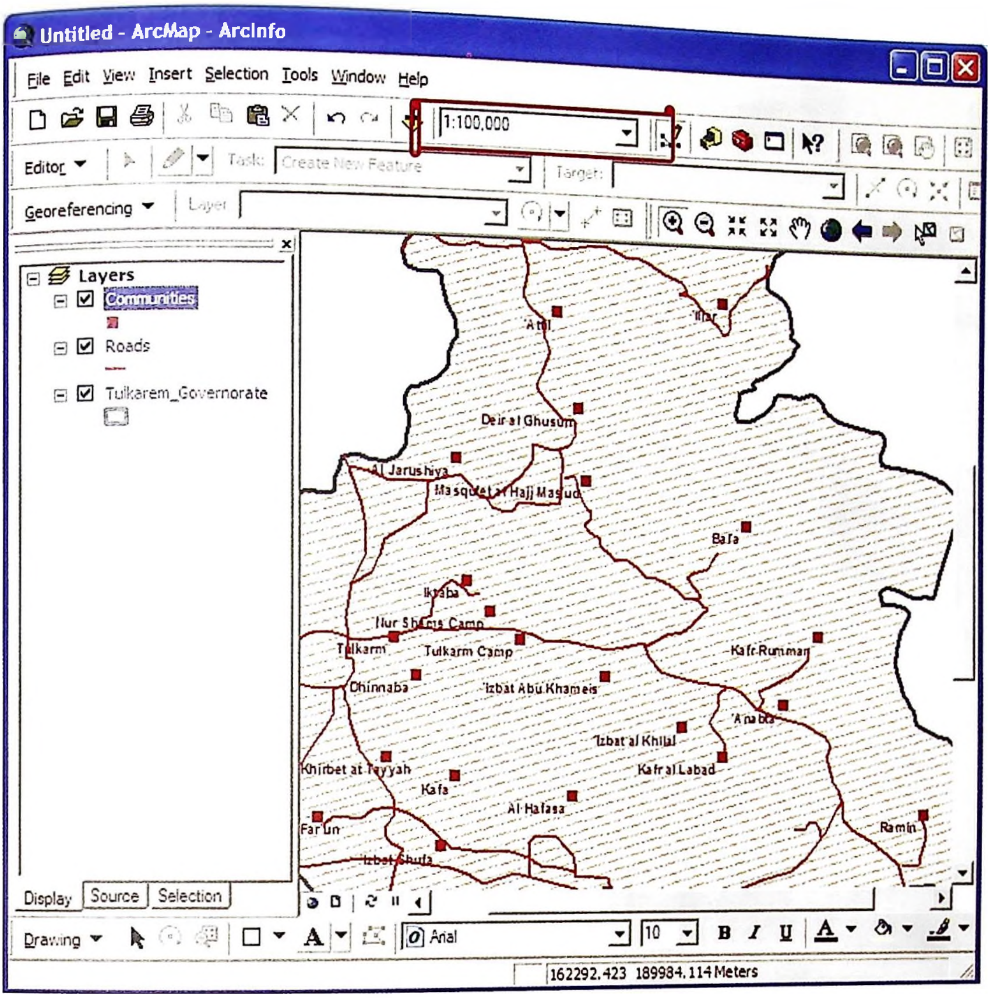


Figure 4.37: Viewing labels within the scale range

4.7.2.3 Adding Labels to the Roads Shapefile

Generally, labeling point, polyline or polygon features is done in the same way illustrated in Section 4.7.2.2. In this example you will label based on the Name field.

1. Right-click the Roads shapefile then click Properties. Choose the Labels tab.
2. Check the Label features in this layer box.
3. Click the Method dropdown list and choose Label all features in the same way.
4. From the Label File, choose Name.
5. In the Text Symbol box, set the following values:
    a. Font: Arial (Bold)
    b. Color: Black
    c. Font Size: 8
6. Click the Placement Properties button to open the Placement window. You will find many options of placement positions. Fill out the Placement window as shown in Figure 4.38.

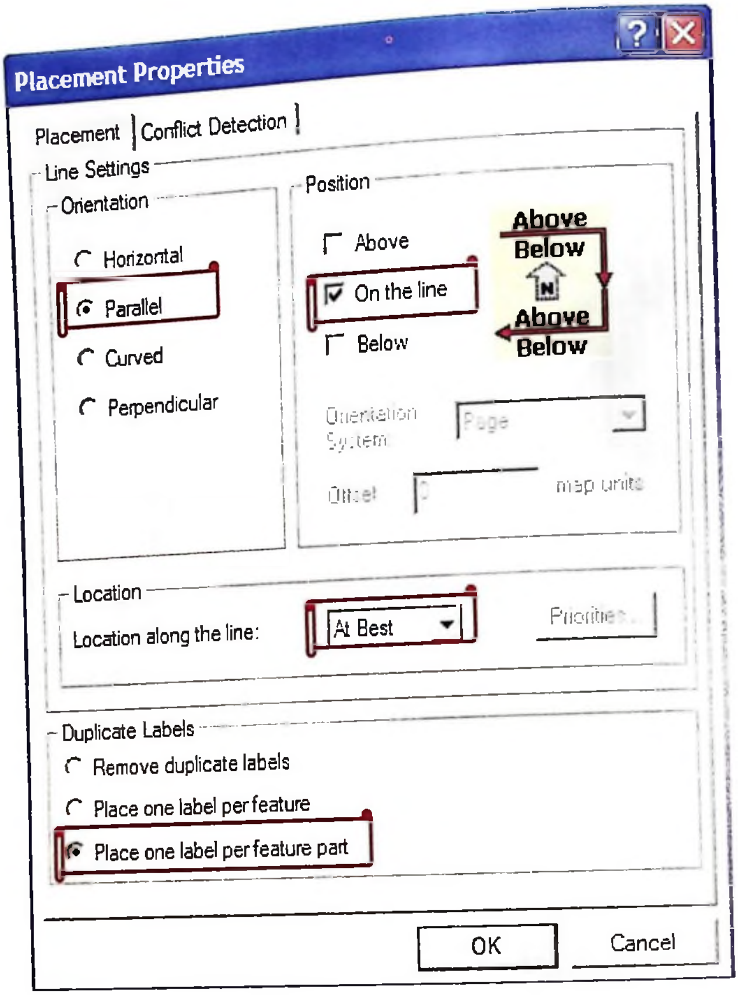


Figure 4.38: Adding labels to line features

7. Click OK to close the Placement window.
8. In ArcGIS, you will find many predefined label styles. To select one of them, click on the Label Styles... button. And then select U.S. Routes from the Label Style Selector window.
9. Click OK until you finish labeling the Roads shapefile.
10. In the Scale Box, select 1:100,000 from the dropdown list. You will find that the labels are added above the road system, Figure 4.39.

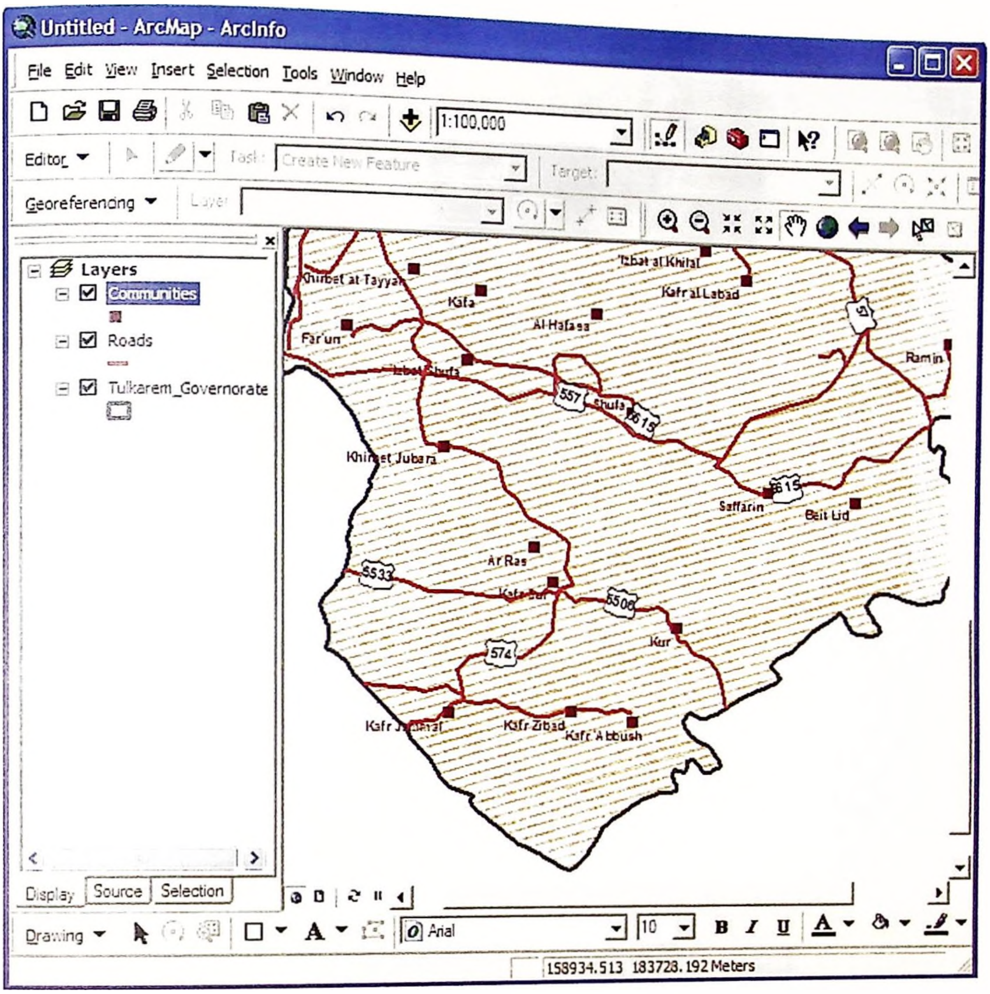


Figure 4.39: Labeling roads on a map

4.7.2.4 Converting Automatic Labeling to Map Annotation

Unlike labels, annotations are static. They may be used for greater control over the placement and style of the text. They have a fixed location and a reference scale, so when you zoom in, the text gets larger on the screen. Therefore, it is important to have the right reference scale when you convert the labels to annotation so that the labels will be plotted in a suitable size relative to the features on the map.

1. Use the same map you created in Section 4.7.2.2 (symbology, labels and reference scale). You will notice that the labels of the communities are not clear enough; some labels are positioned on the roads or on the border of the West Bank. For greater control, you will convert the labels to annotation.
2. Right-click on the Communities shapefile and choose Convert Labels to Annotation, Figure 4.40.

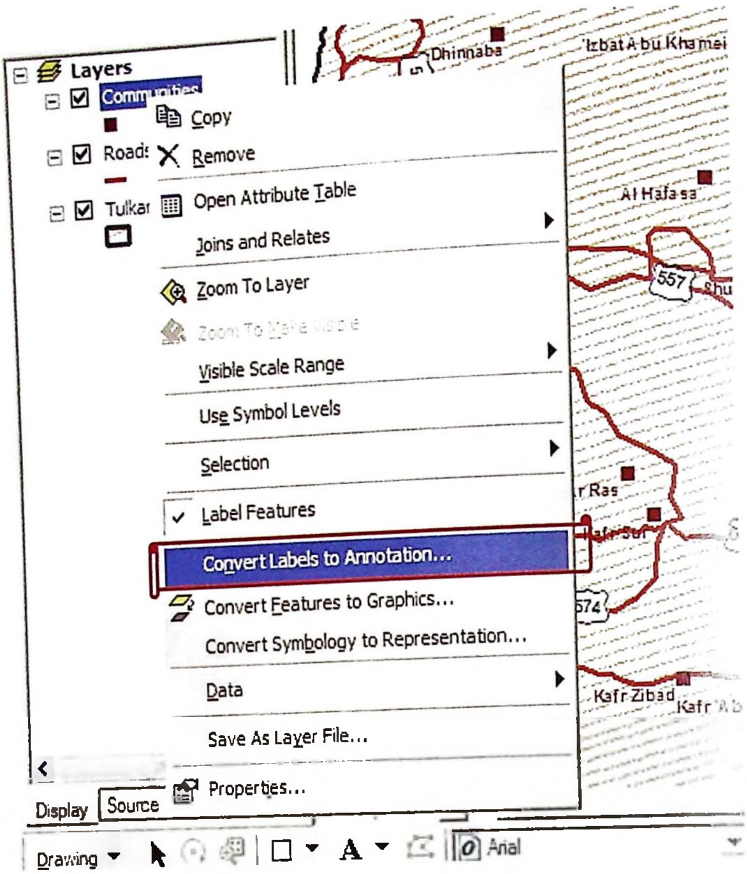


Figure 4.40: Converting labels to annotation

3. In the Convert Labels to Annotation window, choose In the map to store the converted annotations in the current ArcGIS project (mxd). A database is a good place for storing annotations so that you can use them in other map projects, but it requires a Geodatabase to store them in. Note the Reference Scale (the scale of the map with the labels added).
4. Choose to convert all features or just those features in the current extent (visible on the map).
5. You may choose Convert unplaced labels (due to placement conflicts with other labels) in the dialog box, Figure 4.41
6. Click on Convert.

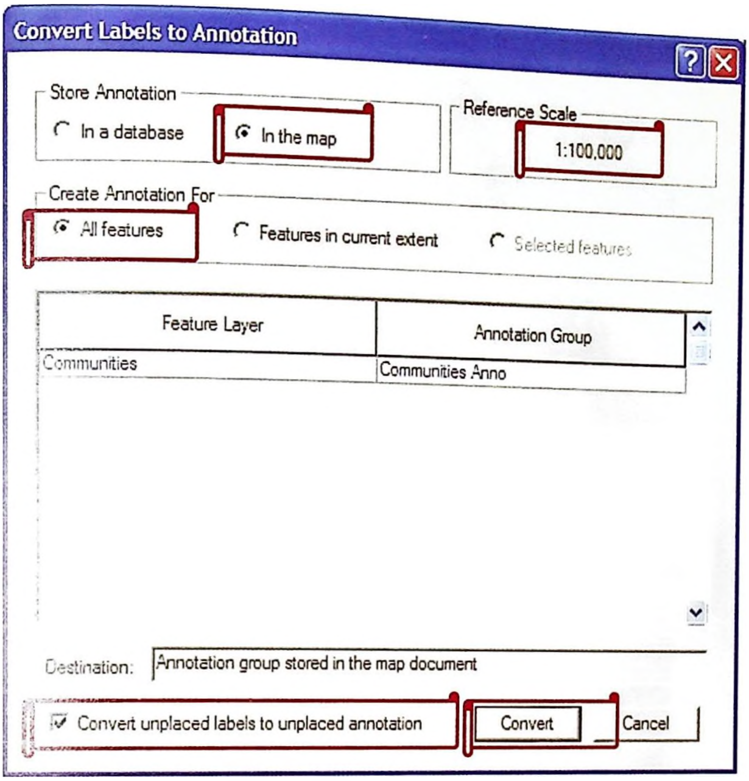


Figure 4.41: Parameters for converting labels to annotations

7. If unplaced labels have been converted, right-click a label and choose to add or delete, use the Flash Feature or Select Feature to assist with locating the feature being labeled. Click Delete if not needed (e.g. duplicates), Figure 4.42. Close the Overflow Annotation box when done.

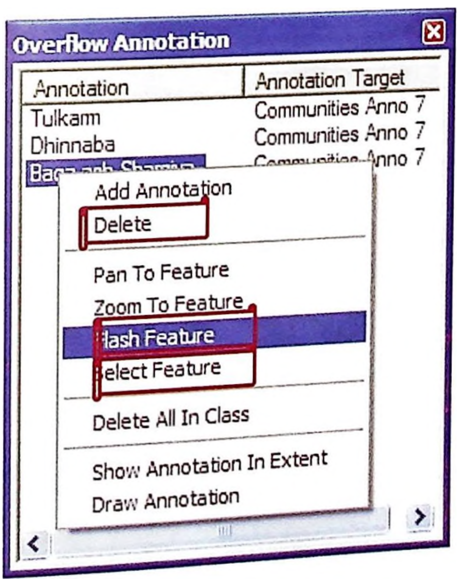


Figure 4.42: Overflow annotation

8. In case you have duplicated annotations or you want to delete some of the unnecessary annotations; use the Select tool to select the annotation on the map and delete it using the right-click option, Figure 4.43.

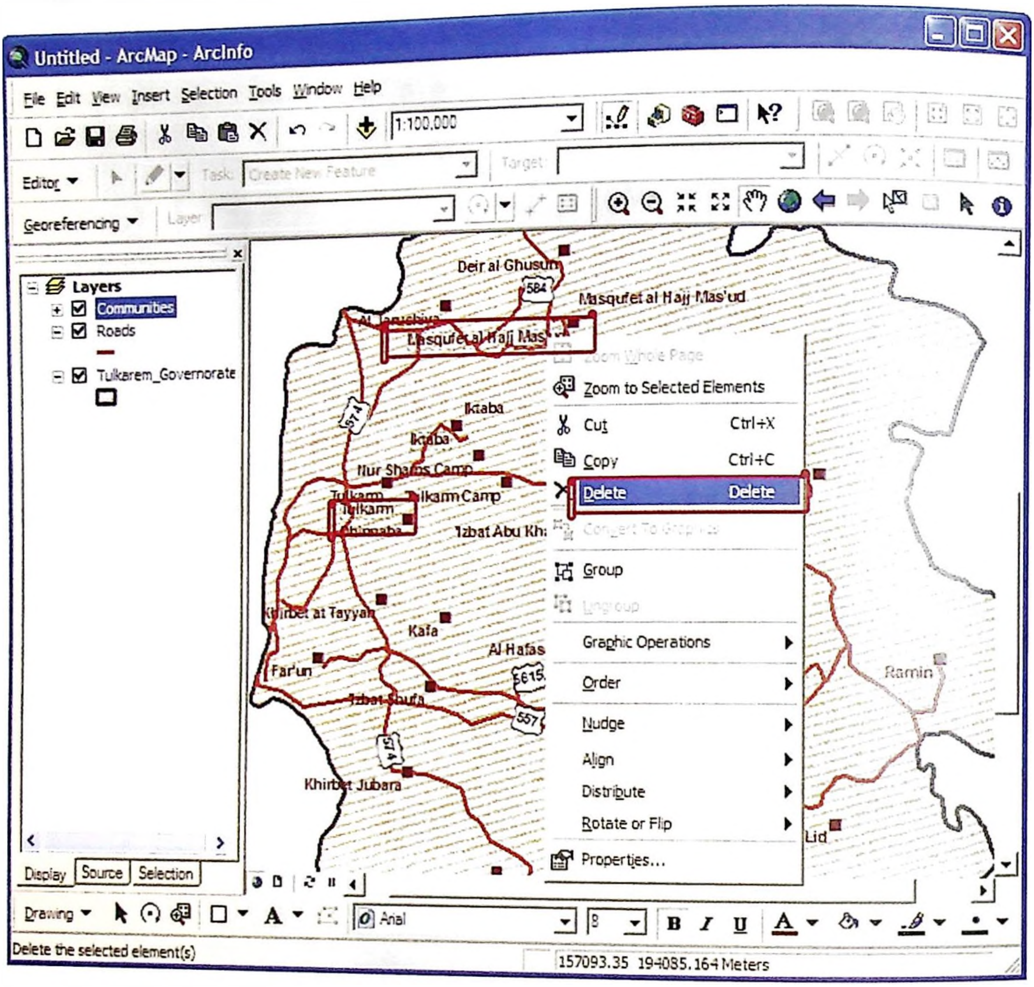


Figure 4.43: Deleting repeated labels

9. Use the Select tool to manually select and relocate individual pieces of annotation.
10. To manage annotation layers, right-click on the Data Frame and choose Properties. Click on the Annotation Groups tab.
11. Check or un-check an annotation group to turn it on or off respectively, Figure 4.44.

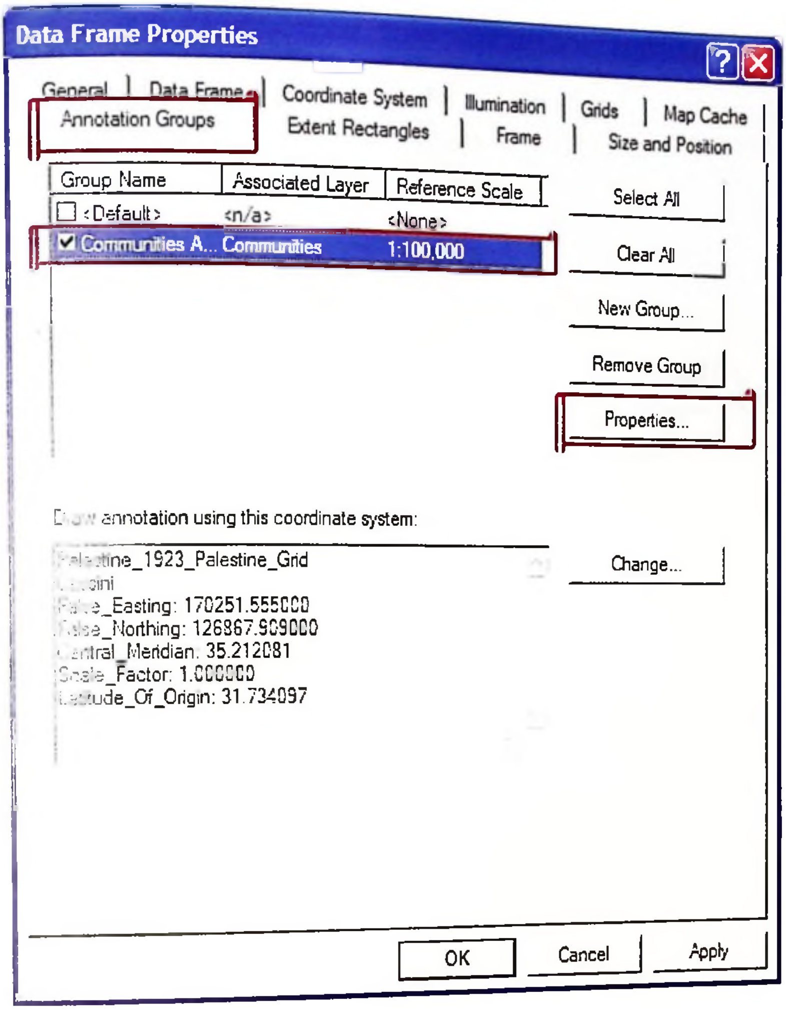


Figure 4.44: Opening the annotation tab

12. Select (highlight) an annotation group then click on the Properties button. You can modify the name and the reference scale as desired or set a scale range, then click OK to finish, Figure 4.45.
13. Click OK to close the Data Frame Properties window.

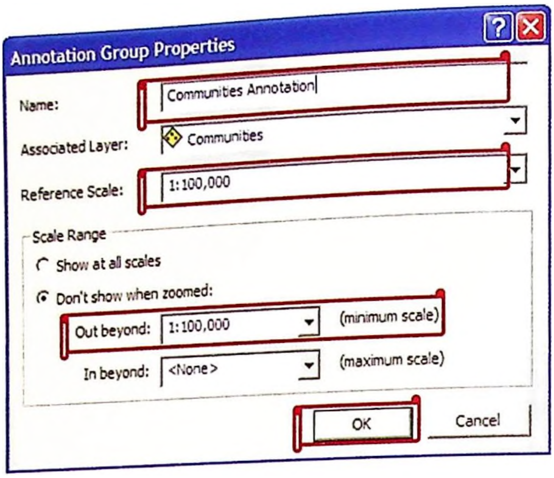


Figure 4.45: Setting annotation group properties

Note that with annotation (if you have set a reference scale), when you zoom in the annotation gets bigger. This is not true for feature-linked labels unless you set a reference scale for the entire Data Frame. Likewise when you pan, the annotation remains in the same location relative to the geographic features while labels will be re-drawn to best fit a new map extent each time you pan or zoom, Figure 4.46.

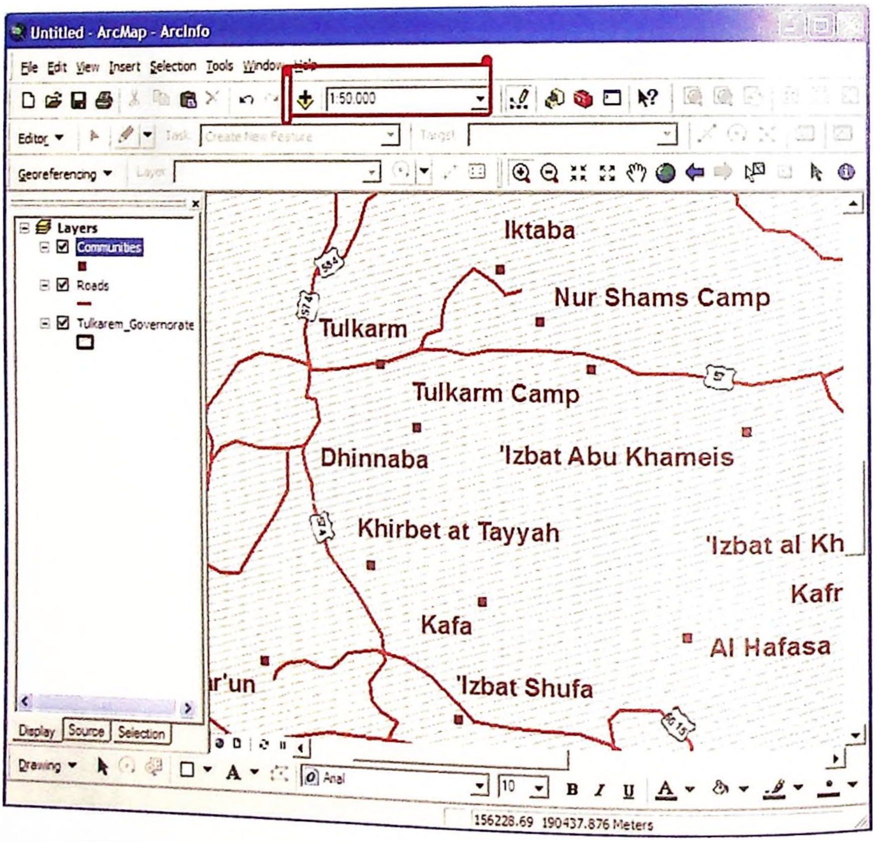


Figure 4.46: Viewing annotations within a defined reference scale

4.7.2.5 Using Multiple Fields for a Label

1. Open a new ArcGIS map. Load the Dead Sea, Jordan River and West Bank_Governorates shapefiles from "C:\GIS_Tutorial\Chapter4\Example4".
2. Classify all the shapefiles in an appropriate way.
3. You can use multiple fields for labeling the West Bank Governorates (e.g. the name and the population of each governorate). Labels from multiple fields can be combined by creating a label expression; right click on the West Bank _Governorates shapefile, click Properties then open the Label tab.
4. Click on the Expression button to open the Label expression window. Double-click on the District field, then click the Append button, double-click the Population field, Figure 4.47.
5. Click OK to close the Expression window.

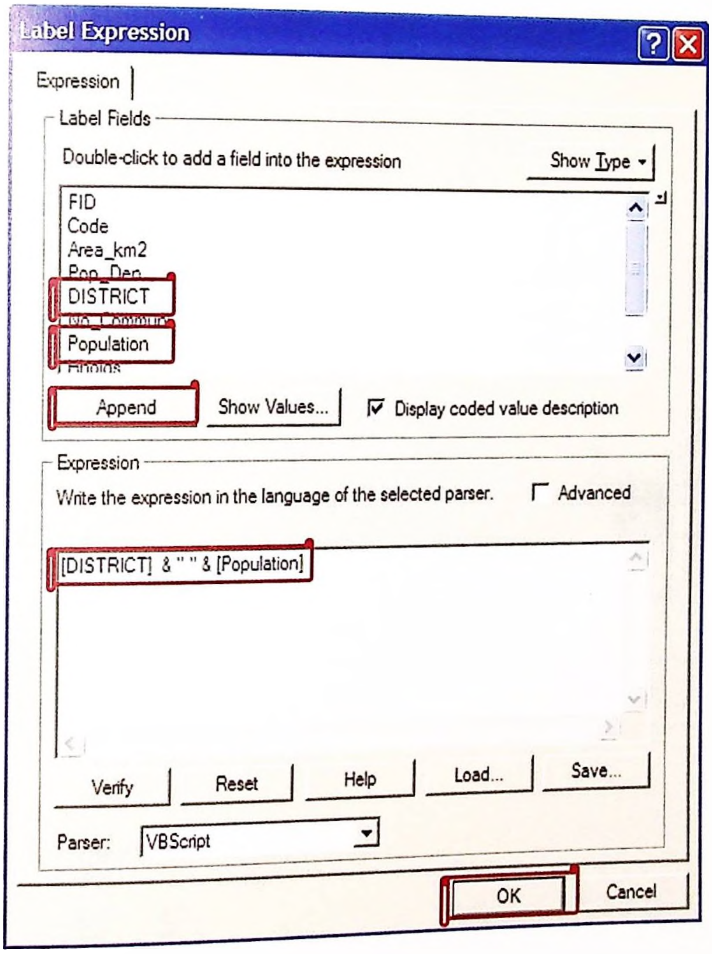


Figure 4.47: Setting multiple attributes for labels

6. In the Label window, check the Label features in this layer box. Then click OK to finish labeling, Figure 4.48.

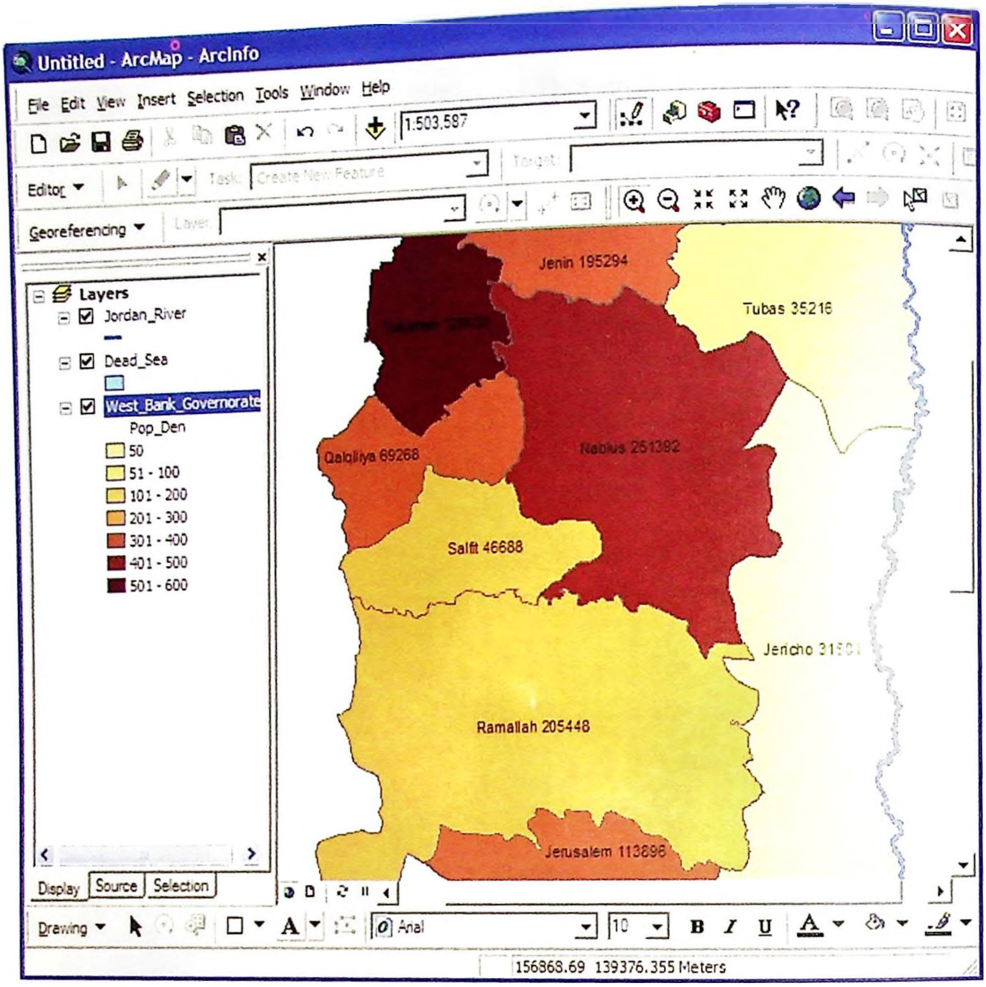


Figure 4.48: Labeling West Bank Governorates using two fields (Name and Population)

It is clear that the labels on the map are not easily understood; therefore it is necessary to add some text to the label in order to inform the reader what is meant by the number (e.g., "Population="). Text can be added to labels by modifying the label expression as shown in Figure 4.49.

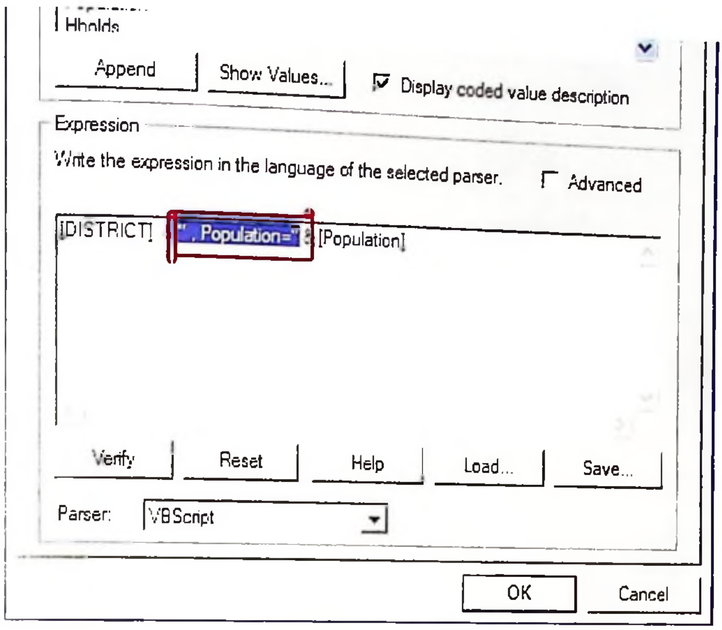


Figure 4.49: Adding text to labels

Figure 4.50, shows that the text Population= is added to the label. Now the user knows what the number represents. However, using long labels makes the map too complicated. To solve this problem, labels may be split into two lines.

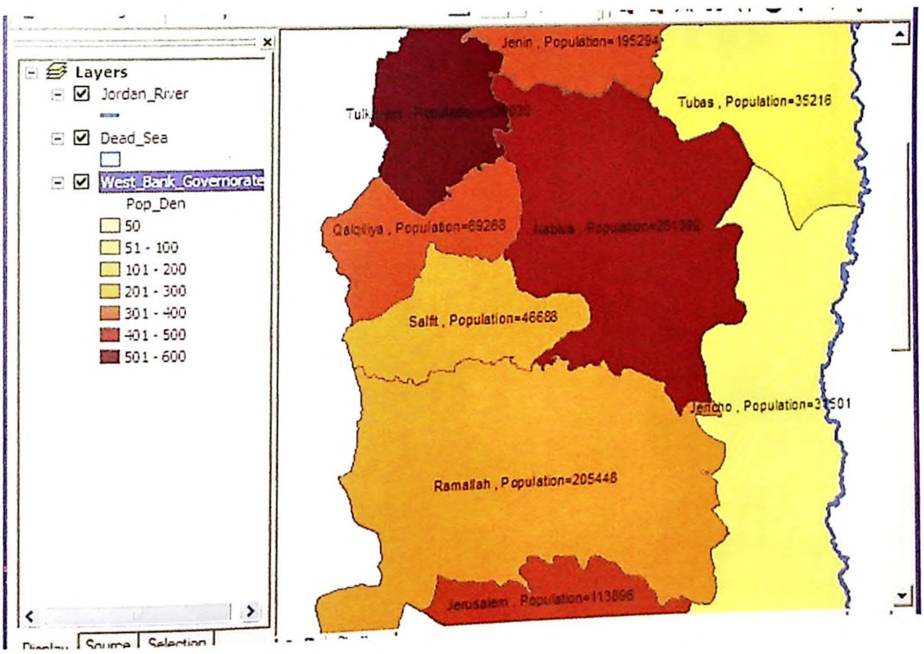


Figure 4.50: Adding Population = to label West Bank Governorates

Labels can be 'stacked' or split into multiple lines by inserting a new line command into the label expression as shown in Figure 4.51.

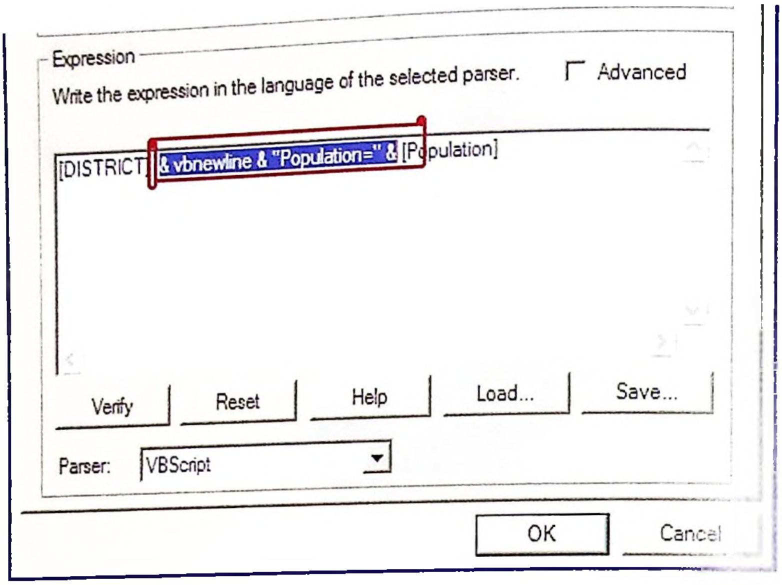


Figure 4.51: Split labels into two text lines

The map should now resemble Figure 4.52.

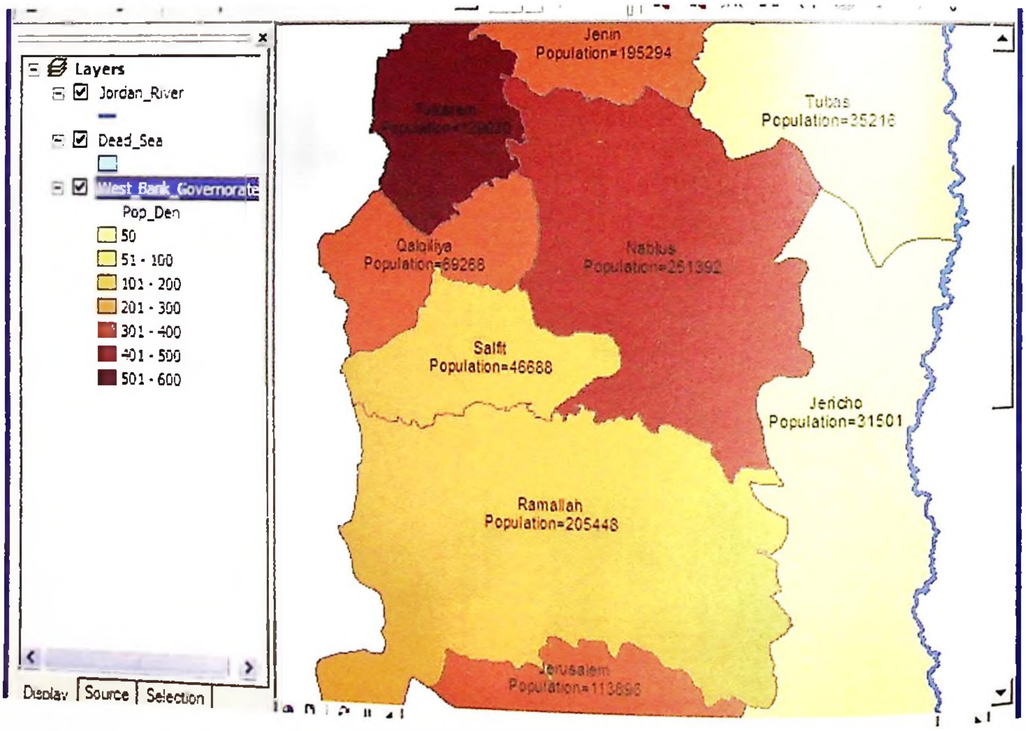


Figure 4.52: Final presentation of West Bank Governorates labels

4.7.2.6 Spline Text

Labels can be manually added and rotated to 'fit' the line work of a feature (such as a road or drainage system). For curved features, the Spline Text tool can provide further customization.

1. Open a new ArcGIS map. Load the Main_Drainage_Tulkarem and Tulkarem_Governorate shapefiles from "C:\GIS_Tutorial\Chapter4\Example7".
2. Symbolize the map as shown in Figure 4.53. Use a map scale of 1:200,000.

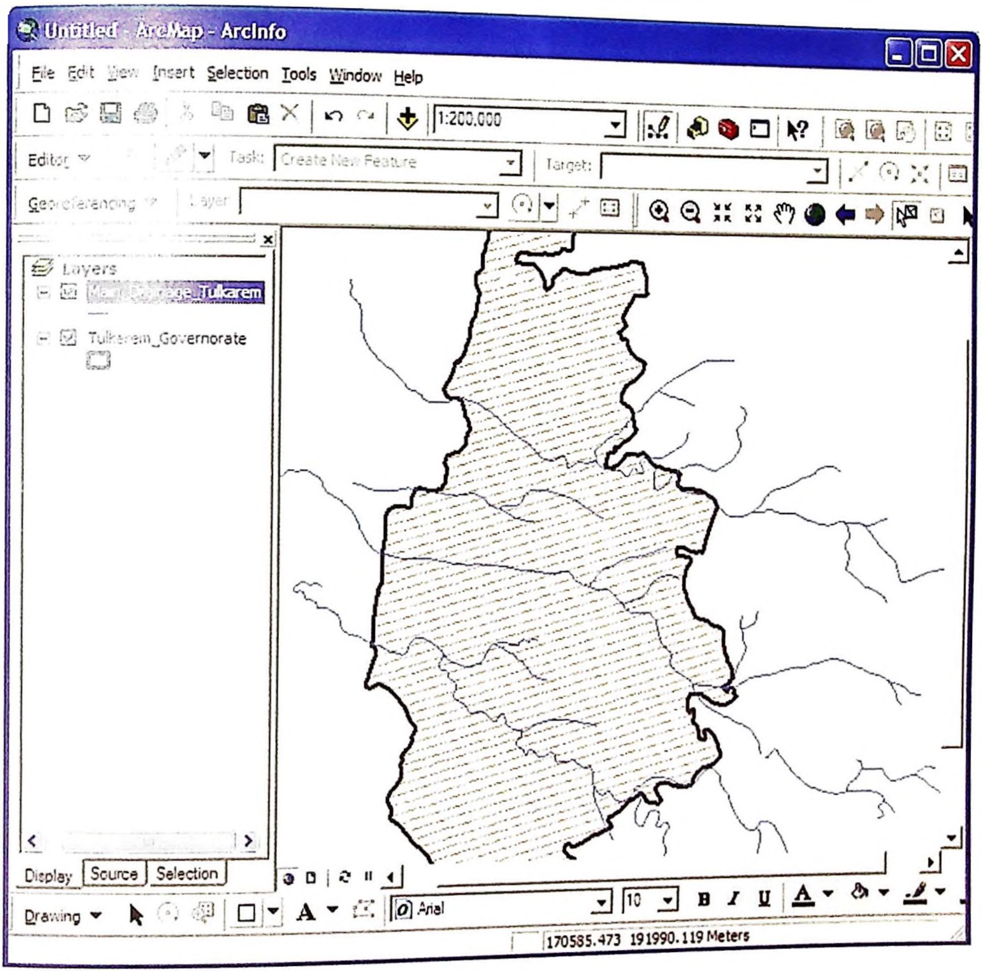


Figure 4.53: Main drainage system in Tulkarem Governorate

3. Click on the New Text button on the Draw toolbar, click on the drainage stream in the middle of the map and type "Zomer Wadi (Nablus-Tulkarem)". Note that the font size, color and style are already set, Figure 4.54.

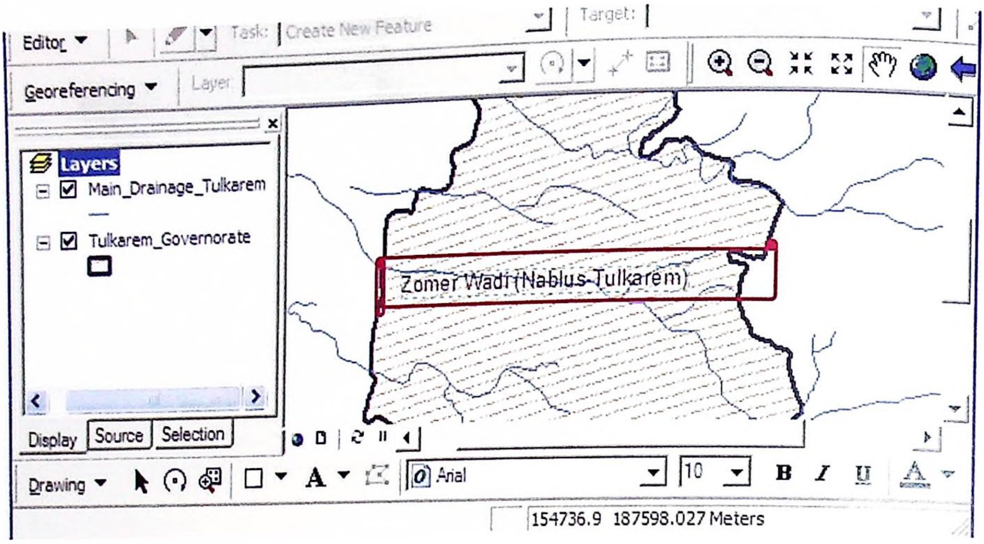


Figure 4.54: Adding a manual label to a line

4. Right-click and choose Properties to edit or add a new text line. Also change the text angle to -15°, Figure 4.55.

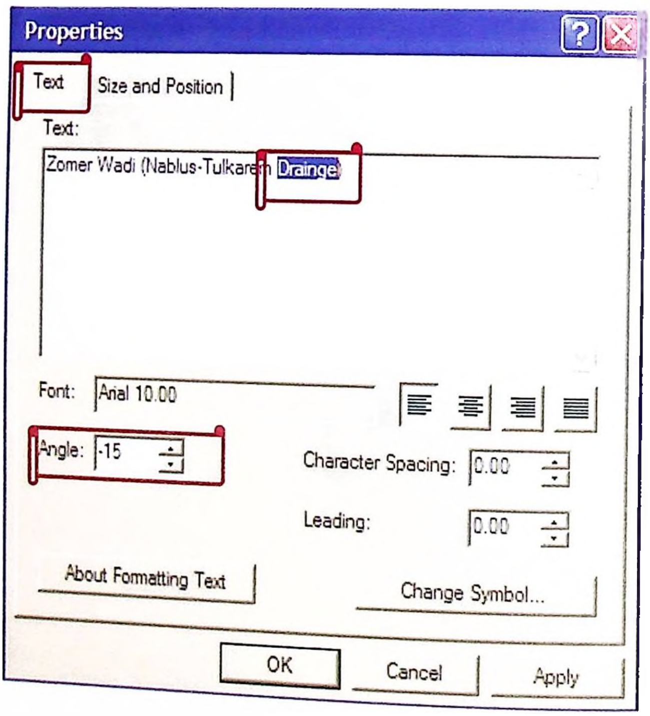


Figure 4.55: Editing labels

5. Click OK to finish, Figure 4.56

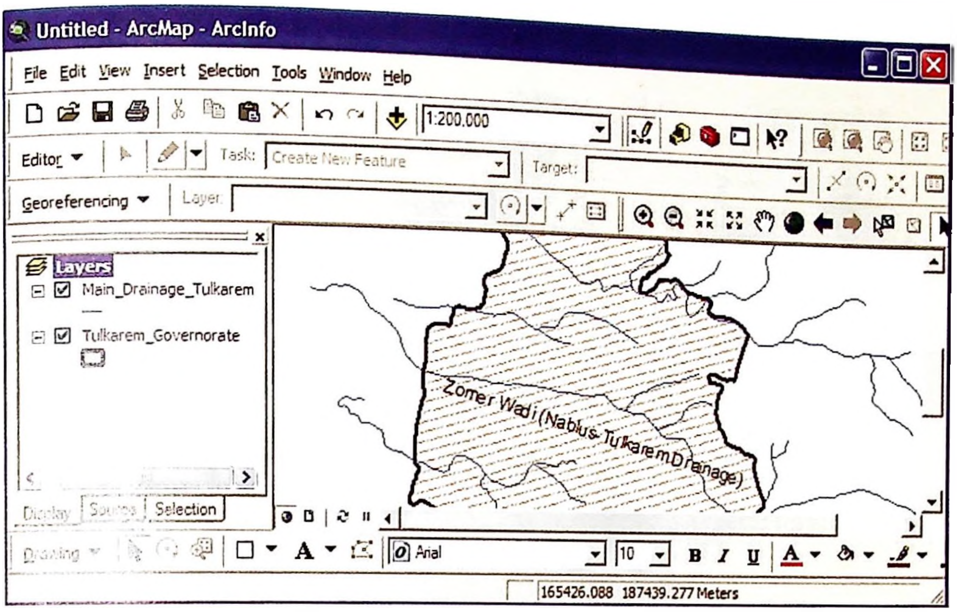


Figure 4.56: The modified label

The name of the drainage is now rotated to an angle but is still not curved with the drainage line. In this case, you should use splined text for better presentation.

