PDHonline Course C423 (15 PDH)

GIS Applications in Water Resources and Environmental Engineering

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COURSE CONTENT – Lecture 1

Course C423 is a practical GIS course with particular reference to applications in Water Resources and Environmental Engineering, addressing some of the basic, yet common GIS needs in these two fields. The course describes the availability of free databases and public domain GIS software, and their use in performing common GIS processing tasks that are relevant to Water Resources and Environmental Engineering. The ability to search, download and make use of such data sets and software is presented within the context of this course. The course consists of 5 lectures, which start off with introductory level material in Lecture 1, and progressively builds up through the remaining four lectures. A basic awareness of the concept of GIS is desirable but not required as a pre-requisite for this course.

The following topics are covered in this 1st lecture of Course C423:
- ❖ Basic introduction to GIS concepts.
- ❖ Projections and Coordinate Systems.
- ❖ Common GIS data types such as:
  - ▪ Shapefiles;
  - ▪ GeoMedia;
  - ▪ ArcInfo Interchange export format (E00); and,
  - ▪ AutoCAD, Microstation, etc.

1.   Basic introductory GIS concepts

Geographic Information Systems (GIS) is a commonly used computer technology that captures, stores, manages, processes, and outputs spatial data to assist in making better decisions.

GIS has many practical uses which allow us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts.   GIS helps to answer questions and solve problems by using digital data in a way that is quickly understood and easily shared among many users.   In today's highly "wired" world, GIS technology is invariably integrated into most information technology frameworks.   For this reason, there are many types of data stored digitally and made available to other users who can integrate them into their various GIS applications.

GIS applications are varied and span various industries, local and federal government, research fraternities, students, academicians, and policy makers.   Excellent resources for GIS application in specific areas are shown in Table 1 below.   There are many other resources available online.

Agriculture [1]	Archaeology [2]
Business GIS [3]	Environment [4]
Geology [5]	Health [6]
Land Information Systems [7]	Military [8]
Natural Hazard Management [9]	Utility [10]
Urban Planning [11]	Natural Resource Management [12]
Transportation [13]	Miscellaneous [14]

Table 1: List of GIS application areas

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[1] http://www.gisdevelopment.net/application/agriculture/overview/index.htm

[2] http://www.gisdevelopment.net/application/archaeology/general/index.htm

[3] http://www.gisdevelopment.net/application/business/index.htm

[4] http://www.gisdevelopment.net/application/environment/overview/index.htm

[5] http://www.gisdevelopment.net/application/geology/mineral/index.htm

[6] http://www.gisdevelopment.net/application/health/overview/index.htm

[7] http://www.gisdevelopment.net/application/lis/overview/index.htm

[8] http://www.gisdevelopment.net/application/military/overview/index.htm

[9] http://www.gisdevelopment.net/application/natural_hazards/overview/index.htm

[10] http://www.gisdevelopment.net/application/utility/power/index.htm

[11] http://www.gisdevelopment.net/application/urban/overview/index.htm

[12] http://www.gisdevelopment.net/application/nrm/overview/index.htm

[13] http://www.esri.com/industries/transport/index.html

[14] http://www.gisdevelopment.net/application/miscellaneous/index.htm

1.1   GIS Software

There is GIS software that is commercially available and those that are free. The market for GIS software is as varied as its application areas. However, users can apply GIS software for various reasons, including:

- ❖ Budget restrictions
- ❖ Software capabilities
- ❖ Popularity of software
- ❖ Ease of use
- ❖ Availability of relevant data sets
- ❖ Type of computer network deployments

Examples of commercial GIS software vendors that have high market share are provided below. Note that the blue texts are links (CTRL + click to follow link) to the webpage where more information can be obtained about the software:

- ❖ Autodesk – Products include Map 3D, Topobase, MapGuide and other products that interface with its flagship AutoCAD software package.
- ❖ Bentley Systems – Products include Bentley Map, Bentley PowerMap and other products that interface with its flagship MicroStation software package.
- ❖ ERDAS IMAGINE by ERDAS Inc; products include Leica Photogrammetry Suite, ERDAS ER Mapper, and ERDAS ECW JPEG2000 SDK (ECW (file format))are used throughout the entire mapping community (GIS, Remote Sensing, Photogrammetry, and image compression).
- ❖ ESRI – Products include ArcView 3.x, ArcView 9.x, ArcGIS, ArcSDE, ArcIMS, ArcWeb services and ArcGIS Server.
- ❖ Intergraph – Products include GeoMedia, GeoMedia Professional, GeoMedia WebMap, and add-on products for industry sectors, as well as photogrammetry.
- ❖ MapInfo by Pitney Bowes – Products include MapInfo Professional and MapXtreme.
- ❖ Smallworld – developed in Cambridge, England (Smallworld, Inc.) and purchased by General Electric and used primarily by public utilities.