6. Delete the angled text. Then use the New Splined Text tool (from the Draw toolbar), Figure 4.57.

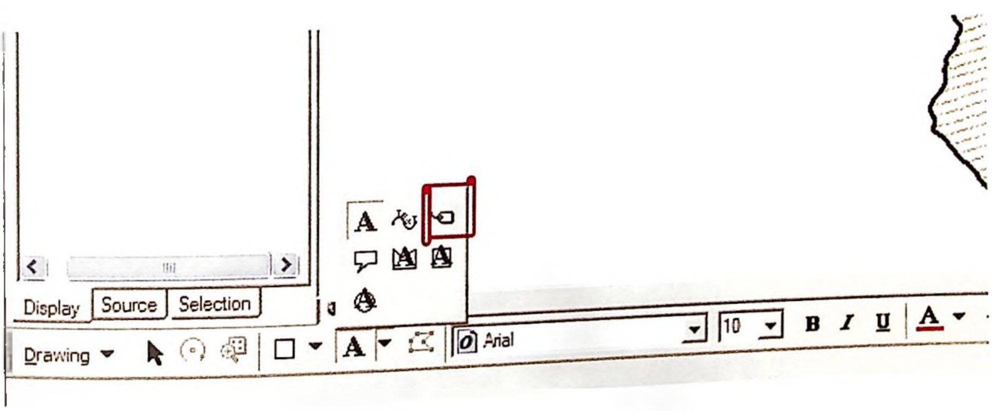


Figure 4.57: Splined Text tool

7. Use the cross cursor to create a line by clicking on the text to follow, double-click to end the spline as shown in Figure 4.58.

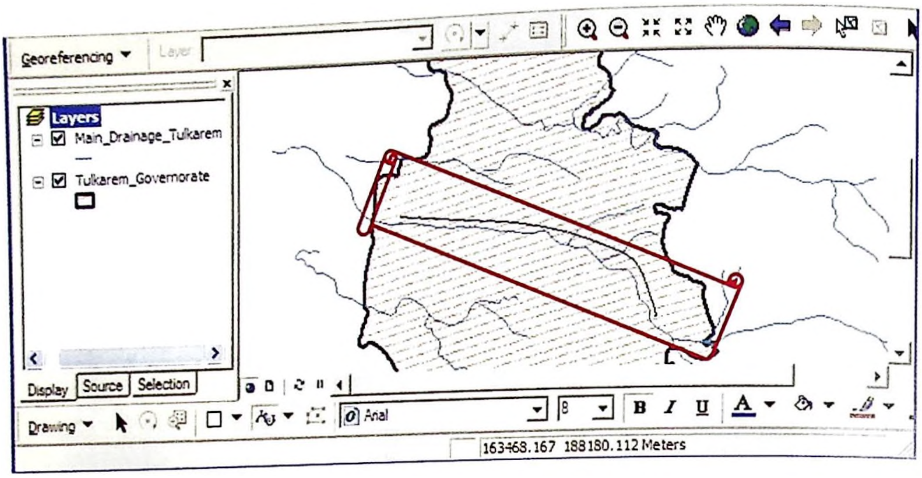


Figure 4.58: Creating the label curve

8. In the text box type "Zomer Wadi (Nablus - Tulkarem Drainage)" then press Enter to apply the spline text, Figure 4.59.

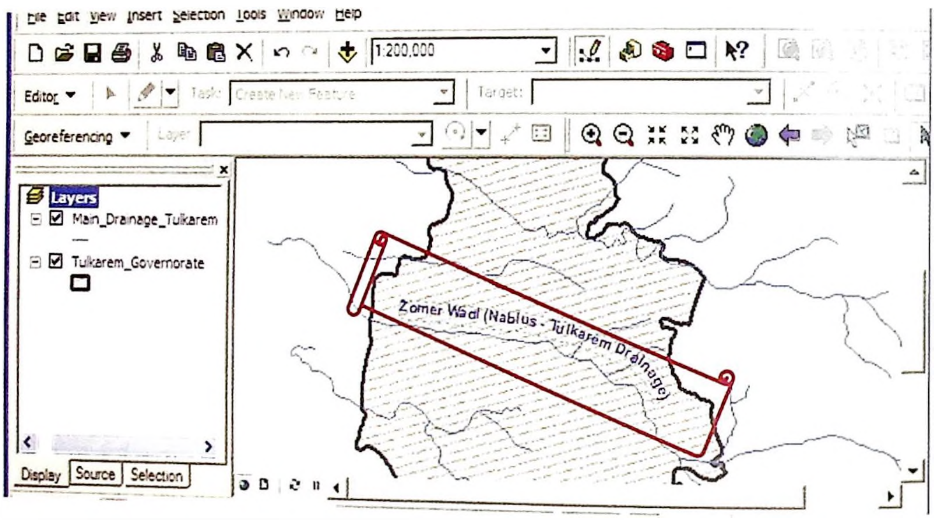


Figure 4.59: Adding spline text

9. You may use the Edit Vertices tool (from the Draw toolbar) to modify the spline. You can move the entire text by moving a vertex (the greenish boxes) or adjust the vertex 'handles' (pink boxes) to increase/decrease the curvature between vertices, Figure 4.60.

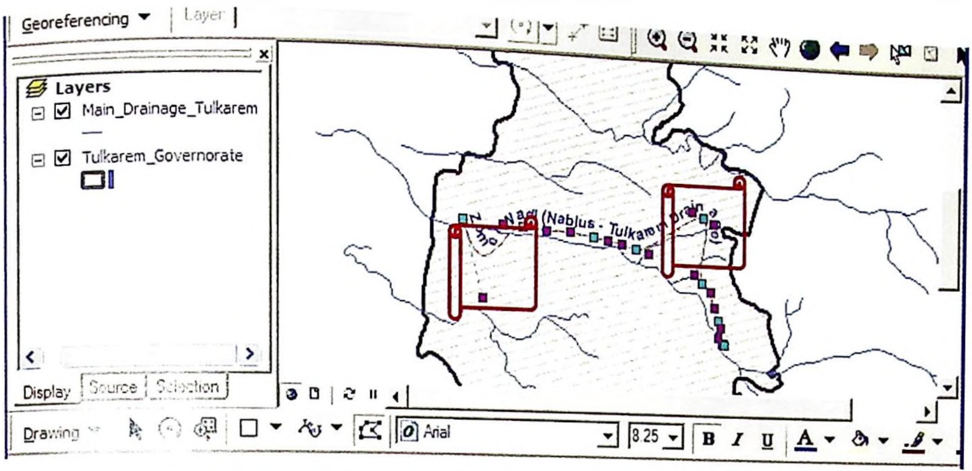


Figure 4.60: Modifying the curve of spline text

4.7.3 Preparing a Layout Using ArcGIS

1. Open a new ArcGIS map. Load the Roads, Communities and Tulkarem_Governorate shapefiles from “C:\GIS_Tutorial\Chapter4\Example8”.
2. Right-click on the Layers data frame, select Properties then open the General tab. Change the name of the data frame to Tulkarem Map.
3. Choose the symbology and labels as shown in Figure 4.61, using 1:150,000 as a map scale.

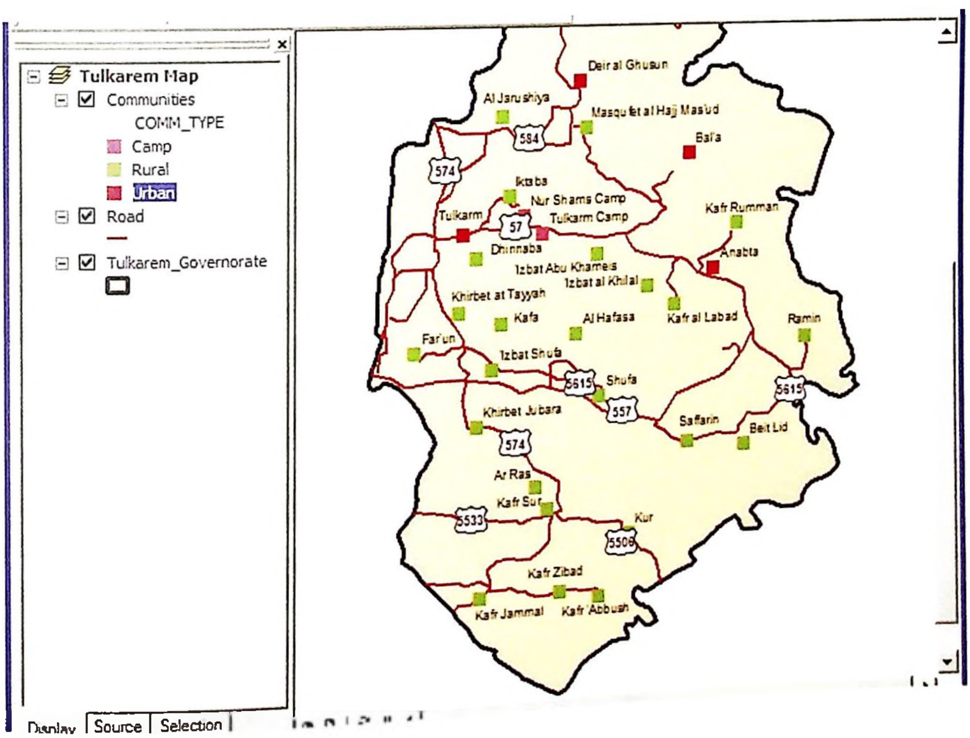


Figure 4.61: Tulkarem Governorate datasets

4. Click on the Insert menu, then click on Data Frame to insert a new map to the view. Rename the new data frame to "West Bank Map".
5. Add the Jordan River, Dead Sea and West_Bank_Governorates shapefiles to the West Bank data frame.
6. Symbolize as shown in Figure 4.62.

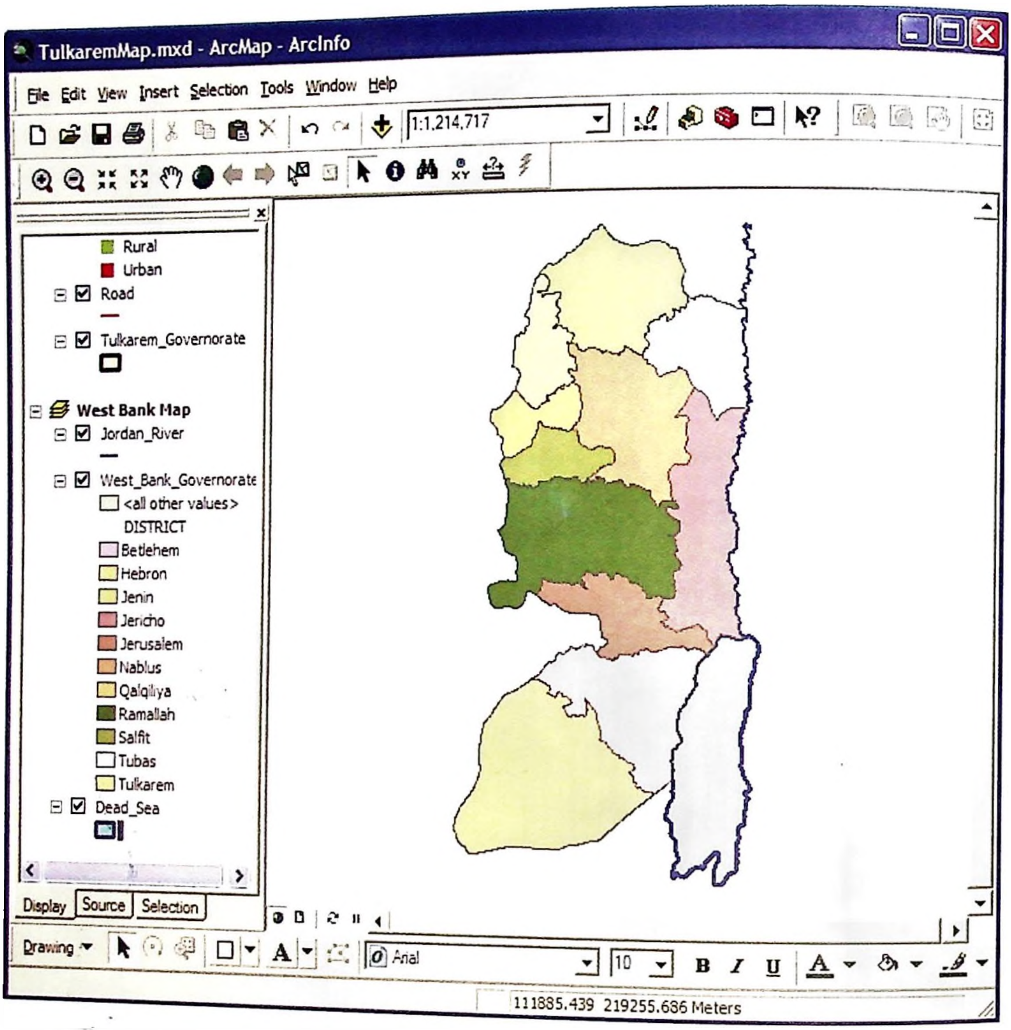


Figure 4.62: West Bank map

Now, you have two maps (data frames) in the same view. You can move from one data frame to another by right-clicking the data frame you want and then select Activate, Figure 4.63.

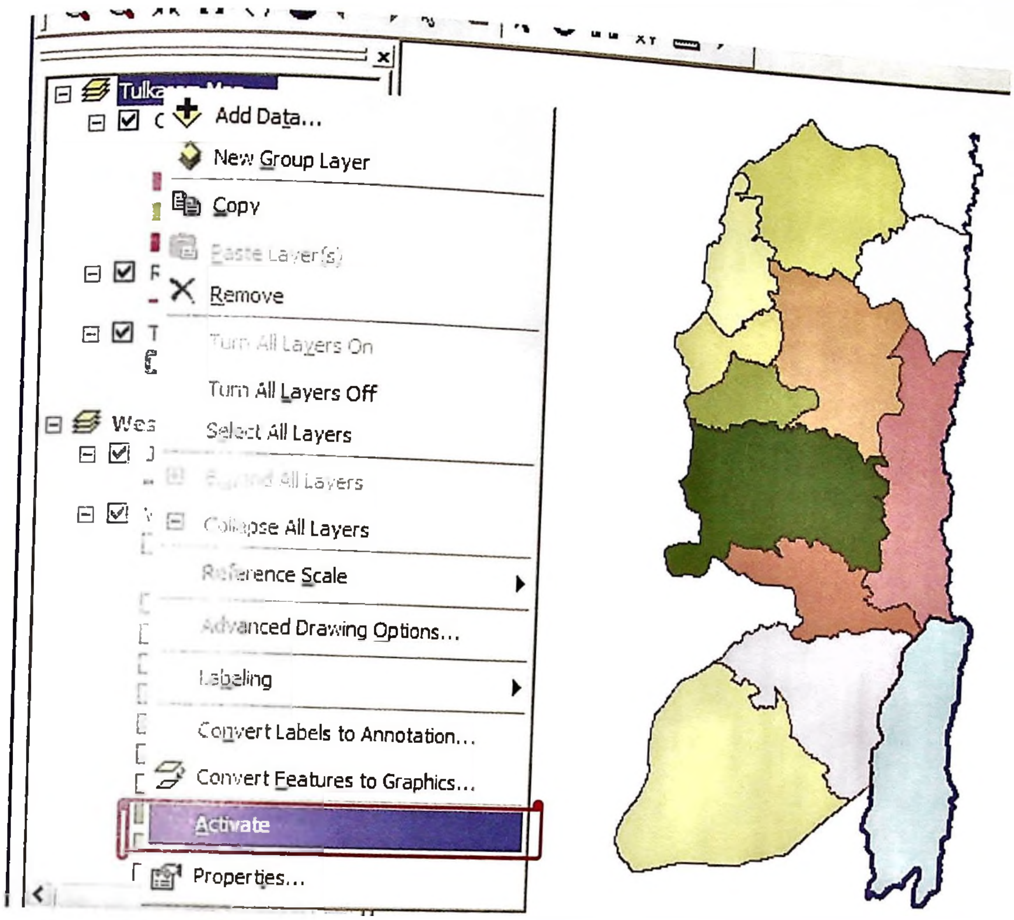


Figure 4.63: Moving between data frames

7. Zoom to full extent for both the Tulkarem Map and West Bank Map data frames.
8. To start preparing a layout, you have to switch to the layout view, Figure 4.64.

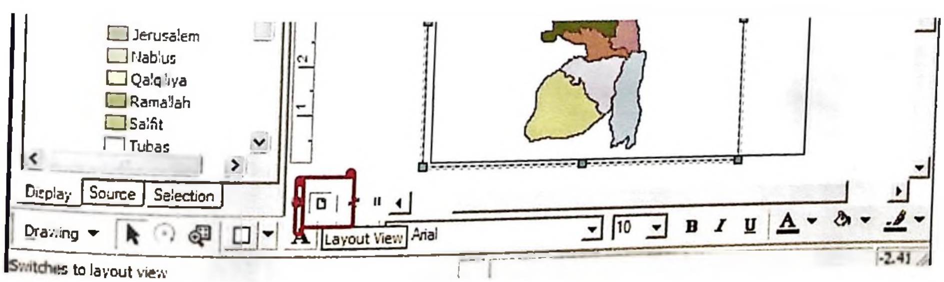


Figure 4.64: Changing to the layout view

9. You will find that the two data frames are located randomly in the layout view.
10. Right-click anywhere on the layout and select Page and Print Setup then fill out the window as shown in Figure 4.65.

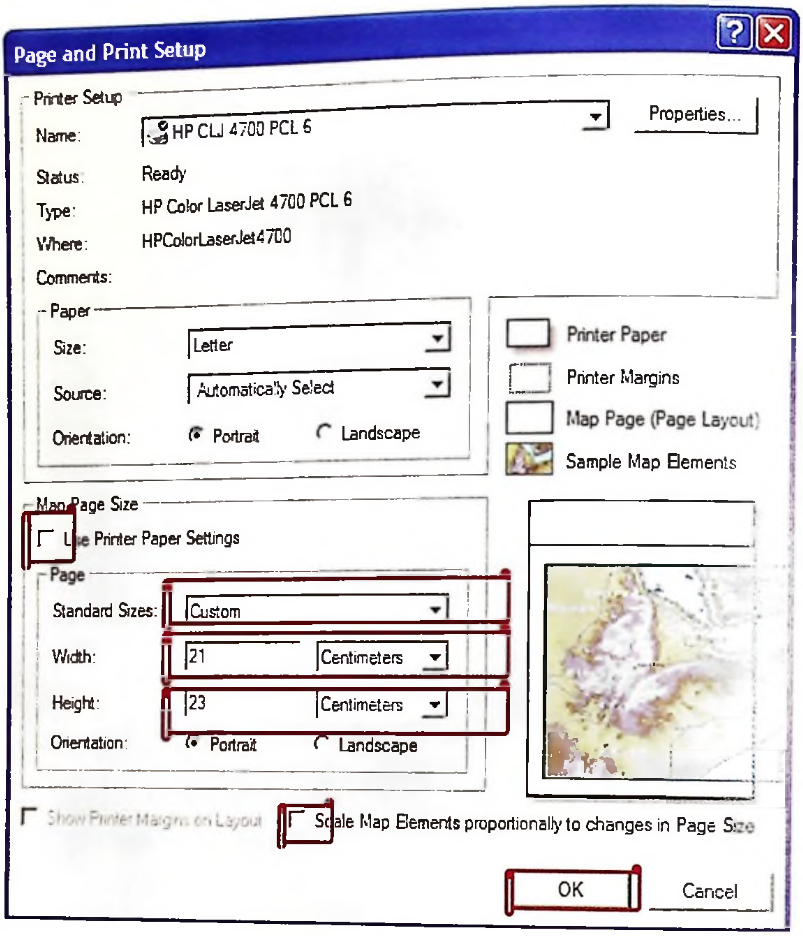


Figure 4.65: Setting up the map size and orientation

11. Click on the Tulkarem Map box, then type 1:150,000 in the scale box. Stretch (if required) the Tulkarem Map box to view the entire map within the box and in the same scale, Figure 4.66.

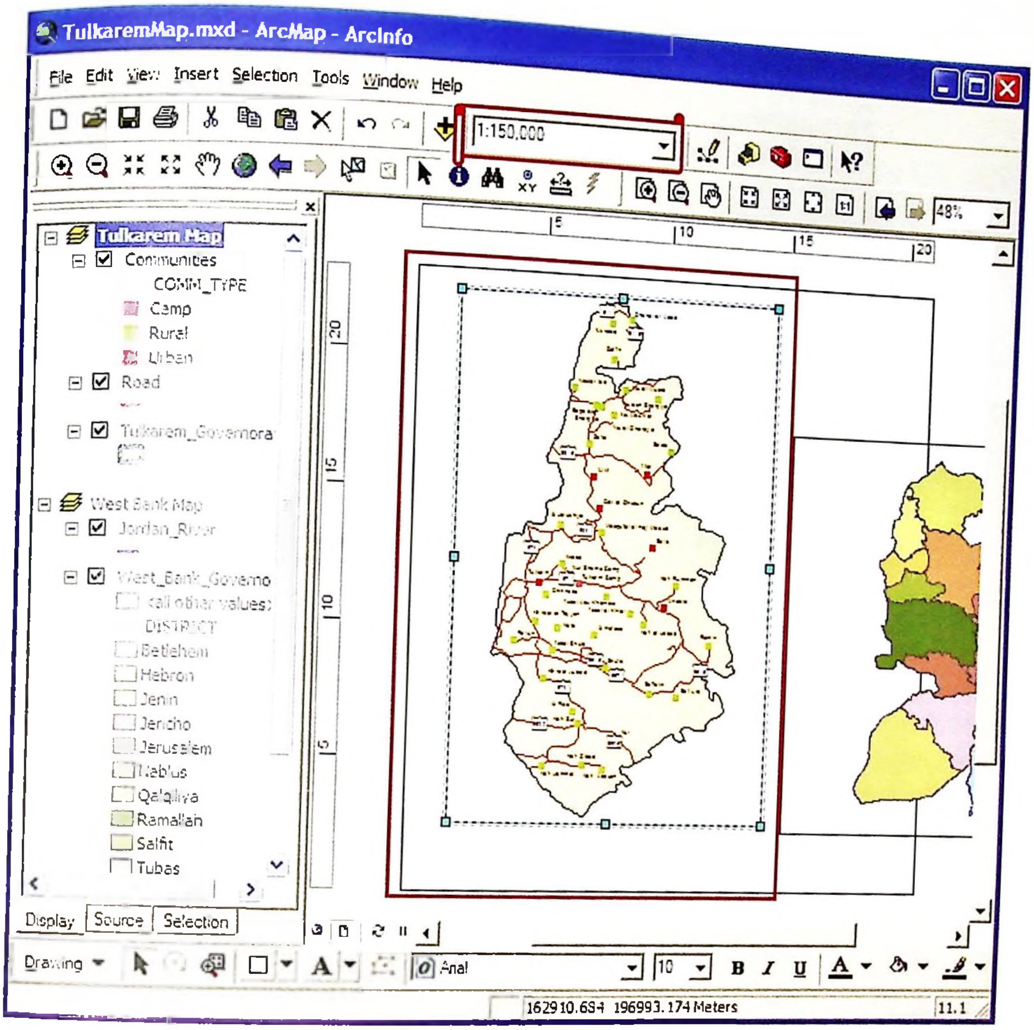


Figure 4.66: Setting the scale for the Tulkarem Governorate map

12. Right-click the Tulkarem Map box, and then click Properties.
13. Select the Position and Size tab, then move the bottom left corner of the box to 1.5 cm from the left side of the page and 1.5 cm from the bottom side of the page, Figure 4.67.

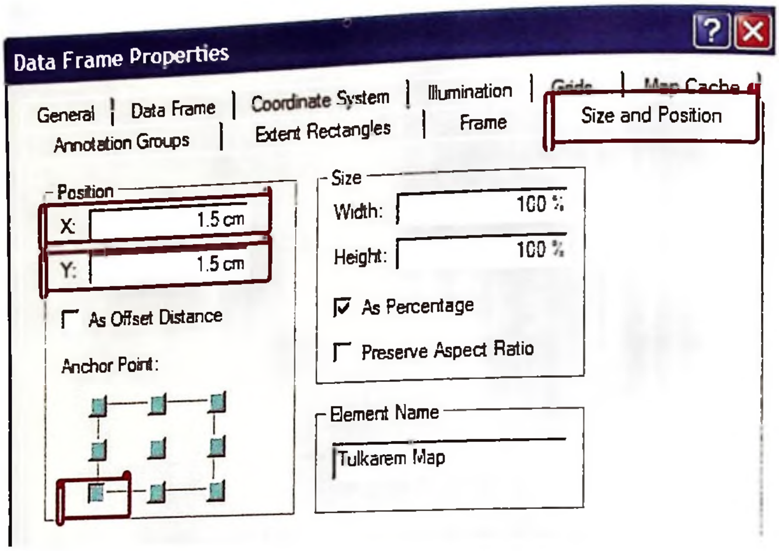


Figure 4.67: Setting the location of the Tulkarem Governorate map within the layout

14. Make sure that the Tulkarem map is activated.
15. Click the Insert menu, select the north arrow shape from the list.
16. Click the Insert menu, select the Scale Bar. Choose the Alternating Scale Bar 1 from the scale bar selector window.
17. Change the properties of the scale bar to resemble Figure 4.68.

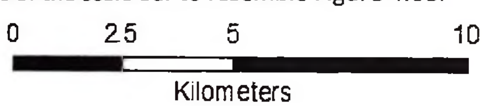


Figure 4.68: Defining the scale bar for the Tulkarem map

18. Click the Insert menu, select Legend. Change the properties of the legend to be similar to those in Figure 4.69. You may need to change the name of the shapefiles in order to arrange the legend's elements (e.g. the Tulkarem_Governorate shapefile changed to Tulkarem Border).

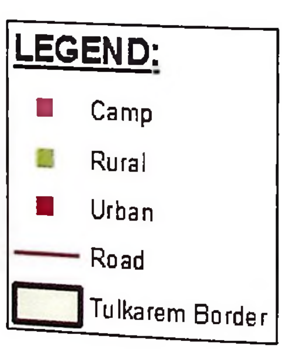


Figure 4.69: Defining the legend (key map) for the Tulkarem map

19. Click the Insert menu, select Text. Type "Data Source: Al Quds University Data Base".

20. Double-click on the textbox and then add two text lines as follows:
    a. "Creation date: Sept. 2008"
    b. "Map projection: Palestinian Grid"
21. Click the Insert menu, select Title. Type "Tulkarem Governorate" as the title of the map. Change the font size to 18, bold.
22. Resize the West Bank Map box to about 5 cm in width and 8 cm in height.
23. Arrange all map elements (north arrow, scale bar, legend, text box, West Bank map and title) as shown in Figure 4.70.

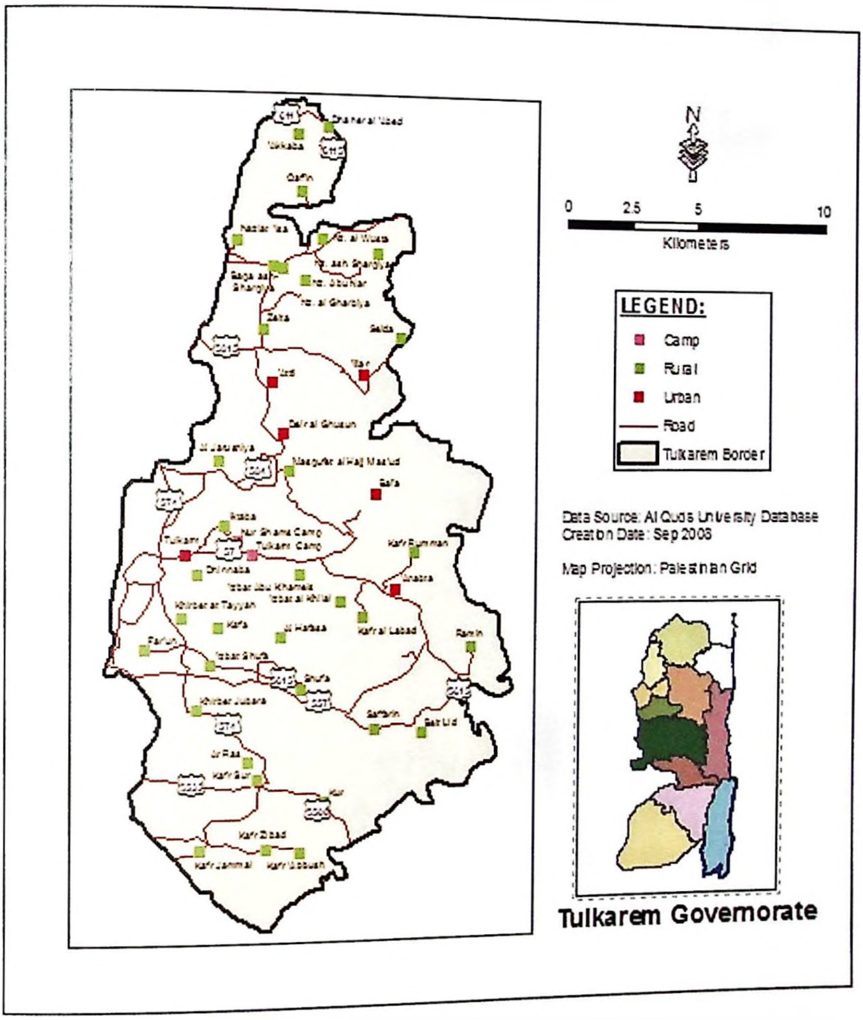


Figure 4.70: Arranging map items within the layout frame

24. Right-click on the Tulkarem Map box. Click Properties then select the Grid tab. Click on New Grid, Figure 4.71. The Grids and Graticules wizard will open.

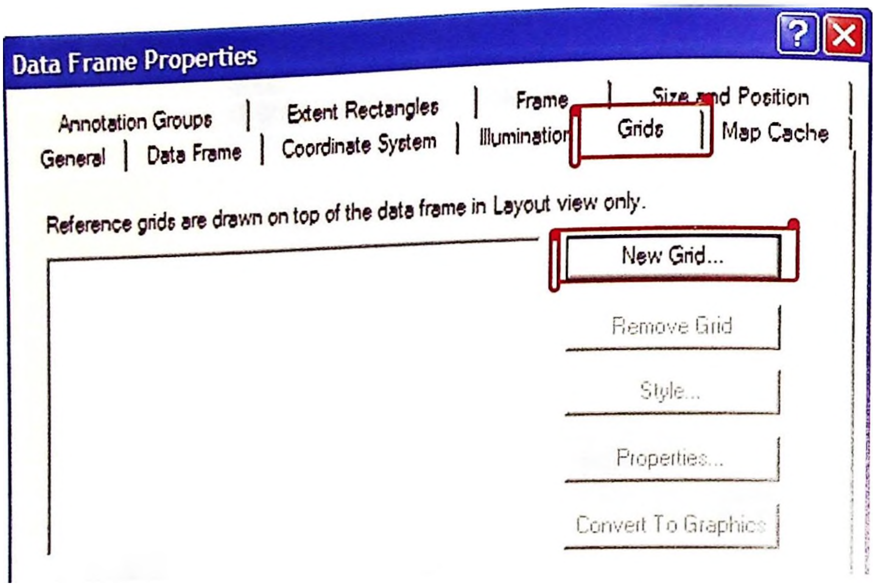


Figure 4.71: Defining a grid for the Tulkarem map

25. Select Measured Grid to divide the map into a grid of map units, then click Next, Figure 4.72.

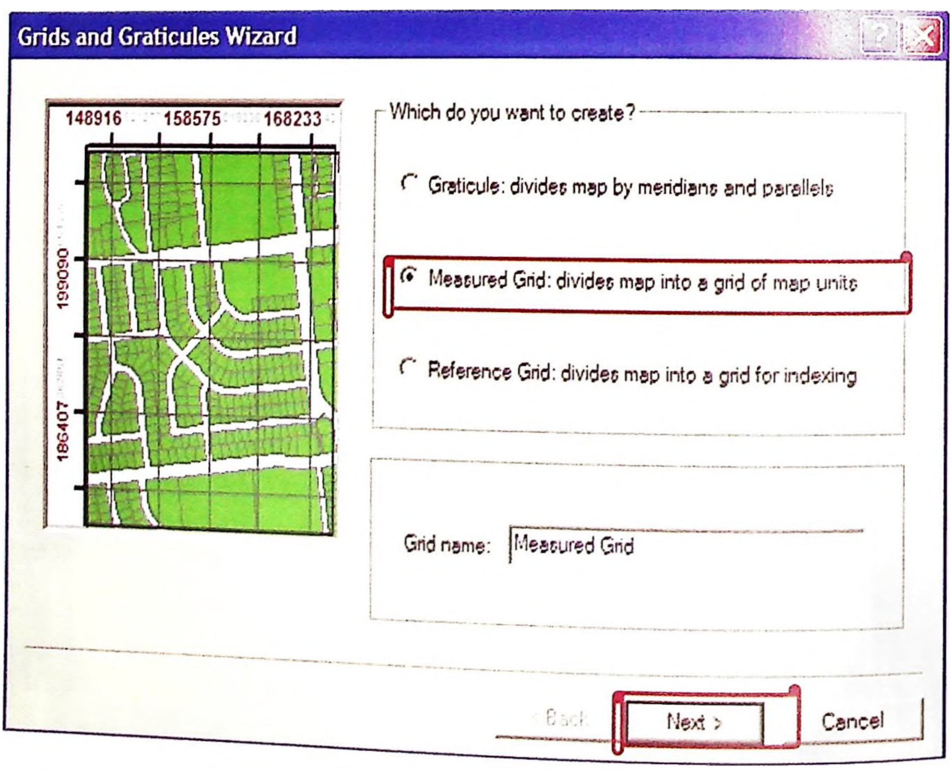


Figure 4.72: Grids and Graticules wizard

26. Click Next until you return to the Grid tab. Click on the Properties button; open the Labels tab from the Reference System Properties window.

27. Click on the Additional Properties button in order to open the Grid Label Properties window
28. Click on the Number Format button to edit the number of decimals to zero, Figure 4.73.
29. Close the Grid Label Properties and Number Format Properties windows by clicking OK.

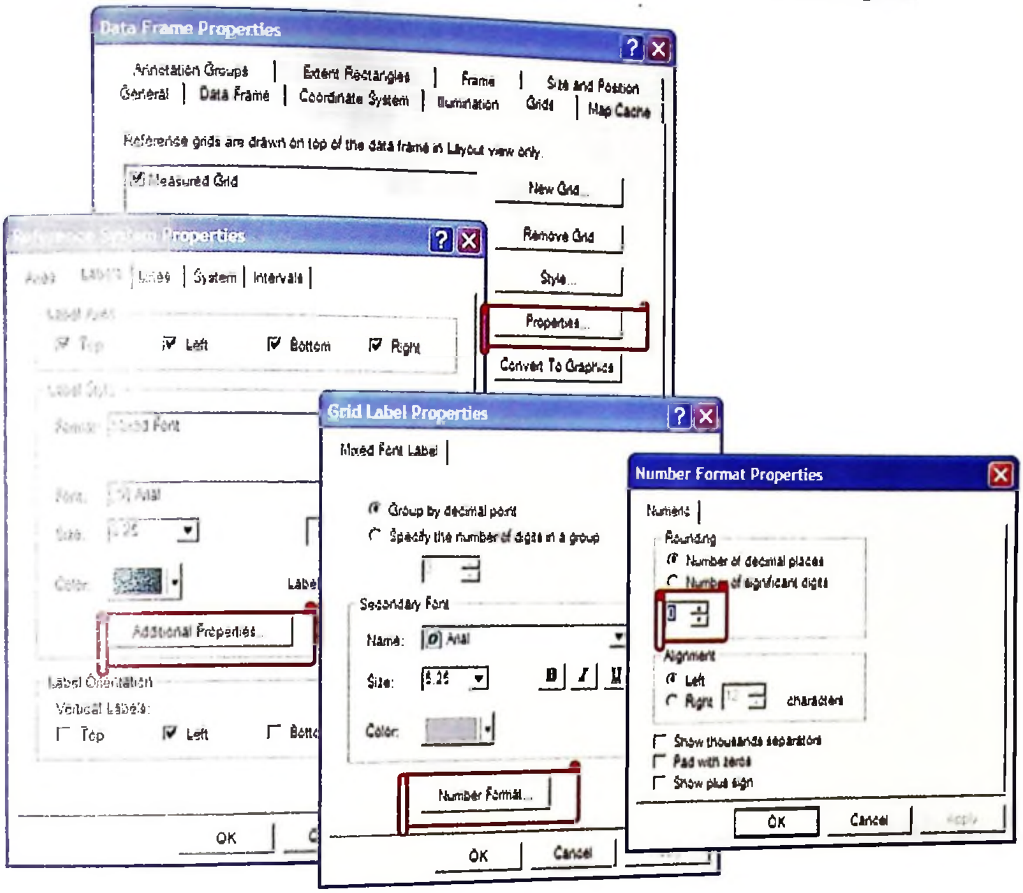


Figure 4.73: Modifying the grid properties

30. Click on the Intervals tab from the Reference System Properties window. Change the X and Y intervals to 2500 meters, Figure 4.74.

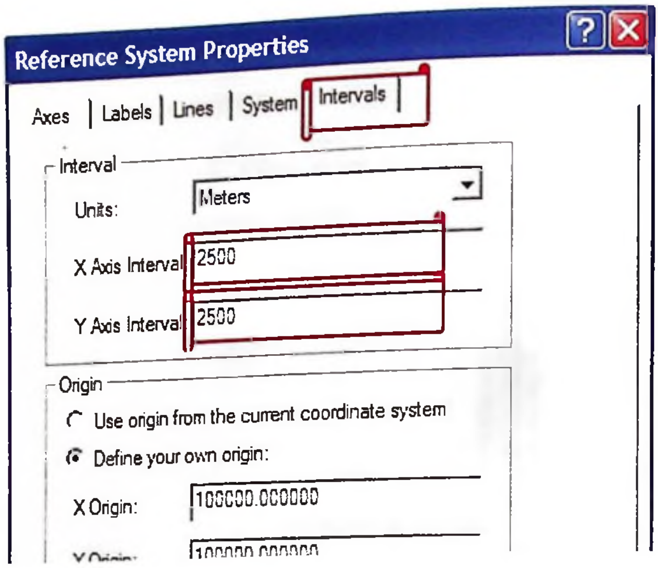


Figure 4.74: Setting grid intervals

31. Click OK until you close all open windows. The grids will be added to the map, Figure4.75.

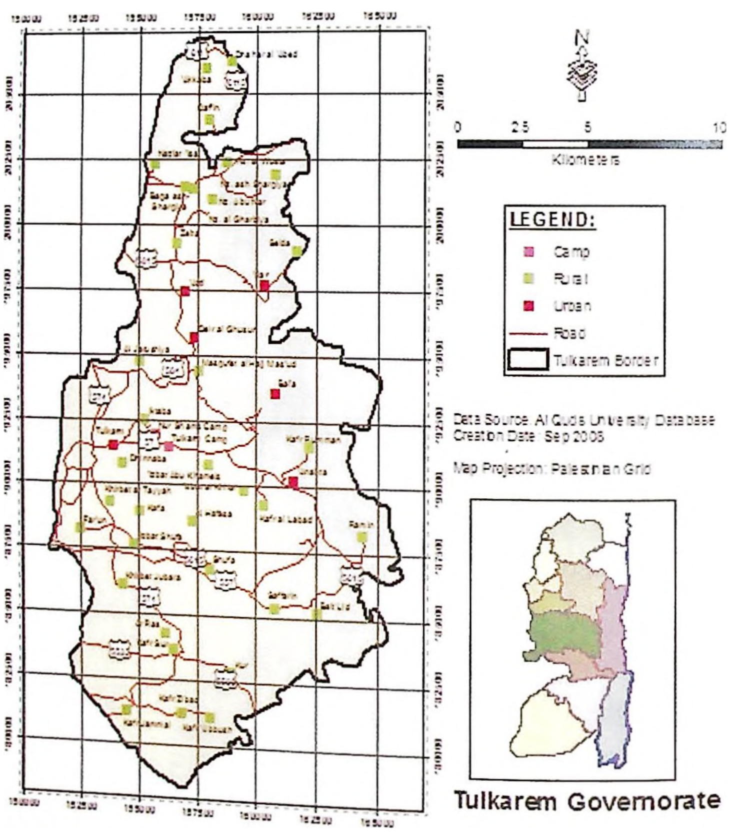


Figure 4.75: Adding grids to the Tulkarem map

32. Click the Insert menu, select Neatline. Fill out the Neatline window details as shown in Figure 4.76, then Click OK.

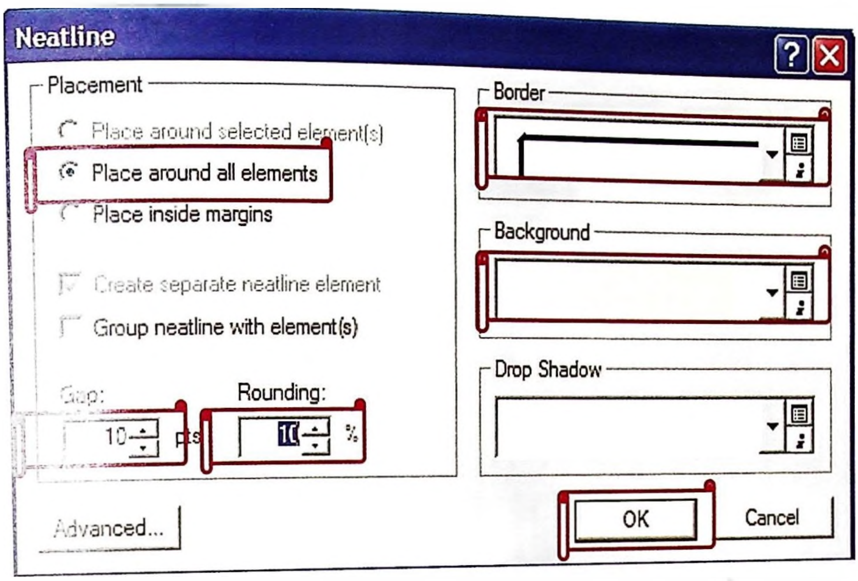


Figure 4.76: Drawing a neatline on the layout

33. The aim of adding the West Bank map to the layout is to show the location of Tulkarem Governorate within West Bank. To view this location, right-click the West Bank map data frame from the table of contents, click Properties then open the Extent Rectangles tab.
34. Add the Tulkarem map to the West Bank data frame, Figure 4.77. A red box around Tulkarem Governorate will appear.

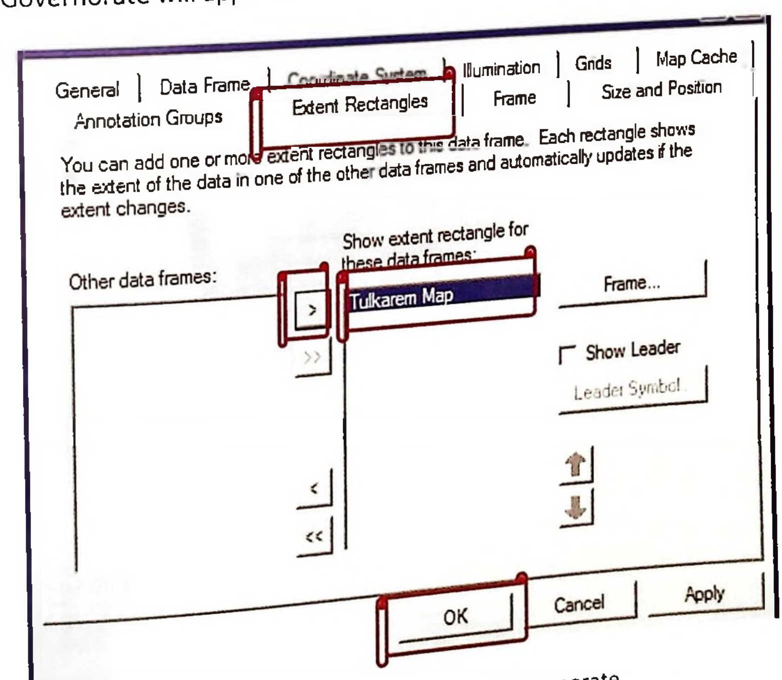


Figure 4.77: Adding a rectangular box around Tulkarem Governorate

35. Open the Frame tab then remove the border around the West Bank map box.
36. You can add the name of the cartographer, where the map is stored on the server and the logo of the institution. The final outline map should resemble Figure 4.78.

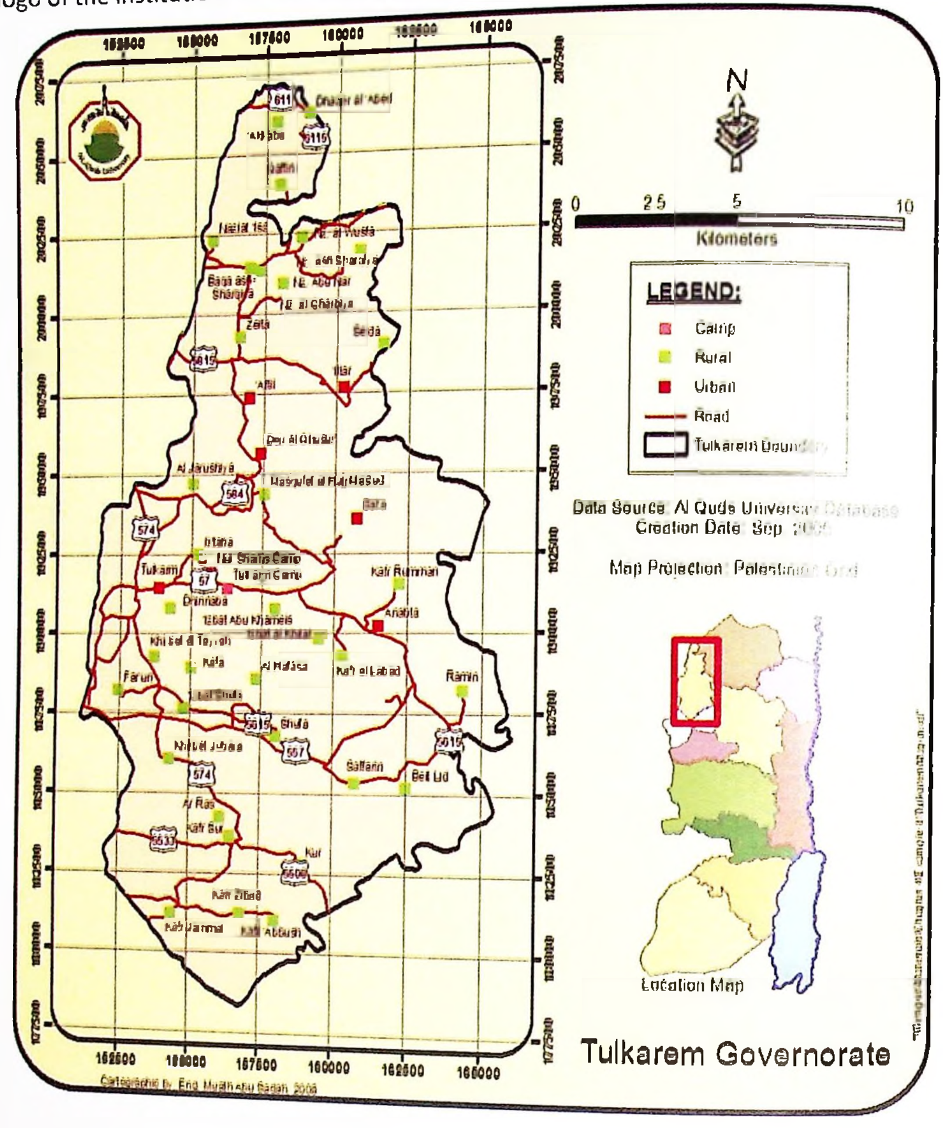


Figure 4.78: Final map layout

4.7.4 Exporting and Printing Maps

The map prepared in Section 4.7.3 may be printed out on paper using a printer or plotter or may be exported as an image with many alternative extensions.

1. Use the same map prepared in the section above, click File, and then click Print to choose the available printer and to set up the page properties as required, Figure 4. 78.

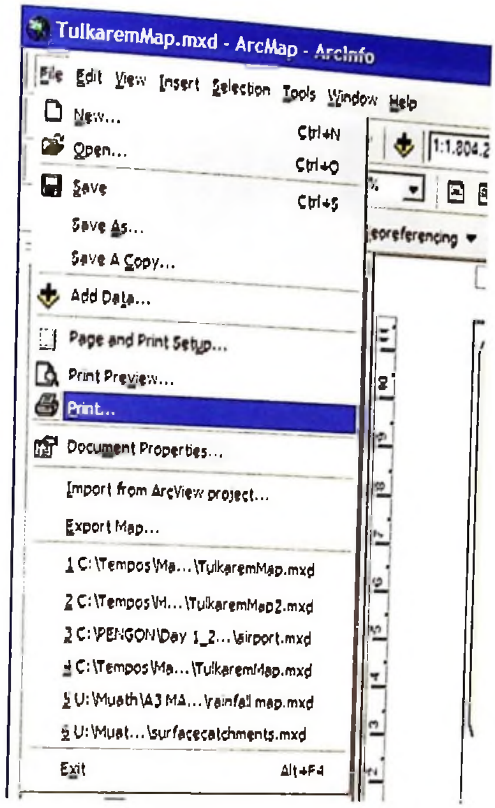


Figure 4.78: Print out a map

2. To export the map as an image, Click File then click Export Map.... The Export dialog box will then open. You can select the folder where you want to store the image, its name, resolution, format and type, Figure 4.79.

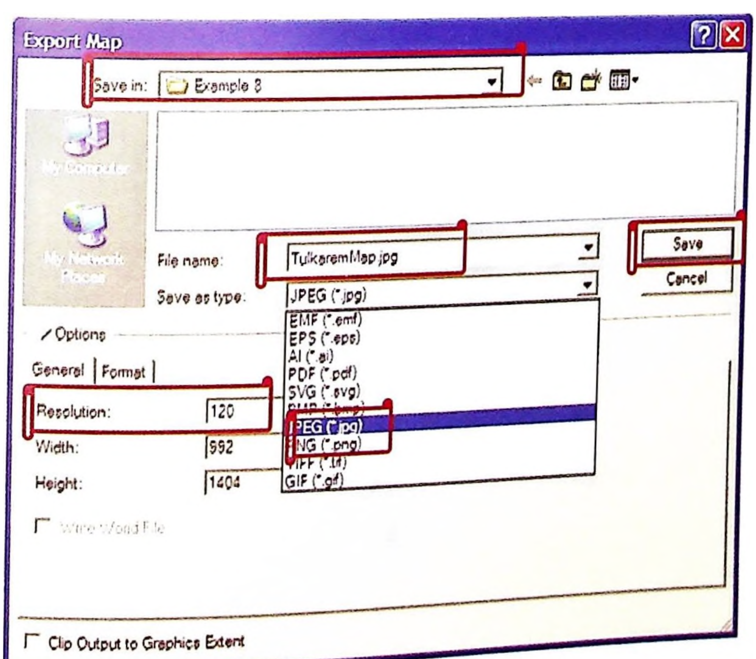


Figure 4.79: Exporting a map as an image

4.8 Discussion

1. Discuss the following terms:
    a. Map
    b. Cartography
    c. Generalization
    d. Data symbology
    e. Map scale
2. What is the best choice for classifying a DEM on a map?
3. What is the difference between the following interval classes?
    a. Equal steps
    b. Quantile
    c. Standard deviation
    d. Natural breaks
4. What is the difference between mutually exclusive classes and exhaustive classes? Give an example.
5. Use the datasets in this Chapter (Example 1- Example 8) to prepare the following maps for Tulkarem Governorate, try to use most of the map elements and also try develop different map styles:
    a. A map showing communities within the Governorates classified according to population size, quantify the symbology (symbol size).
    b. A map showing land use within the Governorate classified according to land use types, use category symbology.
    c. A map that displays geology within the Governorate classified according to the geological formation, use category symbology.

Querying and Editing GIS Datasets

Chapter 5

Querying and Editing GIS Datasets

5.1 Introduction

The ArcGIS Desktop software is rich with tools and functions needed to utilize spatial datasets. This Chapter introduces a range of functions available in the software and the essential tools for visualizing, creating, editing, managing, and analyzing geographic data. The exercises in this Chapter encourage the practice of ArcMap and ArcCatalog applications to perform common GIS tasks and workflows. The main topics covered include:

- Creating and editing features and attributes: creating spatial datasets, working with the Editor toolbar and common editing tools, snapping to features while editing, editing attributes; and calculating values for geometry fields.
- Managing map layers: bookmarks, layer selection and creating hyperlinks.
- Managing tables: getting information from tables, summarizing tables, field properties, and creating graphs.

5.2 Creating and Editing Features in ArcGIS

5.2.1 Creating Features

The most common way to create new lines or polygons is by digitizing the vertices that make up the feature. For example, to create a square building, you would digitize the four corners. In ArcMap, the Editor toolbar contains the most common tools used to create lines and polygons, Figure 5.1.

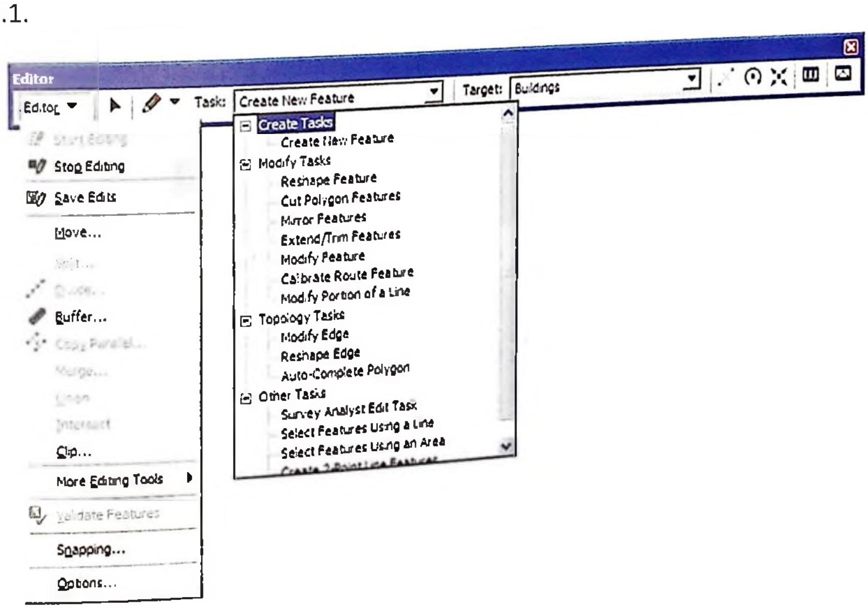


Figure 5.1: Editor Toolbar

In addition to the Editor toolbar comes another toolbox called the Advanced Editing toolbar which is used for creating lines or polygons, Figure 5.2. The Advanced Editing toolbar contains some tools that can be used to create new lines and polygons. For example, if you want to draw a simple rectangle or circle feature very quickly, use the Advanced Editing toolbar.

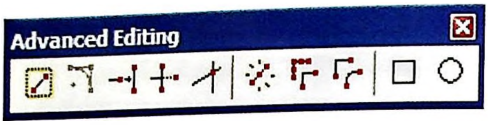


Figure 5.2: Advanced Editing toolbox

To create a new shapefile, you should start from ArcCatalog in order to store all features included within the shapefile.

1. Open ArcCatalog, browse to “C:\GIS_Tutorial\Chapter5\Example1”.
2. Right-click on the “Example 1” folder, click New then select Shapefile to open the Create New Shapefile dialog box, Figures 5.3 and Figure 5.4.

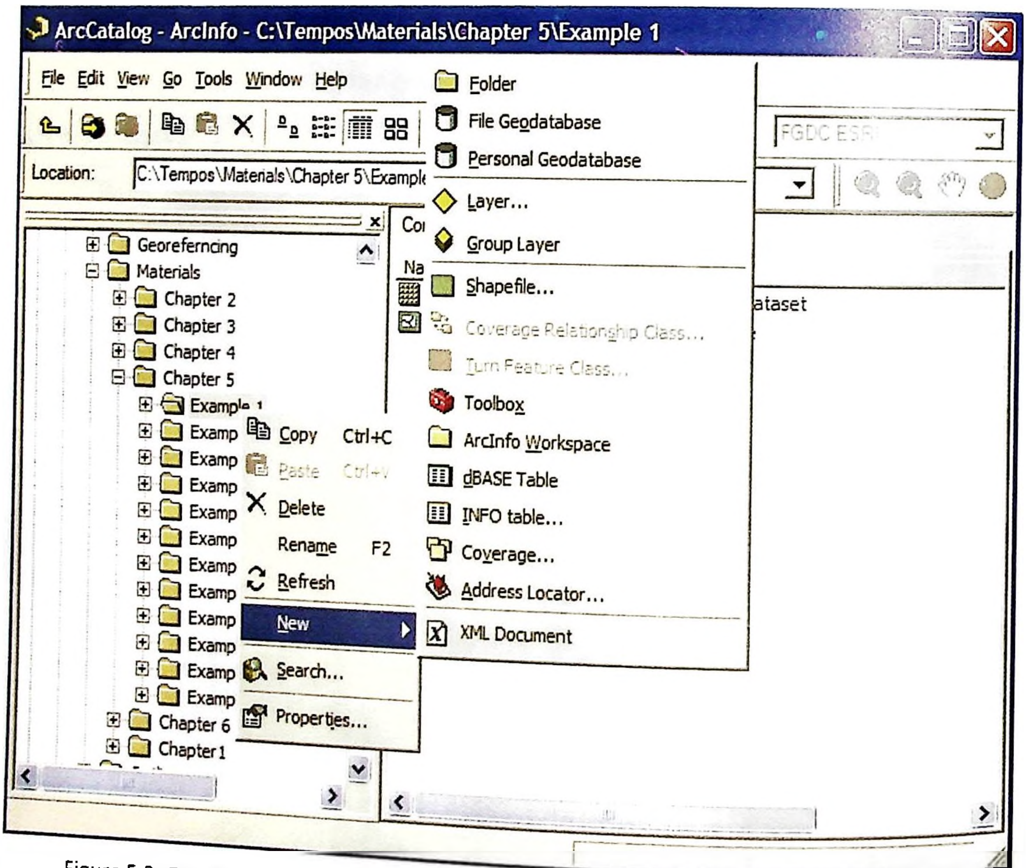


Figure 5.3: Creating a new shapefile

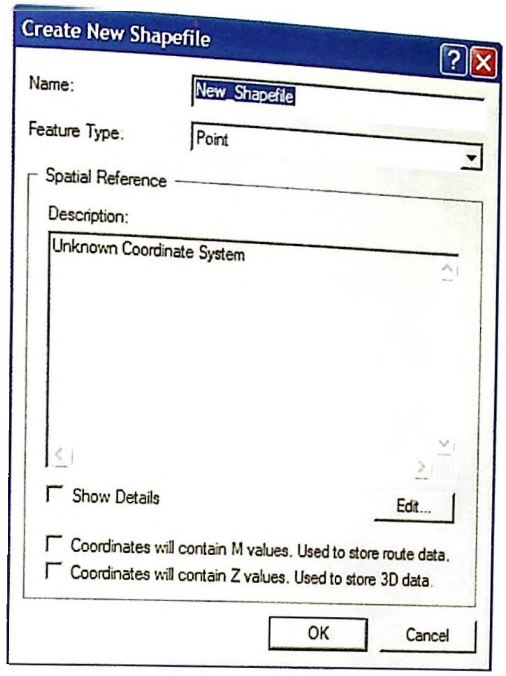


Figure 5.4: Creating a New Shapefile dialog box

3. Type "Landuse" in the Name box as the name of the shapefile.
4. From the Feature Type dropdown arrow box, select Polygon.
5. Click the Edit button to define the grid system of the Landuse shapefile (choose the Palestinian grid system)
6. Click OK to finish creating the Landuse shapefile, Figure 5.5.

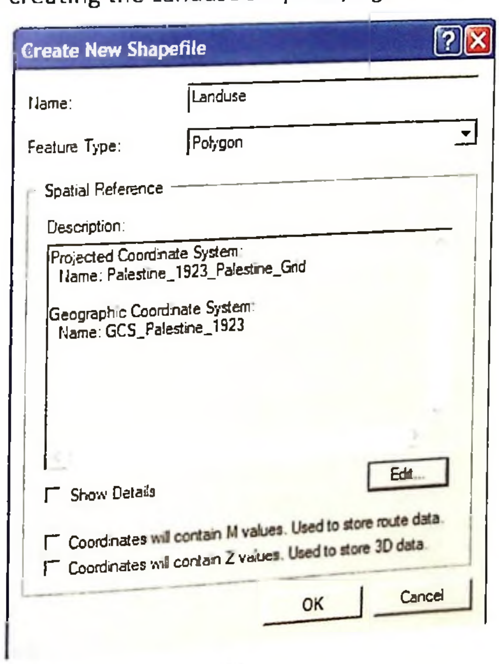


Figure 5.5: Setting new shapefile properties

The creation of the attribute table for a new shapefile is different from the creation of the shapefile itself. Once you have created the shapefile as described above, you need to find that shapefile in ArcCatalog.

7. Expand the "Example 1" folder in ArcCatalog, right-click on the Landuse shapefile and choose Properties.
8. Click on the Fields tab and add two new fields named "Type" and "Area". Notice that for any field you add, you will need to give a name (maximum of 11 characters, no spaces), define the field type, and depending on the type, define the other properties of that field (e.g., length; make sure the length is sufficient enough for the longest value). You can amend these later, but this is the easiest place to set up a table, Figure 5.6.

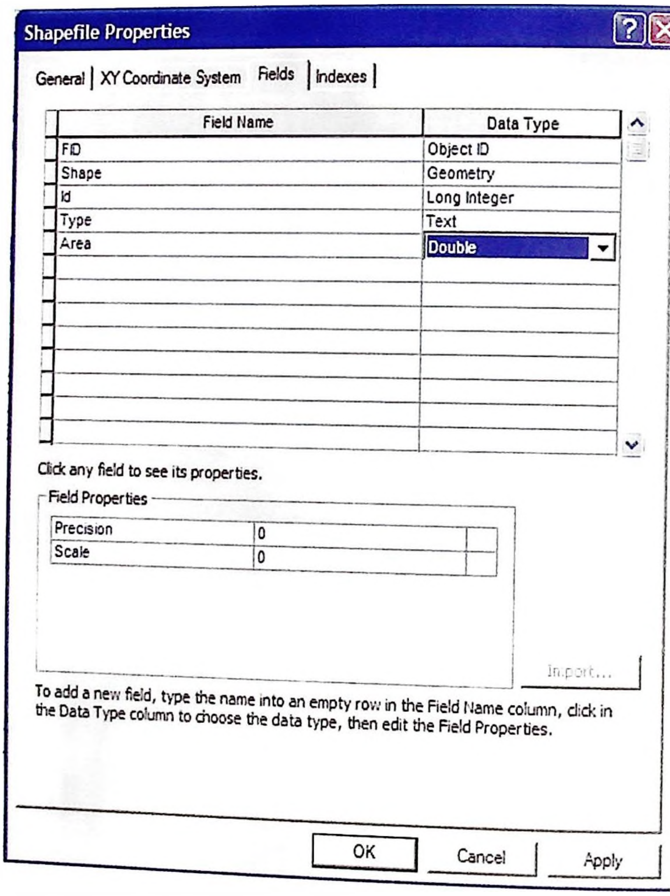


Figure 5.6: Defining new fields for the new shapefile

9. Open a new ArcMap document. Add the Landuse.bmp image and Landuse shapefile from "C:\GIS_Tutorial\Chapter5\Example1".
10. If the Editor toolbar does not appear in the ArcMap interface, click the Editor button, Figure 5.7.

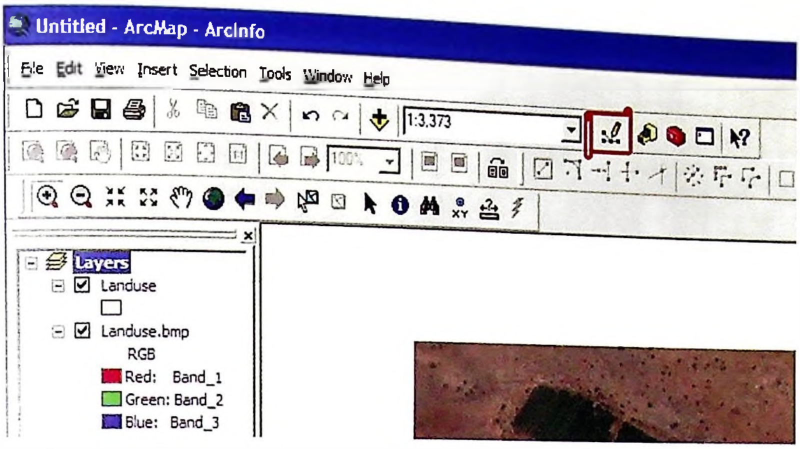


Figure 5.7: Opening the Editor toolbar

11. From the Editor toolbar, click the Editor dropdown arrow and select Start Editing to start editing the target shapefile (i.e. Landuse shapefile). When asked which folder it is in, choose the folder that contains that shapefile ("C:\GIS_Tutorial\Chapter5\Example1", Figure 5.8, then click OK.

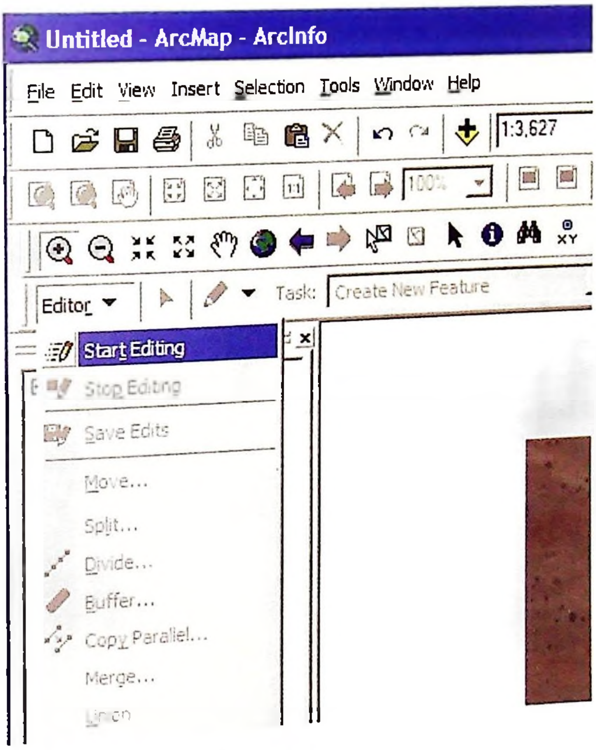


Figure 5.8: Changing ArcMap to editing mode

12. Make sure that on the Editor toolbar, the Task item says Create New Feature, and the Target is the Landuse shapefile, Figure 5.9.

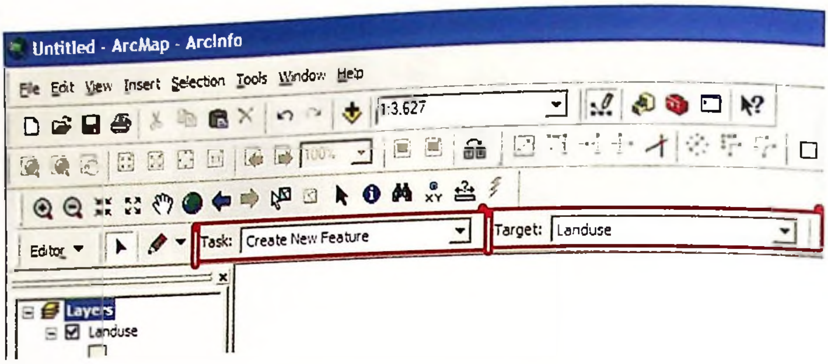


Figure 5.9: Setting the Editing parameters

13. You are now ready to create the first feature in the Landuse shapefile. To do this, click on the Pencil icon (make sure to choose the Pencil, not the other editing tools).
14. Place the cursor on the map where you want to begin your new polygon feature (e.g. start with the Orchard land use type shown in the land use image), you should see a circle with a cross-hair in it, click once. Then go to the next point that defines your parcel and click again. Continue doing this until you are almost back to the last point. To close the polygon, double-click on the next-to-last point, or press F2 after the next-to-last point. If you mix up, you can either double-click to finish, and then press the Delete key on the keyboard, or you can right-click and choose Delete Sketch. It may take a few attempts to get it right, Figure 5.10.

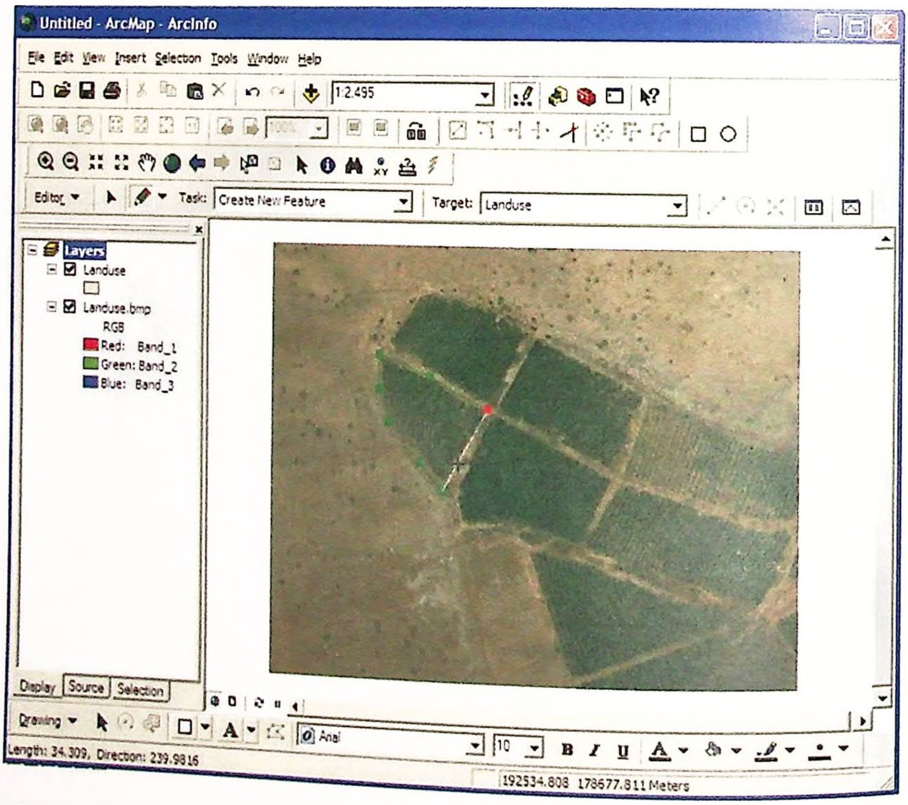


Figure 5.10: Digitizing the first land use parcel

15. If you want to add vertices to a polygon in order to modify it, click the Edit tool from the Editor toolbar, Figure 5.11. Double-click on the polygon you want to add vertices to then put the pointer where you want to add a vertex. Right-click then select Insert Vertex.

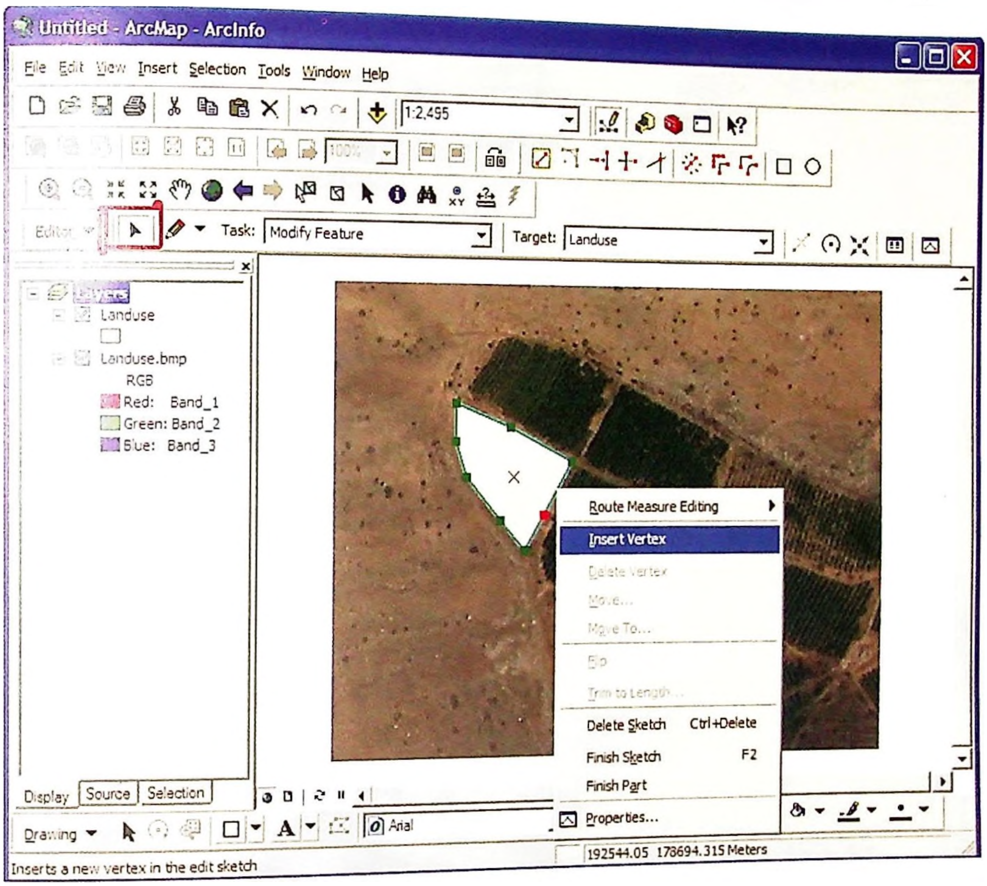


Figure 5.11: Inserting a new vertex

16. To define the type of the digitized land use polygon in the attribute table, click Attributes in the Editor toolbox, then click on the box on the right of the Type field and type in "Orchard", Figure 5.12.

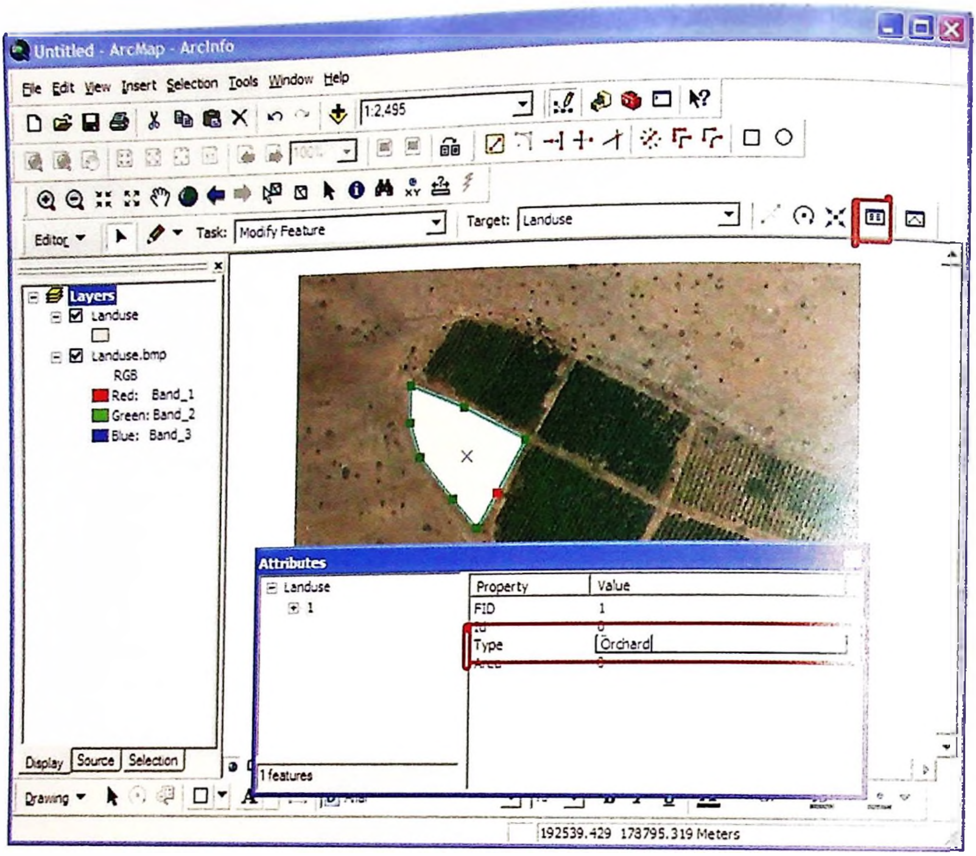


Figure 5.12: Editing feature attributes

5.2.2 Snapping Environment

To digitize other parcels, it is preferred to work in a snapping environment. A snapping environment can help establish exact locations in relation to other features. For example, you can move a parcel and have one of its corners jump, or snap, precisely to a corner of other parcel. Simply move the parcel's selection anchor to its corner vertex after setting the appropriate snapping properties. Then move the parcel toward its new location until the selection anchor snaps to the corner vertex of the other parcel.

1. To set the snap properties for accurately digitizing other polygons click the Editor button in the Editor toolbar. Then choose Snapping to open the Snapping Environment window.
2. You can choose the part of the feature, vertex, edge, or endpoint to which you want your new feature to snap by setting the layer snapping properties. To make your new feature (next land use parcel) snap to the vertex of an existing land use parcel (created in step 14) in the Landuse layer, check the box under Vertex next to the Landuse layer in the Snapping Environment window, Figure 5.13.

In case you have more than one editable layer, you can set the snapping priority for layers on your map. The order of layers listed in the Snapping Environment window determines the order in which snapping will occur. Snapping occurs first in the layer at the top of the list, then in each consecutive layer down the list. You can easily change the snapping priority by dragging the layer names to new locations.

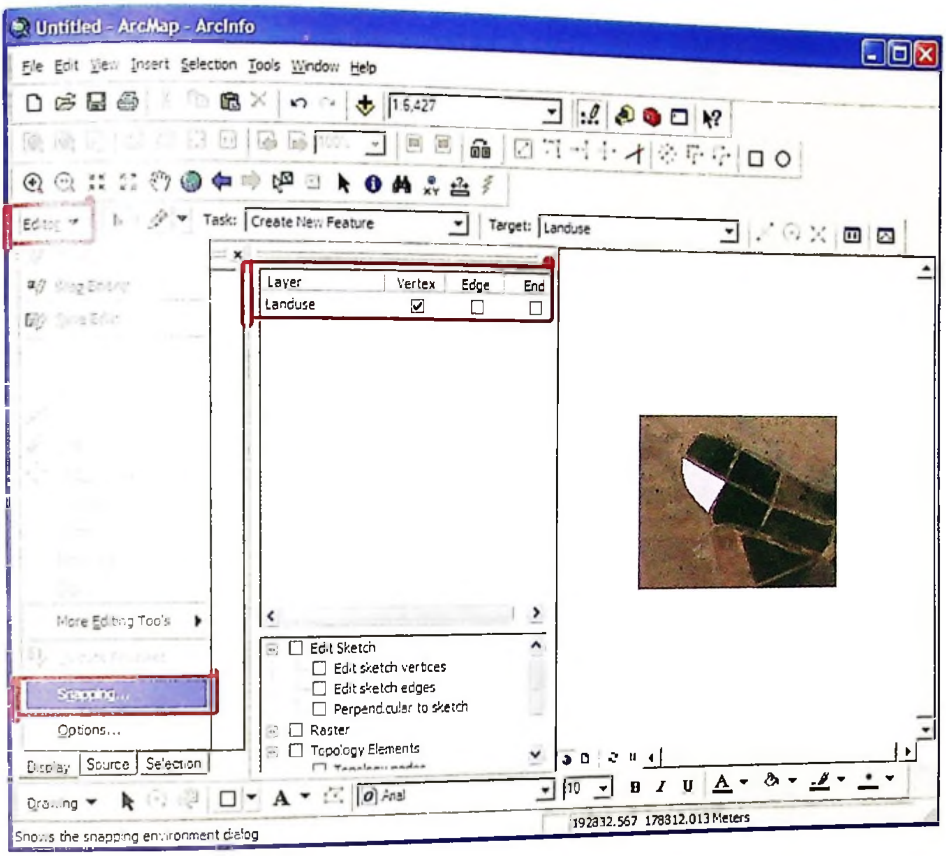


Figure 5.13: Setting the snapping parameters

5.2.3 The Snapping Tolerance

The snapping tolerance is the distance within which the pointer or a feature is snapped to another location. If the element being snapped to, such as a vertex or edge, is within the distance you set, the pointer automatically snaps to the location.

1. Click the Editor button in the Editor toolbar, then click Options.
2. Open the General tab of the Editing Options dialog box.
3. Set 1 map unit as the snapping tolerance as shown in Figure 5.14. Then click OK.

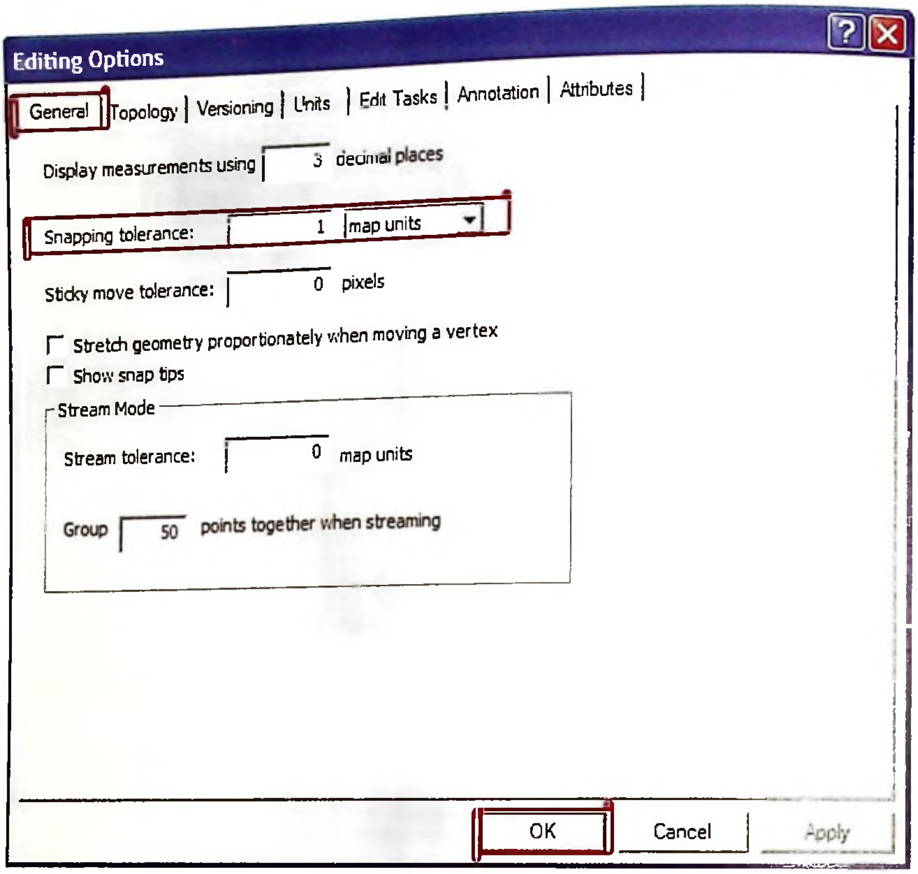


Figure 5.14: Defining the snapping tolerance

4. When editing, press the T key to view a circle illustrating the snap tolerance as drawn in green in Figure 5.15.

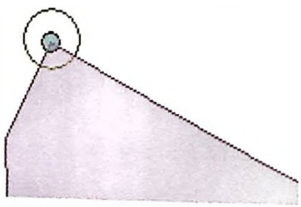
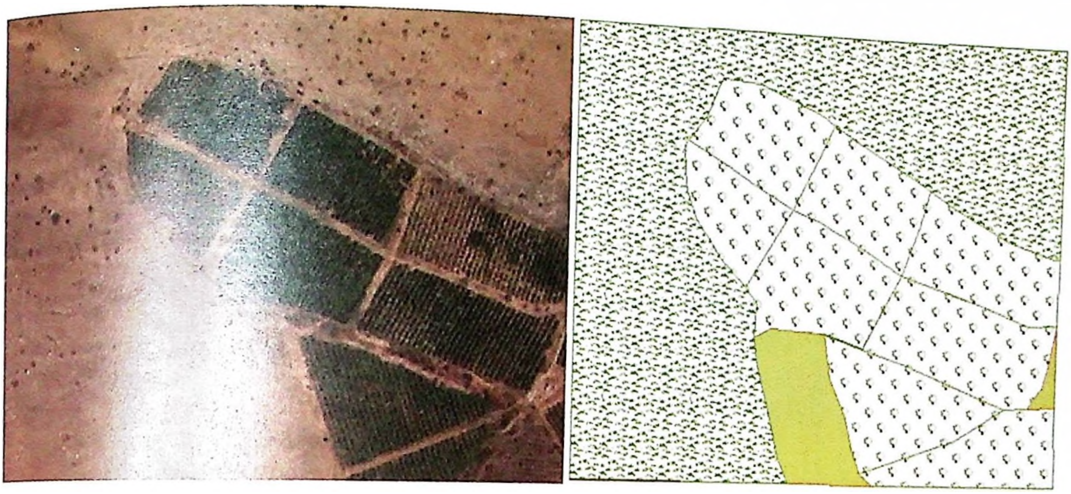


Figure 5.15: Circle of snapping tolerance

5. Complete digitizing the land use image.
6. When finished, click the Editor button in the Editor toolbar, then click Stop Editing to stop and save the digitized features.
7. Use any appropriate classification as shown in Figure 5.16 (compare the two datasets; land use shapefile and land use image).



(a) Land use image (b) Land use feature

Figure 5.16: Digitizing the land use image to land use feature

5.2.4 Editing Features in ArcMAP

In the following example, you will add a new road segment to the existing road network.

1. Open the Roads.mxd map from "C:\GIS_Tutorial\Chapter5\Example2".
2. In the Editor toolbar, click the Editor dropdown arrow and select Start Editing. The shapefile to be edited is the Roads.
3. Set the snap environment. Select vertex, edge and end point from the snap properties.
4. Click the Zoom In button on the Tools toolbar and zoom in to the area around the school buildings.
5. Make sure that on the Editor toolbar, the Task says Create New Feature, and the Target is the Roads shapefile, Figure 5.17.

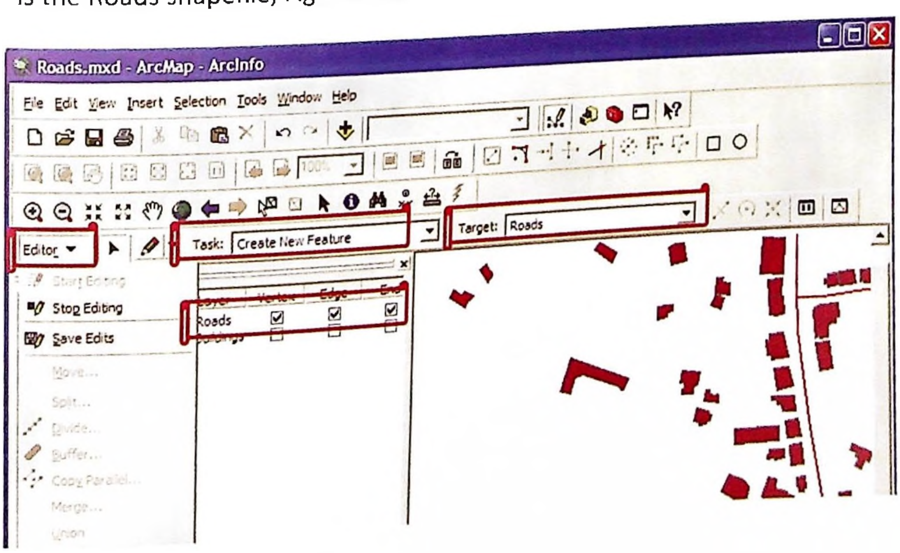


Figure 5.17: Defining a snapping environment

6. Click the Sketch tool (Pencil) on the Editor Toolbar. Move the pointer over the end of the existing road, the circle snaps to the end, Figure 5.18.

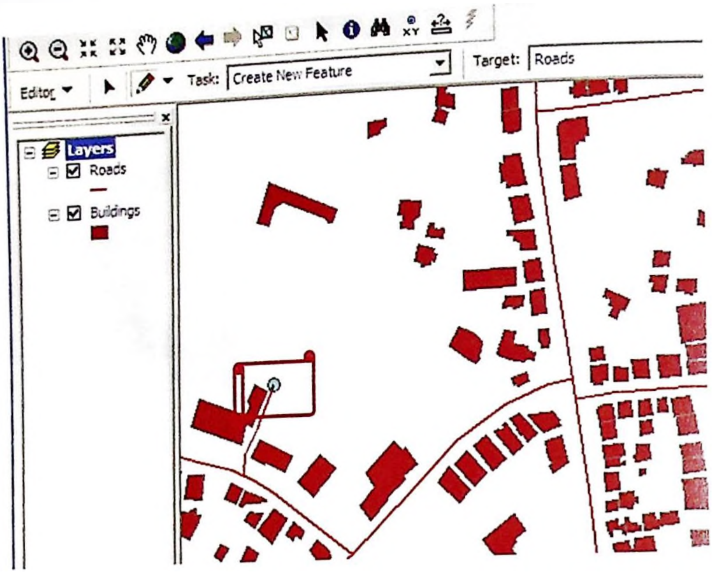


Figure 5.18: Connecting the end point of the road line

7. Click to begin the new road. Move the mouse pointer back over the existing road and right-click to display the context menu.
8. Select Parallel, Figure 5.19, you will find that the pointer moves only in the direction of the existing road that was previously chosen.

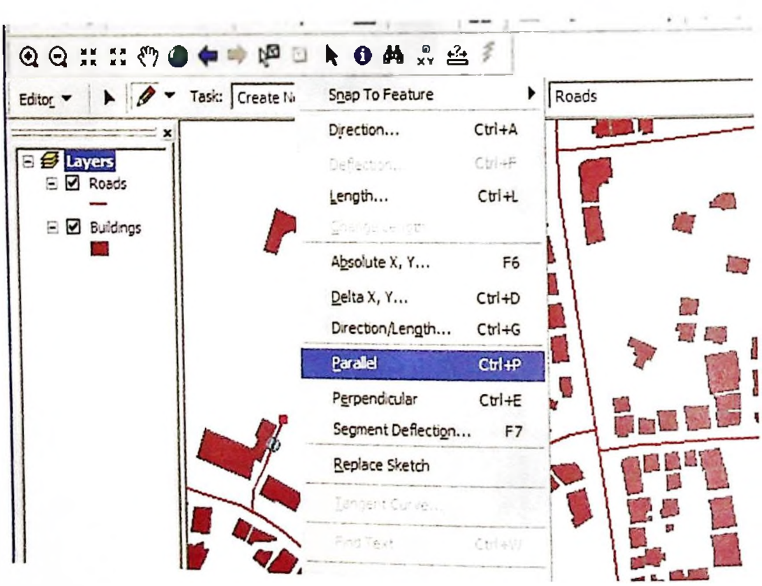


Figure 5.19: Defining the direction of the new road segment, Parallel

9. Move the pointer in the direction you want the new road to take (up and to the right). Right-click and choose Length, Figure 5.20.

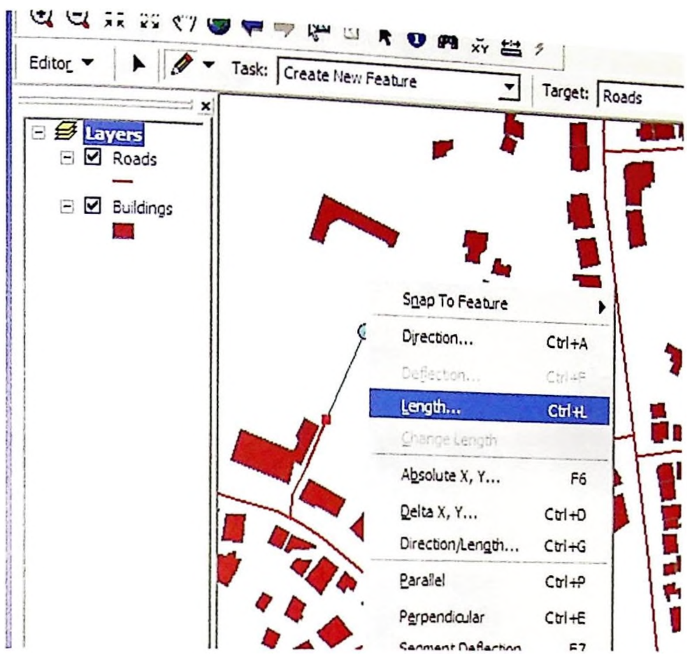


Figure 5.20: Setting the length of the new road segment

10. Type 200 (map units) and press Enter. ArcMap places a vertex at the correct location.
11. Right-click once again and choose Tangent Curve, Figure 5.21.

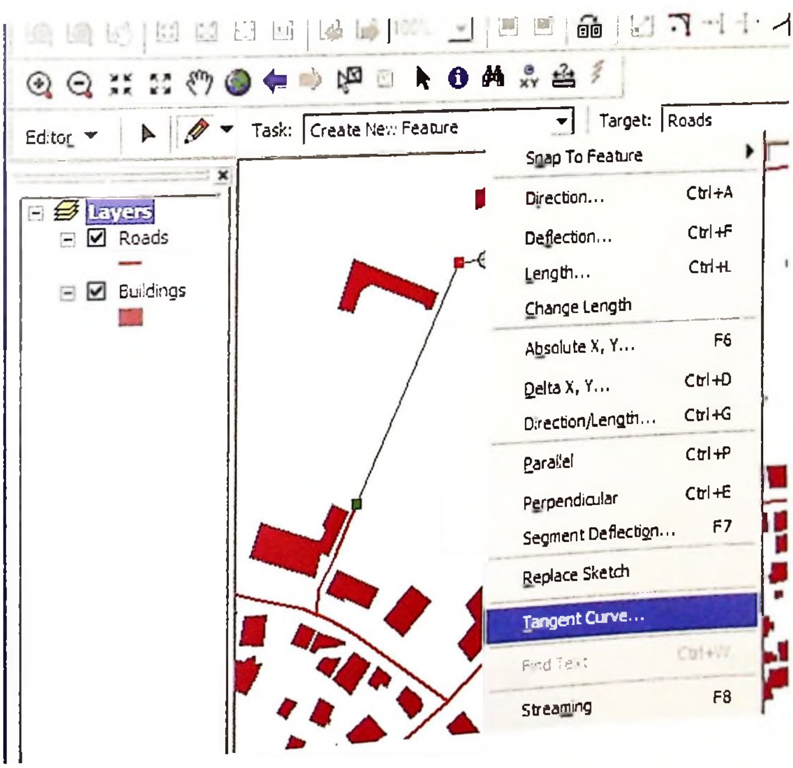


Figure 5.21: Drawing a tangent curve to the new road

12. Click the dropdown arrow in the upper box and choose Arc Length. Click the box to the right and enter a length of 50 (map units). In the lower box, click the dropdown arrow and choose Delta Angle. Click the box to the right and enter 60 (degrees). Click the button next to Right, if necessary, and then press Enter, Figure 5.22.

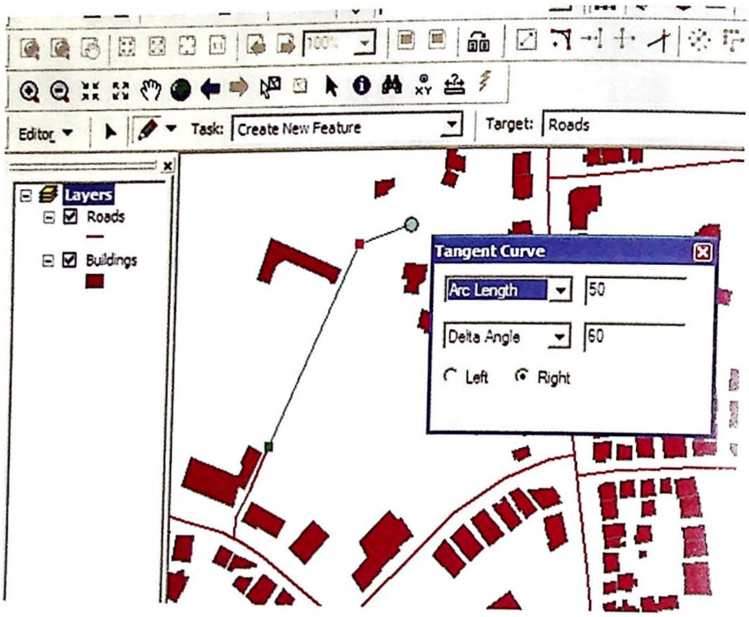


Figure 5.22: Setting the curve dimensions

13. ArcMap then draws the curve, Figure 5.23.

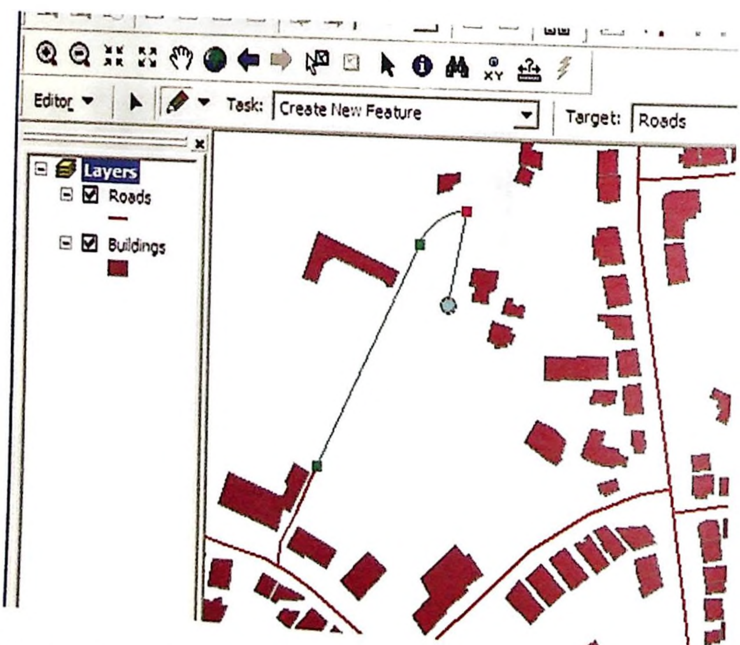


Figure 5.23: Drawing the tangent curve

14. Move the mouse pointer until it snaps to the existing road shown in Figure 5.24, but don't click the mouse. You want the next segment of the new road to be perpendicular to the existing road. Right-click and choose Perpendicular. The line is constrained to be perpendicular to the existing road.

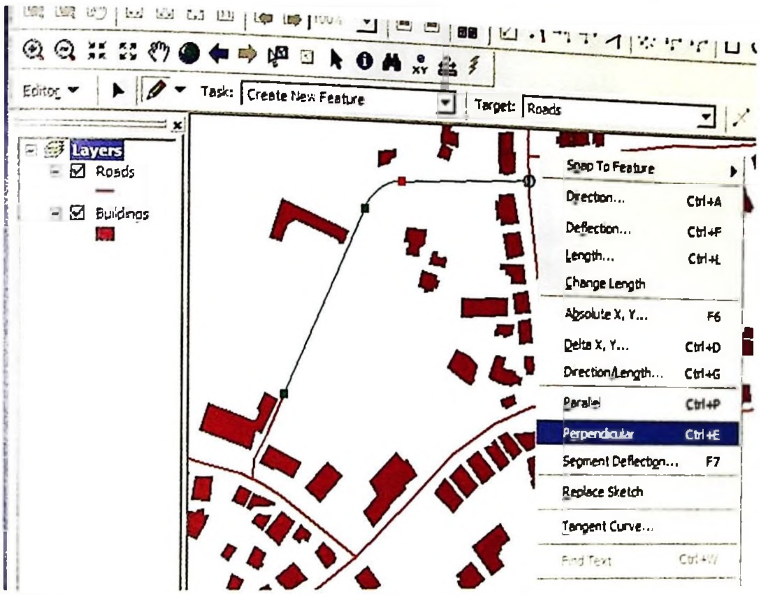


Figure 5.24: Completing the new road segment

15. To complete the road, move the pointer over the road that will intersect the new road. Double-click to end the line, Figure5.25.