Examples of free Open Source GIS Software[15] are as follows.

- ♣ **Key Indicator Data System (KIDS)** -- KIDS was developed by the World Agriculture Information Centre (WAICENT) of the Food and Agriculture Organization of the United Nations. KIDS is a open-source software framework that provides the ability to implement thematic information systems that collect, reference, visualize, exchange and disseminate statistical, survey and indicator data. Visualization is possible through tables, mapping, raster images and graphs.

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[15] http://gislounge.com/open-source-gis-applications/

Basic GIS overlay and legend editing functions are available for non-GIS users.

- **MapCruncher** -- This is a prototype technology from Microsoft Research to make it easy for users to create their own, personalized mash-ups. The system revolutionizes the way people use online maps. MapCruncher makes it easy to publish maps overlaid on Virtual Earth. Once you get familiar with the tool, it will take about ten minutes to make a new map.

- **GeoNetwork OpenSource** -- It is a web based Geographic Metadata Catalogue System developed by FAO-UN, WFP-UN and UNEP. The system implements the ISO19115 Geographic Metadata and ISO 23950 (Z39.50) standards. It provides an OGC-WMS client application InterMap OpenSource and integrates the OGC Web Map Server in its full installer version, including sample data.

- **Map Maker** -- It is simple to use yet powerful map making and GIS software for Windows. It is available as the free program "Map Maker Gratis" and the more advanced "Map Maker Pro". Map Maker Pro is a low-cost system now in use in over 100 countries. It is used in a wide range of environmental work including forestry and fisheries. It supports, raster, vector, and DTM data and can import and export a wide range of formats including ArcView shape files and MapInfo mif/mid files. Map Maker Pro includes 3D features including perspective views, contouring, cross-sections etc.

- **DIVA-GIS** -- It is a free geographic information system (GIS) software. DIVA-GIS was specifically developed for use with biological distribution data such as available from natural history museums and genebanks.

- **GRASS GIS** -- Commonly referred to as GRASS, this is a Geographic Information System (GIS) used for geospatial data management and analysis, image processing, graphics/maps production, spatial modeling, and visualization. GRASS is currently used in academic and commercial settings around the world, as well as by many governmental agencies and environmental consulting companies.

- **SPRING** -- SPRING is a state-of-the-art GIS and remote sensing image processing system with an object-oriented data model which provides for the integration of raster and vector data representations in a single environment.

- **AGIS for Windows** -- It is a simple mapping and GIS shareware package

- **VTP** -- Its goal is to foster the creation of tools for easily constructing any part of the real world in interactive, 3D digital form. This goal will require a synergetic convergence of the fields of CAD, GIS, visual simulation, surveying and remote sensing. VTP gathers information and tracks progress in areas such as procedural scene construction, feature extraction, and rendering algorithms.

VTP writes and supports a set of software tools, including an interactive runtime environment (VTP Enviro). The tools and their source code are freely shared to help accelerate the adoption and development of the necessary technologies.

**GRID-Arendal's Online GIS and Map and Graphics Database -- ** It offers a free collection of maps, graphics and diagrams, illustrating environmental issues. These images are produced using desktop publication software such as Freehand, Adobe Illustrator, CorelDraw, etc.

MapMachine -- It is a is a dynamic atlas used to locate places on Earth, search and print historical, weather, and population maps, and more. Mapmachine is hosted by the National Geographic and powered by ESRI

MapWindow GIS -- The MapWindow application is a free, extensible, geographic information system (GIS) that can be used in many ways: As an alternative desktop GIS To distribute data to others To develop and distribute custom spatial data analyses MapWinGIS ActiveX Control At the core of the MapWindow application is the MapWinGIS ActiveX control. Using this control, you can program custom mapping functionality directly into your own software.

worldKit -- WorldKit is an easy to use and flexible mapping application for the Web. Light weight GIS. It's a SWF based app, configured by XML, data fed by RSS. Stand-alone use or integration in larger projects.