Figure 5.25: Creating a new road segment

5.2.5 Editing Attribute Tables

5.2.5.1 Adding and Deleting Fields

ArcGIS allows you to modify the structure of shapefiles and dBASE tables by adding and deleting fields or attribute columns. The name and data type of an existing field can't be modified; instead, you must add a new field with the appropriate name and data type. A field's name must be no more than 10 characters in length; any additional characters will be truncated.

A shapefile's "FID" and "Shape" field and a dBASE table's OID field can't be deleted. The OID field is a virtual column created by ArcGIS when accessing the table's contents; it guarantees that each record in the table has at least one unique value. Shapefiles and dBASE tables must have at least one attribute field in addition to the FID and Shape fields or the OID field. After adding fields, you must start an edit session in ArcMap to define their attribute values.

1. Open the Roads.mxd map from "C:\GIS_Tutorial\Chapter5\Example3".
2. Right-click the Buildings shapefile in the table of contents and choose Open Attribute Table.
3. Click the Options button then select Add Field, Figure 5.26.

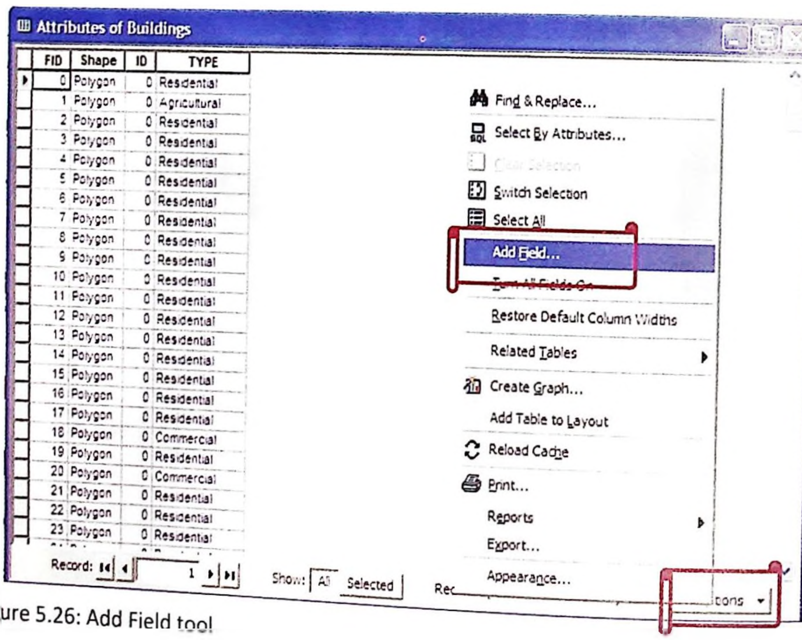


Figure 5.26: Add Field tool

4. Type "Area_m2" as the field name in the Name box.
5. Click the Type dropdown arrow and choose the Double type.
6. The properties that are appropriate for the new field's data type appear in the Field Properties list, Figure 5.27. Properties may include:
    a. Precision: The number of digits that can be stored in a number field. For example, 56.78 has a precision of 4.

b. Scale: The numbers of digits to the right of the decimal point in a number in a float or double type field. For example, 56.78 has a scale of 2.

c. Length: The length of a text field specifies the number of characters.

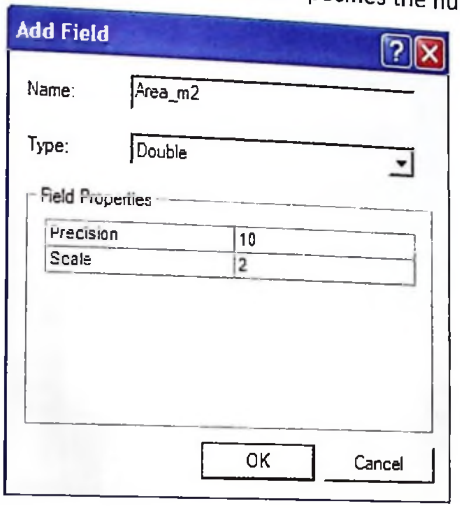


Figure 5.27: Add Field dialog box

7. Click OK to add the Area_m2 field.
8. Add the Length_m field in the attribute table of the Roads shapefile.
9. Add X_Coord. and Y_Coord. fields in the attribute table of the Cistern shapefile.

To delete a field, you can right-click the field's heading in the table and click Delete Field.

5.2.5.2 Performing Field Calculations

Editing or entering values in a table could be carried out using the keyboard. In some cases, you might want to perform a mathematical calculation to set a field value for a single record or even all records. The ArcMap field calculator helps you perform both simple and advanced calculations on all or selected records. For example, the area, length, perimeter, and other geometric properties can be calculated for fields in attribute tables.

5.2.5.2.1 Performing Calculations on Feature Geometry

If you're working with an attribute table of a feature layer, you can easily calculate the area, length, perimeter, x-location, y-location, x-centroid, or y-centroid using the Calculate Geometry dialog box.

You can use the coordinate system of the data source, or the coordinate system of the data frame when performing calculations. Noting that if one or more records are currently selected, then only the selected records are used in the calculations.

Calculate Geometry works with any numeric or text fields. For the most precise results, use a double type field, with the desired number of decimal places. If an integer field is used, the result will be rounded off to a whole number. If a text field is used the unit's abbreviation can be included to develop a ready-to-use field for labeling.

1. Open the Roads.mxd map from "C:\GIS_Tutorial\Chapter5\Example4".
2. Open the attribute tables for the Roads, Buildings and Cistern shapefiles.
3. Right-click on the Area_m2 field name in the Buildings attribute table. Then choose Calculate Geometry, Figure 5.28.

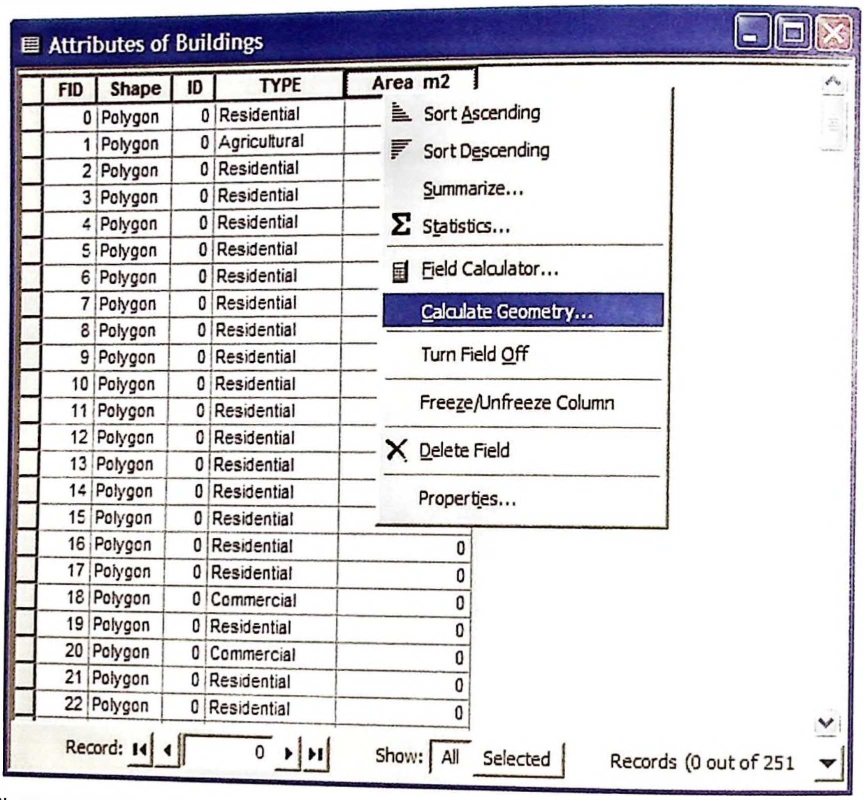


Figure 5.28: Calculating the geometry of a feature

4. In the Calculate Geometry dialog box, select Area in the Property dropdown box. Then click OK to finish, Figure 5.29.

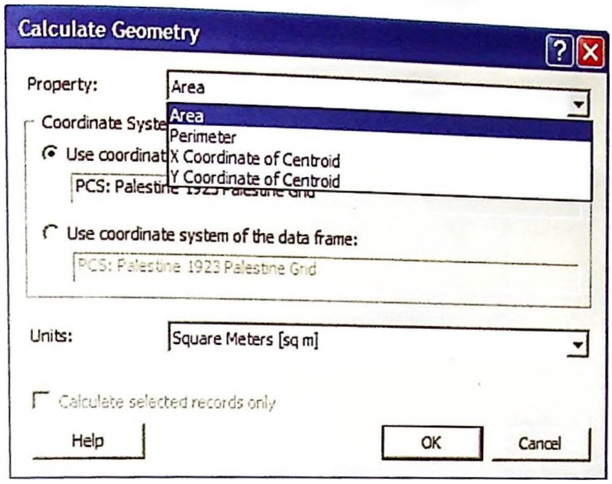
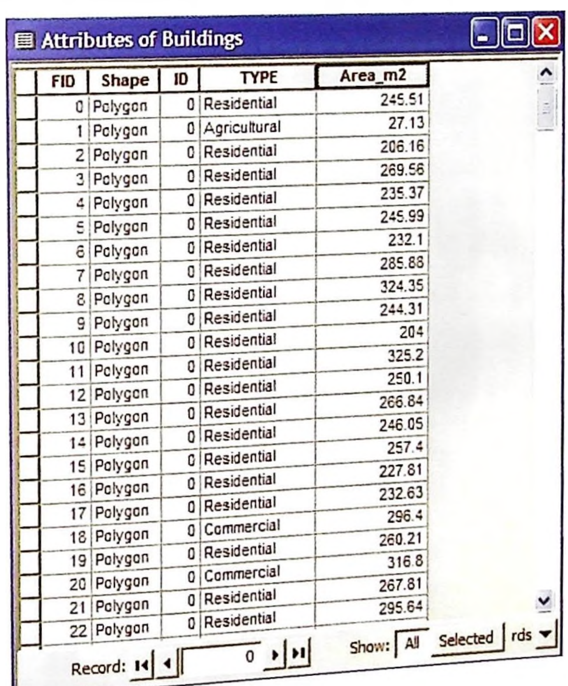


Figure 5.29: Calculating the area of features using Calculate Geometry

5. The area of all the buildings will then be calculated, Figure 5.30.


Attributes of Buildings

FID	Shape	ID	TYPE	Area_m2
0	Polygon	0	Residential	245.51
1	Polygon	0	Agricultural	27.13
2	Polygon	0	Residential	206.16
3	Polygon	0	Residential	269.56
4	Polygon	0	Residential	235.37
5	Polygon	0	Residential	245.99
6	Polygon	0	Residential	232.1
7	Polygon	0	Residential	285.88
8	Polygon	0	Residential	324.35
9	Polygon	0	Residential	244.31
10	Polygon	0	Residential	204
11	Polygon	0	Residential	325.2
12	Polygon	0	Residential	250.1
13	Polygon	0	Residential	266.84
14	Polygon	0	Residential	246.05
15	Polygon	0	Residential	257.4
16	Polygon	0	Residential	227.81
17	Polygon	0	Residential	232.63
18	Polygon	0	Commercial	296.4
19	Polygon	0	Residential	260.21
20	Polygon	0	Commercial	316.8
21	Polygon	0	Residential	267.81
22	Polygon	0	Residential	295.64

Record: 0 Show: All Selected rds

Figure 5.30: Table showing areas of land use parcels

6. Calculate the length of the roads and the x and y coordinates of the Cistern shapefile.

5.2.5.2.2 Using the Field Calculator Tool

The values of attributes could be added using the Field Calculator, this includes entering text/numerical values or calculating the values based on an equation.

1. Open the West Bank.mxd map from "C:\GIS_Tutorial\Chapter5\Example5".
2. Open the attribute table for the West_Bank shapefile.
3. Add two numerical fields: "Area_km2" to include the area of each governorate and "Pop_Den" to calculate the population density (Inhabitant/km^2)
4. Calculate the area of the West Bank Governorates in (km^2)
5. Right-click on the heading of the Pop_Den field. Then click Calculate Field and enter the equation as shown in Figure 5.31.

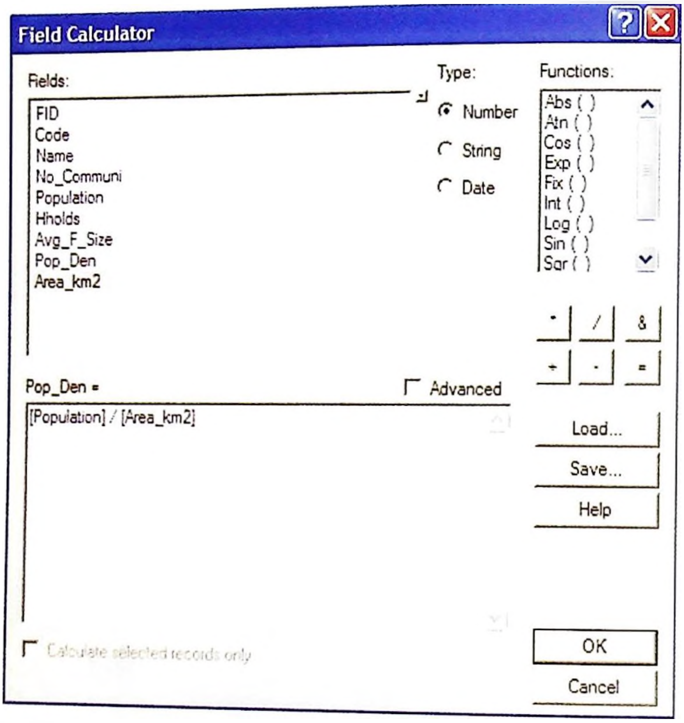
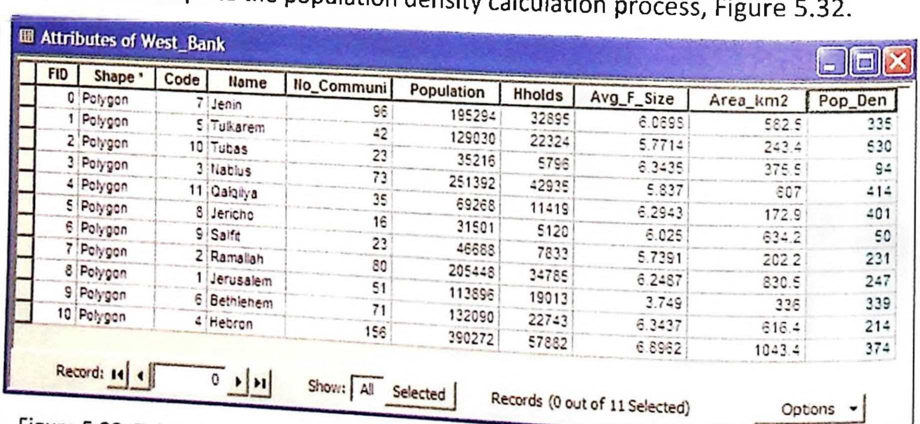


Figure 5.31: Calculating the population density of the West Bank Governorates

6. Click OK to complete the population density calculation process, Figure 5.32.



Attributes of West_Bank

FID	Shape *	Code	Name	No_Communi	Population	Hholds	Avg_F_Size	Area_km2	Pop_Den
0	Polygon	7	Jenin	96	195294	32895	6.0695	582.5	335
1	Polygon	5	Tulkarem	42	129030	22324	5.7714	243.4	530
2	Polygon	10	Tubas	23	35216	5796	6.3435	375.5	94
3	Polygon	3	Nablus	73	251392	42935	5.837	607	414
4	Polygon	11	Qalqilya	35	69268	11419	6.2943	172.9	401
5	Polygon	8	Jericho	16	31501	5120	6.025	634.2	50
6	Polygon	9	Salfit	23	46688	7833	5.7391	202.2	231
7	Polygon	2	Ramallah	80	205448	34785	6.2487	830.5	247
8	Polygon	1	Jerusalem	51	113896	19013	3.749	336	339
9	Polygon	6	Bethlehem	71	132090	22743	6.3437	616.4	214
10	Polygon	4	Hebron	156	390272	57882	6.8962	1043.4	374

Record: 0 Show: All Selected Records (0 out of 11 Selected) Options

Figure 5.32: Table showing the population density of the West Bank Governorates

5.3 Identifying Features in ArcMap

The Identifying Feature tool is used when information about a displayed feature is needed. It is located on the Tools toolbar in ArcGIS, Figure 5.33.

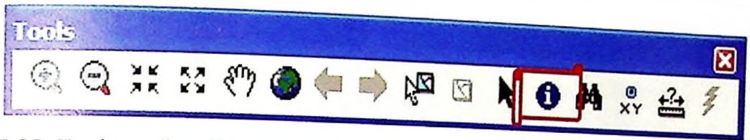


Figure 5.33: Tools toolbar (Identify tool)

The Identify tool allows you to see the attributes of your data and is an easy way to learn something about a location in a map. Clicking the Identify tool on a location inside a data frame will present the attributes of the data at that location. When identifying features with the Identify tool, the attributes are presented in a feature-by-feature manner in the Identify window, Figure 5.34.

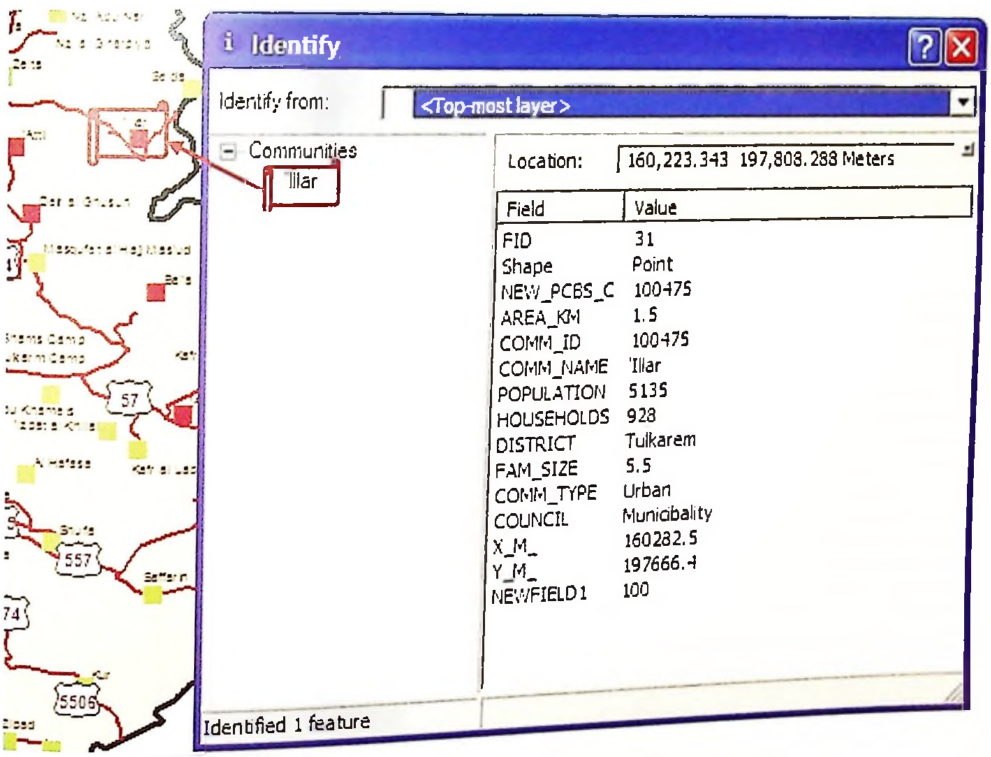


Figure 5.34: Identify window

The Identify tool can be customized to narrow down the amount of data you see by either filtering the layers you are interested in or by customizing the field properties of those layers. By reducing the number of layers the Identify tool works with, you can quickly focus on what is important to you when exploring a map. By customizing which fields are shown, you can ensure that the Identify tool returns only the most appropriate fields, using field names that are easy to understand.

Accessing the Identify Tool

The Identify tool can be accessed in a number of ways. The most popular way is to click it on the Tools toolbar, but you can also access it by right-clicking the map in the data view, Figure 5.35. When you click the Identify tool on the Tools toolbar in ArcMap, the Identify window immediately appears, enabling you to choose which layers you want to identify before you click the map to identify a feature. This makes the Identify tool more convenient if you don't want to use the default topmost layer setting. It also enables you to position the window conveniently on the screen so it does not cover up the map area you are viewing. In ArcCatalog, the Identify tool doesn't open the Identify window when it's selected because you normally only work with one layer at a time in the ArcCatalog Preview window.

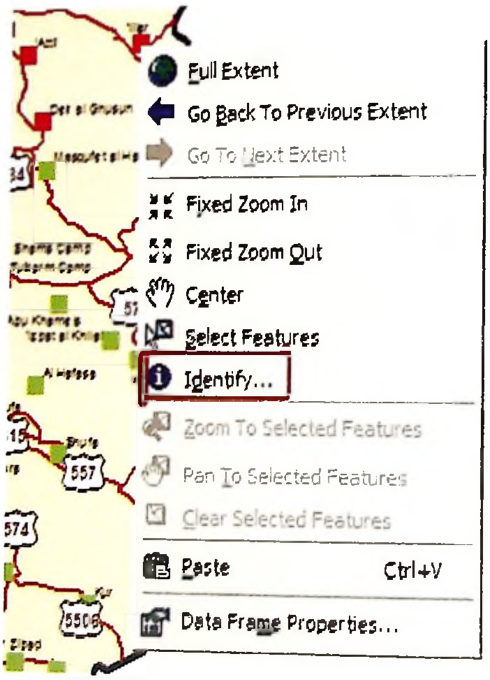


Figure 5.35: Accessing the Identify tool by a right-click

5.3.1 Choosing which Layers to Identify

When you use the Identify tool, it identifies the topmost layer in the map by default. You can use the Layers dropdown list at the top of the Identify window to choose from specific layers in your map or generic layer settings.

The Identify tool will act on whichever option you choose in the Layers dropdown list, Figure 5.36:

1. Topmost layer: Identify will list the attributes of the feature or features from the layer that is uppermost in the drawing hierarchy; in other words, the highest layer in the table of contents. This option would not identify features in a layer that is turned off in the table of contents or that do not appear because of the scale of the map. With this setting, you will

usually get the attributes of the feature you click without getting the attributes of features in other layers that are drawn underneath that feature.

2. Visible layers: Identify will list the attributes of the features belonging to all layers that are currently drawn on the map at the location you click.
3. Selectable layers: Identify will mention the attributes of the features belonging to layers at the location you click that are checked on in the table of contents, the Selection tab or the Set Selectable Layers dialog box. If a layer is selectable, its features will be identifiable even if the layer is not currently drawn on the map. The Selectable layers option can be useful as the default because it restricts Identify to the same set of layers on which interactive selection operates.
4. All layers: Identify will give the attributes of the features from all the layers at the clicked location. This includes layers that are not currently drawn on the map. This setting is useful if you want to create a cross-section of all the attributes of all layers at a particular location.
5. Specific layer: A specific layer in the map can be chosen to be identified. If you choose a particular layer name rather than a generic option, its features will be identifiable.

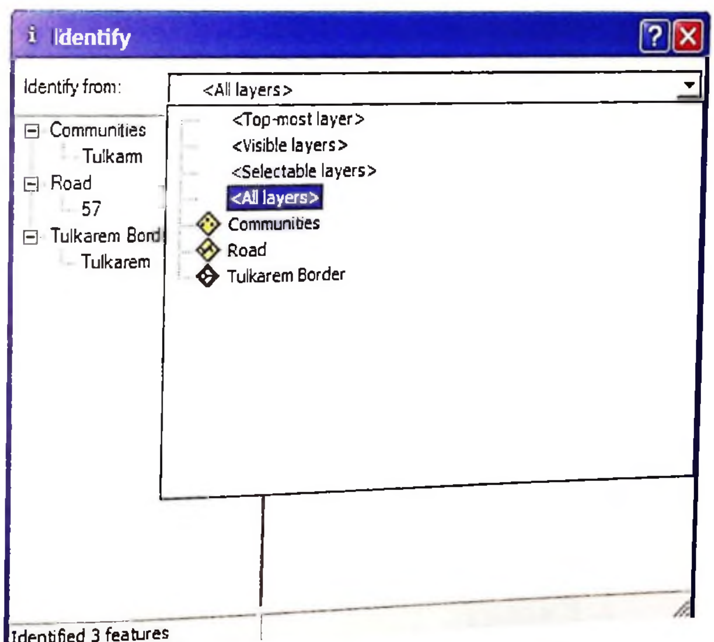


Figure 5.36: Choosing layers to identify in the Identify window

5.3.2 Working in the Identify Window

The results of an identify request are displayed in the window and show three categories of information: a list of features that have been identified, the attributes belonging to each identified feature, and location coordinates, Figure 5.34.

Each feature that has been identified is listed on the left side of the window. Features are listed using the value of the layer's primary display field, under the name of the layer to which they belong. You will see multiple layers listed if you have identified features from more than one layer.

The right side of the window shows the attributes of the feature you identified. When you have identified features, you can click a particular feature in the list on the left and view its attributes in the right panel. In this way, you can compare attributes for different features. You can interact with the attributes of identified features by right-clicking within the attributes panel.

The x, y coordinates for the location you clicked are displayed on the right side of the window above the attributes panel. When you click on an identified feature from the list on the left, the location box will display the x, y coordinates of that feature's location (if it is a point feature) or centroid (if it is any other type of feature). You can also choose the units with which these coordinates are displayed, select the coordinates and copy them.

5.3.3 Working with Identify Results

You can interact with identified features by right-clicking a feature in the list on the left side of the window. This menu allows you to do a number of actions with the identified feature, including selecting, flashing, zooming, and panning to it. You can also manage and access hyperlinks set for the feature, create spatial bookmarks based on the extent of the identified feature, organize the list of identified features, and copy the feature's attributes, Figure 5.37.

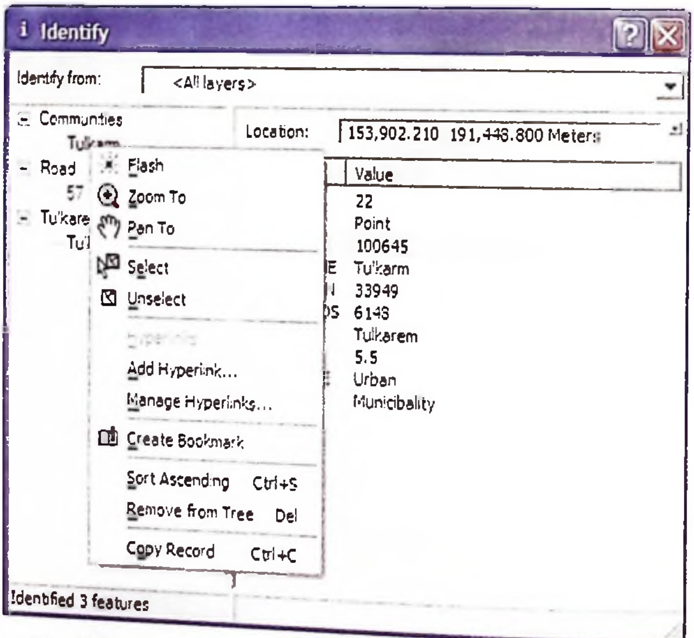


Figure 5.37: Interact with the attributes of identified features

The Identify window is one way of viewing related information about the feature you identified. Related information is data that has been expressly associated with the geographic feature you clicked by either a geodatabase relationship class or relate in ArcMap. For example, if you have a description table of groundwater wells that are related to a groundwater wells feature class, you can identify a well feature, and then view the related attributes in the description table. You can use the expansion controls to navigate any related information, Figure 5.38.

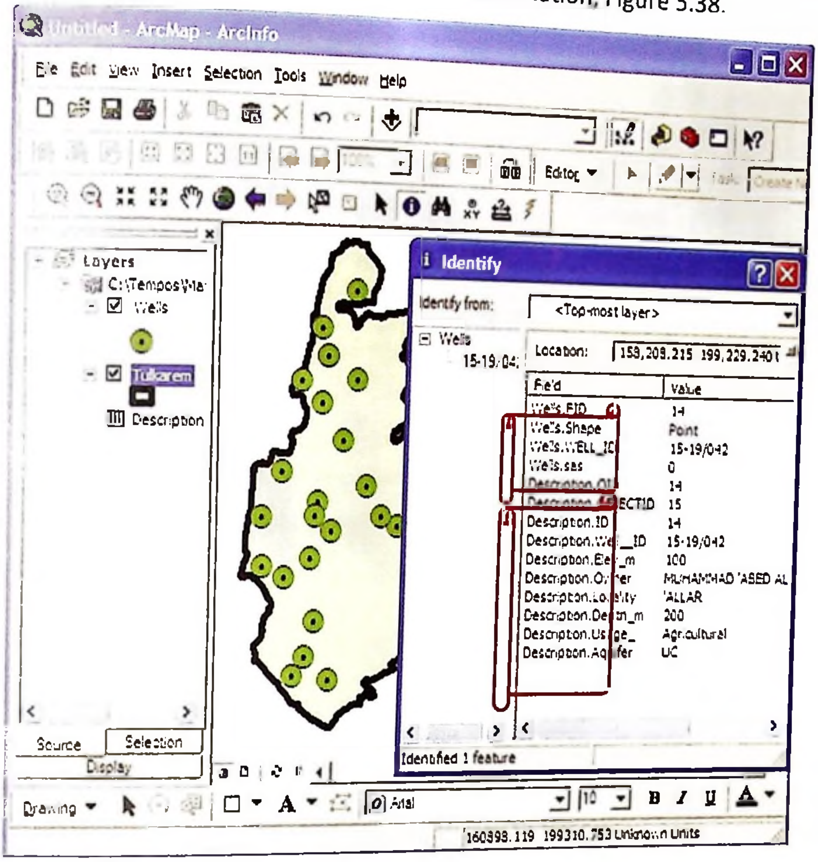


Figure 5.38: Viewing related information

5.3.4 How to Identify Features

1. Click the Identify tool on the Tools toolbar, the Identify window opens.
2. Click the pointer over the map feature you want to identify. The features in the topmost layer (by default) under the pointer will be identified. (You can drag a box with the Identify tool to identify all the features inside the box).
3. Right-click the left side of the window to interact with the identified features, or the right side to work with their attributes.

5.4 Adding Hyperlinks to Features

You can access documents or Web pages related to features using the "Hyperlink" tool on the Tools toolbar, Figure 5.39. Hyperlinks allow you to provide additional information about the features to people who will be using your maps with ArcMap.

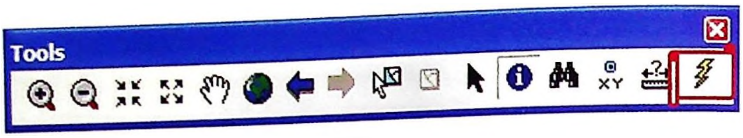


Figure 5.39: Hyperlink tool on the Tools toolbar

Hyperlinks have to be defined before you use the Hyperlink tool, and can be of one of three types:

1. Document: When you click a feature with the Hyperlink tool, a document or file is launched using the application with which that file type is currently associated.
2. Uniform Resource Locator (URL): When you click a feature with the Hyperlink tool, a Web page is launched in the default Web browser.
3. Macro: When you click a feature with the Hyperlink tool, a value is sent to a macro. This option helps you create customized hyperlink behavior.

You can define a hyperlink for the features in a layer using Field-based hyperlink or Dynamic hyperlinks.

5.4.1 Field Based Hyperlinks

With this type of hyperlink, the target document, URL, or macro value that will be launched is specified for each feature in a field in the layer's attribute table. The values of the field that you choose to provide document or URL hyperlinks for can include the full path to the target document or the full URL of the target Web page.

In this section, you will hyperlink photos to land use features using field-based hyperlinks.

1. Open a new ArcGIS map, load the Landuse shapefile from "C:\GIS_Tutorial\Chapter5\Example6".
2. Open the attribute table of the Landuse shapefile.
3. Add a new text field to the attribute table (Name ="Hyper" and length = 100 characters).
4. Select all features with a land use type equal to Olives, then use the Field Calculator tool to fill the "hyper" field with "C:\GIS_Tutorial\Chapter5\Example6\Images\olive.jpg".
5. Repeat step 4 for the Shrubs, Rainfed and Citrus land use types. Use Shrub.jpg, Rainfed.jpg and Citrus.jpg respectively.
6. The table will resemble that in Figure 5.40.

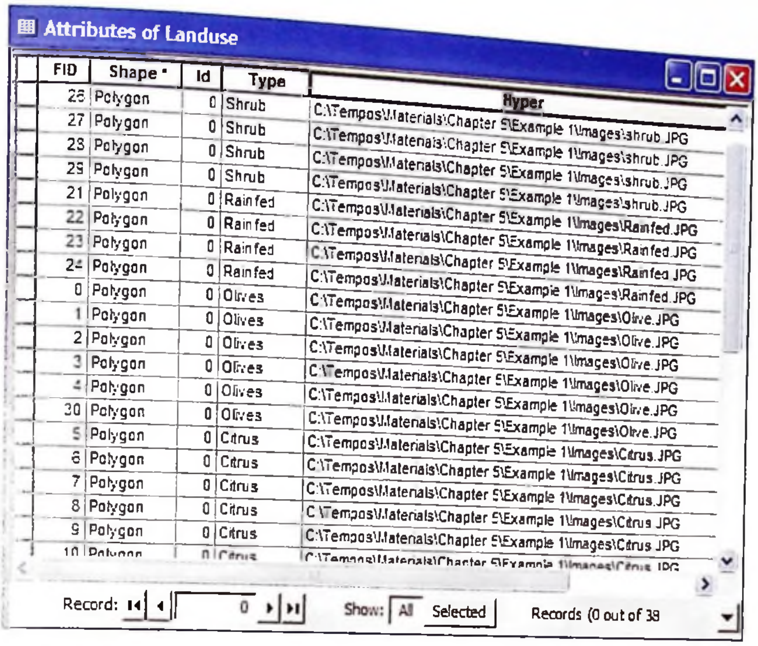


Figure 5.40: Defining the location of hyperlinked images

7. Double-click the Landuse shapefile in the table of contents.
8. Click the Display tab.
9. Check the Support Hyperlinks using field: item.
10. Click the dropdown arrow and choose the Hyper field (the field containing the hyperlink target).
11. Click Document to specify the type of hyperlink required.
12. Click OK, Figure 5.41.

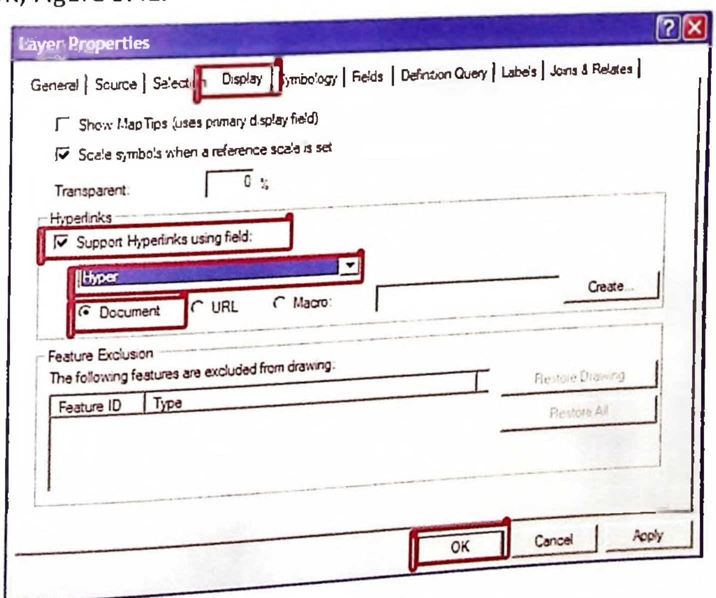


Figure 5.41: Adding hyperlinks to land use parcels

13. Make sure that the land use feature for which you want to access a hyperlink is checked on (visible) in the table of contents.

14. Click the Hyperlink tool from the Tools toolbar. Any visible features in the map that have hyperlinks defined are drawn in blue (the default color) or outlined in blue in the case of polygons. When you are over a feature for which a hyperlink exists, the pointer turns into a pointing hand and you see a pop-up tip with the name of the target.

15. Click on any of the Olive polygons, you will find that the image of an olive tree opens, Figure 5.42. If more than one hyperlink has been defined for the feature you clicked, a dialog box will appear from which you can select the hyperlink you want to launch.

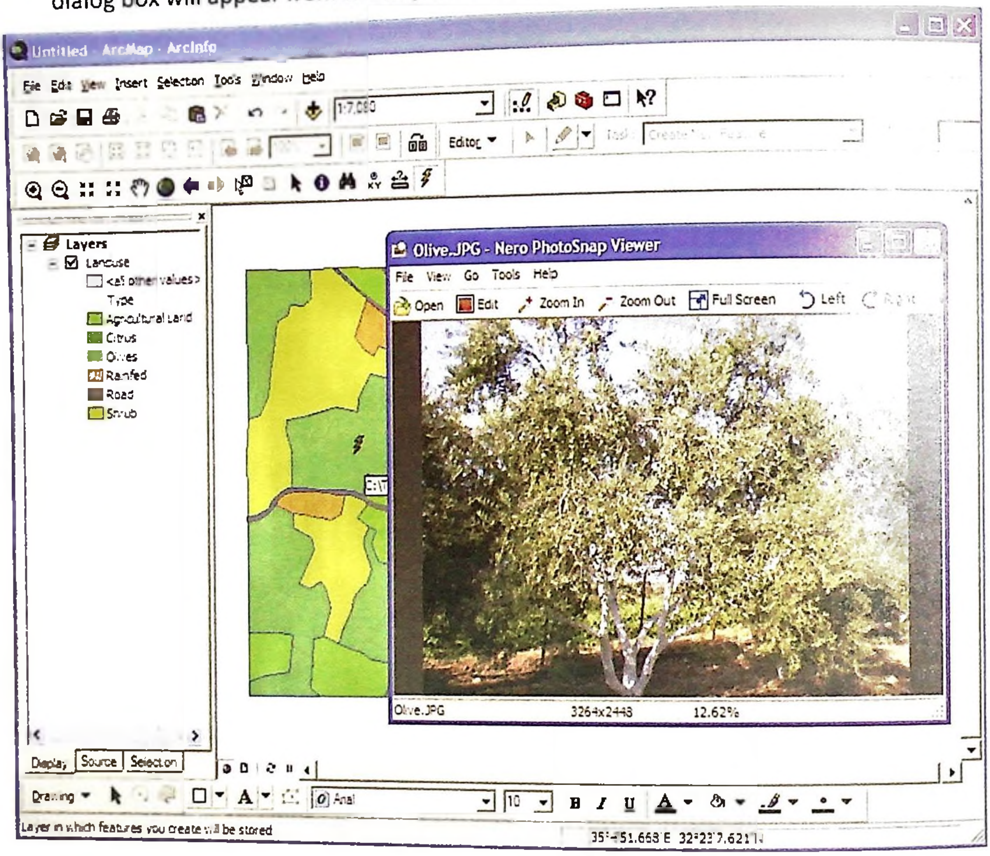


Figure 5.42: Opening a hyperlinked document

16. Repeat step 11 for the "Citrus", "Shrubs" and "Rainfed" types.

In this example, the full path of the hyperlink was typed in the Hyper field. Alternatively, the value may just contain the name of the target document (image) and you can use the Hyperlink Base property to specify the path where the target can be found. The Hyperlink Base property is specified using Document Properties in the File menu, Figure 5.43. Using this property makes it easier to manage hyperlinks; if the location of the targets changes, you can simply edit this setting instead of having to edit each value of the field providing the hyperlink targets.

17. Click the File menu, then choose Document Properties. The document properties dialog box will open. Type "C:\GIS_Tutorial\Chapter5\Example6\Images" in the Hyperlink base: box. This will be used as the path of the hyperlinked images, Figure 5.43.

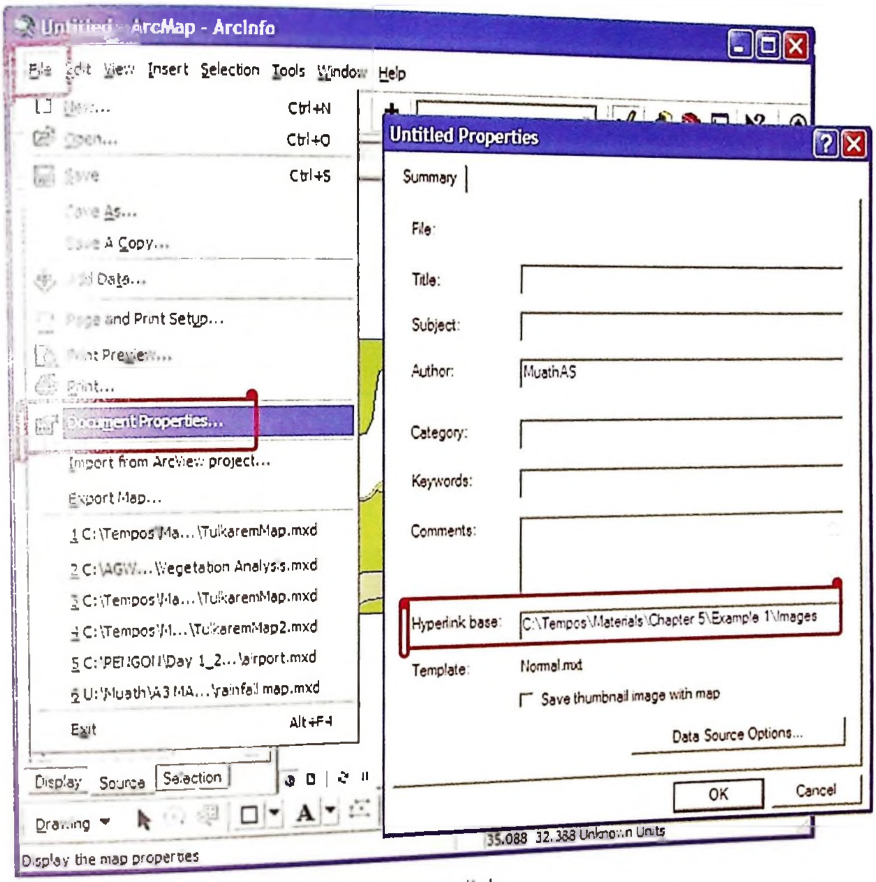
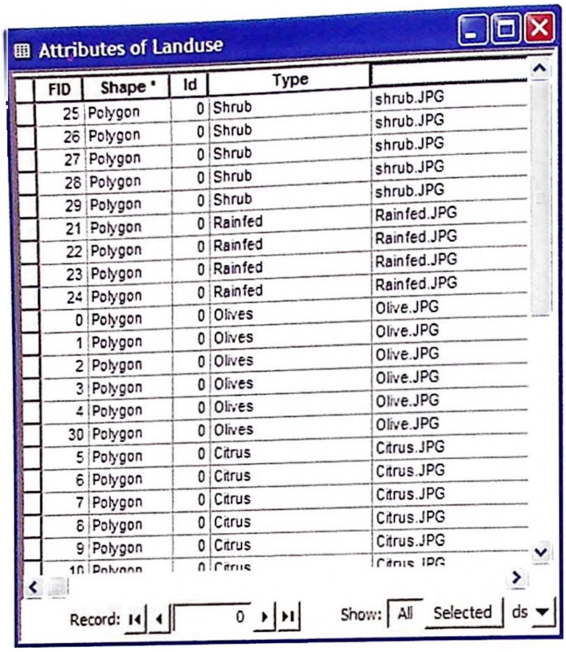


Figure 5.43: Setting a location source for hyperlinks

18. Remove the full path names from the attribute table of the Landuse shapefile you defined before, Figure 5.44.



FID	Shape *	Id	Type	
25	Polygon	0	Shrub	shrub.JPG
26	Polygon	0	Shrub	shrub.JPG
27	Polygon	0	Shrub	shrub.JPG
28	Polygon	0	Shrub	shrub.JPG
29	Polygon	0	Shrub	shrub.JPG
21	Polygon	0	Rainfed	Rainfed.JPG
22	Polygon	0	Rainfed	Rainfed.JPG
23	Polygon	0	Rainfed	Rainfed.JPG
24	Polygon	0	Rainfed	Rainfed.JPG
0	Polygon	0	Olives	Olive.JPG
1	Polygon	0	Olives	Olive.JPG
2	Polygon	0	Olives	Olive.JPG
3	Polygon	0	Olives	Olive.JPG
4	Polygon	0	Olives	Olive.JPG
30	Polygon	0	Olives	Olive.JPG
5	Polygon	0	Citrus	Citrus.JPG
6	Polygon	0	Citrus	Citrus.JPG
7	Polygon	0	Citrus	Citrus.JPG
8	Polygon	0	Citrus	Citrus.JPG
9	Polygon	0	Citrus	Citrus.JPG
10	Polygon	0	Citrus	Citrus.JPG

Figure 5.44: Removing paths of hyperlinked documents from the attribute table

19. Repeat steps 11 and 12 once again.

5.4.2 Dynamic Hyperlinks

With this method, the target document or URL is specified for a particular feature in the Add Hyperlink dialog box accessed from the Identify window, Figure 5.37. This allows you to introduce hyperlinks directly without having to use a field to supply the targets. The Add Hyperlink dialog box lets you specify either a file or a URL target. The names of the targets you specify in this way are stored with the layer in your map. They are also stored with the layer if you save the layer to a file. You can define any number of dynamic hyperlinks for a feature. If more than one hyperlink is defined for a feature, when the feature is clicked with the Hyperlink tool, a dialog box will appear from which the desired hyperlink can be selected. The Hyperlink Base setting has no effect on dynamic hyperlinks.

1. Open a new ArcGIS map, load the Wells and Tulkarem_Border shapefiles from "C:\GIS_Tutorial\Chapter5\Example7".
2. Use the Select by Attribute tool to select well 15-19/047.
3. Click the Identify tool on the Tools toolbar.
4. Click on well 15-19/047 for which you want to define a hyperlink.
5. Right-click the feature in the Identify window and choose Add Hyperlink.
6. Specify the desired hyperlink target "C:\GIS_Tutorial\Chapter5\Example7\Images\well 15_19_047.JPG".

7. Click OK.
8. Click the Hyperlink tool from the Tools toolbar.
9. Click on well 15-19/047 and its image will appear. To manage the dynamic hyperlinks, click the Identify tool on the Tools toolbar.
10. Click the feature that has the dynamic hyperlinks you want to manage (well 15-19/047).
11. Right-click the feature in the Identify window and click Manage Hyperlinks.
12. Click Add New, Remove, Remove All, or Jump To. Then click OK.

5.5 Creating a Graph

Before you create a graph, you should determine what sort of information you want to convey. Deciding on whether you wish to show the trends, relationships, distributions or proportions in your data will help you select the appropriate type of graph.

You can graph all features from a dataset, or just selected ones. The dataset can be a feature class, a layer, or an integer raster. You can also graph tabular data. Some graphs can effectively display only a limited amount of data, so choose your graph type appropriately. Alternatively, you might consider making more than one graph.

5.5.1 Graph Wizard

The Create Graph Wizard, Figure 5.45, will lead you through the steps necessary to create a graph.

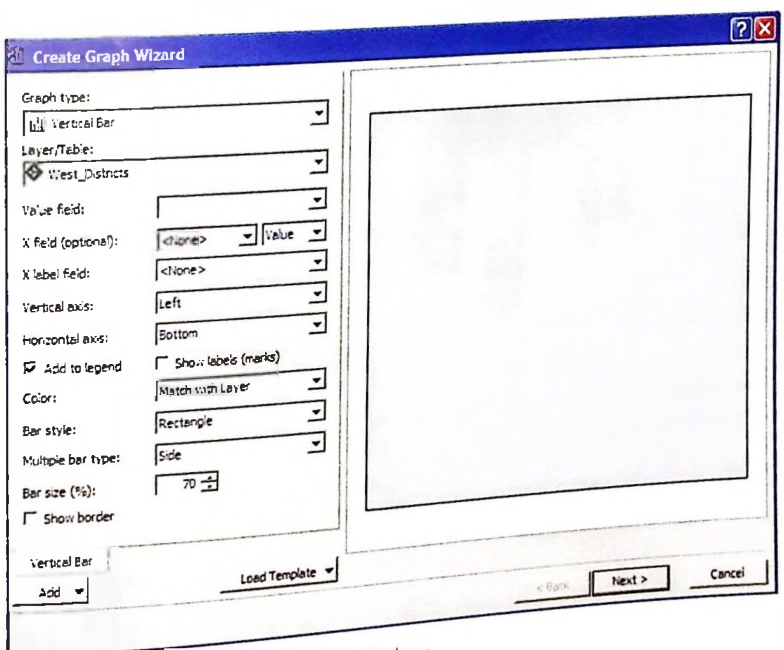


Figure 5.45: Create Graph Wizard, first window

The basic steps of creating a graph (common to all the available types) include:

1. Start the Create Graph Wizard.
2. Select the graph type.
3. Set the data source.
4. Select the fields to be graphed.
5. Set the color to be applied.
6. Add additional series or functions to the graph, if desired.
7. Proceed to the second page of the Wizard, Figure 5.46, to set the general properties of the final graph (title, etc).

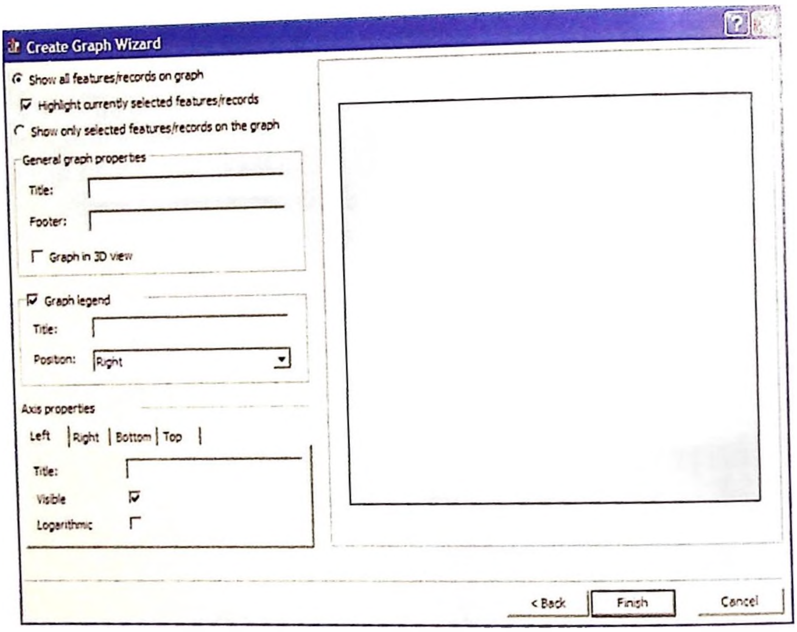


Figure 5.46: Create Graph Wizard, second window

8. Accept your settings.

Once you have completed these steps, the graph will be created in ArcMap as a floating window. Additional options are available to give further control, as well as specific options that apply to individual types of graphs.

5.5.2 Creating a Simple Graph

To become familiar with the way graphs are created in ArcGIS, the following is the basic procedure used to create a simple, common type of graph. The easiest graph to make is a vertical bar graph.

1. Open the West Bank.mxd map from "C:\GIS_Tutorial\Chapter5\Example8".

2. Click the Tools menu, point to Graphs, and choose the Create button to start the Graph Wizard, Figure 5.47.

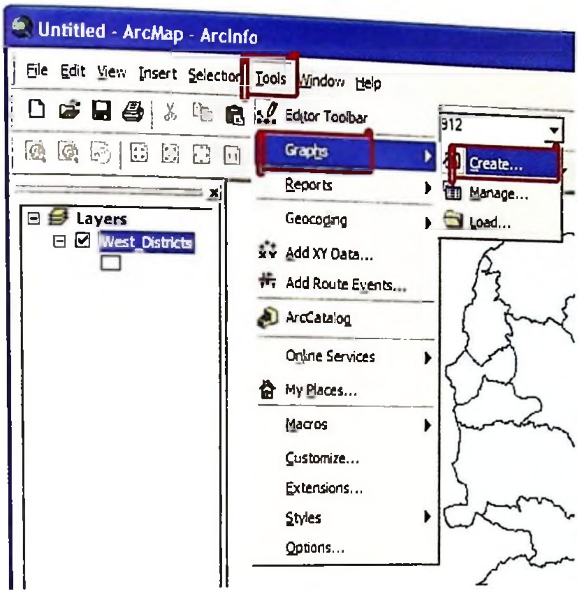


Figure 5.47: Create a simple graph

3. Click the Graph type dropdown arrow and select Vertical Bar, Figure 5.48.

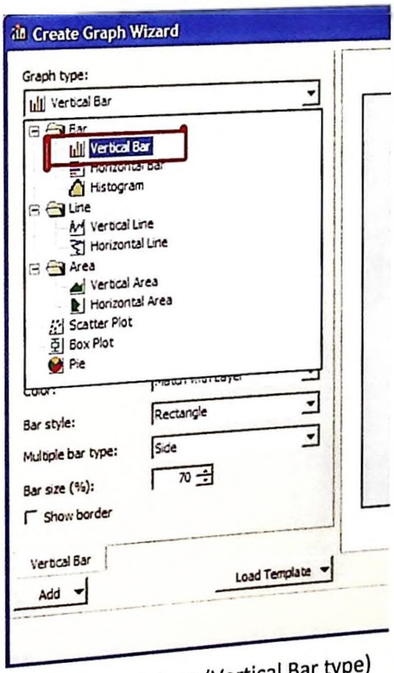


Figure 5.48: Setting the simple graph type (Vertical Bar type)

4. Click the Layer/Table dropdown arrow and select West Bank_Districts as the source of the data values you want to graph.

5. Click the Value field dropdown arrow and select the No_Communities field to graph. The Wizard will preview the initial version of the graph, Figure 5.49.

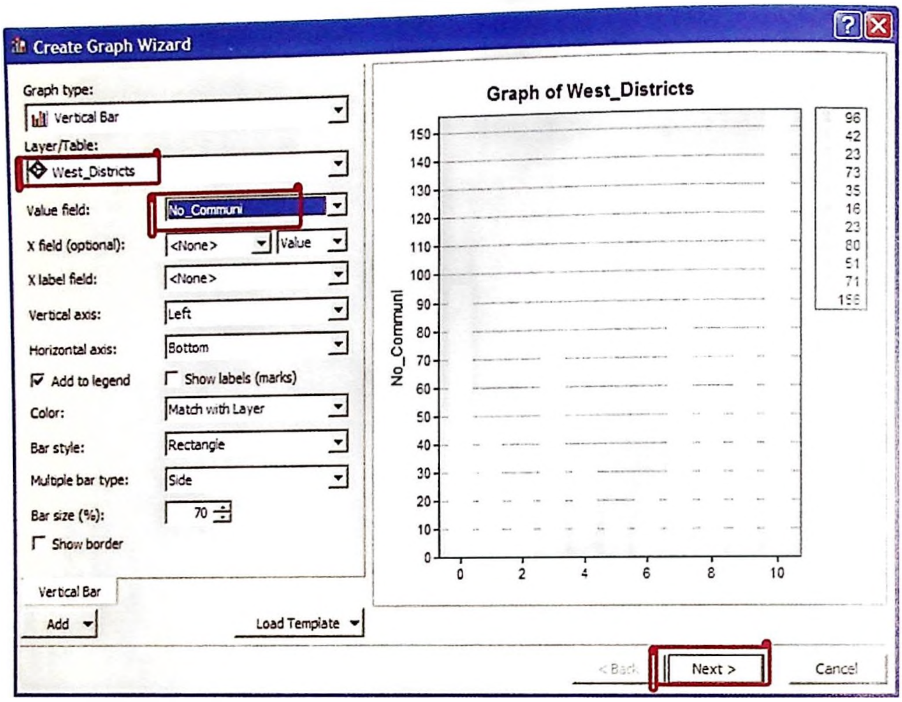


Figure 5.49: Initial version of the simple graph

6. Click the X label field dropdown arrow and select the Name field to label the x axis with the names of the West Bank Governorates.
7. Keep the vertical axis on the left of the graph and the horizontal axis on the bottom.
8. Uncheck the Add to Legend and Show labels (marks) items.
9. Click the Color dropdown arrow and select Palette. Select Windows XP from the dropdown arrow on the right of the Color dropdown arrow.
10. Keep the Bar style, Multiple bar type and Bar size as the default values.
11. Tick the Show border box to draw a frame around each bar. The Create Graph Wizard will look like Figure 5.50.

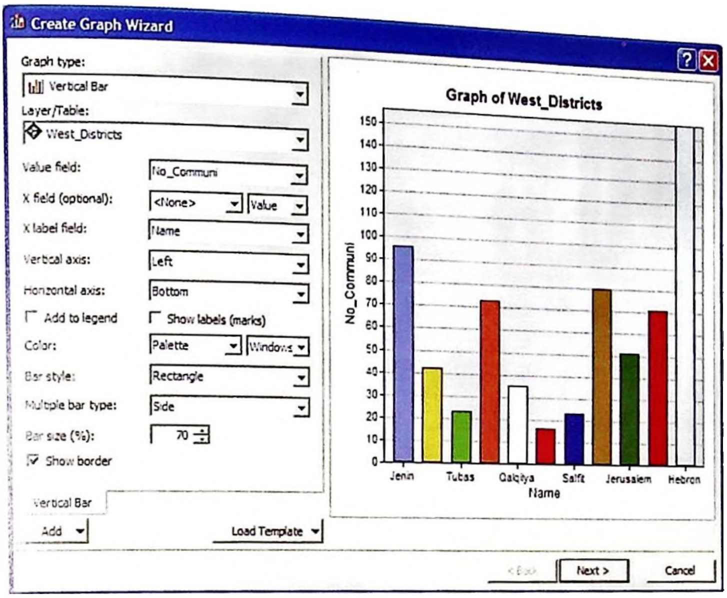


Figure 5.50: Final version of the simple graph

12. Click "Next" to move on to the second page of the Wizard.
13. Change the Graph Title to "West Bank Governorates".
14. In the footer box type "Population Distribution in the West Bank Governorates".
15. Rename the left axis to "Number of Communities" and the bottom axis to "Governorate". The second window of the Create Graph Wizard will look like Figure 5.51.

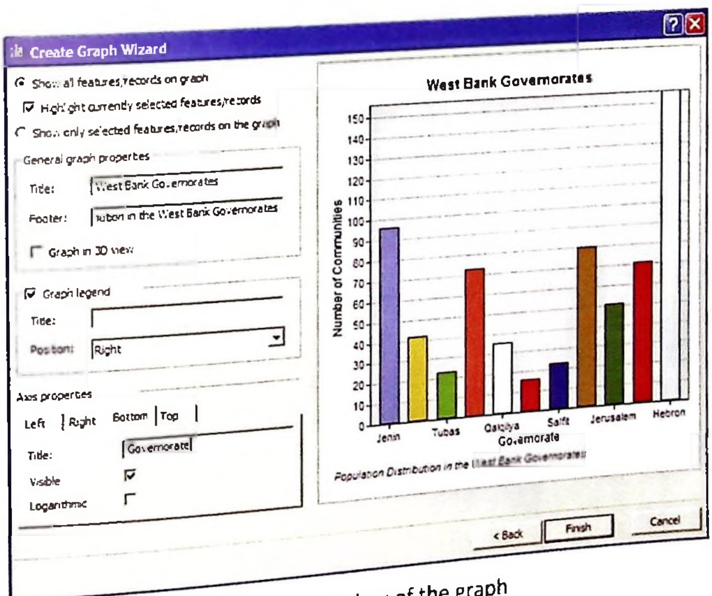


Figure 5.51: Setting the second window of the graph

16. Click Finish. The graph should appear in a new floating window as shown in Figure 5.52.

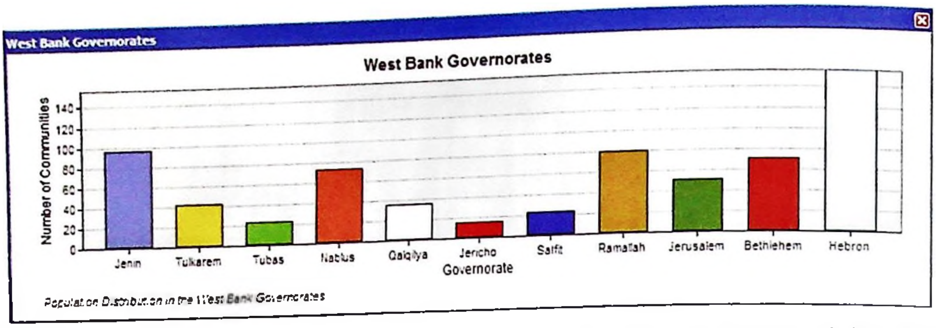


Figure 5.52: Number of communities versus West Bank Governorates graph (Vertical Bar)

The color of the bars could be similar to those used for the West Bank Governorates.

17. Classify the West Bank Governorates according to their names using Categories Classification.
18. Double-click on the Graph window.
19. Click the Color dropdown arrow and select Match with layer. Then click OK. You will find that the colors of the graph bars are the same as those of the West Bank features, Figure 5.53.

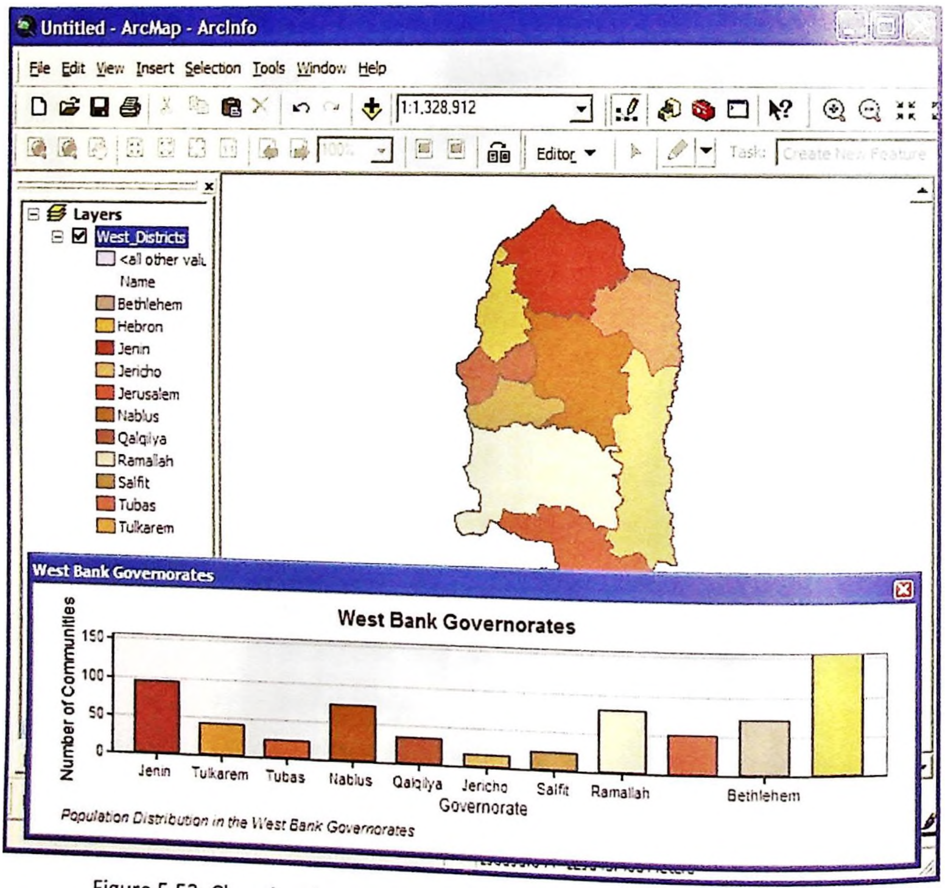


Figure 5.53: Changing the color of the graph to match the color of the features

The type of the graph used can be changed based on the type of the data and the purpose of the graph. To change the type of the graph above from vertical bars to a pie chart do the following steps:

20. Double-click on the graph, click the Graph type dropdown arrow and select Pie.
21. Repeat the steps above to select the graph parameters, Figure 5.54.
22. Tick the Add to legend box then click apply.

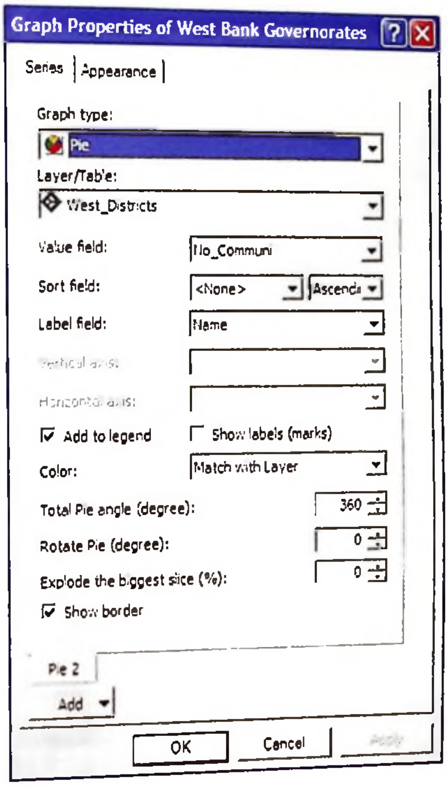


Figure 5.54: Changing the graph type to a pie shape

23. The graph will resemble Figure 5.55. Notice that the legend has also been added to the graph.

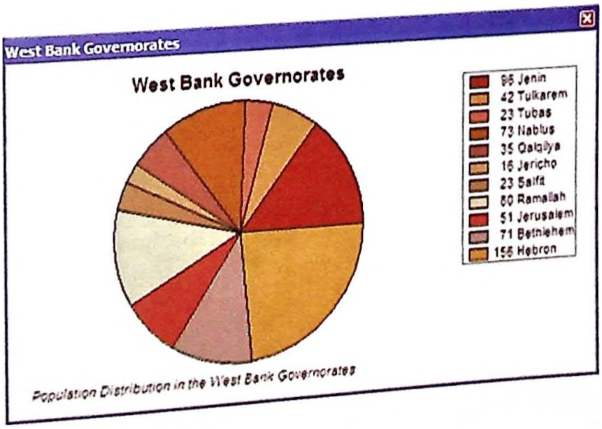


Figure 5.55: Pie shape graph

24. You can replace the legend with labels added to the pie graph by un-checking the Add to label box and check the box left to the Show labels (marks) item. You will find that the labels are now on the pie graph as shown in Figure 5.56.

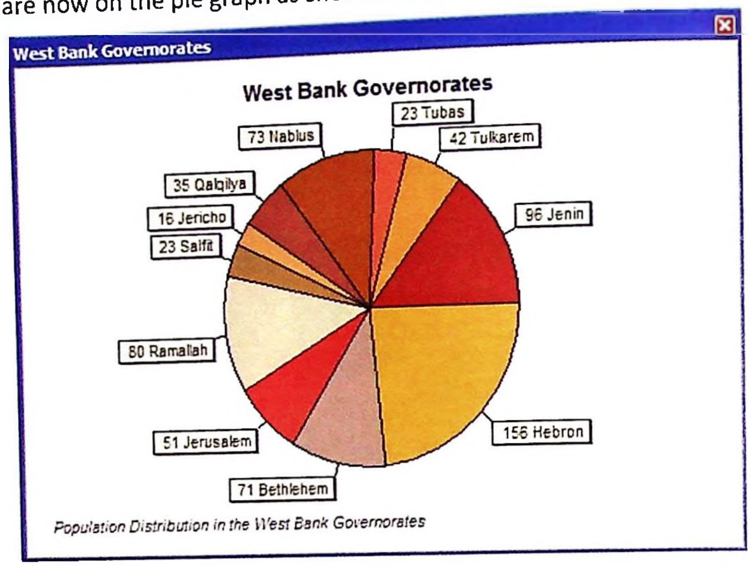


Figure 5.56: Number of communities versus West Bank Governorates graph (Pie)

You can also create a multiple series graph, for example, a graph between the population and the number of communities in the West Bank Governorates.

25. Create a graph between the Number of Communities versus West Bank Governorates as done before using a custom color (e.g. Blue), Figure 5.57.

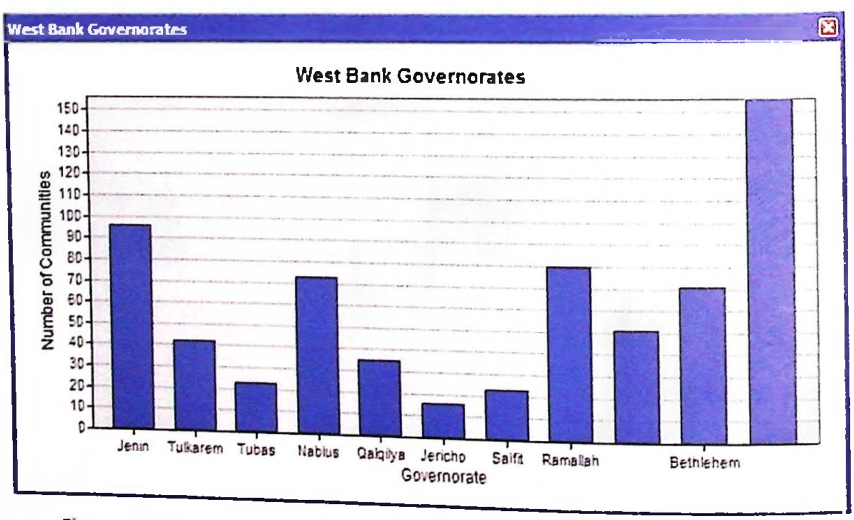


Figure 5.57: Number of communities versus West Bank Governorates graph (Single color)

26. Open the Graph Wizard for the graph above. Click the Add button on the bottom of the Graph Wizard, then select New Series, Figure 5.58.

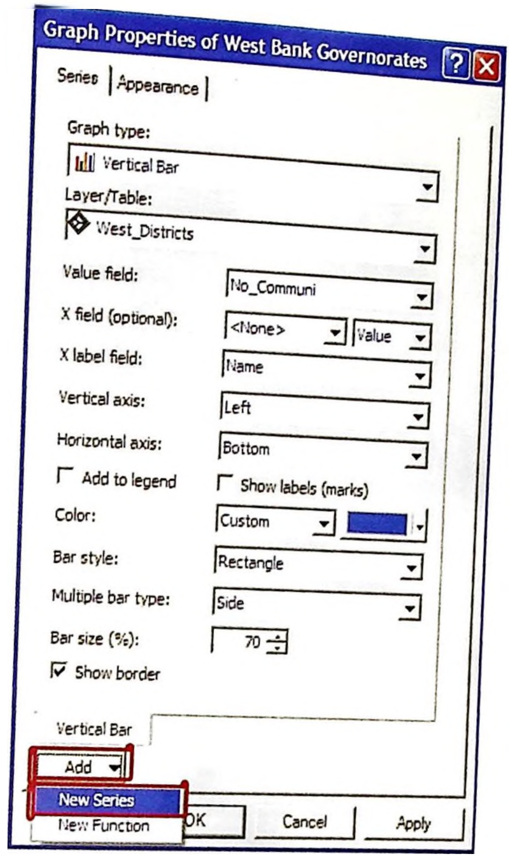


Figure 5.58: Adding a new series to the graph

27. A new vertical bar will be created. From the Value field dropdown list select the Population field.
28. Modify the rest of the boxes with the following information:
    a. X label field: Name
    b. Vertical axis: Right
    c. Color: Custom, select the green color
    d. Check the Add to legend box
    e. Check the Show border box
29. Click twice on Vertical Bar 2 to rename it to "Population".
30. Click twice on the Vertical Bar 1 to rename it to "# Communities", also check the Add to Legend box.
31. The Appearance table can be used to change the location of the legend and to rename the right axes.
32. Click Apply to finish, the graph will look like Figure 5.59.

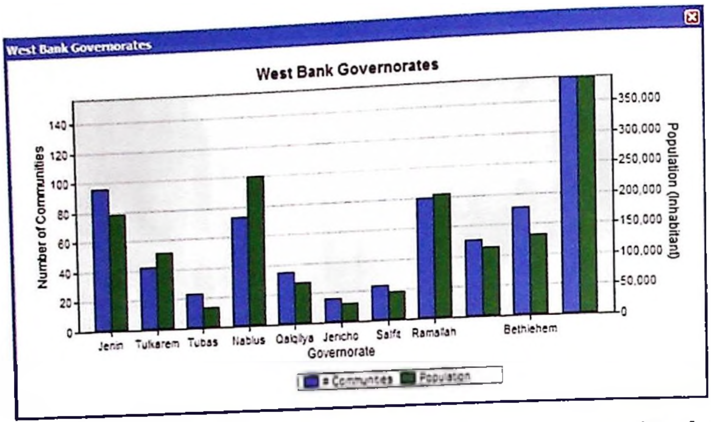


Figure 5.59: Two series graph for the West Bank Governorates (# of communities and population)

6 Querying Data Using ArcGIS

5.6.1 Selecting Features Interactively

Selecting features allows you to identify or more easily locate a subset of features on your map. You will most likely work with selected features when you are querying, exploring, analyzing, or editing data. Applying a selection is also a way of specifying the features for which you want to calculate statistics, view attributes, move, and so on.

There are several ways you can select features. You can select features with your mouse by clicking them one at a time or by dragging a box around them on the map using the Select Feature tool in the Tools toolbar, Figure 5.59. You can also select features in the map by selecting their records in the table or graph window with your mouse.

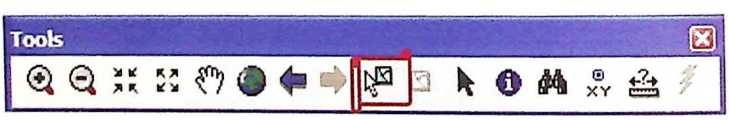


Figure 5.59: The Select Feature tool

Before you select features using one of these methods, you can specify which layers are selectable. Do this when the features you want to select overlap or are close to features from other layers. For example, if you have an area where many of the buildings are close to main roads, you can avoid selecting roads by specifying that you want to select from the buildings layer only. You can select from the layers that are checked in the Selection tab at the bottom of the table of contents or in the Set Selectable Layers dialog box, Figure 5.60, which you can open by clicking on the Selection menu and choosing Set Selectable Layers, Figure 5.61. Uncheck the layers you do not want to be able to select from. In this example, you would make sure that the buildings are checked, but you should uncheck the Roads layer.

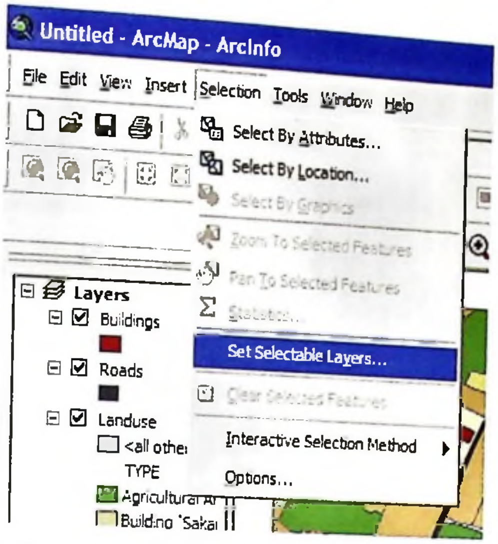


Figure 5.60: Choose the selectable layers

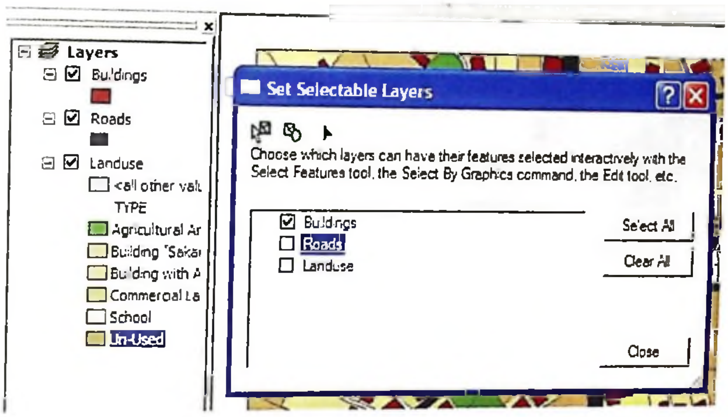


Figure 5.61: Set Selectable Layers window

As you are selecting features, the number of features selected is shown immediately in the lower left corner of the ArcMap window. It is also shown after the layer name on the Selection tab of the table of contents, Figure 5.62.

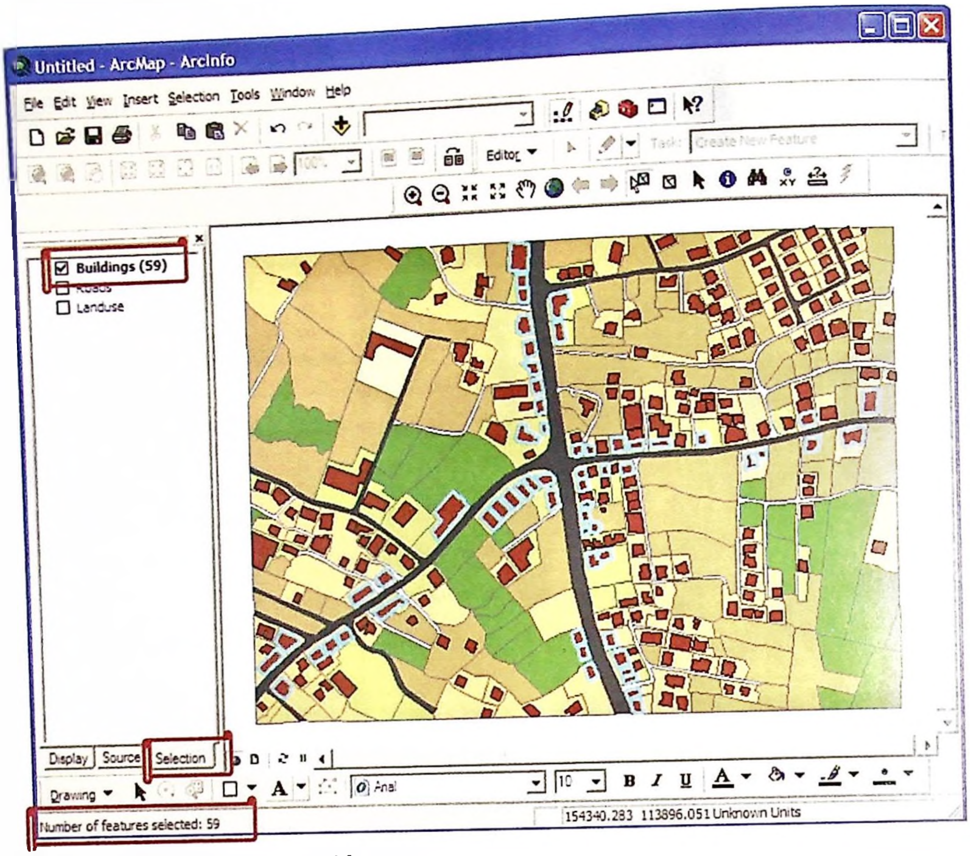


Figure 5.62: Highlighting selected features

1. Open a new ArcMap document. Load the Buildings, Roads and Landuse shapefiles from "C:\GIS_Tutorial\Chapter5\Example9".
2. Use the appropriate symbology for the map.
3. Click the Selection menu and choose Set Selectable Layers or click the Selection tab from the table of contents.
4. Check the boxes next to the layers that you want to be able to select. Uncheck the boxes next to the names of other layers (Roads and Landuse shapefiles) which you do not want to be able to select. Note that layers whose names are unchecked are still visible in your map but cannot be selected.
5. Click the Select Features tool on the Tools toolbar.
6. Click the feature you want to select.
7. Hold down the Shift key to select additional features.

If you want to select a number of buildings in a specific area, you can do this by dragging a box around them as follows:

8. Click the Select Features tool on the Tools toolbar.
9. Click and drag a box around the features you want to select (from the Buildings layer).

10. Hold down the Shift key as you drag the box to select additional features, Figure 5.63.

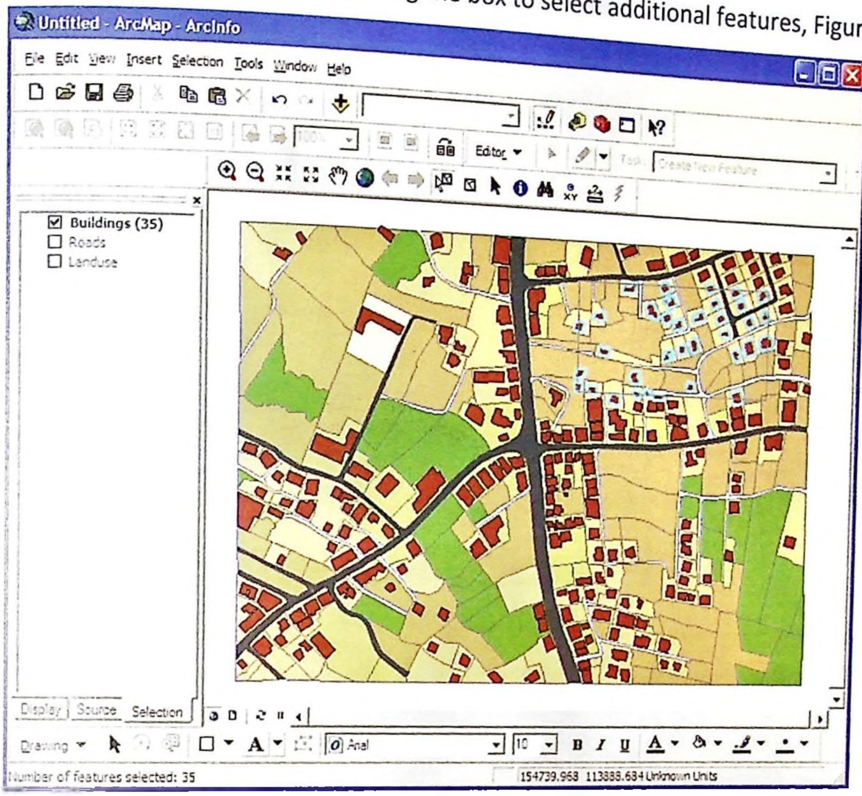


Figure 5.63: Selection by dragging a box over the desired features

To remove a feature from the selected set, click the Selection menu, point to the Interactive Selection Method, and then click Remove From Current Selection, Figure 5.64. Drag a box around the features you want to deselect.

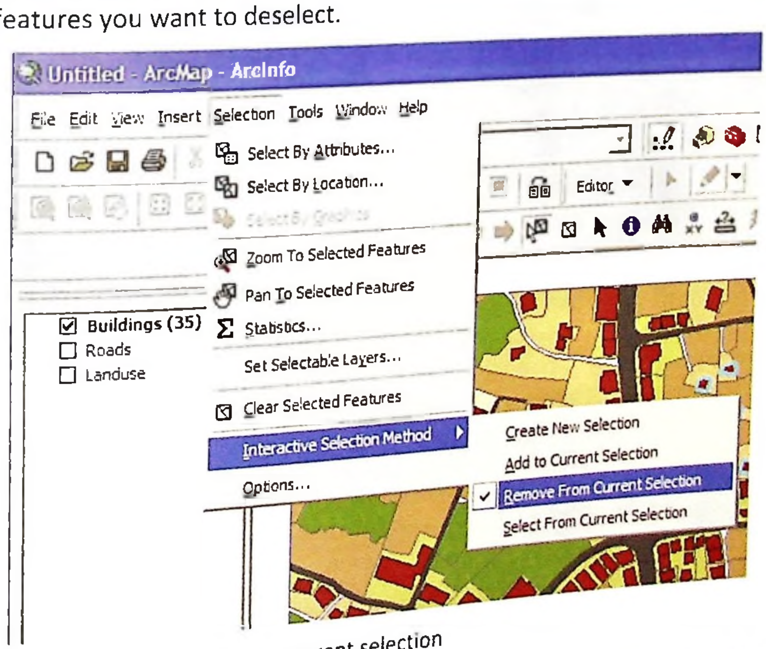


Figure 5.64: Remove features from a current selection

You can unselect all the selected features by clicking the Unselect tool from the Tools toolbar, Figure 5.65.

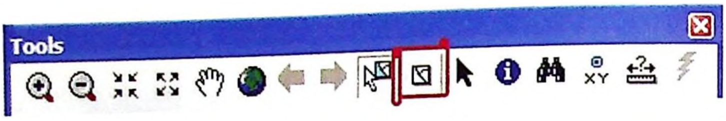
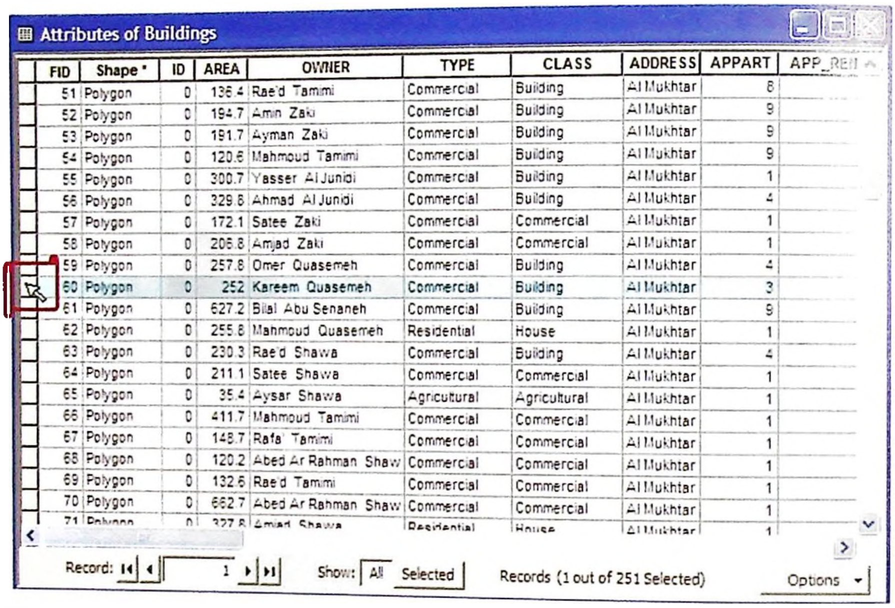


Figure 5.65: Clear selection tool

Features could also be interactively selected by choosing them from the table.

11. Right-click the Buildings layer in the table of contents and choose Open Attribute Table.
12. Select a feature in the table by clicking on the left of the desired record, Figure 5.66.



FID	Shape *	ID	AREA	OWNER	TYPE	CLASS	ADDRESS	APPART	APP_REN
51	Polygon	0	136.4	Rae'd Tamimi	Commercial	Building	Al Mukhtar	8	
52	Polygon	0	194.7	Amin Zaki	Commercial	Building	Al Mukhtar	9	
53	Polygon	0	191.7	Ayman Zaki	Commercial	Building	Al Mukhtar	9	
54	Polygon	0	120.6	Mahmoud Tamimi	Commercial	Building	Al Mukhtar	9	
55	Polygon	0	300.7	Yasser Al Junidi	Commercial	Building	Al Mukhtar	1	
56	Polygon	0	329.6	Ahmad Al Junidi	Commercial	Building	Al Mukhtar	4	
57	Polygon	0	172.1	Satee Zaki	Commercial	Commercial	Al Mukhtar	1	
58	Polygon	0	206.8	Amjad Zaki	Commercial	Commercial	Al Mukhtar	1	
59	Polygon	0	257.8	Omer Quasemeh	Commercial	Building	Al Mukhtar	4	
60	Polygon	0	252	Kareem Quasemeh	Commercial	Building	Al Mukhtar	3	
61	Polygon	0	627.2	Bilal Abu Senaneh	Commercial	Building	Al Mukhtar	9	
62	Polygon	0	255.8	Mahmoud Quasemeh	Residential	House	Al Mukhtar	1	
63	Polygon	0	230.3	Rae'd Shawa	Commercial	Building	Al Mukhtar	4	
64	Polygon	0	211.1	Satee Shawa	Commercial	Commercial	Al Mukhtar	1	
65	Polygon	0	35.4	Aysar Shawa	Agricultural	Agricultural	Al Mukhtar	1	
66	Polygon	0	411.7	Mahmoud Tamimi	Commercial	Commercial	Al Mukhtar	1	
67	Polygon	0	148.7	Rafa' Tamimi	Commercial	Commercial	Al Mukhtar	1	
68	Polygon	0	120.2	Abed Ar Rahman Shaw	Commercial	Commercial	Al Mukhtar	1	
69	Polygon	0	132.6	Rae'd Tamimi	Commercial	Commercial	Al Mukhtar	1	
70	Polygon	0	662.7	Abed Ar Rahman Shaw	Commercial	Commercial	Al Mukhtar	1	
71	Polygon	0	327.8	Amjad Shawa	Residential	House	Al Mukhtar	1	

Figure 5.66: Select features from a table

13. Hold down the Ctrl key and click any additional features.
14. To deselect a feature, hold down the Ctrl key and click the feature or click the Options button and then choose Clear Selection, Figure 5.67.

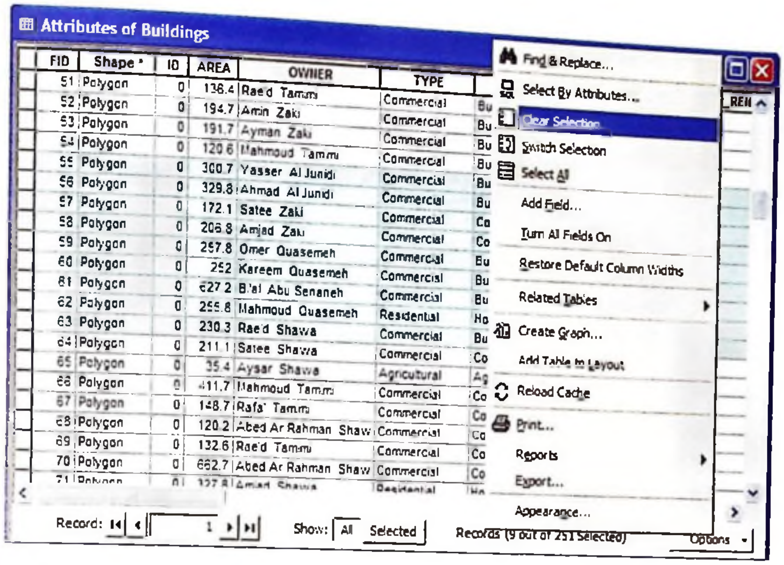


Figure 5.67: Clear selection from table

15. To select consecutive records in a table, click and drag the pointer up or down.

5.6.2 SQL Expression

Structured Query Language (SQL) is a standard computer language for accessing and managing databases. SQL expressions are used in many parts of ArcGIS and its extensions to define a subset of data on which to perform some operation. You use it in ArcMap to select features with the Select by Attributes dialog box, Figure 5.68, or with the Query Builder dialog box to set a layer definition query. It can also be used in geoprocessing to define a subset of features or records to perform an operation on or to select features programmatically.

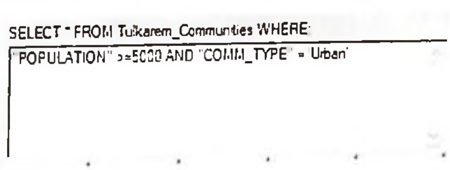


Figure 5.68: Typical SQL statement

5.6.3 Using Select by Attributes

The Structured Query Language (SQL) is a powerful language you use to define one or more criteria that can consist of attributes, operators, and calculations. For example, imagine you have a map of groundwater wells and want to find the wells that have abstraction levels equal to or more than 100,000 m^3/year and are used for agricultural purposes. This could be done using the expression: Abstraction >= 100,000 AND type = 'Agriculture'.

When you search with SQL expressions, you can select features or table records in any data format supported by ArcMap. However, you format expressions differently depending on the format of the data you are querying.

The Select By Attributes dialog box allows you to select features from a given layer using an SQL expression. This option is clarified in the following example.

1. Open a new ArcMap document. Add the Tulkarem Roads, Tulkarem Communities and Tulkarem Border shapefiles from "C:\GIS_Tutorial\Chapter5\Example10\"
2. Click Selection on the main menu then choose Select By Attributes, Figure 5.69.

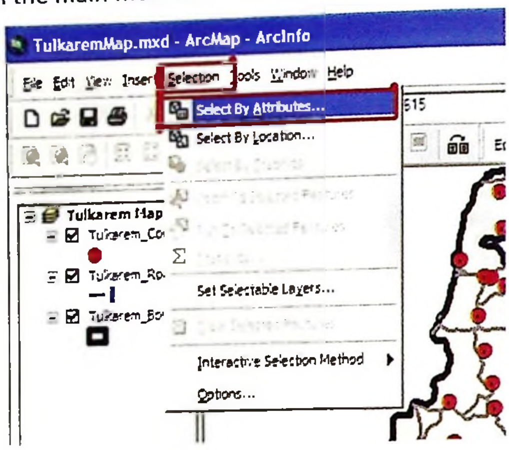


Figure 5.69: Selection by attributes

3. From the Select By Attributes dialog box, click the Layer dropdown arrow and choose the layer containing the features you want to select. In this example you are going to select features from the Tulkarem Communities shapefile.
4. Click the Method dropdown arrow and choose Create a new selection.
5. Double-click the Population field to add it to the expression box below.
6. Click the ">=" operator to add it to the expression.
7. Write "3000" in the expression window on right to the ">=" operator, Figure 5.70.

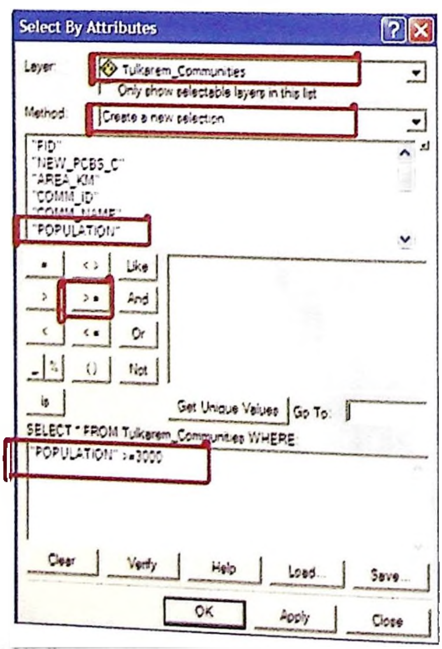


Figure 5.70: Select By Attributes window

8. Click OK. The result is colored in cyan, Figure 5.71.

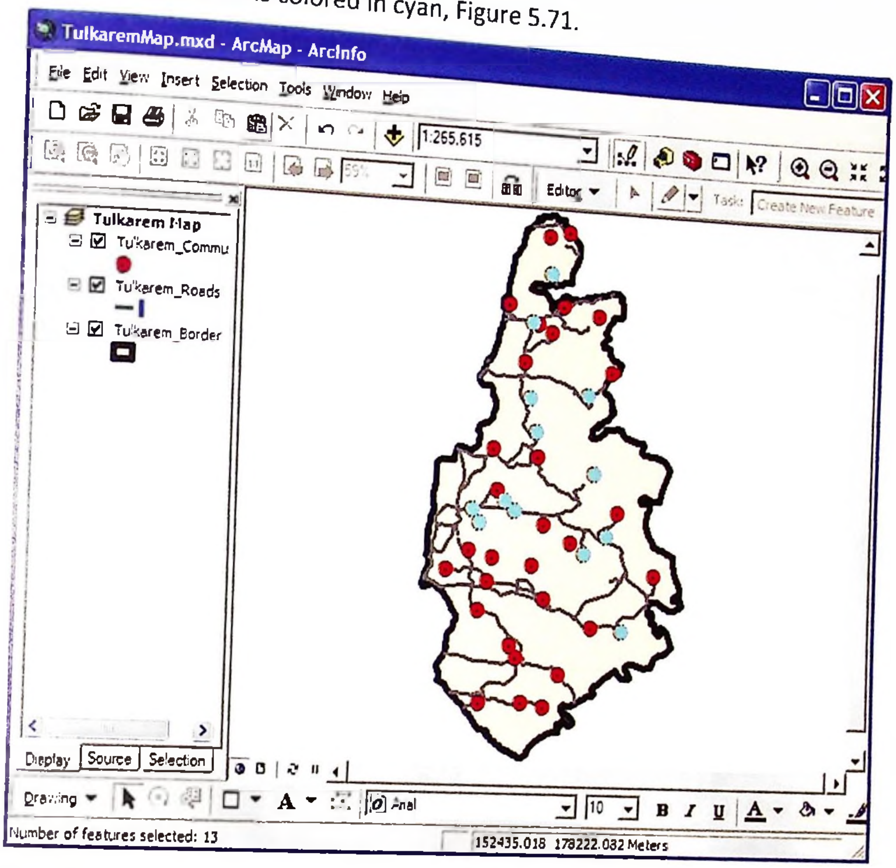


Figure 5.71: Selection results

You can extend your search by adding a new constraint to the SQL function.

9. Click Selection from the main menu and click Select By Attributes.
10. You will find the previous expression still written in the Expression box. Change the selection method to "Select from Current Selection" to select from the previous selection.
11. Click the "AND" operator to add it to the expression.
12. Double-click the COMM_TYPE field to add the field name to the Expression box.
13. Click the "=" operator to add it to the expression.
14. Click Get Unique Values to see the values for the selected field.
15. Double-click the Rural value to add it to the expression to select all rural communities that have a population equal or more than 3000 inhabitants.
16. Click the Verify button to see if you are using proper syntax or if the criteria you have entered select any features, Figure 5.72.
17. You can use the Save and Load buttons respectively to save your current query as a file or load an existing one.

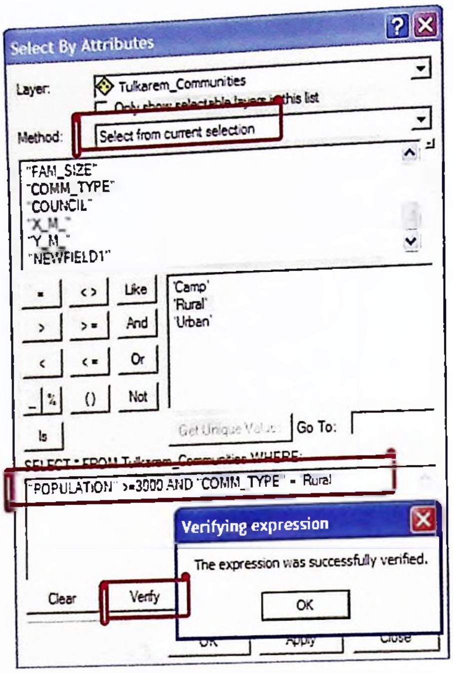


Figure 5.72: Verifying the SQL statement

18. Click Apply. This will remove all communities which are not rural from the previous selection, Figure 5.73.

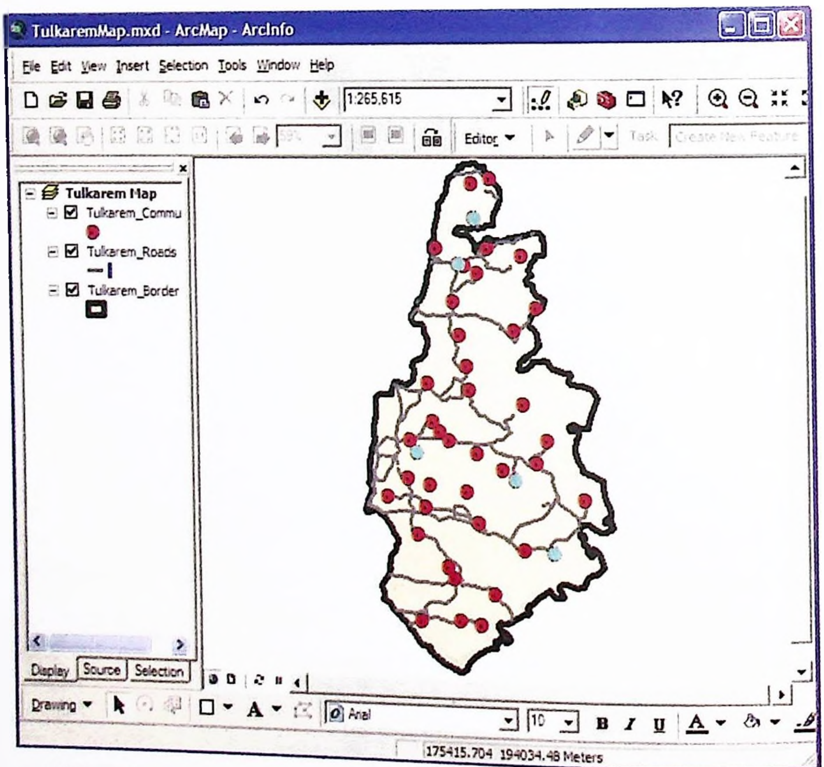


Figure 5.73: Refining the previous selection

19. Use the Clear button to empty the Expression box.

You can do the same selection from the attribute table of the Tulkarem_Communities layer.