BASINS -- BASINS is a multi-purpose environmental analysis system that integrates a geographical information system (GIS), national watershed data, and state-of-the-art environmental assessment and modeling tools into one convenient package.

SharpMap -- SharpMap is a simple-to-use map renderer that renders GIS data for use in web and desktop applications. The engine is written in C# and based on the .NET 2.0 framework.

SAMT -- A commercial GIS is very expensive while a free GIS (GRASS) is not easy to use. We need a modeling system with a few GIS-features, like spatial analysis, some spatial techniques and a simple in and export function to a GIS. The main focus is to have an open system to include different models.

mezoGIS -- mezoGIS is a GIS application, a graphical interface to query and analyze spatial data. mezoGIS does not store or compute data directly, but operates external PostGIS databases. The goal of mezoGIS is to provide a tool for geo-spatial analysis with PostGIS, through on-the-fly SQL queries as well as through larger, external plugin scripts.

MapWindow -- The MapWindow GIS open source project includes a Microsoft Windows compatible desktop application capable of viewing shapefile, and raster data in many formats. It can reproject data, clip, merge, and perform

other geoprocessing through a "GIS Tools" plug-in. Developer-users can extend the application by writing plug-ins using any .NET Framework compatible language, or developers can write GIS enabled software using the MapWinGIS ActiveX control.

- **HidroSIG** -- HidroSIG is a Geographical Information System (GIS) written in Java with special tools that will allow you to make estimations and analysis of hydrological, climatic and geomorphological variables.

- **HUGO** -- Hugo is moving map software for UNIX platforms. Hugo can view maps in simple raster (XPM), vector, and TIFF formats. ESRI shape file support is in progress but not yet useful.

- **gvSIG** -- gvSIG is a tool for handling geographical information. It has a friendly interface, and can access several (raster and vector) formats. It will integrate in a single view both local and remote data through WMS or WFS (WMS now working). It is meant for end-users of geographical information, and currently has Spanish, Valencian, English, French, and Italian interfaces.

- **GeoVista Studio** -- GeoVISTA Studio is an open software development environment designed for geospatial data. Studio is a programming-free environment that allows users to quickly build applications for geocomputation and geographic visualization.

- **Virtual Terrain Project (VTP)** -- The goal of VTP is to foster the creation of tools for easily constructing any part of the real world in interactive, 3D digital form. This goal will require a synergetic convergence of the fields of CAD, GIs, visual simulation, surveying and remote sensing. VTP gathers information and tracks progress in areas such as procedural scene construction, feature extraction, and rendering algorithms.

- **VGMap** -- VGMap is a new library created by Eyebeam R&D that allows designers, developers, and mapping geeks to overlay data on top of Google Maps in a richer way than is possible using their standard system. It is called VGMap because it adds vector-drawing capability to the already-awesome GMap API.

- **TOPAZ** -- TOPAZ (Topographic Parameterization) is an automated digital landscape analysis tool for topographic evaluation, drainage identification, watershed segmentation and subcatchment parameterization. While TOPAZ is designed primarily to assist with topographic evaluation and watershed parameterization in support of hydrologic modeling and analysis, it also has application to a variety of geomorphological, environmental and remote sensing applications.

- **POPulation MAPper** -- POPulation MAPper (popmap for friends) is a utility that creates population maps. Popmap will read from a configuration file the different

sites and the weight of a certain type of population for each site. Then popmap will retrieve the best map for the set of sites from mapblast and draw dots in the given sites coordinates proportional to the weight of the population.

- **PloneMap** -- A mapping application for Plone based on MapServer. It enables you to create interactive maps inside your Plone site. Web visitors can navigate the map and browse or edit geo-positioned data in a collaborative manner. PloneMap adds geographical representation on top of the powerful Plone content management system.

- **MapLab** -- MapLab is a suite of effective and intuitive web-based tools to create and manage MapServer web mapping applications and map files. It consists of three components: MapEdit, MapBrowser and GMapFactory.

- **MapJunction** -- MapJunction3D is the first web-based mapping system to combine fast display of maps, aerial photos and GIS information.

- **MapIt!** -- MapIt! is a web-application that lets you navigate raster-maps through your web-browser and lets you zoom in and out and select objects and object classes that are identified on the map.

- **InterMap** -- InterMap is an Internet mapping application that allows the user to combine interactive maps from distributed Internet Map Servers in a browser. InterMap supports OpenGIS WMS and ESRI-ArcIMS and can be fully integrated with the GeoNetwork Metadata portal.

- **GeoTools** -- Geo Tools is a free Java based mapping toolkit that allows maps to be viewed interactively on web browsers without the need for dedicated server side support.

- **SAV GIS**

- **SPRING GIS**

- **AvisMap Free Viewer Publisher's Description** -- The free AvisMap Viewer opens most GIS/CAD and raster image file types and most ArcView, ArcExplorer, and MapInfo projects. Besides just opening and viewing files, the Viewer supports an extensive list of features including visual layer properties control, legend control, thematic mapping, spatial and attribute querying, custom labeling, on-map measurements, hyper-linking, PDF export and much more.

This software can be downloaded at:

http://www.avismap.com/download/avismap_free_viewer_52.exe

- **AvisMap GIS Engine** -- AvisMap GIS Engine is a comprehensive SDK designed for custom GIS applications. This software can be downloaded at:

  http://www.avismap.com/download/AvisMap_GIS_Engine_Development_Package_50.exe

- **LookWMS** -- LookWMS is a Java Web Map Client with several unique features. LookWMS includes PDT by IDELIX, a virtual lens tool for more effective viewing and interaction with multi-layer data. LookWMS allows you to access and layer information from multiple servers, open GeoTIFFs, and work offline.

- **LookOUT** -- LookOUT is a great new add-in for Microsoft~ Outlook~ that enables you to easily map a location or find directions straight from your Outlook Contacts window. With a couple of clicks you can map a location, find directions from one contact to another, and search for products or services in a specific area.

- **Spatial Console** -- Spatial Console is the ultimate tool for controlling data in an Oracle Spatial environment. The product enables users to import shapefiles into Oracle Spatial or Locator with control over metadata, database constraints, feature history, versioning and coordinate rounding. Exporting from Oracle to several formats is also supported. The import and export facilities of Spatial Console can be conducted in batch mode via the command line if required.

- **SAGA** -- System for an Automated Geo-scientific Analysis -- is a free GIS. One can understand SAGA as a geographic information system with a special 'Application Programming Interface' (API) for geographic data processing. This API makes it easy to implement new algorithms and exempts the developer from hassle programming overhead like user-interface design or file-input-output. The SAGA API supports grid data like digital terrain models and satellite images, vector data, and tables.

- **AccuGlobe 2004** -- Digital Data Technologies (DDTI) and GeoMicro have made AccuGlobe 2004 available for free download. The product is built on GeoMicro's AltaMap components. AccuGlobe 2004 contains many GIS features such as feature editing, charts, smart labeling, web updates and creating project files. The primary purpose of AccuGlobe is to provide a mapping platform for organizations or people that have previously been unable to use GIS software because of the expensive license fees.

- **sdts2dem: a Translator for STDS DEM Files** -- (Version 0.018: April 29, 2002). The sdts2dem program translates USGS DEM files from STDS format to "native" format. It is in the public domain and may be freely redistributed.

- **SIGIS** -- A Freeware version of Geomatique SIGISCO integrated vector/raster GIS and remote sensing application running under Windows (95/98/NT/ME/2000). It features satellites image processing, raster and vector

spatial analysis, geographically linked database management, mapping and 3D surface rendering & animation.

- **MBBuilder: RAD Tool for MapInfo** -- The RAD MBBuilder 1.5 gives an opportunity to shift from the traditional programming interface elements in MapBasic commands to their visual design.

- **MapInfo Callback Manager DLL** -- microOLAP MapInfo Callback Manager is the ready-to-use inproc COM server solution allowing to implement MapInfo Callbacks.