16. Right-click the Tulkarem_Communities layer in the table of contents and choose Open Attribute Table.
17. Click the Options button and then choose Select By Attribute, Figure 5.74, type in the same SQL statement.

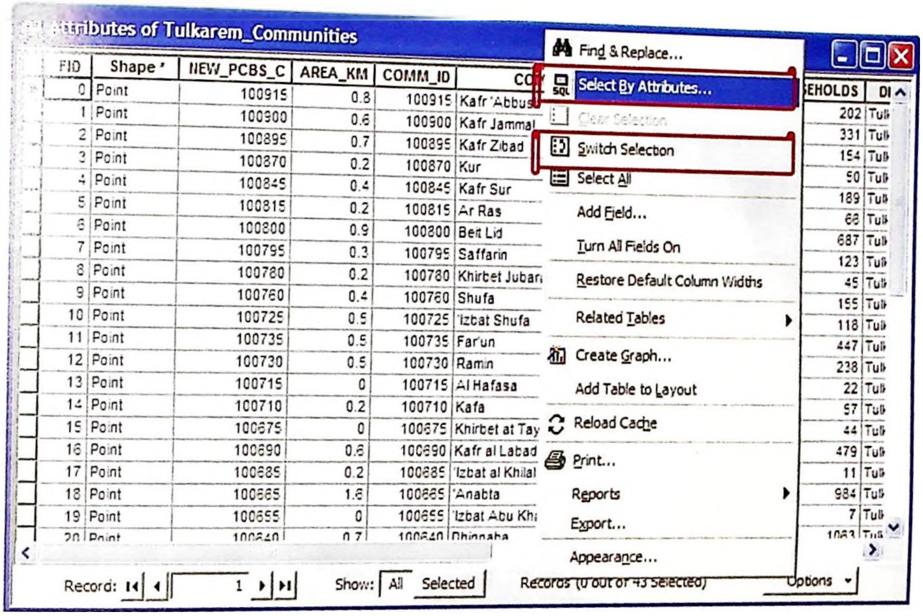


Figure 5.74: Selection by attributes from an attribute table

You can also reverse your selection by clicking Switch Selection from the Options dropdown list, Figure 5.74.

5.6.4 Using Select by Location

The Select By Location dialog box, Figure 5.75, selects features based on their location relative to other features. For example, you could select all the groundwater wells that are located within the urban boundary. This type of question is known as a spatial query.

By combining queries, you can perform more complex searches. For example, suppose you want to find all groundwater wells that are located within or 1 km around the urban areas and have a chloride concentration less than 50 mg/l. You would first select wells located within a 1 km radius (select by location), then refine the selection by finding those wells that have a chloride concentration less than 50 mg/l from the chloride attribute.

You can use a variety of selection methods to select the point, line, or polygon features in one layer that are near or overlap the features in the same or another layer.

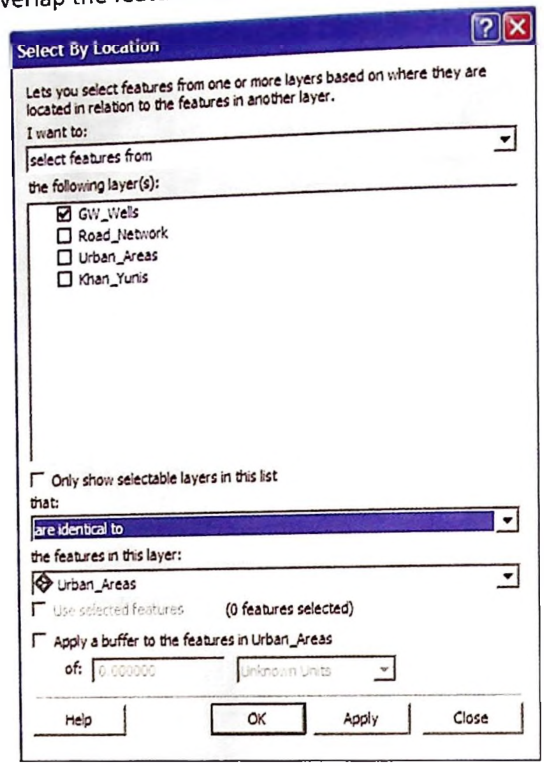


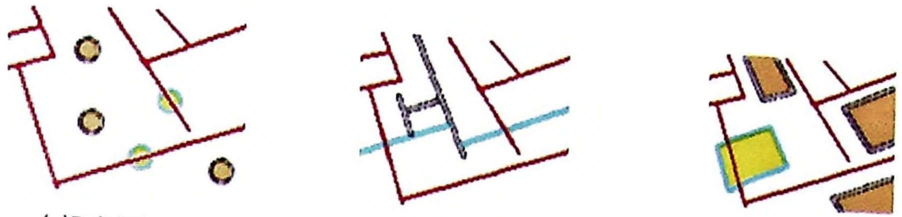
Figure 5.75: Select By Location window

5.6.4.1 Intersect

Intersect is the most generic operator. As its name implies, it will return any feature that geometrically shares a common part with the source feature (or features). Figures 5.76, 5.77 and 5.78 show how different types of features could be selected based on other features. Note that the highlighted cyan features are selected because they intersect with the features in red.

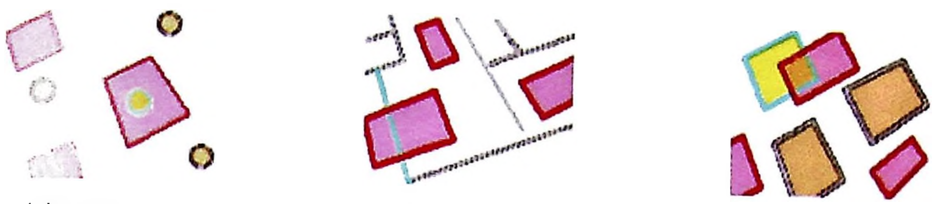
(a)Point Feature (b)Line Feature (c)Polygon Feature

Figure 5.76: Selecting features that intersect with point features



(a)Point Feature (b)Line Feature (c)Polygon Feature

Figure 5.77: Selecting features that intersect with line features



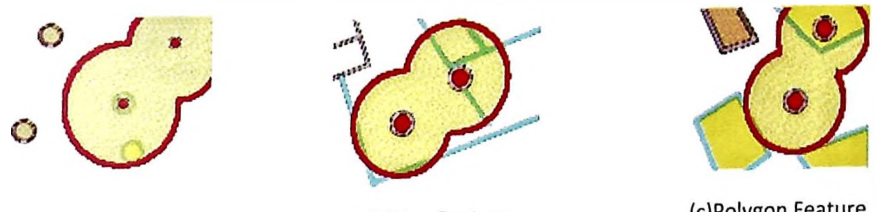
(a)Point Feature (b)Line Feature (c)Polygon Feature

Figure 5.78: Selecting features that intersect with polygon features

5.6.4.2 Are Within a Distance of Option

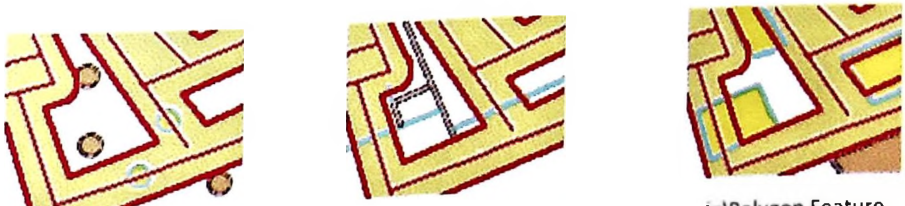
The Are within a distance of operator creates a buffer (or buffers) with a size equal to the distance specified around the source feature (or features), then returns all the features intersecting the buffer (or buffers). Its typical use would be to retrieve wells within a specified distance from an urban area, roads, shops or businesses, and so on.

Figures 5.79, 5.80 and 5.81 show how different types of features could be selected based on other features. Note that the highlighted cyan features are selected because they are within the specific distance of the red features.



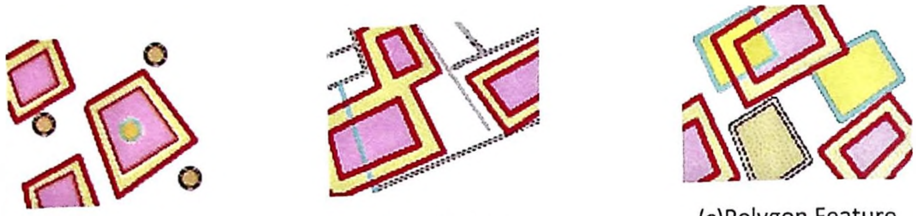
(a)Point Feature (b)Line Feature (c)Polygon Feature

Figure 5.79: Selecting features that are within a specified distance from point features



(a)Point Feature (b)Line Feature (c)Polygon Feature

Figure 5.80: Selecting features that are within a specified distance from line features



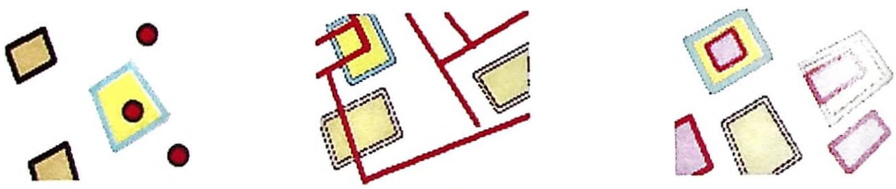
(a)Point Feature (b)Line Feature (c)Polygon Feature

Figure 5.81: Selecting features that are within a specified distance from polygon features

5.6.4.3 Completely Contain

For a feature to be considered as completely containing another feature, each point in the geometry of the source feature must fall inside the geometry of the target feature, excluding its boundaries. The target feature in this type of selection is limited to a polygon feature.

Figure 5.82 shows how different types of features could be selected based on other polygon features. Note that the highlighted cyan features are selected because they completely contain the red features.



(a)Point Feature (b)Line Feature (c)Polygon Feature

Figure 5.82: Selecting features that are completely contain other polygon features

5.6.4.4 Are Completely Within

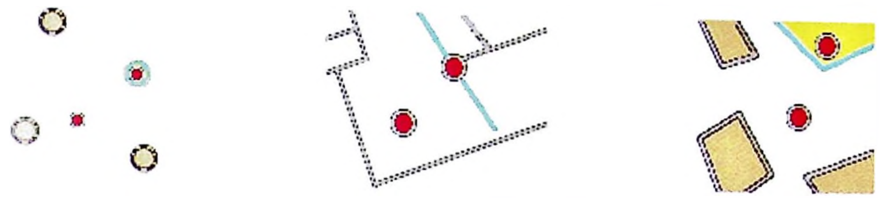
For a feature to be considered as being completely within another feature, each point in the geometry of the target feature must fall within the geometry of the source feature excluding its boundaries. This is opposite to the Completely Contain operator. The source feature must be a polygon or you must apply a buffer around point and line features to be able to use this operator. Figure 5.83 shows how different types of features could be selected based on polygon features. Note that the highlighted cyan features are selected because they are completely within the red features.

(a)Point Feature (b)Line Feature (c)Polygon Feature

Figure 5.83: Selecting features that are completely within another polygon feature

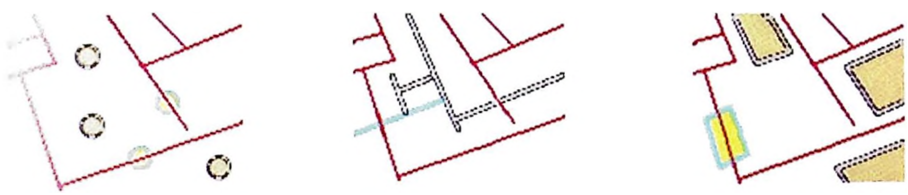
5.6.4.5 Have their Center in

A target feature will be selected by this operator if the centroid of its geometry falls into the geometry of the source feature or on its boundaries. Figures 5.84, 5.85 and 5.86 show how different types of features could be selected using this option. Note that the highlighted cyan features are selected because their centers are in the red features.



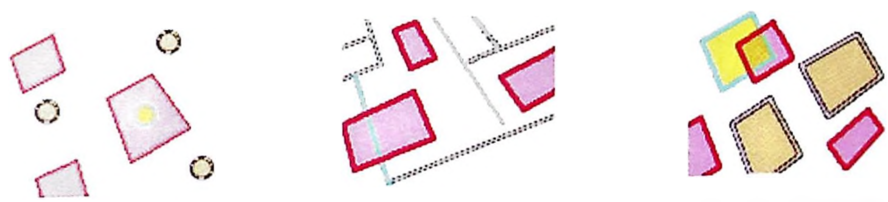
(a)Point Feature (b)Line Feature (c)Polygon Feature

Figure 5.84: Selecting features that have their centers within a distance of a point feature



(a)Point Feature (b)Line Feature (c)Polygon Feature

Figure 5.85: Selecting features that they have their centers within a distance of a line feature



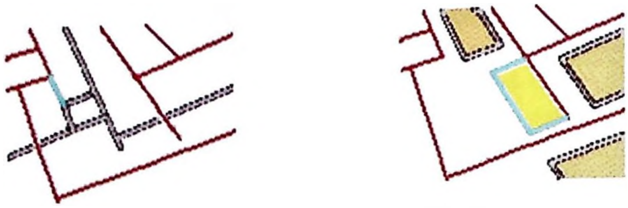
(a)Point Feature (b)Line Feature (c)Polygon Feature

Figure 5.86: Selecting features that they have their centers within a distance of a polygon feature

5.6.4.6 Share a Line Segment with

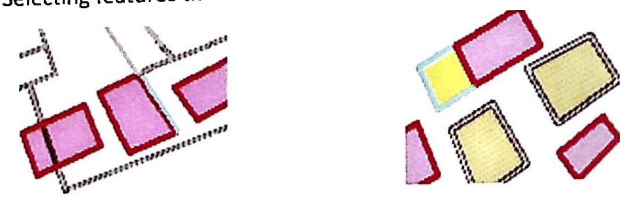
With this method, the source and target features will be considered as sharing a line segment if their geometries have at least two contiguous vertices in common. The target and source feature in this type of selection is limited to polygon or line features.

Figures 5.87 and 5.88 show how different types of features could be selected using this option. Note that the highlighted cyan features are selected because they share a line segment with the red features.



(a)Line Feature (b)Polygon Feature

Figure 5.87: Selecting features that share a line segment with line features



(a)Line Feature (b)Polygon Feature

Figure 5.88: Selecting features that share a line segment with polygon features

5.6.4.7 Touch the Boundary of

The target and source features must be either line or polygon features. A target feature will be returned by this function if the intersection of its geometry with the geometry of the source feature is non-empty, but the intersection of their interiors is empty.

Figures 5.89 and 5.90 illustrate how different types of features could be selected using this option. Note that the highlighted cyan features are selected because they touch the boundary of the red features.

(a)Line Feature (b)Polygon Feature

Figure 5.89: Selecting features that touch the boundary of line features

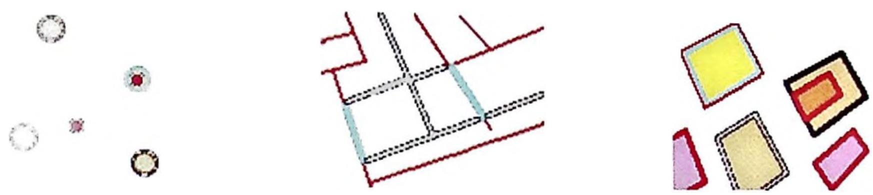
(a)Line Feature (b)Polygon Feature

Figure 5.90: Selecting features that touch the boundary of polygon features

5.6.4.8 Are Identical to

Two features are considered identical if their geometries are strictly equal. The feature types must be the same, for instance, you can use this operator to compare two polygon layers, but comparing a point layer and a polygon layer for identity will always return an empty selection.

Figure 5.91 shows how different types of features could be selected using this option. Note that the highlighted cyan features are selected because they are identical to the red features.



(a)Point Feature (b)Line Feature (c)Polygon Feature

Figure 5.91: Selecting features that are identical to other polygon features

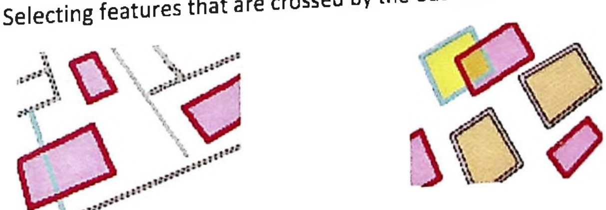
5.6.4.9 Are Crossed by the Outline of

For this operator, the boundaries of the source and target feature must have at least one edge, vertex, or endpoint in common but must not share a line segment. The source and target features must be either line or polygon features.

Figures 5.92 and 5.93 show how different types of features could be selected using this option. Note that the highlighted cyan features are selected because they intersect with the red features.

(a)Line Feature (b)Polygon Feature

Figure 5.92: Selecting features that are crossed by the outline of a line feature



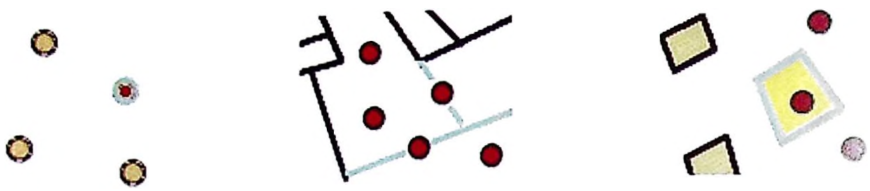
(a)Line Feature (b)Polygon Feature

Figure 5.93: Selecting features that are crossed by the outline of a polygon feature

5.6.4.10 Contain

This method differs from the Completely Contain method in that the geometry of the source feature must fall inside the geometry of the target feature including its boundaries. The target feature must be a polygon.

Figures 5.94, 5.95 and 5.96 show how different types of features could be selected using this option. Note that the highlighted cyan features are selected because they contain a red feature.



(a)Point Feature (b)Line Feature (c)Polygon Feature

Figure 5.94: Selecting features that contain a point feature

(a)Line Feature (b)Polygon Feature

Figure 5.95: Selecting features that contain a line feature

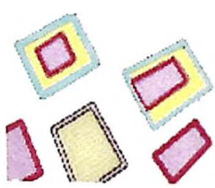
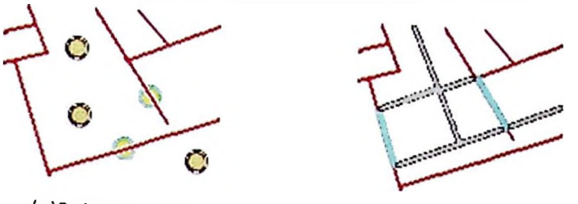


Figure 5.96: Selecting features that contain a polygon feature

5.6.4.11 Are Contained by

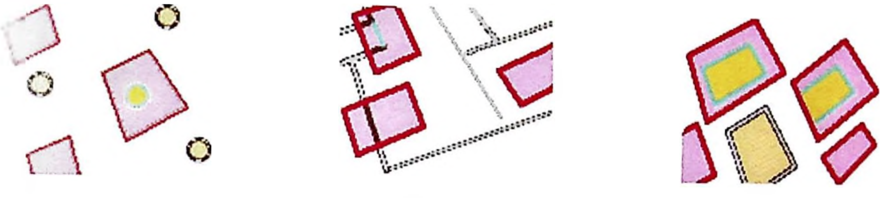
This method differs from the Are completely within method in that the geometry of the target feature must fall inside the geometry of the source feature including its boundaries. Figures 5.97, 5.98 and 5.99 show how different types of features could be selected using this option. Note that the highlighted cyan features are selected because they are contained by a red features.

Figure 5.97: Selecting features that are contained by a point feature



(a)Point Feature (b)Line Feature

Figure 5.98: Selecting features that are contained by a line feature



(a)Point Feature (b)Line Feature (c)Polygon Feature

Figure 5.99: Selecting features that are contained by a polygon feature

5.6.4.12 Practicing Selection by Location

1. Open a new ArcMap document. Load the Buildings, Roads, Cisterns, Sewage and Landuse shapefiles from "C:\GIS_Tutorial\Chapter5\Example11".
2. Use the appropriate sybmology for the map (e.g. Figure 5.100)

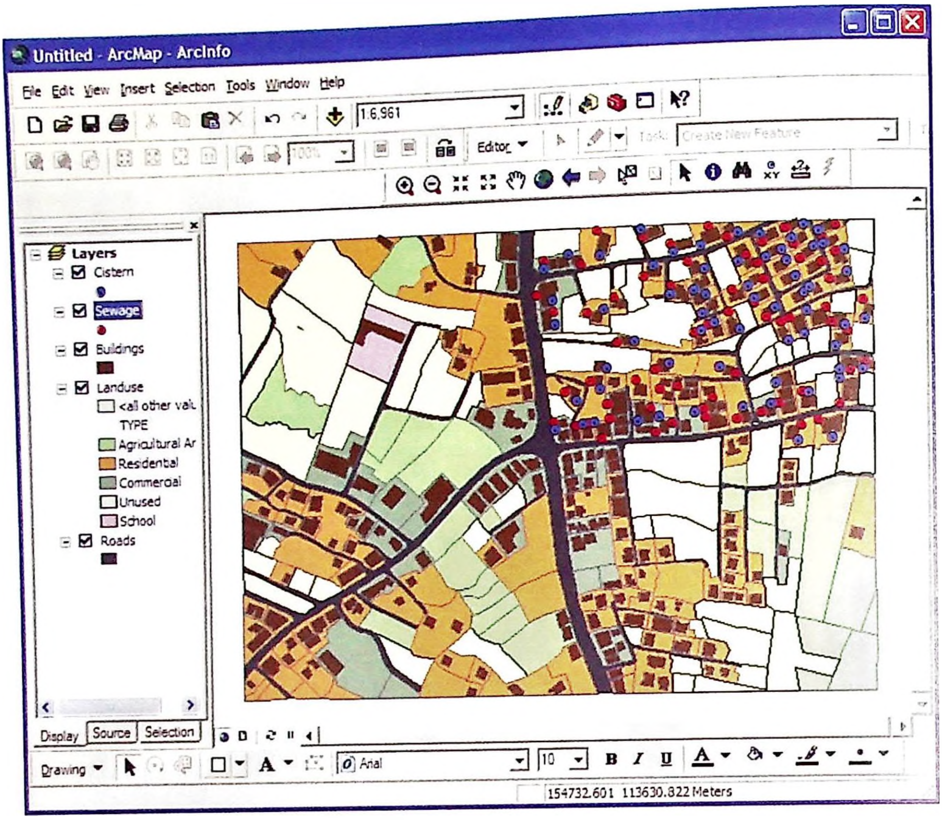


Figure 5.100: General map used for practicing Selection By Location

In the villages of the West Bank, most of the Palestinians use both rainwater harvesting cisterns which are mainly used for domestic purposes and sewage cesspits used to dispose wastewater from their households. In this example, all cisterns that are close to the cesspits will be identified. The water in these selected cisterns could be contaminated as a result of the leaching wastewater which could ultimately affect the health of the residents consuming this source.

3. Click Selection, choose Select By Location.
4. Click the dropdown arrow and choose on the Select features from item.
5. Check the features of the Cistern layer which you would like to select.
6. Click the dropdown arrow and choose the desired selection method (Are within a distance of).
7. Click the dropdown arrow, and then choose the Sewage layer from which you want to select features from.
8. Check Apply a buffer to the features in Sewage and set the distance within which to search for features (15 meters).
9. Click OK to execute the query and close the dialog box, Figure 5.101.

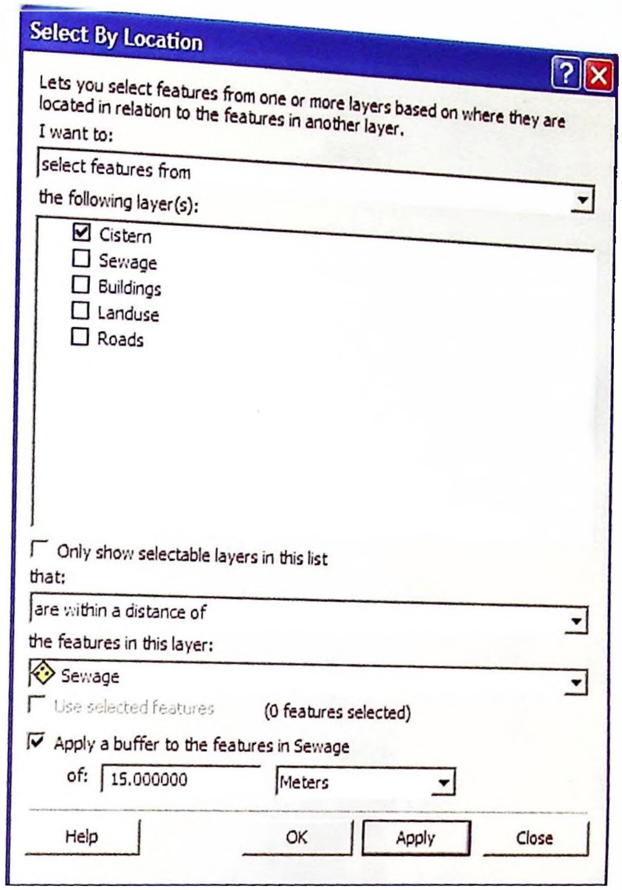


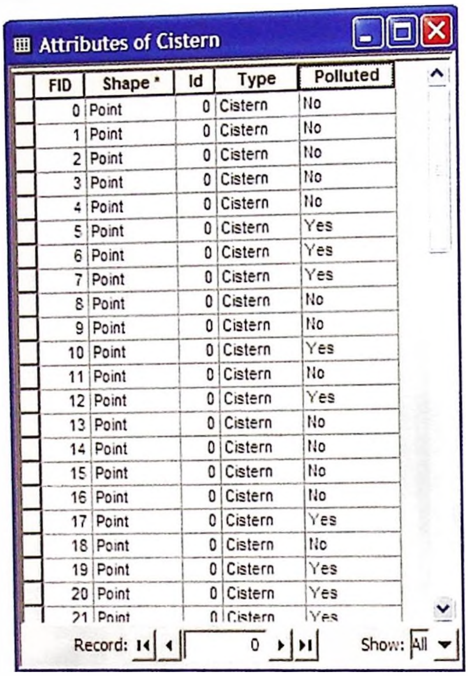
Figure 5.101: Selection of features from the Cisterns shapefile based on the Sewage shapefile

ArcMap will select all the features that match the criteria mentioned above, Figure 5.102.

Figure 5.102: Result of the Selection By Location option

10. Open the Cisterns attribute table.

11. Create a new text field, name it "Polluted". Use the Calculate Field tool to fill in the values of all the selected cisterns in this field with "Yes". This means that all these selected cisterns have the potential for pollution. Fill in the values of the other cisterns with "No", Figure 5.103.



Attributes of Cistern

FID	Shape *	Id	Type	Polluted
0	Point	0	Cistern	No
1	Point	0	Cistern	No
2	Point	0	Cistern	No
3	Point	0	Cistern	No
4	Point	0	Cistern	No
5	Point	0	Cistern	Yes
6	Point	0	Cistern	Yes
7	Point	0	Cistern	Yes
8	Point	0	Cistern	No
9	Point	0	Cistern	No
10	Point	0	Cistern	Yes
11	Point	0	Cistern	No
12	Point	0	Cistern	Yes
13	Point	0	Cistern	No
14	Point	0	Cistern	No
15	Point	0	Cistern	No
16	Point	0	Cistern	No
17	Point	0	Cistern	Yes
18	Point	0	Cistern	No
19	Point	0	Cistern	Yes
20	Point	0	Cistern	Yes
21	Point	0	Cistern	Yes

Record: 0 Show: All

Figure 5.103: Filling in the Polluted field based on the selection results

Now, you are going to find new areas that are suitable for building new schools, the selection criteria include:

a. Land use types should either be unused, agricultural or commercial lands.

b. The area should be equal to or more than 5000 m^2.

c. No buildings are on the land use parcels.

d. Parcels should be within a 25 m distance from the nearest road.

12. Remove the cisterns and cesspits from the map.

13. Click Selection and then Select By Attributes.

14. Check the Landuse layer whose features you would like to select from.

15. Click the selection method from the dropdown list, choose Create new selection.

16. Type in the SQL statement as shown in Figure 5.104.

17. Click OK to execute the query and close the dialog box.

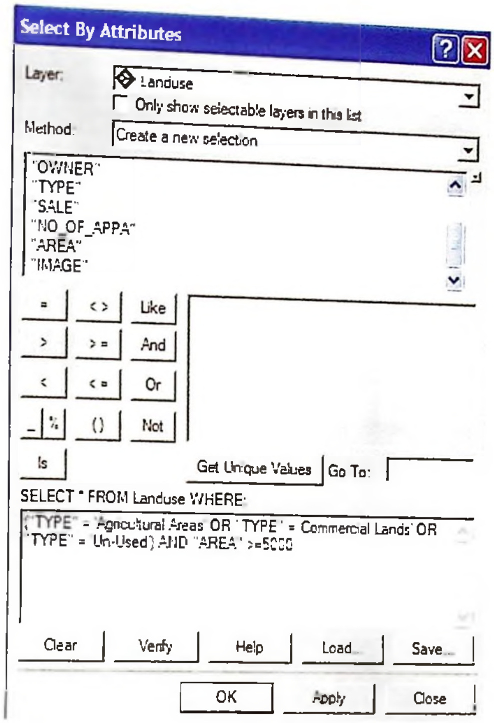


Figure 5.104: Select By attributes from the Landuse shapefile

18. ArcMap will select all features that answer the SQL statement, Figure 5.105.

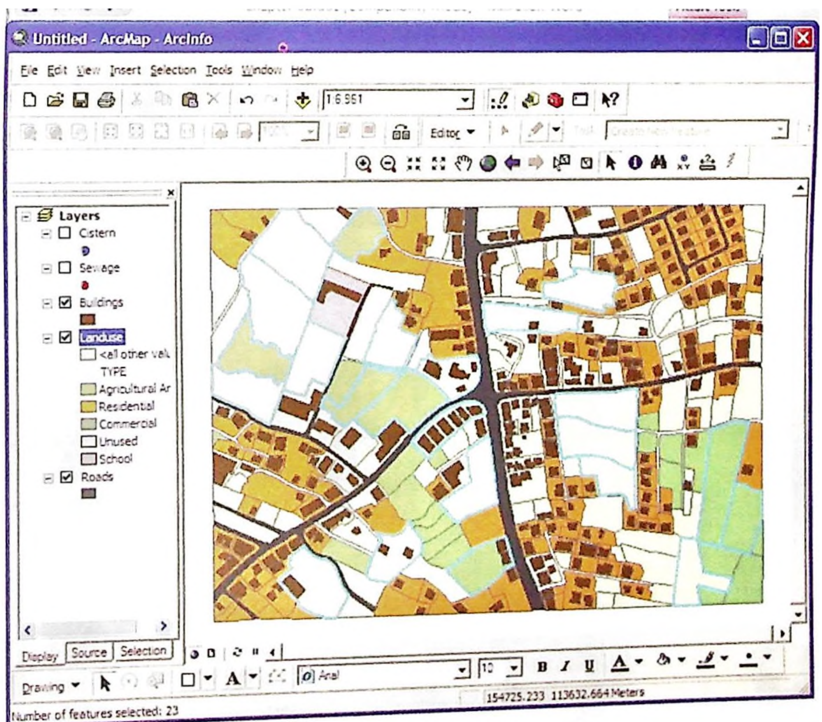


Figure 5.105: Results of selection query (Select By Attributes)

19. Click Selection and then choose Select By Location.

20. Click the selection method dropdown arrow and select Remove from currently selected features in.
21. Check the Landuse layer whose features you would like to select from.
22. Select Intersect from the dropdown list.
23. Click the dropdown arrow and choose the Buildings layer to remove all areas that overlap with buildings.
24. Click OK to execute the query and close the dialog box, Figure 5.106.

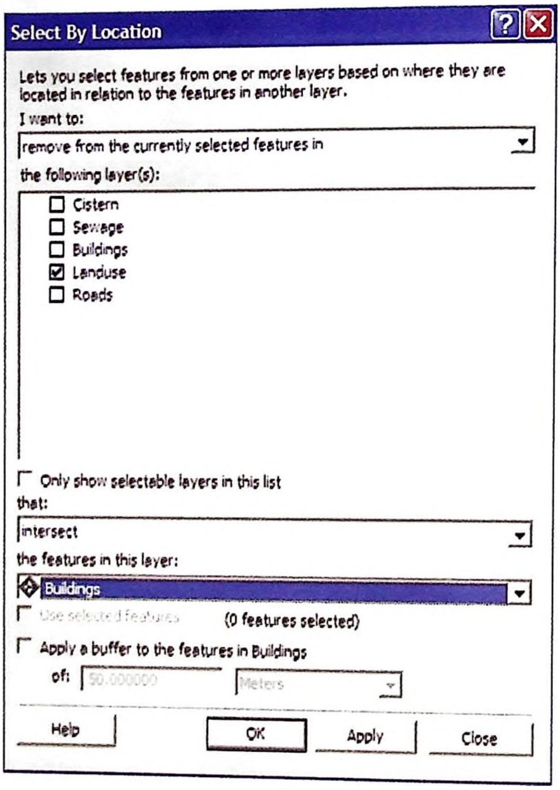


Figure 5.106: Remove selected features from the Landuse shapefile based on the locations of the buildings

25. ArcMap will remove all the areas that contain buildings, Figure 5.107.

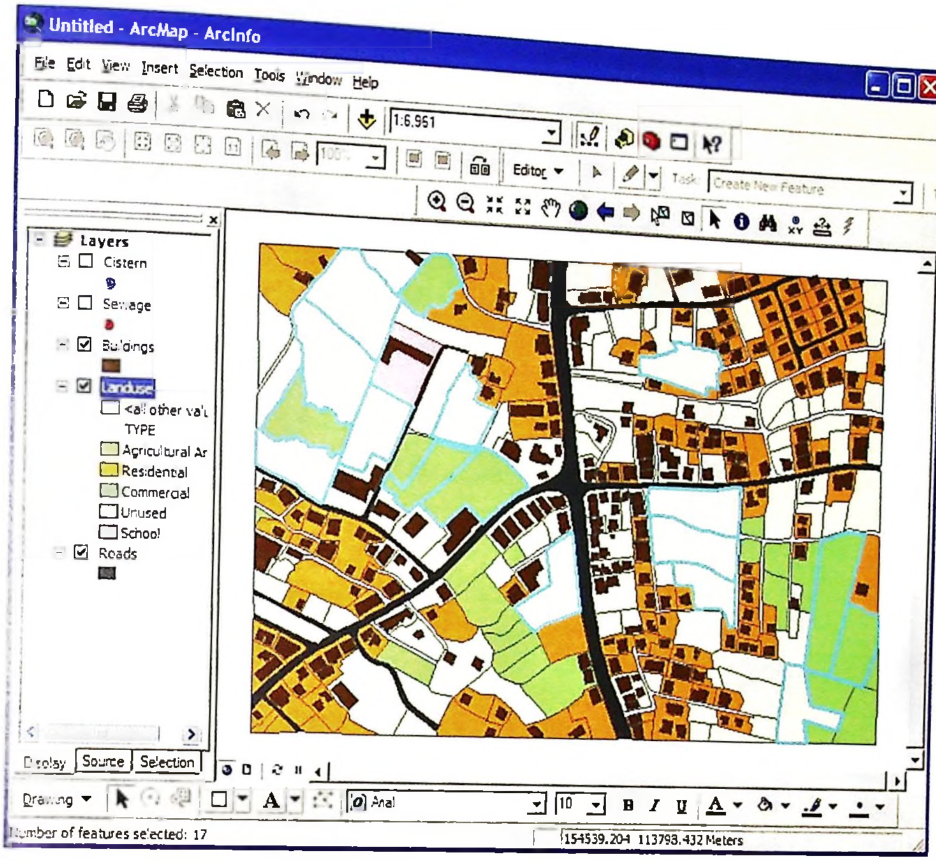


Figure 5.107: Results of selection

26. Click Selection and then click Select By Location.
27. Click the selection method dropdown arrow and choose Select from the currently selected features in.
28. Check the Landuse layer whose features you would like to select from.
29. Select are within a distance of from the selection criteria dropdown arrow.
30. Click the dropdown arrow and select the Roads layer to remove all areas far from the roads.
31. Check Apply a buffer to the features in Roads and set the distance within which to search for features (25 meters).
32. Click OK to execute the query and close the dialog box, Figure 5.108.

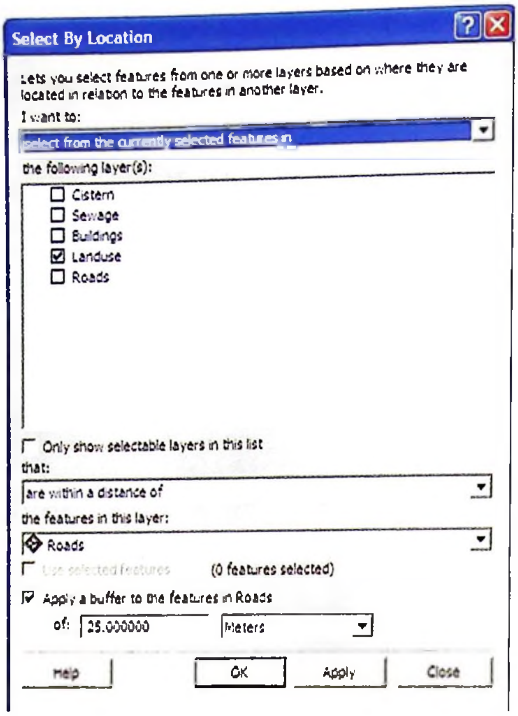


Figure 5.108: Select features from the currently selected features using Select By Location

33. Finally, ArcMap will select all the areas that are suitable for building new schools based on the above mentioned criteria, Figure 5.109.

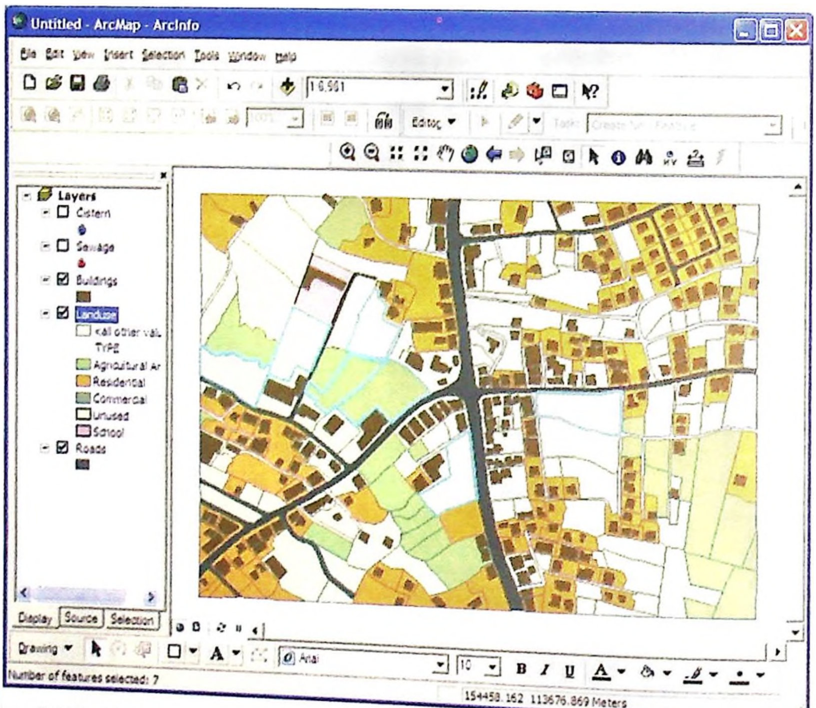


Figure 5.109: Final results of selection

5.6.5 Selection By Graphics

The Select By Graphics command allows you to select features (from all selectable layers) that intersect a selected graphic element. This can be used with most graphic elements except those containing text or curves.

1. Open a new ArcMap document. Load the Buildings, Roads, Cisterns, Sewage and Landuse shapefiles from "C:\GIS_Tutorial\Chapter5\Example12".
2. Use appropriate symbology for the map.
3. Click the Selection menu, then click Set Selectable Layers. Uncheck the Roads and Landuse layers. Make sure that the Buildings layer is also checked.
4. To create a new graphic, click the New Graphics tool dropdown arrow on the Draw toolbar, Figure 5.110, choose a tool, such as the New Polygon tool, and draw a new graphic in the view around the center of the study area. Optionally, click the Fill Color dropdown arrow and choose No Color. When the features are selected, you can see the selected features under the graphic.

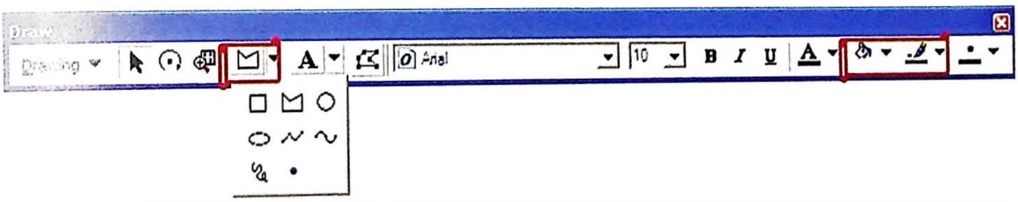


Figure 5.110: Creating graphics

5. Click the Select the graphic element to select.
6. Click Selection from the Main menu and choose Select By Graphics. The features contained by or intersecting the graphic will be highlighted to show they are selected, Figure 5.111.

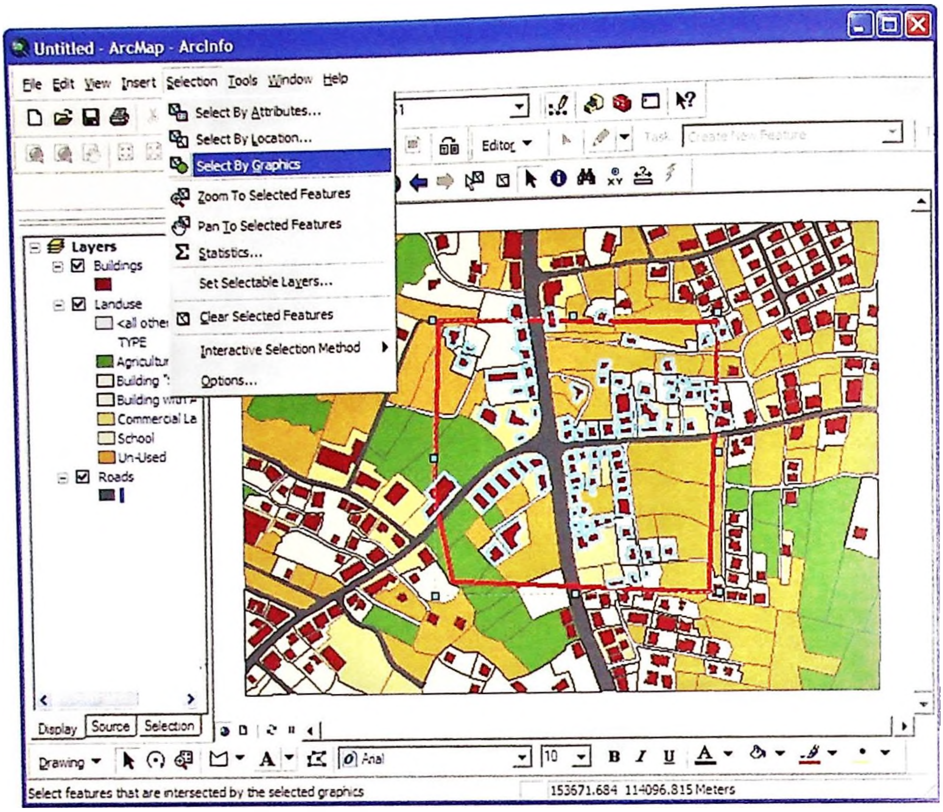


Figure 5.111: Selection By Graphics

5.7 Viewing Statistics of a Table

When exploring a table, you can get statistics describing the values in numeric columns such as the number of entries in each column, and the sum, minimum, mean, maximum, and standard deviation of these entries. A histogram is also provided showing how the column's values are distributed. Statistics are calculated for all numeric columns in the table.

1. Open a new ArcMap document. Add the West_Bank_Districts and Communities shapefiles from "C:\GIS_Tutorial\Chapter5\Example13".
2. Open the attribute table of the West Bank Districts shapefile. In the attribute table the name, population and other attributes are recorded for each community in the West Bank. To determine the sum, minimum, mean, maximum, and standard deviation of the communities in the West Bank Governorates, right-click the heading of a population field and click Statistics, Figure 5.112.

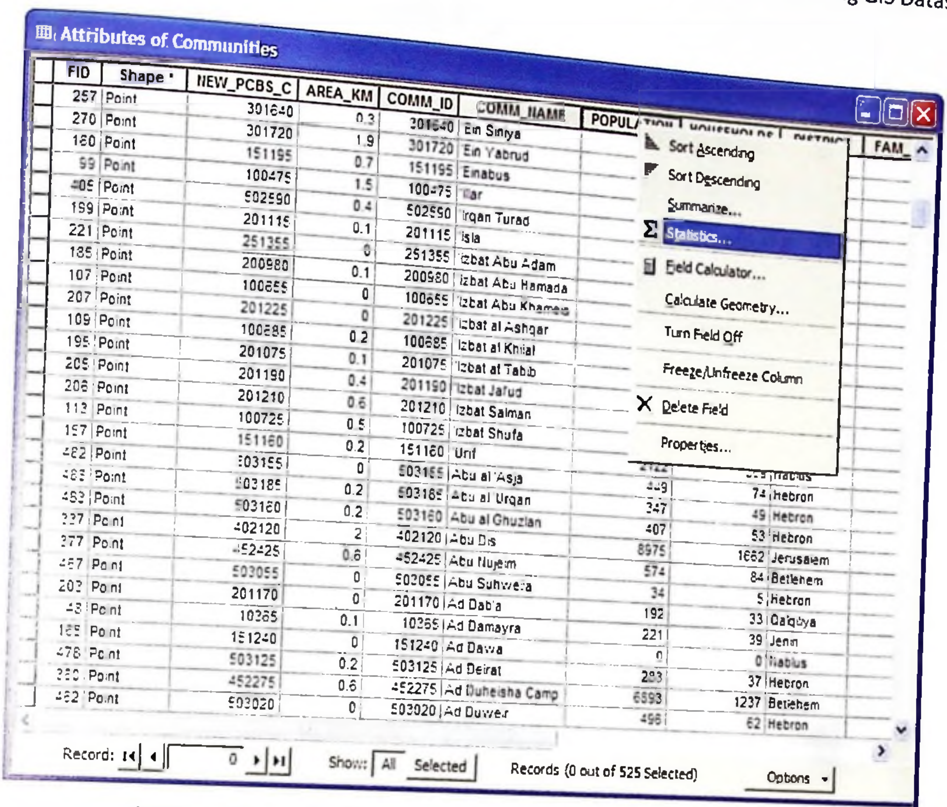


Figure 5.112: Getting field statistics

3. In the Statistics dialog box, you will see a statistical summary of the values in the Population field, Figure 5.113.

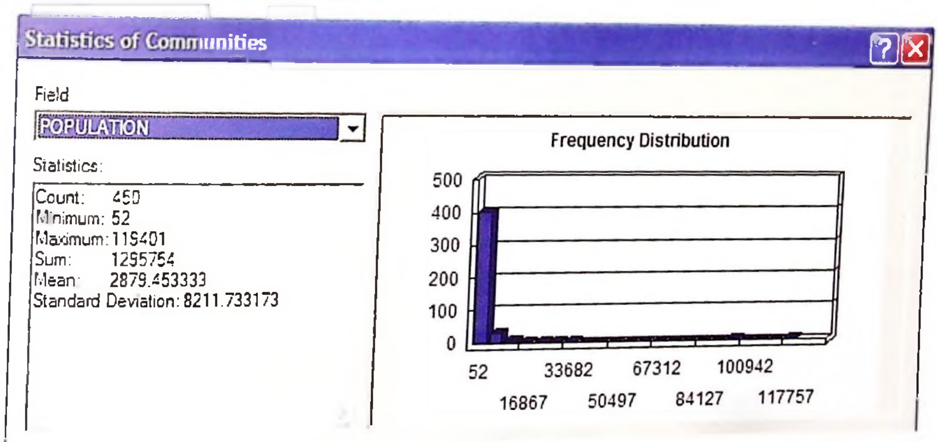


Figure 5.113: Statistics of the Population field

From Figure 5.113, you can conclude the following information about the population distribution in the West Bank Governorates:

a. Number of communities: 450 communities

b. The smallest community has 52 inhabitants

c. The largest community has 119,401 inhabitants

d. The mean population is 2879 inhabitants

e. The sum is 1295754 inhabitants

f. The standard deviation is 8211.7 inhabitants

4. If you want to see statistics for another numeric field (e.g. Family size), click the Field dropdown arrow and choose the Fam_Size field, Figure 5.114.