- **GIS Developer Kernel (DK)** -- A comprehensive GIS development toolkit, with more than 2,000 functions and properties. The DK is offered as a Borland Delphi/C++ Builder/Kylix VCL library, and is an ActiveX component for compatibility with Visual Basic, Visual C++, and scripting languages. The DK can be used to create an application that compiles into a single executable file, is free of Dynamic Library Links, compatible with a wide range of data formats (SHP, EOO, MIF/MID, TAB, DXF, DGN, TIGER, TIFF, JPG, BMP, SPOT, and TatukGIS PixelStore), royalty-free, and provided with full source code.

- **GIS Internet Map Server** -- An ASP component for the creation of web-based GIS solutions. As the interactive map samples on this website demonstrate, the IS internet-publishes both vector and raster data, and supports rich interactive GIS functionality via HTML or WAP browser. The IS shares the same architecture as the DK, supporting the same 2,000+ functions and properties and compatibility with the same wide range of data formats.

- **ArcExplorer** -- ArcExplorer is a lightweight GIS data viewer developed by ESRI. This freely available software offers an easy way to perform basic GIS functions. ArcExplorer is used for a variety of display, query, and data retrieval applications and supports a wide variety of standard data sources. It can be used on its own with local data sets or as a client to Internet data and map servers.

- **Geomatica FreeView** -- New viewing environment for working with a variety of data, including imagery, vectors, and graphical bitmaps.

- **SPANS Observer** -- SPANS Observer allows you to display, query, annotate and create slides of your SPANS data. It is an excellent package for quick desktop presentations.

- **GRASS GIS** -- GRASS GIS (Geographic Resources Analysis Support System) is a Geographical Information System (GIS) with raster, topological vector, image processing, and graphics production functionality that operates in the UNIX environment through a graphical user interface and shell in X-Windows. It is released under GNU GPL.

- **ERDAS** -- The following products are available for Free download. Registration is required before downloading.

    a. **ERDAS Viewfinder** -- ERDAS ViewFinder is a free viewing tool with basic image viewing and manipulation capabilities, including the ability to Display, Continuously roam, rotate and zoom the displayed imagery to any display scale, Spatially query image files prior to exporting, Overlay, etc.

    b. **MapSheets Express v1.3** -- MapSheets Express is the FREE viewing and mapping tool from ERDAS, for working with imagery and vector map data.

- **ILWIS** – ILWIS (Integrated Land and Water Information System) integrates image, vector and thematic data.

    1. **NAPIS Lite** -- NAPIS integrates geographic information system (GIS) technology using ESRI's Map Objects, which allows text-field database tables to be related to spatial features on computer-based maps.

    2. **TNTlite** -- MicroImages provides TNTlite as a free version of TNTmips, our professional software for geospatial data analysis.

    3. **WinQuery for WinGIS Evaluation Version** -- The Evaluation Version has all the functionalities of WinQuery Standard and comes with an evaluation license-key, which allows you to try the software for a period of 30 days free of charge, before purchase.

    4. **MapIt** -- MapIt is a web-application that lets you navigate raster-maps through your web-browser and lets you zoom in and out and select objects and object classes that are identified on the map.

    5. **Dime** -- Dime is a C++ class library for reading, constructing, manipulating, and writing DXF file data. The name is an acronym for DXF Import, Manipulation, and Export library.

    6. **AGIS for Windows** -- An update of AGIS that corrects problems with pasting AGIS metafiles to Word and Excel 2000 and Windows 2000/XP.

1.2   GIS processing tools

GIS is a set of tools that captures, stores, analyzes, manages, and presents data that are linked to location(s). In the simplest terms, GIS is the merging of cartography, statistical analysis, and database technology. GIS applications are tools that allow users to create interactive queries (user-created searches), analyze spatial information, edit data, maps, and present the results of all these operations.

GIS was used since as the 1800's. For example in 1854, John Snow, a physician, depicted a cholera outbreak in London using points to represent the locations of some individual cases, possibly the earliest use of the geographic method.[16] As shown in Figure 1, his study of the distribution of cholera led to the source of the disease, a contaminated water pump (the Broad Street Pump, shown on the left, whose handle he had disconnected, thus terminating the outbreak) within the heart of the cholera outbreak.
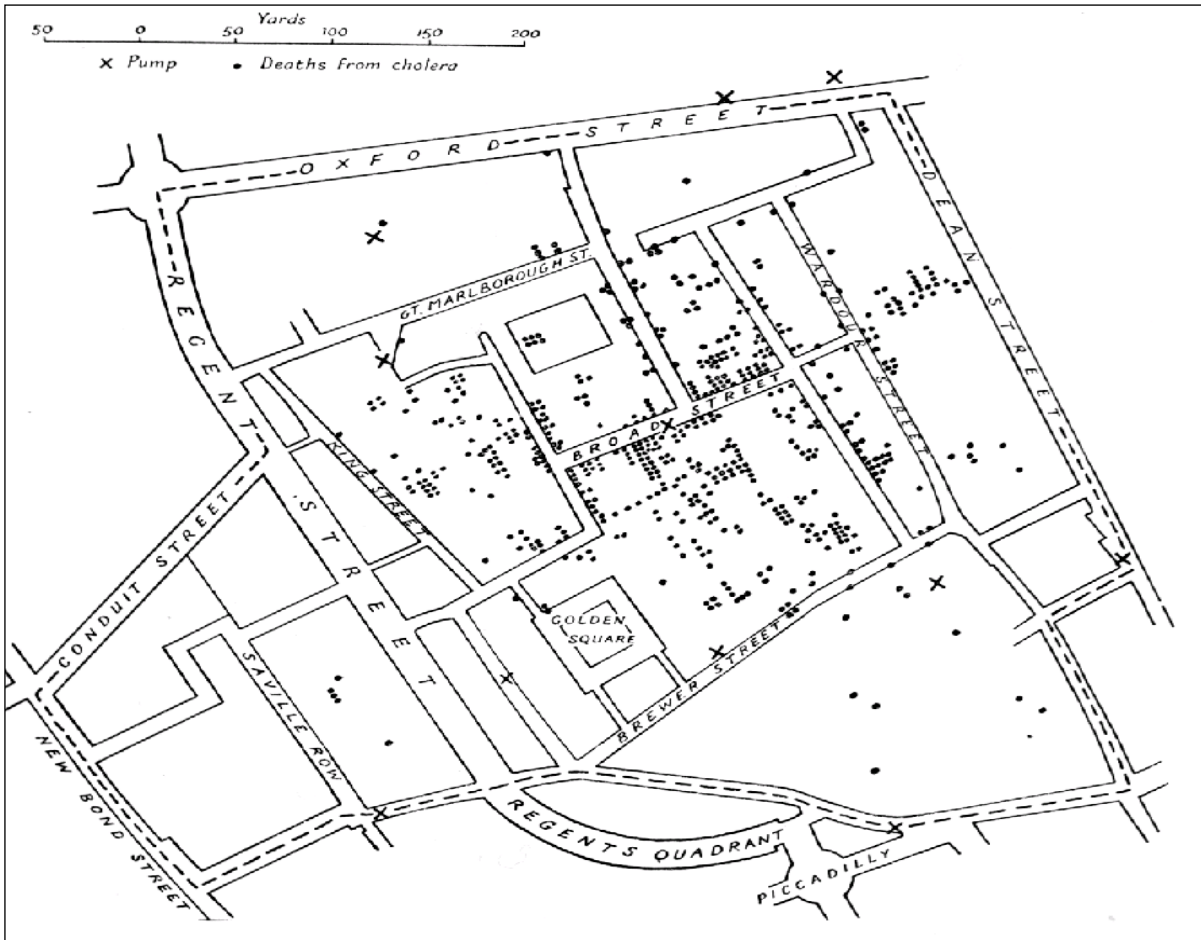
Figure 1: Dr. Snow's use of GIS in 1854

A GIS takes the traditional map to new heights and may be described by its process, data, and analytical capabilities. The GIS process involves encoding, storage, processing and display of computerized (digital) maps. Processing functions include:

- computer mapping;

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[16] "John Snow's Cholera Map". York University.
http://www.york.ac.uk/depts/maths/histstat/snow_map.htm. Retrieved 2007-06-09.

- spatial database management; and
- spatial statistics, analysis and modeling.

These functions are descriptive and interpretive as well as prescriptive in nature. Computer mapping is a descriptive process that rapidly creates and updates map products. It provides tools for automating the cartographic process, but does not alter the inherent nature of a traditional map.