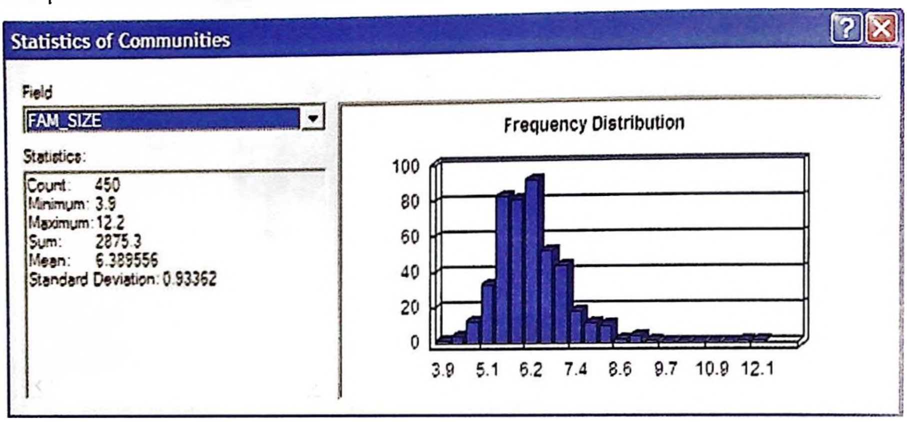


Figure 5.114: Statistics of the Fam_size field

5. Press the Close button when finished exploring the statistics.

5.8 Summarizing Data in a Table

Sometimes the attribute information you have about map features is not organized the way you want; for instance, you have population data by community when you want it by Governorate. By summarizing the data in a table, you can derive various summary statistics including the count, average, minimum, and maximum value. ArcMap creates a new table containing the summary statistics. You can then join this table to the attribute table of a layer so you can symbolize, label, or query the layer's features based on the values of the summary statistics.

1. Open a new ArcMap document. Add the West_Bank_Districts and Communities shapefiles from C:\GIS_Tutorial\Chapter5\Example14.
2. Open the attribute table of the West Bank Communities.
3. Right-click the District field heading and then click Summarize, Figure 5.115.

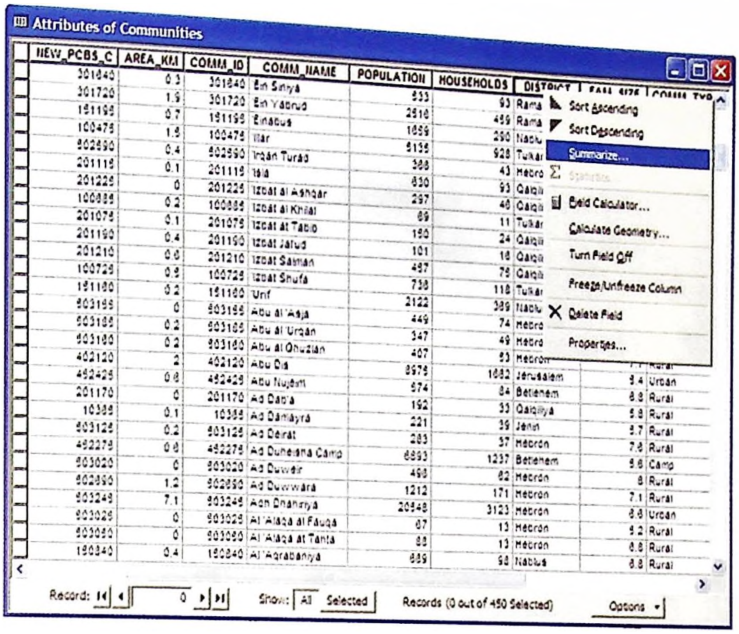


Figure 5.115: Summarizing the communities attribute table

4. Check the box next to the Population field to get the summary statistics you want to include in the output table.
5. Type the name and location of the output table you want to create or click the Browse button and navigate to a folder, Figure 5.116, (e.g. C:\GIS_Tutorial\Chapter5\Example14\West Bank_Population.dbf)
6. Click OK.
7. Click Yes when prompted to add the new table to your map.

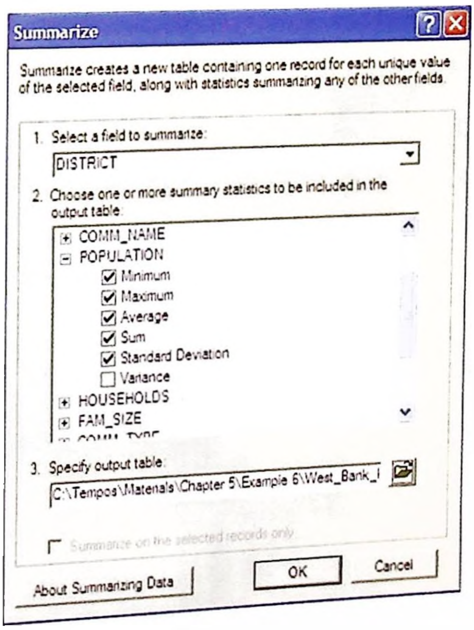


Figure 5.116: Summarize window

8. Open the West_Bank_Population.dbf table to view the summarization results, Figure 5.117.

Attributes of West_Bank_Population

OID	DISTRICT	Count_DIST	Minimum_POPULATION	Maximum_POPULATION	Average_POPULATION	Sum_POPULATION	StdDev_POPULATION
0	Betlehem	46	72	11285	1749.0435	80456	2567.922
1	Hebron	101	58	119401	3362.802	339643	12557.0607
2	Jenin	65	54	26681	2607.8	169507	4291.0416
3	Jericho	9	278	14744	3150.8889	28358	4602.0256
4	Jerusalem	25	276	18967	3512.72	87818	3973.5536
5	Nablus	48	115	100231	4448.0417	213506	14308.8112
6	Qalqiliya	27	101	31772	2406.1111	64965	6026.326
7	Ramallah	63	124	18017	2377.9365	149810	2595.204
8	Salfit	18	52	7103	2457.2222	44230	1838.4794
9	Tubas	14	53	4207	741	10374	1168.6169
10	Tulkarem	34	69	33949	3149.6176	107087	5994.095

Record: 1 Show: All Selected Records (0 out of 11 Selected) Options

Figure 5.117: Results of summarizing the Population field based on Governorates

5.9 Working with Spatial Bookmarks

A spatial bookmark identifies a particular geographic location that you want to save and reference later. For example, you might create a spatial bookmark that identifies a study area. As you pan and zoom around your map, you can easily return to the study area by accessing the bookmark. You can also use spatial bookmarks to highlight areas on your map you want others to see.

You can create a spatial bookmark at any time. As a shortcut, you can create bookmarks when you find and identify map features. Spatial bookmarks, however, can only be defined on spatial data; they cannot be defined on an area of the page in the layout view.

Each data frame on your map maintains its own list of bookmarks. In the Layout View, the list reflects the bookmarks of the active data frame.

1. Open the West Bank.mxd document from "C:\GIS_Tutorial\Chapter5\Example15".
2. Pan and zoom the map to the area where you want to create a bookmark (e.g. zoom to Ramallah Governorate).
3. Click the View menu, point to Bookmarks, and choose Create, Figure 5.118.

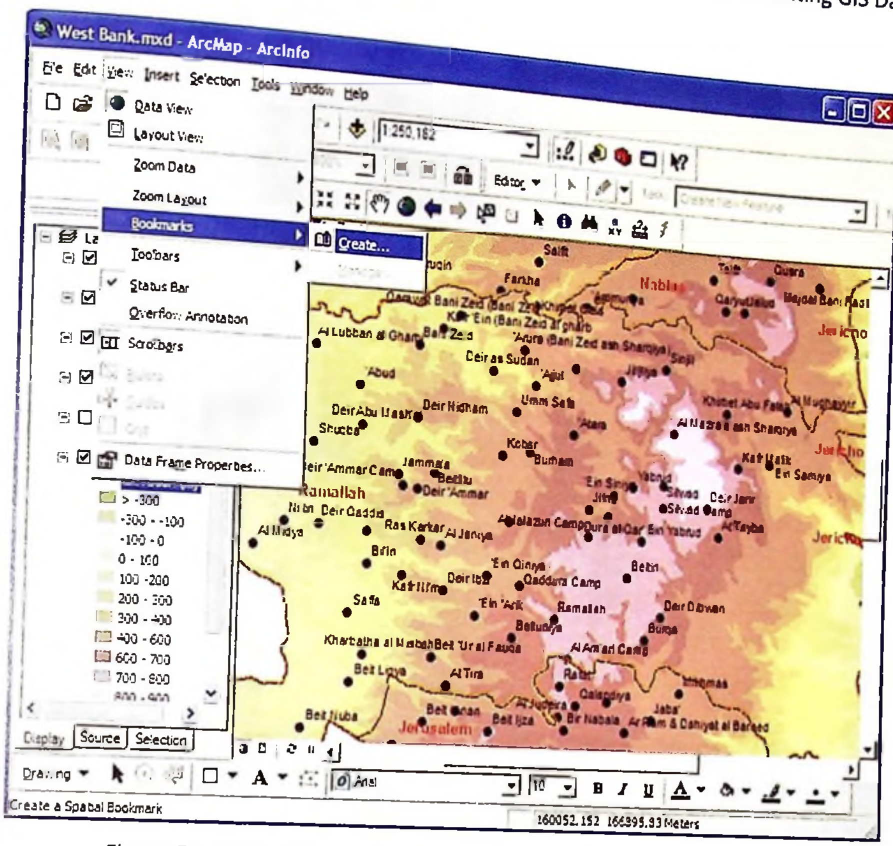


Figure 5.118: Creating spatial bookmarks

4. Type a name for the bookmark, (e.g. "Ramallah Governorate"), Figure 5.119, then click OK.

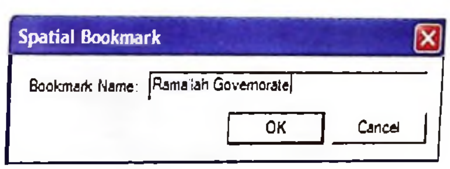


Figure 5.119: Spatial Bookmark window

5. Create a new bookmark for Tulkarem Governorate.
6. Click Zoom to Full Extend from the Tools toolbar to view the entire map.
7. To use the defined spatial bookmarks, you can find them in the View menu and point to the name of the bookmark you want, Figure 5.120.

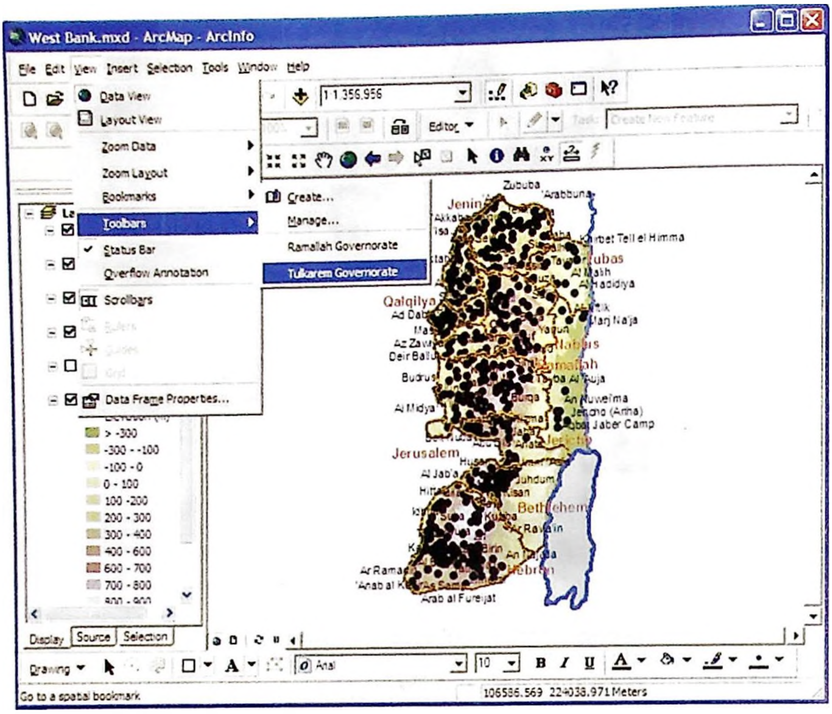


Figure 5.120: Opening the Tulkarem Governorate bookmark

8. You can also create a spatial bookmark from the Identify window, Click the Identify button on the Tools toolbar. Click the mouse pointer over the map feature to identify (e.g. Nablus Governorate).

9. Right-click the identified feature in the Identify window and click Create Bookmark, Figure 5.121.

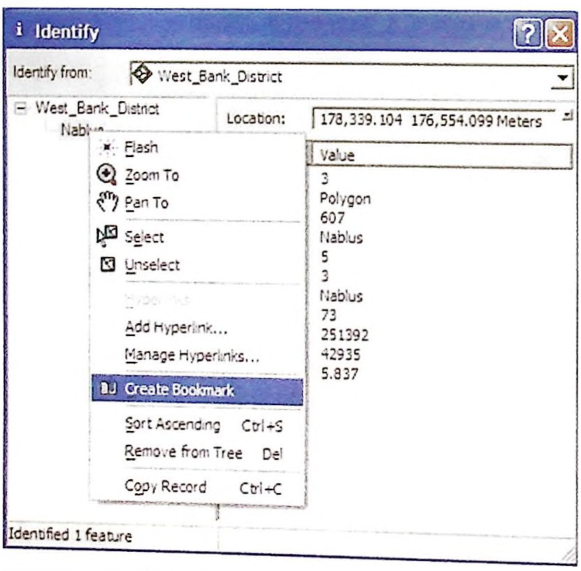


Figure 5.121: Creating spatial bookmarks using the Identify tool

10. To remove a spatial bookmark, click the View menu, point to Bookmarks, and click Manage, Figure 5.120.
11. Select the bookmark you want to remove and click Remove, Figure 5.122.

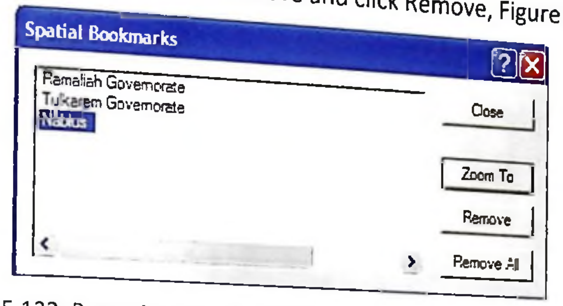


Figure 5.122: Removing a spatial bookmark from the bookmarks list

5.10 Measuring Distances and Areas

The Measure tool, Figure 5.123, lets you draw on the map to measure the length of lines and areas. You can use this tool in several ways. For example, you can draw a line or polygon on the map and get its length or area, or you can even click directly on a feature and get measurements information.

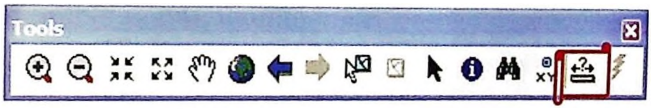


Figure 5.123: Measuring tool

When you click the Measure tool, the Measure window appears. This dialog box allows you to set different measuring options, including whether to measure lines, areas, or features; use snapping; and set the reporting units. Measurements are displayed inside the window, so it is easy to copy and paste them into other applications, Figure 5.124.

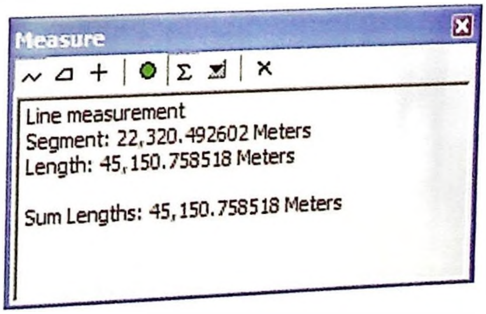


Figure 5.124: Measure toolbar

The Measure window contains tools for measuring distance and features. By default, the distance (line) measurement tool is enabled until a different option from the Measure window is chosen. The tools in the Measure window are listed below, Figure 5.125:

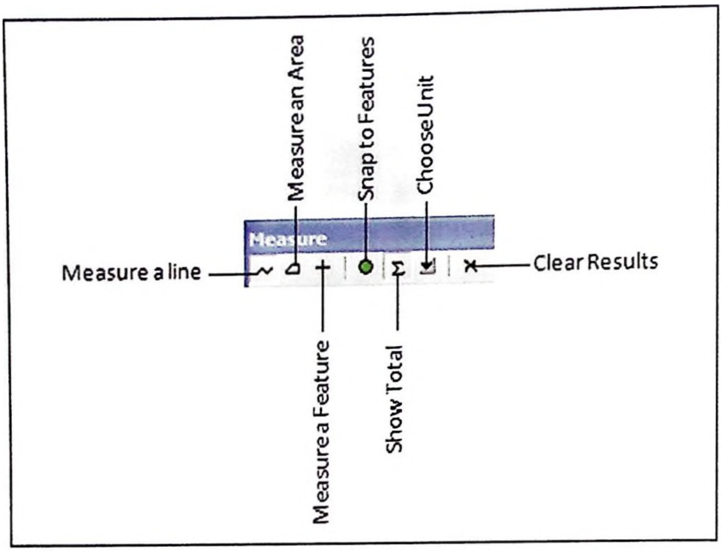


Figure 5.125: Measure tools in the measure window

a. Measure a Line: used to measure the length by digitizing a line.
b. Measure an Area: used to measure the area by digitizing a polygon.
c. Measure Feature: used for features to measure length (line), perimeter, and area (polygon) or (x, y) location (point features).
d. Snap to Features: used to snap while measuring length or area.
e. Show Totals: used to keep a sum of consecutive measurements.
f. Choose Unit: used to set the distance and area measurement units. The measurement units are those of the map by default.
g. Clear Results: used to clear the previous measurements.

5.11 Discussion

1. Use the image Wells.jpg stored in "C:\GIS_Tutorial\Chapter5\Exercise1" shown in Figure 5.126 and Table 5.1 below to create a wells shapefile as follows:

    a. Use ArcCatalog to create a point shapefile named "Well.shp".

    b. Create all necessary fields for the Wells shapefile.

    c. Open ArcMap, and then add both the Wells shapefile and Wells image.

    d. Georeference the image based on the coordinates shown on it.

    e. Set ArcMAP to start the editing mode.

    f. Digitize all wells shown in the image and enter all related data from Table 5.1

    g. Summarize the Wells attribute table based on the West Bank Governorates. Find the total abstraction from each Governorate.

    h. Create a simple graph illustrating Abstraction versus Governorate

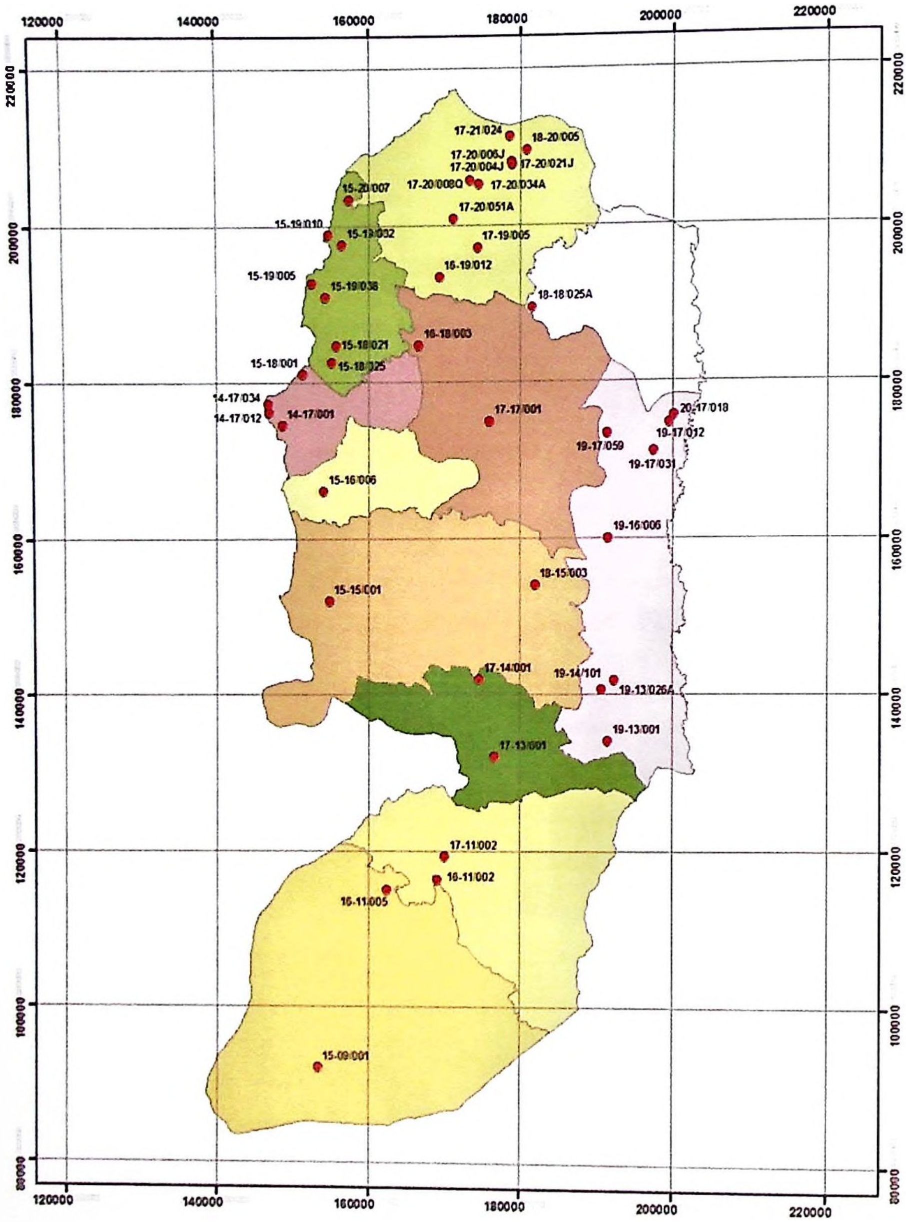


Figure 5.126: Domestic wells in the West Bank

Table 5.1: List of domestic wells in the West Bank

Well Code	Name	GOVERNATE	Depth	Use	Formation	Aquifer Type	Aquifer	Abstraction Rate	Ownership
16-11/002	BAIT FAJJAR NO. 3	BEHTLEH	305	Agricultural	T	Confined	Eastern	0	Private
17-11/002	HERODION (BUTN EL GHUL)	BEHTLEH	770	Domestic	LC	Confined	Eastern	2211043	Private
15-09/001	AL SAMU' NO.1	HEBRON	191	Domestic	T	Confined	Western	326759	Municipality
16-11/005	AL 'ARRUBAGRICULTURAL S	HEBRON	0	Agricultural	T	Perched	Eastern	0	WBWD
15-20/007	'AWNI 'ABD AL HADI	JENIN	180	Agricultural	UC	Confined	Western	103626	PWA
16-19/012	SANUR WELL	JENIN	466	Domestic	uc	Confined	North-Eastern	985723	WBWD
17-19/005	ARMY WELL No.5	JENIN	0	Domestic	E	UNConfined	North-Eastern	0	Private
17-20/004J	HELMI 'ABBUSHI	JENIN	63	Agricultural	E	Perched	North-Eastern	6152	Private
17-20/006J	MUHAMMAD 'AREF	JENIN	93	Agricultural	E	UNConfined	North-Eastern	113667	Mekoroth
17-20/008Q	ISMA'EEL ABU GHANNAM	JENIN	0	Abandoned	E	UNConfined	North-Eastern	0	Private
17-20/021J	SA'EED IBRAHEEM HASHSHA	JENIN	0	Abandoned	E	UNConfined	North-Eastern	0	Municipality
17-20/034A	FAYEZZ AL 'ASI	JENIN	0	Abandoned	E	UNConfined	North-Eastern	0	Private
17-20/051A	'ARRABAH	JENIN	371	Domestic	T	Confined	North-Eastern	563218	Private
17-21/024	NEJMAH HAJ YASEEN	JENIN	56	Agricultural	E	UNConfined	North-Eastern	15159	Private
[illegible]-20/005	'ALI AL FAZA'	JENIN	0	Abandoned	E	Perched	North-Eastern	0	PWA
19-[illegible]/001	KALYA NO. 1	JERICHO	0	Domestic	UC	Confined	Eastern	0	Municipality
19-[illegible]/026A	THE NEW WELL	JERICHO	0	Abandoned	E	UNConfined	Eastern	0	PWA
19-14/001	JERICHO No.1	JERICHO	244	Domestic	UC	Confined	Eastern	475277	WBWD
19-16/006	SUMSAM NEMER	JERICHO	151	Agricultural	T	Confined	Eastern	39183	WBWD
19-17/012	MARJ NA'JAH C5	JERICHO	0	Abandoned	E	Confined	Eastern	0	Mekoroth
19-17/051	'ABED AL LATEEF HAYDAR	JERICHO	100	Agricultural	E	Confined	Eastern	135434	Municipality
19-17/059	GETEET No.3	JERICHO	646	Domestic	LC	Confined	Eastern	672482	Mekoroth
[illegible]-17/019	MUHAMMAD 'ALI SALMI & P	JERICHO	69	Agricultural	E	Perched	Eastern	231639	Mekoroth
17-13/001	AL'IZAREYA	JERUSAL	827	Domestic	LC	UNConfined	Eastern	750340	Private
17-14/001	MUKHMAS	JERUSAL	774	Agricultural	LC	Confined	Eastern	0	Private
16-16/003	DAIR SHARAF NO. 2	NABLUS	0	Abandoned	UC	Confined	North-Eastern	273421	Private
17-17/001	MACHANE HORON	NABLUS	585	Domestic	LC	Confined	North-Eastern	1989751	Private
18-18/025A	MUHAMMAD 'ALI 'ABDALLAH	NABLUS	92	Agricultural	E	UNConfined	North-Eastern	247650	Private
14-17/001	MUHAMMAD QADDURAH & PAR	QALQILI	155	Agricultural	UC	Confined	Western	174216	WBWD
14-17/012	'ALI IDREES SHANTI	QALQILI	59	Agricultural	UC	Confined	Western	85503	Private
14-17/034	QALQILYA MUNICIPALITY	QALQILI	122	Domestic	UC	Confined	Western	594418	Private
15-18/001	SADEQ AL SALEM	QALQILI	155	Agricultural	UC	Confined	Western	133253	Private
15-15/001	SHEBTEEN NO. 1	RAMALLA	0	Abandoned	LC	Confined	Western	0	Private
19-15/003	EIN SAMYAH NO. 3	RAMALLA	250	Agricultural	UC	Confined	Eastern	256365	Mekoroth
15-16/006	AL ZAWYAH WELL	SALFIT	285	Domestic	LC	Confined	Western	151323	PWA
15-18/021	'AREF 'ABED AL QADER	TULKARM	0	Abandoned	UC	Confined	Western	0	Mekoroth
15-18/025	SAL'EET	TULKARM	0	Domestic	UC	Confined	Western	251450	Private
15-19/005	'ABED ALRAHMAN ABU SALE	TULKARM	106	Agricultural	E	Perched	Western	159591	Private
15-19/010	ZAITA VILLAGE COUNCIL	TULKARM	262	Domestic	E	UNConfined	Western	97742	Private
15-19/032	SALEH YASEEN HAMDAN	TULKARM	205	Agricultural	E	UNConfined	Western	256353	Mekoroth
15-19/033	AS'AD TAFFAL & AHMAD KH	TULKARM	136	Agricultural	UC	Confined	Western	156742	Private

2. Open the West Bank.mxd map and do the following:
   a. Find all communities that have an elevation more that 500 m above sea level.
   b. From the selection results above find:
      i. The number of communities
      ii. Total inhabitants living in these communities
      iii. Smallest and largest commuities within the selection
   c. Find all commuities located within a 1 km distance from the main roads. Save them in a new shapefile.
   d. Find all communities located within a 20 km distance from Ramallah City. Then create bookmarks for the selected commuinities.

Introduction
to
Geoprocessing

Chapter 6

Introduction to Geoprocessing

6.1 Geoprocessing in ArcGIS

6.1.1 Introduction

Geoprocessing is a fundamental part of ArcGIS. In Chapter One, you learned that GIS has three views: Geodatabase, Geovisulization and Geoprocessing. Geoprocessing provides the data analysis, data management, and data conversion tools necessary for all GIS users.

Geoprocessing consists of operators, called tools, that operate on the data within ArcGIS (tables, feature classes, rasters, TINs, and so on), and perform tasks that are necessary for manipulating and analyzing geographic information across a wide range of disciplines. Each geoprocessing tool performs an essential operation on geographic data, such as projecting datasets from one map projection to another, adding fields to a table, or creating buffer zones around features. ArcGIS includes over 400 geoprocessing tools. A geoprocessing tool uses ArcGIS datasets as input (such as feature classes, tables, rasters, and CAD files), operates on this data, and creates a newly derived dataset as output.

6.1.2 ArcToolbox

ArcToolbox is a persistent entity that contains geoprocessing tools, Figure 6.1. The Figure shows a collection of system toolboxes that are installed with ArcGIS. Toolboxes are composed of tools, grouped by functionality. For example, the Analysis Toolbox contains tools to perform overlay and proximity analyses.

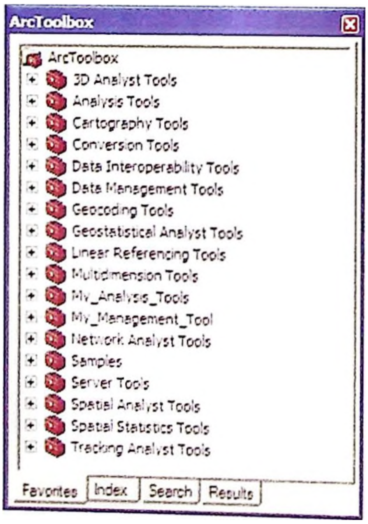


Figure 6.1: ArcToolbox interface

6.1.3 Tools

As mentioned, a Geoprocessing tool can be referred to as an operation that can take an input or set of inputs and generate one or more outputs. These inputs are referred to as parameters. However, there are two other main types of Geoprocessing tools: a model tool and a script tool, Figure 6.2.

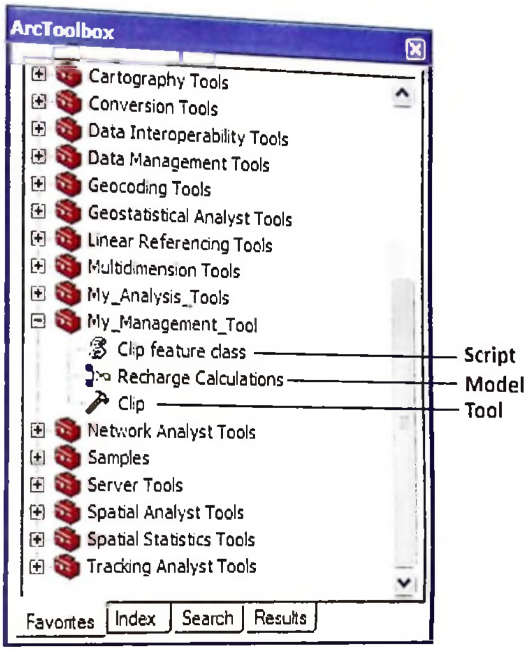


Figure 6.2: Main types of Geoprocessing tools

is a tool that you author to automate your work flow, and keep track of your geoprocessing tasks. A model consists of one process or, more commonly, multiple processes strung together. A process consists of a tool, and its parameter values. The most important thing to note here is that models are just tools. They behave exactly like all other tools. A model tool runs your GIS workflow to generate a new output, Figure 6.3.

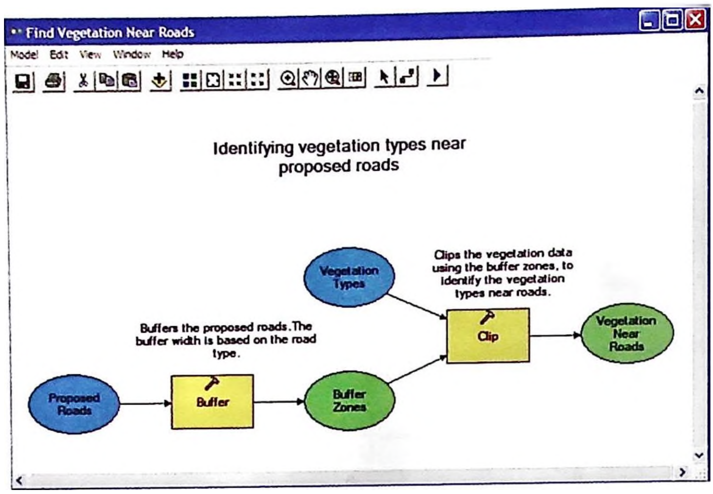


Figure 6.3: Sample of a Model tool

A Script: can be a tool that you author using a scripting language such as Python. Scripts are analogous to models, in that they can be used to automate a geoprocessing workflow. All geoprocessing tools can be accessed and executed inside a script, Figure 6.4.

multi_clip.py - C:\AGWE_Module II\Day1_14.12.2008\Results\Ex2\GP_Tutorial\multi_clip.py

File Edit Format Run Options Windows Help

```
#Create the Geoprocessor object
import arcgisscripting, sys, os
gp = arcgisscripting.create()

#Set the input workspace
gp.workspace = sys.argv[1]

#Set the clip feature class
clipFeatures = sys.argv[2]

#Set the output workspace
out_Workspace = sys.argv[3]

#Set the cluster tolerance
xyTolerance = sys.argv[4]

try:
    #Get a list of the feature classes in the input folder
    fcs = gp.ListFeatureClasses()
    #Loop through the list of feature classes
    fcs.Reset()
    fc = fcs.Next()
    while fc:
        #GDB's don't support "." in the fc name, so replace these with "_".
        #For example "climate.shp" will be converted to "climate_shp".
        outFeatureClass = out_Workspace + "/" + gp.ValidateTableName(fc, out_Wor

        #Clip each feature class in the list with the clip feature class
        #Do not clip the clipFeatures, it may be in the same workspace
        if str(fc) != str(os.path.split(clipFeatures)[1]):
            gp.clip_analysis(fc, clipFeatures, outFeatureClass, xyTolerance)
        fc = fcs.Next()
```

Ln: 1 Col: 0

Figure 6.4: Sample of a Script tool

6.1.4 Opening the ArcToolbox Window

In any ArcGIS desktop application, you open the ArcToolbox window with the Show/Hide ArcToolbox window button on the Standard toolbar. Once opened, you can move the ArcToolbox window by clicking on the bar at the top and dragging it to a preferred location, Figure 6.5.

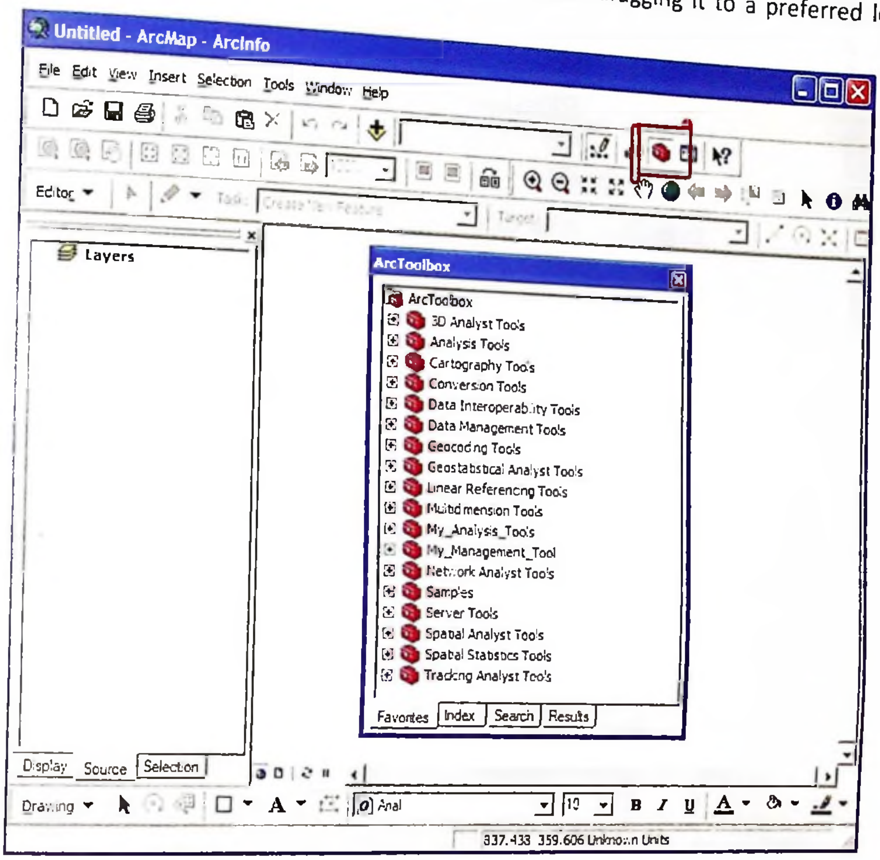


Figure 6.5: Opening the ArcToolbox window

6.1.5 Finding Tools with the Index and Search Tabs

6.1.5.1 Using the Index Tab

If you know the name of the tool you want, but just can't remember what toolbox or toolset it's in, use the Index tab. You can type the first few letters of the tool name and the list will scroll to that tool, or you can scroll to the tool manually. Once you have chosen the tool in the list, you can double-click by opening its dialog. Clicking the Locate button will switch back to the Favorites tab with the tree-view expanded to your tool.

When in the Index window, tool names are followed by the name of the toolbox they belong to. This is because duplicate tool names are allowed, as in the case of Clip in the illustration below, so there needs to be a way to determine the exact tool. Duplicate tool names are not allowed in the same toolbox, only among different toolboxes, Figure 6.6.

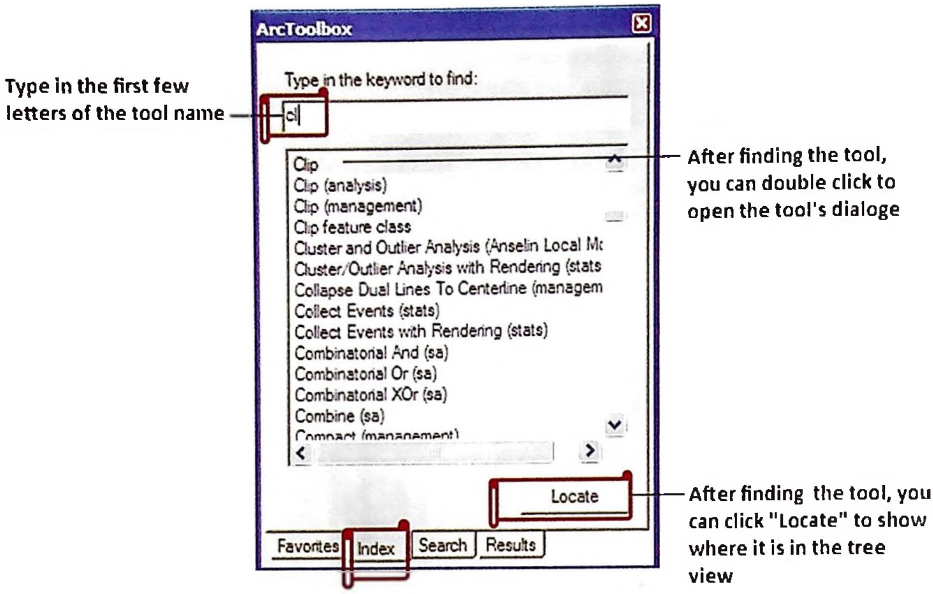


Figure 6.6: Finding tools using the Index tab

6.1.5.2 Using the Search Tab

The Search tab behaves a lot like the Index tab except that the search is not only by tool name, but also by its description and list of keywords, Figure 6.7.

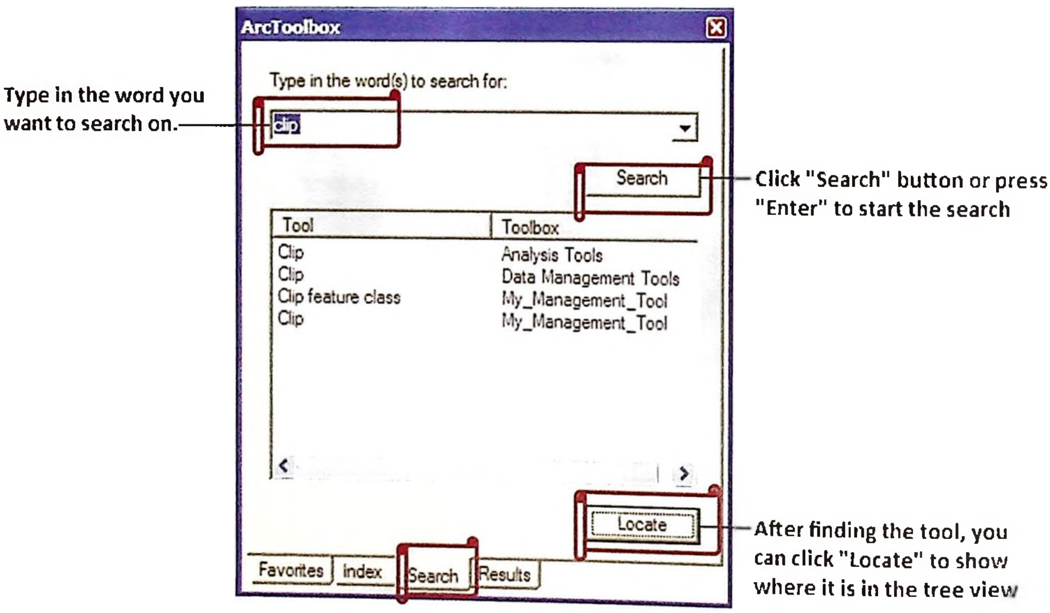


Figure 6.7: Finding tools using the Search tab

6.2 Practicing Geoprocessing

6.2.1 Analysis Toolbox

The Analysis toolbox provides a powerful set of tools to perform various geoprocessing operations of all types of vector data. With the tools in this toolbox, you can perform overlays, create buffers, calculate statistics, perform proximity analysis, and much more. When you need to solve a spatial or statistical problem, you should always look in the Analysis toolbox.

The Analysis toolbox was designed to analyze vector data in GIS. A powerful function of the Analysis toolbox is that the output of one procedure can be used as input to another. The Analysis toolbox has four toolsets. Each toolset performs specific GIS analysis of vector data. The following points list the toolsets available in the Analysis toolbox:

1. Extract: Contains tools to extract features and attributes from a feature class or a table based on attribute queries or spatial extraction and stores them in a new shapefile or geodatabase feature class. These tools include Clip, Select, Split, and Table Select.
2. Overlay: Contains tools to overlay multiple feature classes to combine, erase, or update spatial features into a new feature class. There are several types of overlay operations, such as Identity, Intersect, Union, and Update.
3. Proximity: Contains tools to determine the proximity of spatial features within a feature class or between two feature classes. These tools include Buffer, Near, and Point Distance.
4. Statistics: Contains tools to perform standard statistical analysis on attribute data. They perform mean, minimum, maximum, and standard deviation analysis on attribute data and save the results in a new table. These tools include Frequency and Summary Statistics

6.2.1.1 Extract Tools

6.2.1.1.1 Clip Tool

The Clip tool is used when you want to cut out a piece of one feature class using one or more of the features in another feature class as a "cookie cutter". This is particularly useful for creating a new feature class that contains a geographic subset of the features in another, larger feature class.

For example, suppose you are studying the topography of Ramallah Governorate. You would like to work with a feature class that contains only the topography that fall inside Ramallah's boundaries, but all you have is a feature class containing the topography of the West Bank Governorates. You can clip the topography in the West Bank topography feature class using the Ramallah polygon as the cookie cutter to create a new feature containing only the topography in Ramallah Governorate.

The Clip toolbox is shown in Figure 6.8, the parameters of this tool are defined as follows:

- Input Features: are the features to be clipped which may be a be point, line, or polygon (e.g. West Bank topography)
- Clip Features: are the features used to clip the input features, which should be polygon features (e.g. boundary of Ramallah Governorate).
- Output feature class: is the feature class to be created (e.g. Ramallah Governorate topography).
- XY Tolerance: The minimum distance separating all features coordinates. You can set the value to be higher for data that has less coordinate accuracy and lower for datasets with extremely high accuracy.

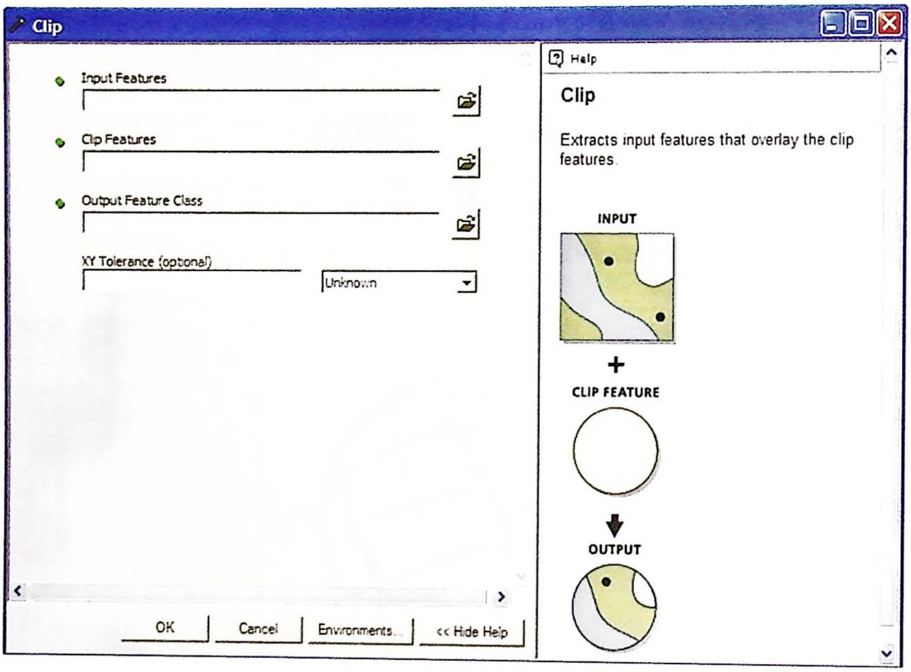


Figure 6.8: Clip dialog box

1. Open the Clip.mxd map from "C:\GIS_Tutorial\Chapter6\Example1"
2. Expand the Analysis tool from the ArcToolbox window.
3. Expand the Extract tools, and then double-click on the Clip tool to open the Clip window.
4. Fill in the Clip window as shown in Figure 6.9.

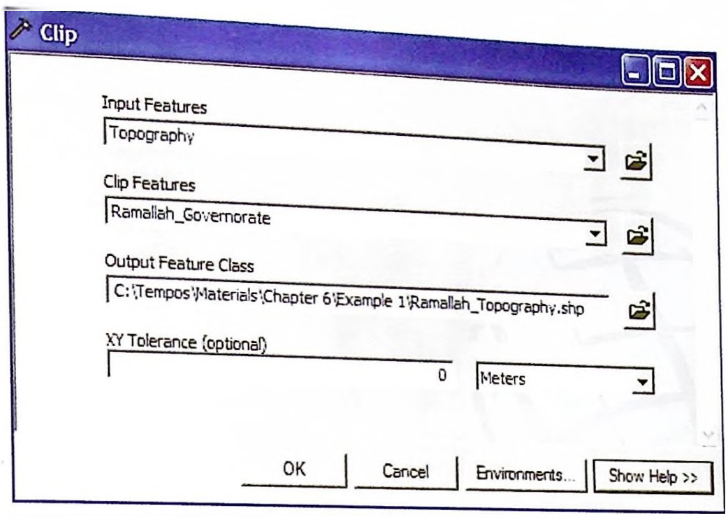


Figure 6.9: Clipping the topography of Ramallah Governorate

5. Click OK to execute the Clip tool, the result is shown in Figure 6.10.

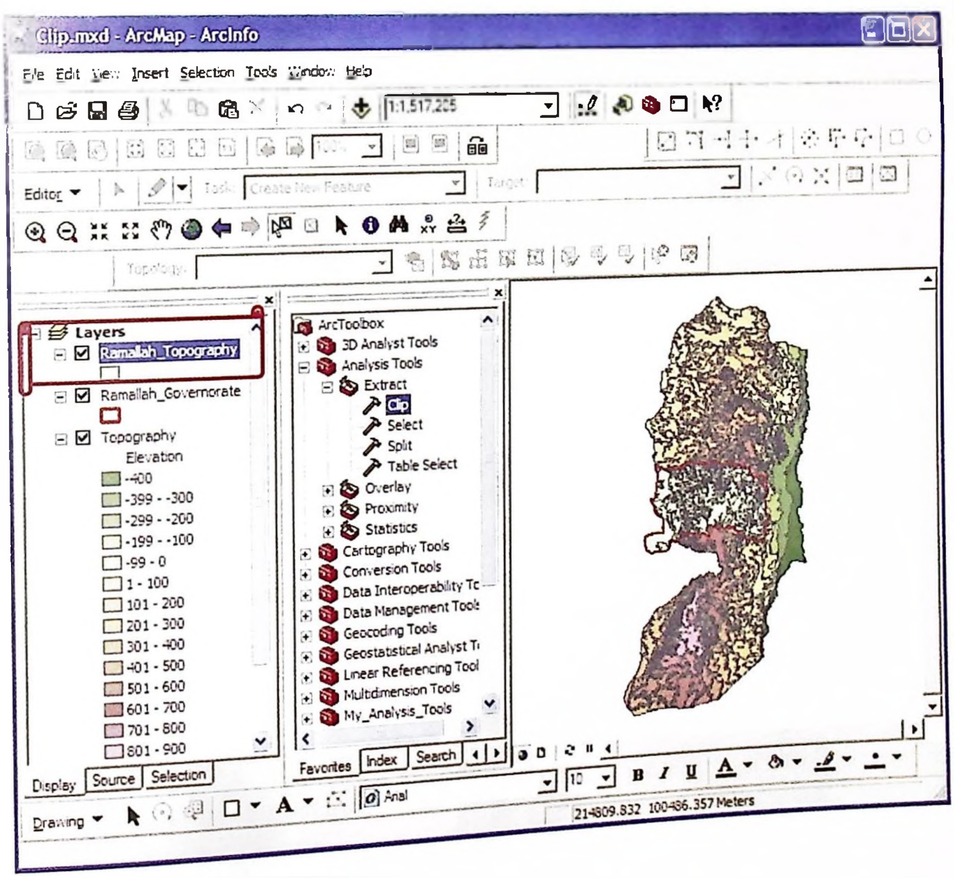


Figure 6.10: Result of using the Clip tool

6.2.1.1.2 Select Tool

Extracts features from an input feature class and stores them in a new output feature class. The output feature class may be created with a subset of features based on a Structured Query Language (SQL) expression (see Section 5.6 in Chapter 5).