Spatial database management is used to combine and interpret sets of mapped data. It provides new procedures for *geo-query* of the data. For example, a database map can be searched for map compartments with certain requirements (i.e., low pH values in a certain soil type), then produce a map locating these areas. The spatial modeling capabilities extend the descriptive and interpretive uses of maps by deriving new information through the relationships among existing maps. For example, template maps can be "summarized" for typical characteristics (such as average slope for each mapping compartment), and the result can be added as a new column to the database.

1.3   GIS data formats

Traditional maps are graphical abstractions containing inked lines, shadings and symbols to locate landscape features. The three cartographic primitives used to draw maps are points, line, and areas. Figure 2 shows the distinction between the primitives.

__Points__ represent dimensionless features, such as wells. *__Lines__* depict features with length, such as streams or waterways. *__Areas__* (or *__polygons__*) have length and width, such as agricultural fields. Add depth and areas are extended to *volumes*, such as the entire body of water in a pond.

The cartographic primitives are used in the GIS environment by way of the two generic data formats known as **vector** and **raster** data formats.

In a vector data set, map features are represented by *x, y* coordinates. Points are identified as a single coordinate pair. Lines are a connected set of points (like a connect-the-dot picture). Areas, such as soil type units, are identified by a list of coordinates defining the line segments forming their borders.

A raster data set, uses an imaginary grid of cells (similar to a spreadsheet layout) to represent the landscape. Points are individual column/row entities (*grid cells*), lines are a set of connected cells and areas are stored as all the cells within the interior of each map feature.

Although raster data has several advantages, it has a major disadvantage—lack of spatial precision.   If a stream passes through an acre grid cell, the whole cell is identified as containing the stream.
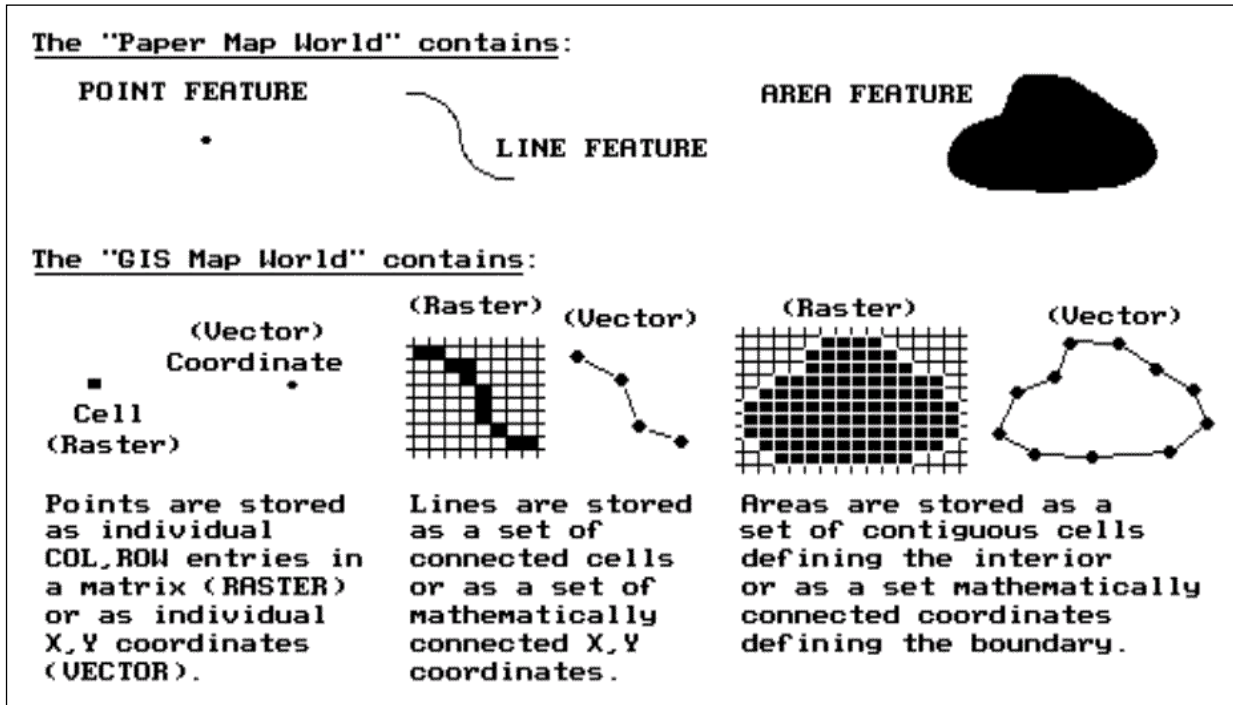
Figure 2: GIS data formats