1. Open Select.mxd map from "C:\GIS_Tutorial\Chapter6\Example2"
2. Expand the Analysis tool from the ArcToolBox window.
3. Expand the Extract tools, and then double-click on the Select tool to open the Select window.
4. Fill in the Select window as shown in Figure 6.11. Note that you may open the Query Builder window to write the SQL statement.

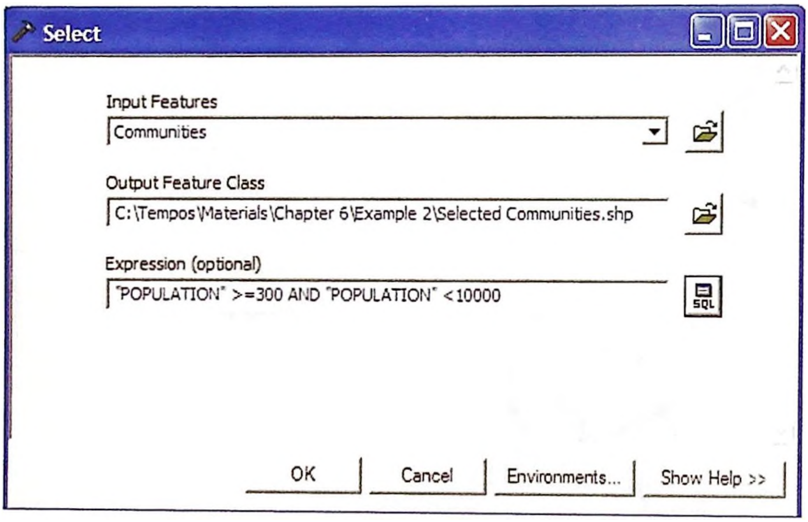


Figure 6.11: Select tool window

5. Click OK to execute the Selection criteria, the result is shown in Figure 6.12.

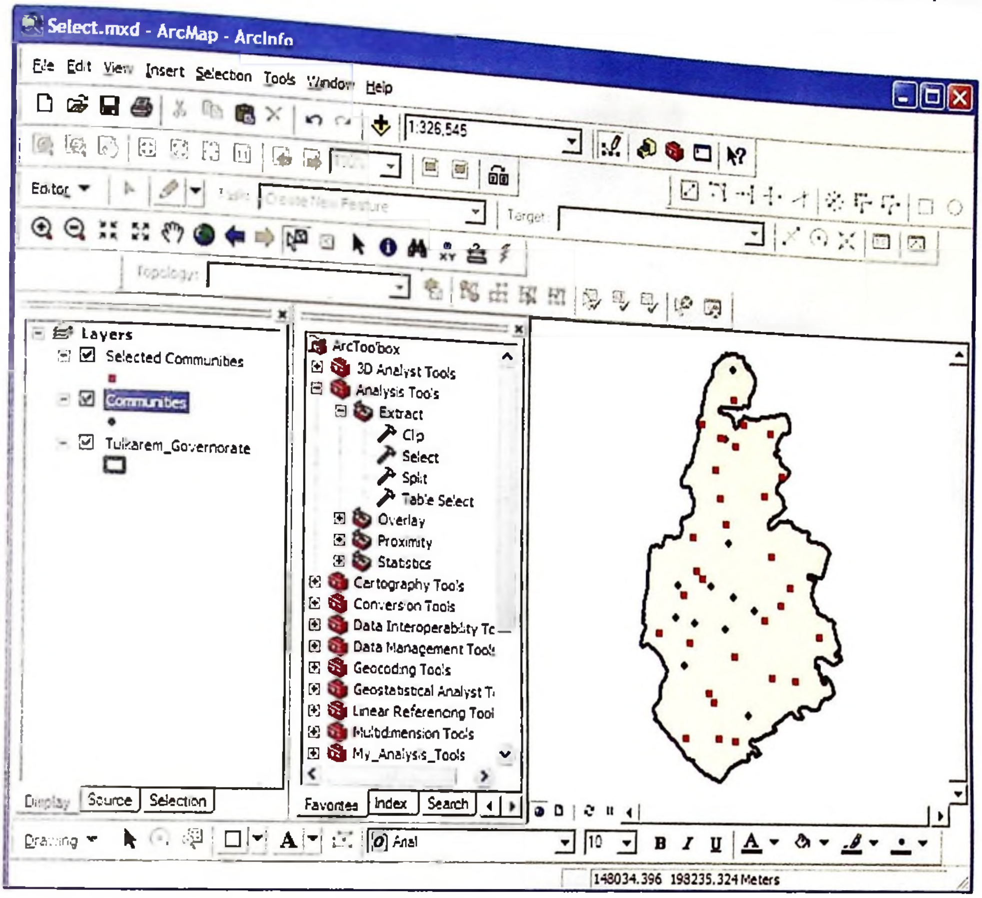


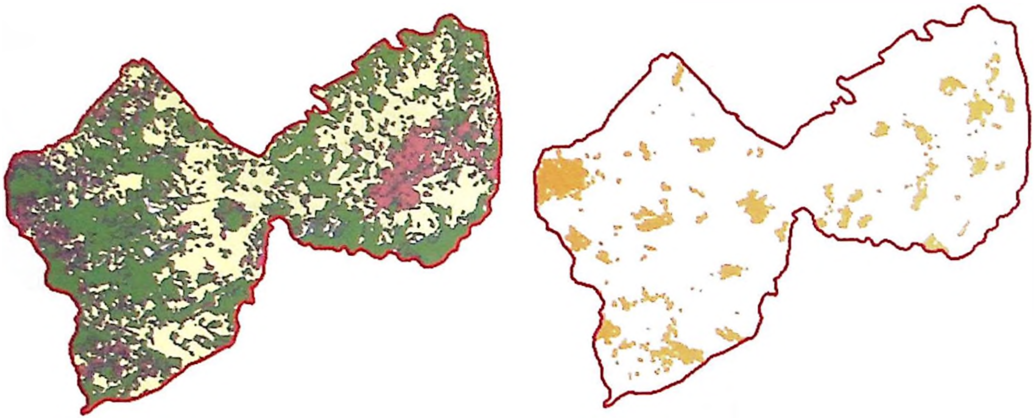
Figure 6.12: Result of using the Selection tool

6.2.1.2 Overlay Tools

6.2.1.2.1 Erase Tool

The Erase tool is used to create a feature class by overlaying the Input Features with the polygons of the Erase Features. Only those portions of the Input Features falling outside the Erase Features outer boundaries are copied to the Output Feature Class.

For example, suppose you are going to create a new land use shapefile excluding the urban areas in Qalqiliya Governorate. In your database, you have the Landuse and Urban_areas shapefile for Qalqiliya Governorate, Figure 6.13. You can use the Erase tool to do this task.



(a) Input Features (b) Erase Features

Figure 6.13: Erase parameters

1. Open the Erase.mxd map from "C:\GID_Tutorial\Chapter6\Example3"
2. Expand the Analysis tool from the ArcToolBox window.
3. Expand the Overlay tools, and then double-click on the Erase tool to open the Identify window.
4. Fill in the Erase window as shown in Figure 6.14.

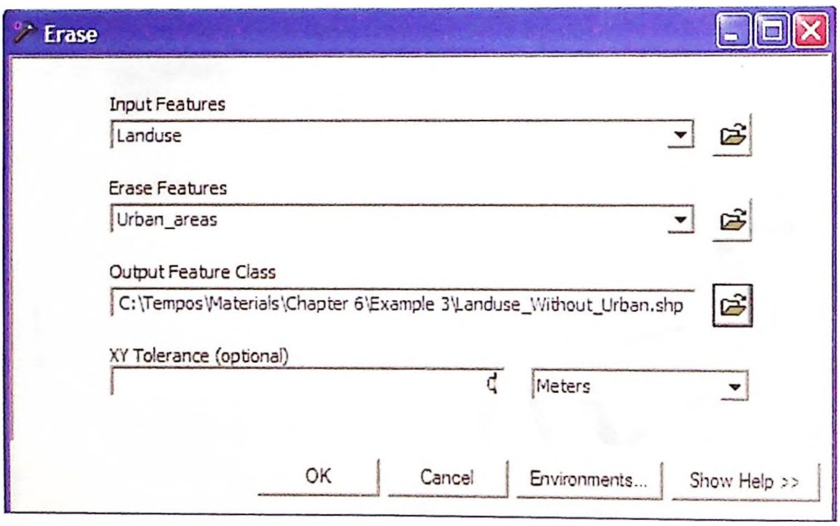


Figure 6.14: Erase tool window

5. Click OK to execute the Erase tool, the result is shown in Figure 6.14.

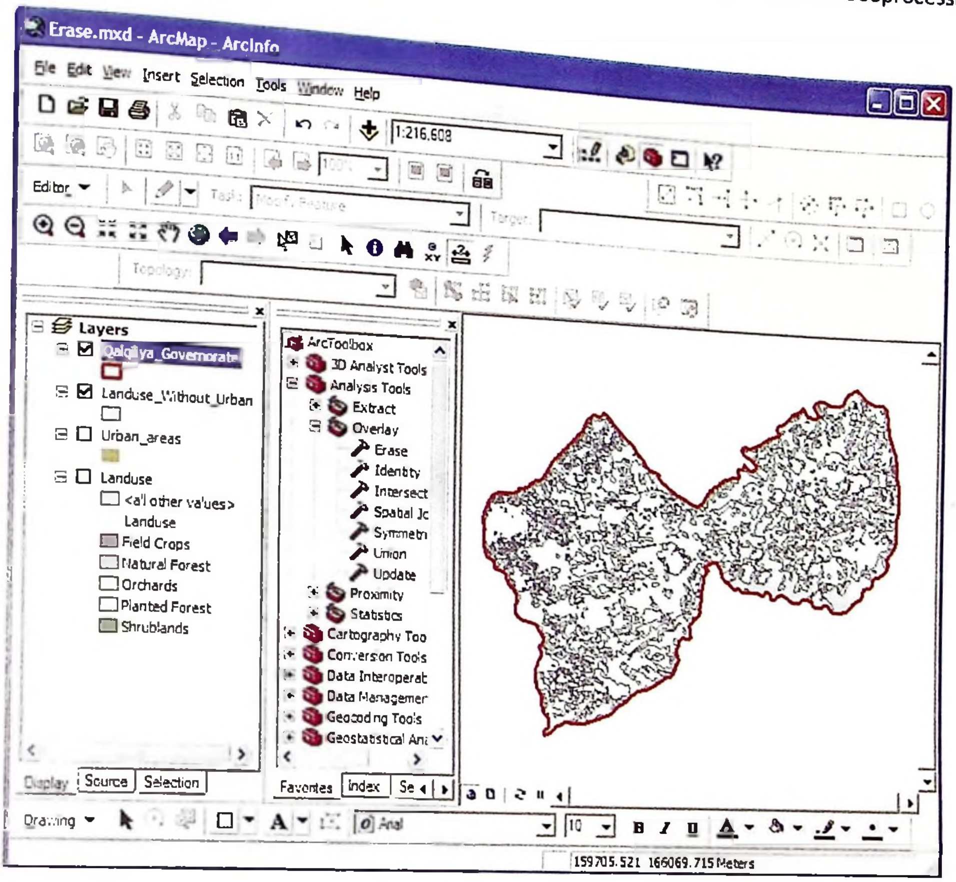


Figure 6.14: Result of using the Erase tool

6.2.1.2.2 Identify Tool

The Identify tool is used to compute a geometric intersection of the Input Features and Identity Features. The Input Features or portions thereof that overlap the Identity Features will take the attributes of those Identity Features.

For example, suppose you have a topographic layer for the West Bank. In the attribute table of this layer, the average elevation of each polygon feature is recorded. If you want to find the maximum, minimum and average elevations for each West Bank Goveranorate, then you have to identify (divide) the topograpy layer based on the West Bank Governorates, then summrize the attibute table of the output layer.

1. Open the identify.mxd map from "C:\GIS_Tutorial\Chapter6\Example4"
2. Check the attribute tables of both the West Bank Governorates and Topography shapefiles, Figure 6.15.

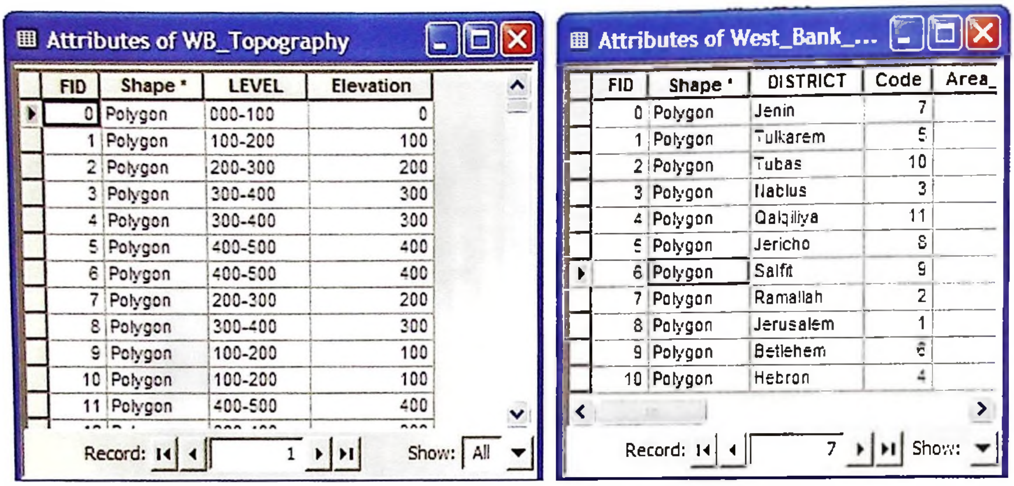


Figure 6.15: Attribute tables of input and identify features

3. Expand the Analysis tool from the ArcToolBox window.
4. Expand the Overlay tools, and then double-click on the Identify tool to open the Identify window.
5. Fill in the Identify window as shown in Figure 6.16. Note that you want to create a new topographic shapefile with the Governorates' name assigned to each feature.

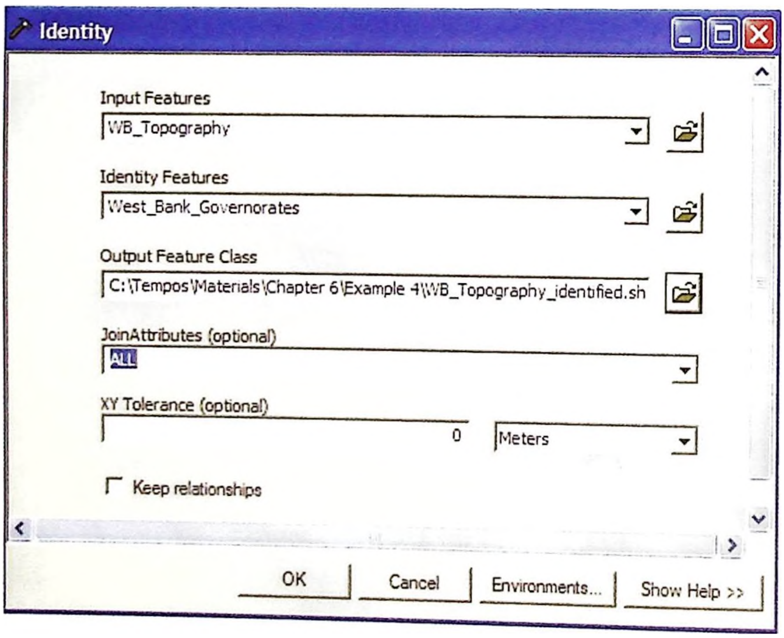
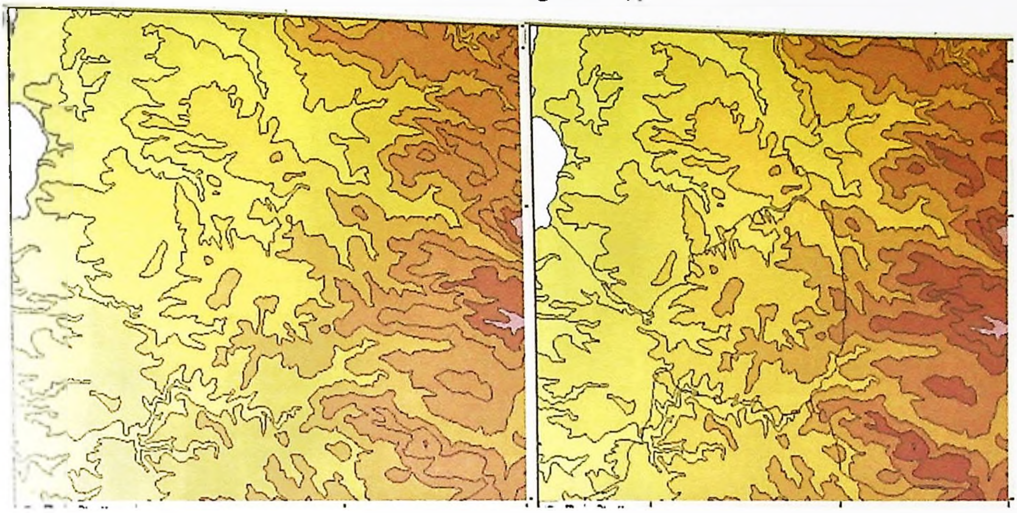


Figure 6.16: Identify tool window

6. Click OK to execute the Identify tool, the result will be similar to the original WB_Topography shapefile except that the shapefile is divided into more polygons based on West Bank Governorates, Figure 6.17.



(a) Topography (input) (b) Topography (output)

Figure 6.17: Input and output topography shapefiles

7. Open the attribute table of the WB_Topography_Identified shapefile. You will find that a new field is added to the attribute table listing the name of the Governorate for each attribute, Figure 6.18.

Attributes of WB_Topography_Identitied

FID	Shape *	FID_WB_Top	LEVEL	Elevation	DISTRICT	FID_Wes
94	Polygon	36	-300--200	-300	Betlehem	
95	Polygon	37	400-500	400	Jenin	
96	Polygon	38	100-200	100	Tulkarem	
97	Polygon	39	400-500	400	Tubas	
98	Polygon	40	500-600	500	Jenin	
99	Polygon	41	<-300	-400	Tubas	
100	Polygon	42	500-600	500	Jenin	
101	Polygon	42	500-600	500	Tubas	
102	Polygon	43	100-200	100	Tulkarem	
103	Polygon	44	600-700	600	Jenin	
104	Polygon	44	600-700	600	Tubas	
105	Polygon	45	300-400	300	Tubas	
106	Polygon	46	500-600	500	Jenin	
107	Polygon	47	<-300	-400	Tubas	
108	Polygon	48	400-500	400	Jenin	
109	Polygon	49	400-500	400	Tubas	
110	Polygon	50	200-300	200	Tulkarem	
111	Polygon	51	400-500	400	Tubas	
112	Polygon	52	200-300	200	Tulkarem	
113	Polygon	53	500-600	500	Tubas	

Record: 17 Show: All Selected Records (0 out

Figure 6.18: Attribute table of the identified shapefile

8. Summarize the table produced in step 7 based on Governorate name to find the minimum, maximum and average elevations (see Section 5.8 in Chapter 5). Figure 6.19.

Attributes of Sum_Output

OID	DISTRICT	Count_DISTRICT	Minimum_Elevation	Maximum_Elevation	Average_Elevation
1	Betlehem	62	-400	900	391.9355
2	Hebron	67	100	1001	673.3134
3	Jenin	46	0	700	378.2609
4	Jericho	32	-400	500	65.625
5	Jerusalem	24	-400	800	350
6	Nablus	60	-200	900	543.3333
7	Qalqilya	13	0	500	269.2308
8	Ramallah	41	-100	1001	526.8537
9	Salfit	14	0	700	364.2857
10	Tubas	44	-400	500	195.4545
11	Tulkarem	20	0	400	205

Record: 1 Show: All Selected Records (1 out of 12 Selected) Options

Figure 6.19: Summarization of the topography attribute table

6.2.1.2.3 Update Tool

The Update tool is used to compute a geometric intersection of the Input Features and Update Features. The attributes and geometry of the Input Features are updated by the Update Features. The results are written to the Output Feature Class.

For example, suppose you have an old land use shapefile for Qalqiliya Governorate, and you want to update it with new changes in land use, Figure 6.19. The Update tool can be used to create a new updated land use shapefile.

1. Open Update.mxd map from "C:\GIS_Tutorial\Chapter6\Example5"
2. Expand the Analysis tool from the ArcToolBox window.
3. Expand the Overlay tools, and then double-click on the Update tool to open the Update window.
4. Fill in the Update window as shown in Figure 6.20.

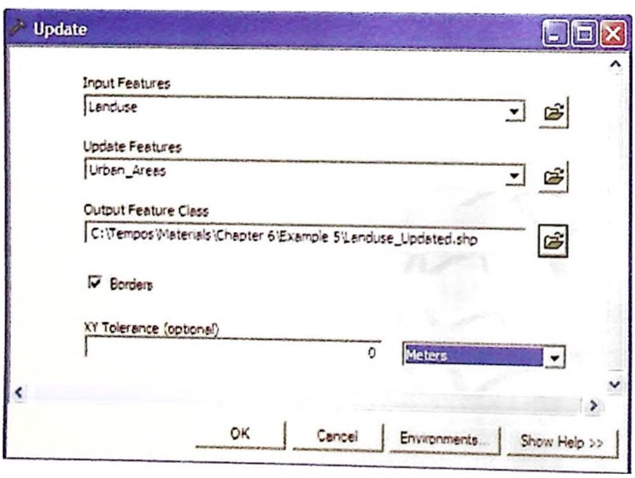
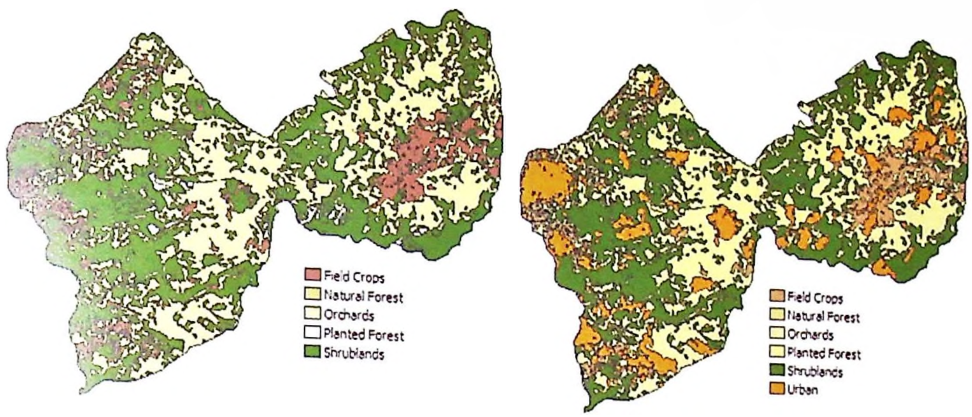


Figure 6.20: Update tool window

Click OK to execute the Update tool, Figure 6.21 shows both the old and the updated land use shapefiles.



(a) Old land use shapefile (input) (b) Updated land use shapefile (output)

Figure 6.21: Input and output land use shapefiles

6.2.1.3 Proximity Tools

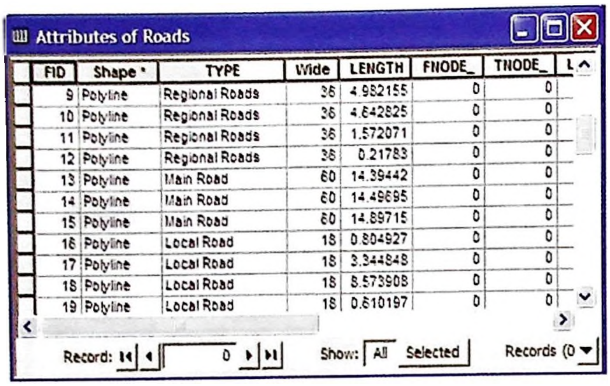
6.2.1.3.1 Buffer Tool

The Buffer tool is used to create a new feature class of buffer polygons around specified input features. Features can be polygons, lines, or points. The width of the buffer can be specified in one of two ways:

1. Fixed distance: Specify a constant distance to apply to the input features.

a) From a field: Choose the name of a numeric distance field from the specified feature class. Each feature will be buffered according to its associated value in the chosen field.

1. Open the Buffer.mxd map from "C:\GIS_Tutorial\Chapter6\Example6"
2. Expand the Analysis tool from the ArcToolBox window.
3. Expand the Proximity tools, and then double-click on the Buffer tool to open the Buffer window.
4. Open the attribute table of the Roads shapefile to understand its contents, Figure 6.22. You will find that the width in meters of each road is recorded as well as the road type.



FID	Shape *	TYPE	Wide	LENGTH	FNODE_	TNODE_
9	Polyline	Regional Roads	36	4.982155	0	0
10	Polyline	Regional Roads	36	4.642825	0	0
11	Polyline	Regional Roads	36	1.572071	0	0
12	Polyline	Regional Roads	36	0.21783	0	0
13	Polyline	Main Road	60	14.39442	0	0
14	Polyline	Main Road	60	14.49695	0	0
15	Polyline	Main Road	60	14.89715	0	0
16	Polyline	Local Road	18	0.804927	0	0
17	Polyline	Local Road	18	3.344848	0	0
18	Polyline	Local Road	18	8.573908	0	0
19	Polyline	Local Road	18	0.610197	0	0

Figure 6.22: Attribute table of the roads shapefile

5. In this example you are going to create a new roads shapefile (Polygon) with a fixed width (e.g. 60 meter). To do this, fill in the Buffer window as shown in Figure 6.23.

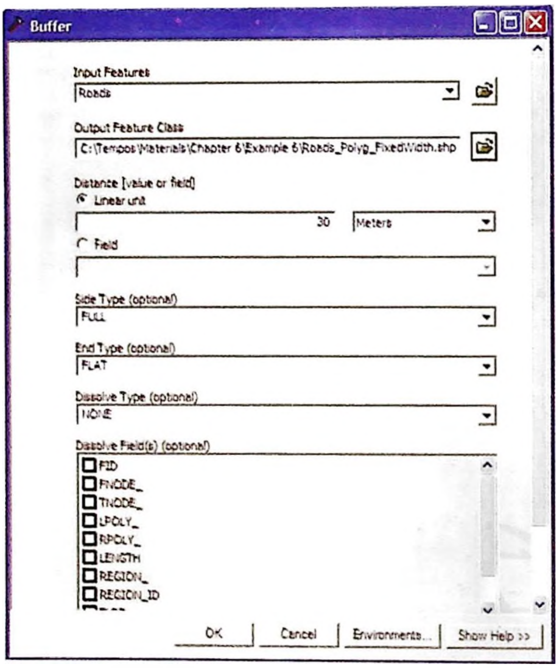


Figure 6.23: Buffer tool window (using fixed width)

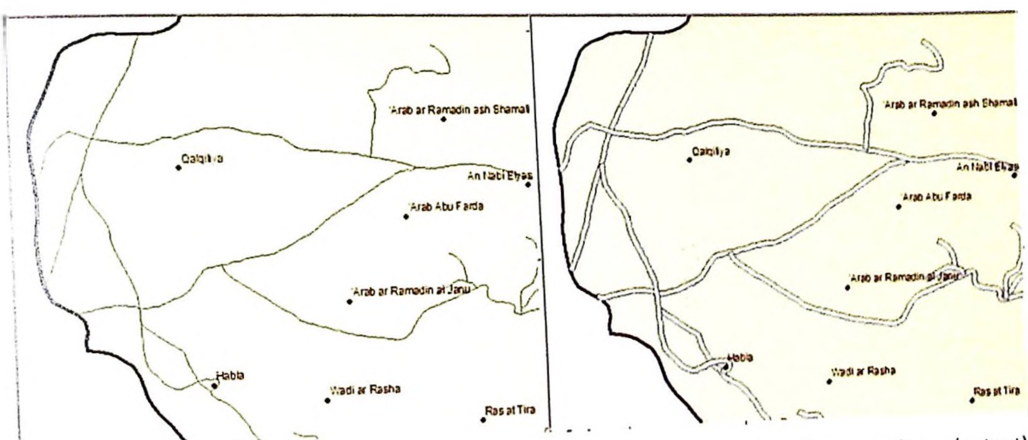
In the Buffer window, you will have the following options:

a) Side Type: used to generate buffers at the topological left or right of a line.
   a. Full: a buffer will be generated on both sides of the line. In this example, using 30 meters as a fixed road width means that the actual road width will be 60 meters.
   b. Left: the topological left of the line will be buffered
   c. Right: the topological right of the line will be buffered.
b) End Type: used for line features to define the end points of the buffered line.

a. Round end: the end line will be in the shape of a half circle.
b. Flat end: the end line will be in the shape of a rectangle.

c) Dissolve Type: specifies whether a dissolve will be performed to remove buffer feature overlap:
   a. None: means that the individual buffer for each feature is maintained, regardless of the overlap.
   b. All: this option will dissolve all the buffers together into a single feature and remove any overlap.
   c. List: this will dissolve buffers by a given list of fields.

6. Click OK to execute the Buffer tool, Figure 6.24 shows a sample of both the original roads shapefile (lines) and the buffered roads as polygon features.



(a) Roads shapefile as a line (input) (b) Roads shapefile as a polygon (output)

Figure 6.24: Input and output roads shapefiles (using the fixed width method)

If you want to buffer roads based on the Width field in the attribute table of the Roads shapefile, then you have to make sure that the field represents half of the roads' widths. Otherwise a new field must be introduced to contain the calculated result of half of the total width.

7. Open the Buffer window, and then fill it in as shown in Figure 6.25.

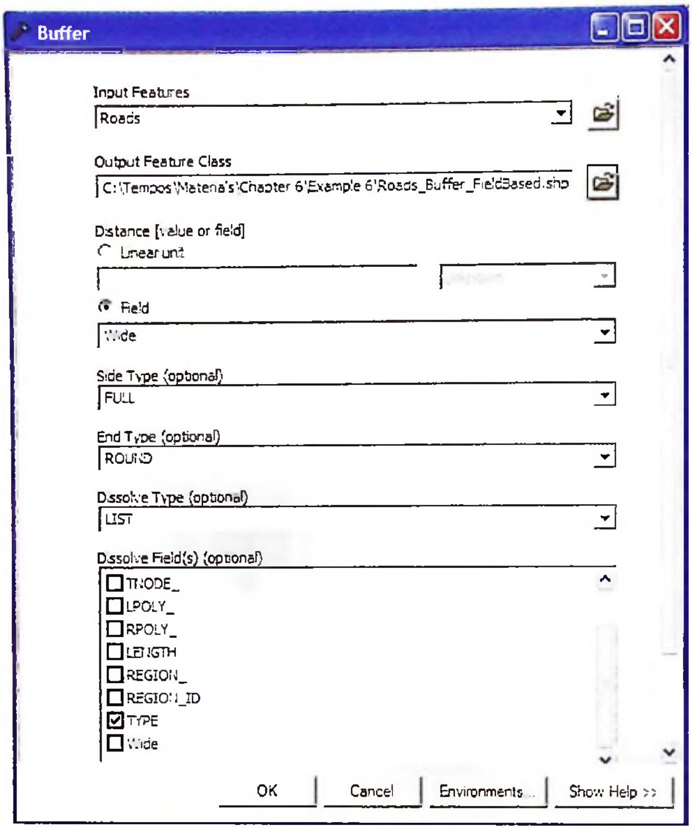
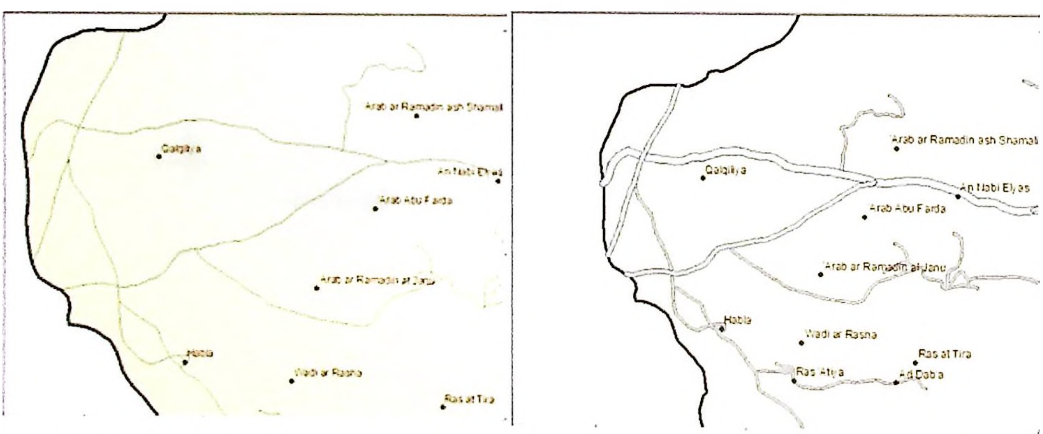


Figure 6.25: Buffer tool window (using based field width)

8. Click OK to execute the buffer tool, Figure 6.26 shows a sample of both the original roads shapefile (lines) and the buffered roads as polygon features.



(a) Roads shapefile as a line (input)

(b) Roads shapefile as a polygon (output)

Figure 6.26: Input and output roads shapefiles (using based field method)

9. Compare the two results shown in Figures 6.24 and 6.26.

6.2.2 Data Management Tools

The Data Management toolbox provides a rich and diverse collection of tools that are used to develop, manage, and maintain feature classes, datasets, layers, and raster data structures. While the Analysis toolbox is used to solve spatial or statistical questions, the Data Management toolbox lets you perform tasks from managing basic structures, such as fields and workspaces, to more complex tasks related to topology and versioning (e.g. convert a shapefile to a CAD file).

6.2.2.1 Multipart to Singlepart Tool

The Multipart to Singlepart tool is used to separate (explode) multipart features into separate singlepart features. For example, suppose you have a shapefile that contains all urban areas in Qalqiliya Governorate as one feature, Figure 6.27, if you want to create a new shapefile that contains all urban areas as separate polygons in order to calculate the areas of each polygon:

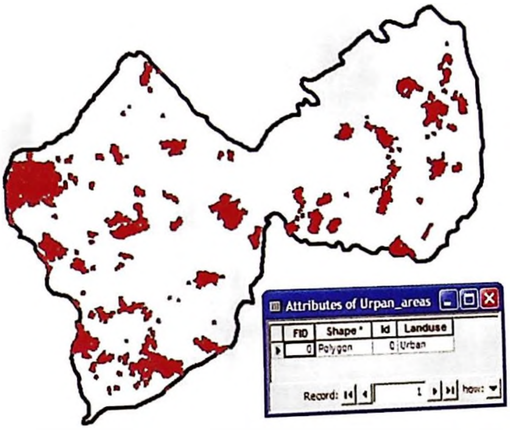


Figure 6.27: Urban areas as one polygon

1. Open the Multipart.mxd map from "C:\GIS_Tutorial\Chapter6\Example7"
2. Open the attribute table of the Urban_areas shapefile and check how many rows are in the table.
3. Expand the Data Management tools from the ArcToolBox window.
4. Expand the Features tools, and then double-click on the Multipart to Singlepart tool to open the Multipart to Singlepart window.
5. Fill in the tool window as shown in Figure 6.28.

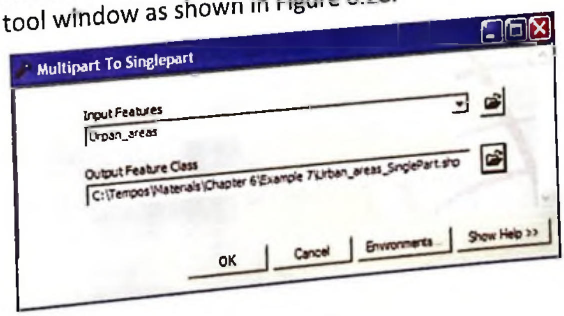
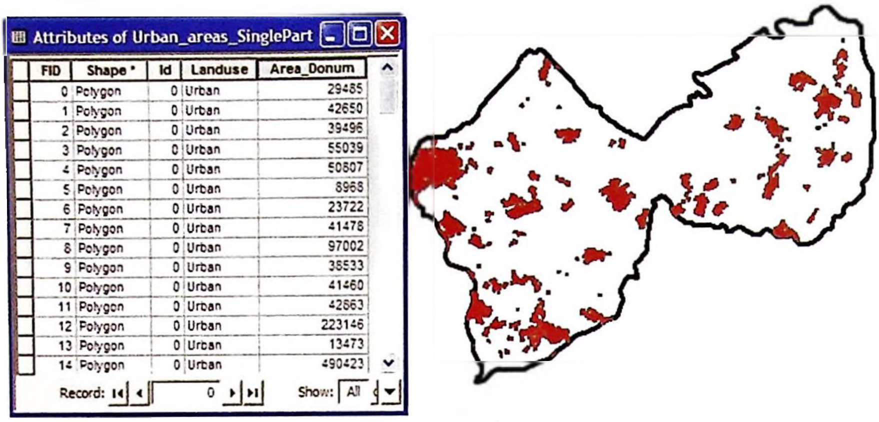


Figure 6.28:Multipart To Singlepart tool window

6. Click OK to explode the Urban_Areas shapefile.
7. Open the attribute table of the new shapefile.
8. Add a new field named Area_Donum, and then calculate the area of all the polygons, Figure 6.29.



Attributes of Urban_areas_SinglePart

FID	Shape *	Id	Landuse	Area_Donum
0	Polygon	0	Urban	29485
1	Polygon	0	Urban	42650
2	Polygon	0	Urban	39496
3	Polygon	0	Urban	55039
4	Polygon	0	Urban	50807
5	Polygon	0	Urban	8968
6	Polygon	0	Urban	23722
7	Polygon	0	Urban	41478
8	Polygon	0	Urban	97002
9	Polygon	0	Urban	38533
10	Polygon	0	Urban	41460
11	Polygon	0	Urban	42663
12	Polygon	0	Urban	223146
13	Polygon	0	Urban	13473
14	Polygon	0	Urban	490423

Record: 0 Show: All

Figure 6.29: Explode the urban areas shapefile

6.2.2.2 Merge Tool

The Merge tool combines input features from multiple input sources (of the same data type) into a single, new, output feature class. The input data sources may be point, line, or polygon feature classes or tables. For example, suppose you have three land use shapefiles for Qalqiliya Governorate. Each shapefile covers part of the Governorate. If you want to combine the three shapefiles into one land use shapefile then you could use the Merge tool.

1. Open the Merge.mxd map from "C:\GIS_Tutorial\Chapter6\Example8" Expand the Data Management tools from the ArcToolBox window.
2. Expand the General tools, and then double-click on the Merge tool to open the Merge window.
3. Drag the three land use shapefiles into the Input Datasets window. Also, fill in the tool window as shown in Figure 6.30.

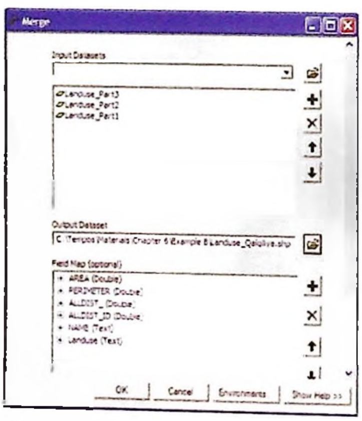


Figure 6.30: Merge tool window

4. Click OK to merge the land use shapefiles, Figures 6.31 & 6.32.

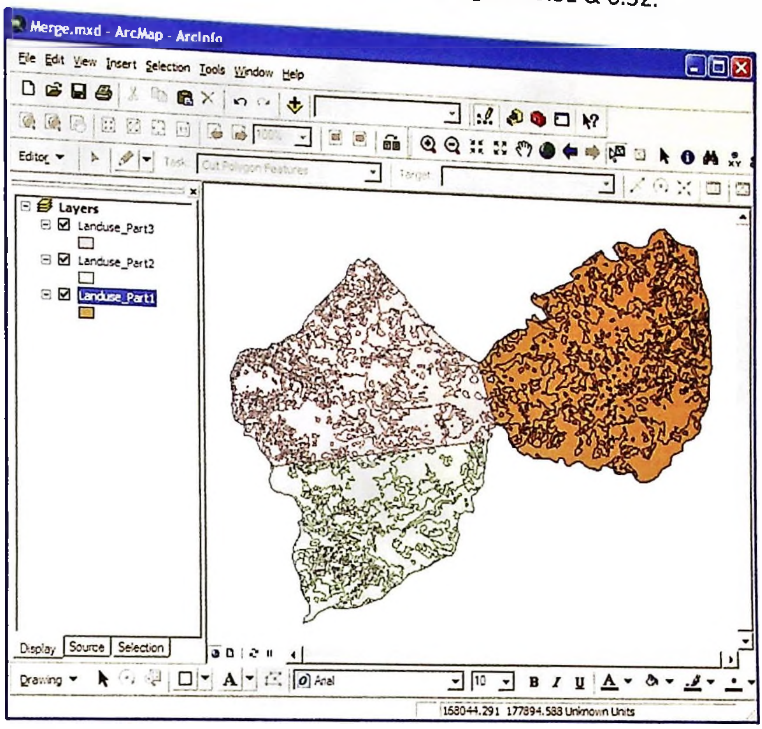


Figure 6.31: Un-merged land use shapefiles (three shapefiles)

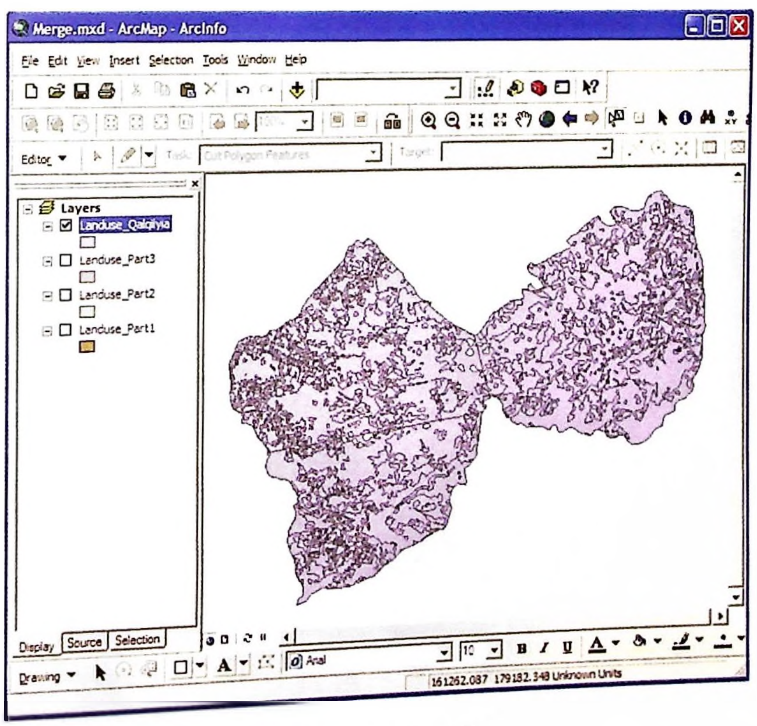
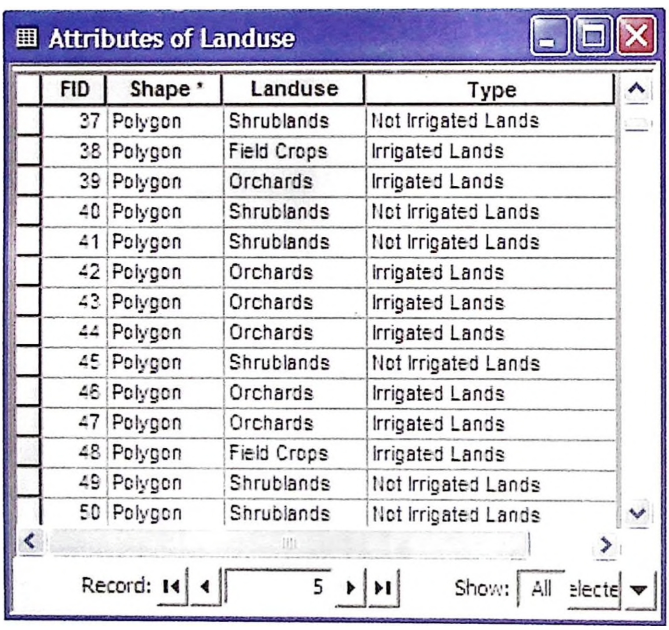


Figure 6.32: Merged land use shapefile (one shapefile)

6.2.2.3 Dissolve Tool

The Dissolve tool is used to aggregate features based on a specified attribute or attributes. For example, suppose you have a land use shapefile for Qalqiliya Governorate containing different land use types and you want to generate a new feature class showing two types of land use; the first type includes all irrigated areas while the second type presents all non-irrigated areas (e.g. forests, urban, shrub lands, etc). You can use the Dissolve tool located within the Generalization tools as shown in the following example.

1. Open the Dissolve.mxd map from "C:\GIS_Tutorial\Chapter6\Example9".
2. Open the attribute table of the Land use shapefile.
3. Add a new text field named "Type".
4. Use the Select By Attribute tool to select all Field crops and Orchards records.
5. Right-click on the Type field, use the Field Calculator tool to fill in all selected records with "Irrigated Lands".
6. Use the Switch selection tool (from Options) to reverse the section above.
7. Repeat step 5, fill in all selected records with "Not Irrigated Lands", Figure 6.33.



FID	Shape *	Landuse	Type
37	Polygon	Shrublands	Not Irrigated Lands
38	Polygon	Field Crops	Irrigated Lands
39	Polygon	Orchards	Irrigated Lands
40	Polygon	Shrublands	Not Irrigated Lands
41	Polygon	Shrublands	Not Irrigated Lands
42	Polygon	Orchards	Irrigated Lands
43	Polygon	Orchards	Irrigated Lands
44	Polygon	Orchards	Irrigated Lands
45	Polygon	Shrublands	Not Irrigated Lands
46	Polygon	Orchards	Irrigated Lands
47	Polygon	Orchards	Irrigated Lands
48	Polygon	Field Crops	Irrigated Lands
49	Polygon	Shrublands	Not Irrigated Lands
50	Polygon	Shrublands	Not Irrigated Lands

Figure 6.33: Attribute table of Land use shapefile

8. Expand the Data Management tools from the ArcToolBox window.
9. Expand the Generalization tools, and then double-click on the Dissolve tool to open the Dissolve window.
10. Fill in the tool window as shown in Figure 6.34.

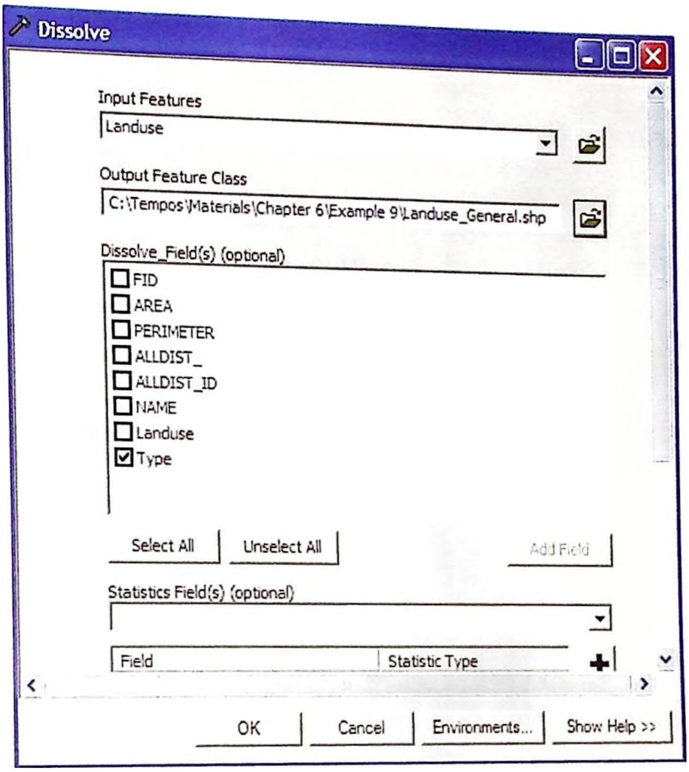
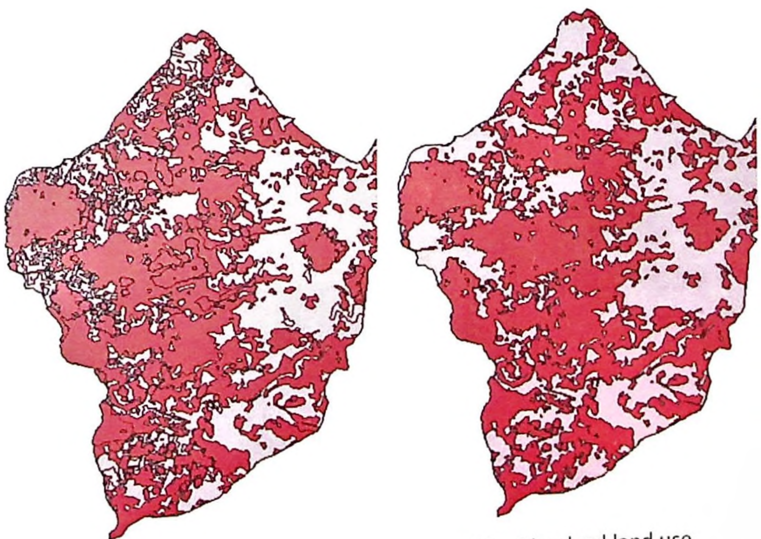


Figure 6.34: Dissolve tool window

11. Click OK to dissolve the land use shapefiles.
12. Classify the Landuse_General and the Landuse shapefile based on the Type field and then compare between the two shapefiles, Figure 6.35.



a) Un-dissolved land use

b) Dissolved land use

Figure 6.35: Dissolving the Landuse shapefile

6.3 Discussion

1. What does Geoprocessing mean?
2. Locate the following tools and study the function of each:
    a. Intersect
    b. Near
    c. Point Distance
    d. Export to Cad
    e. Polygon to raster
    f. Polygon to line
    g. Append
    h. Smooth line
3. What is the main difference between a Model Tool and a Tool?
4. Use the ArcGIS Help option to learn using the Batch Grid Control.
5. Check the coordinate systems of all shapefiles in the Example Folders, define the suitable grid system using the Batch tool.

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