Using the basics of GIS, the development of GIS has grown to bigger and better applications, the extent of which spans from the simplest query application on a stand-alone computer to that of web-based applications where there is real time data updates. Figure 3 shows an example of a GIS methodology for an Application of Participatory GIS for Rural Community Development and Local Level Spatial Planning System in Sri Lanka.[17] The methodology shows the entire system development which starts from the data collection to the information presentation.

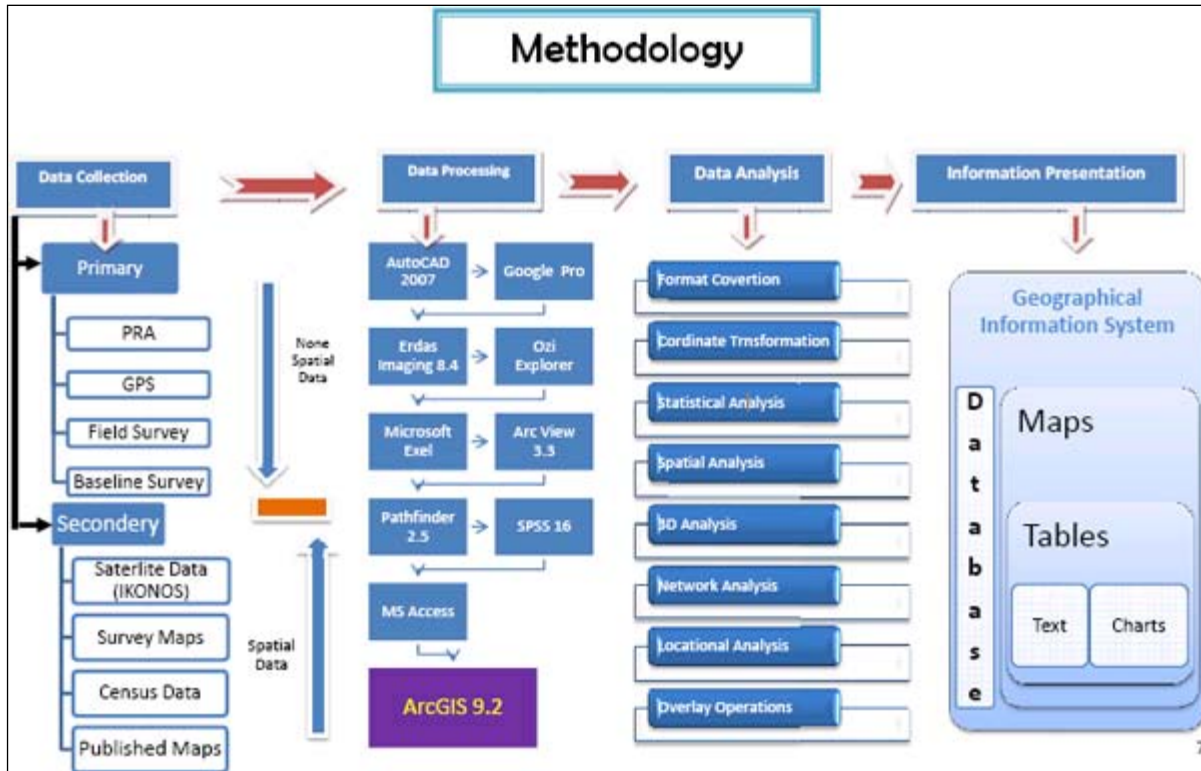[17] http://www.gisdevelopment.net/application/lis/rural/srilanka.htm

Figure 3: Example of a GIS methodology

The expectation is that all GIS users will have their various methodologies for which they will have the different tools used to perform the data analyses. Listing the tools available in GIS is not realistic because there is a wide variety available. However, a common set of tools that all GIS will have is shown in Table 2.

georeference	buffer	geocode	query	Hyperlink
distance	area	rasterize	vectorize	Extract
merge	dissolve	layout	union	Intersect
clip	overlay	charts	and so on……	

Table 2: Sample of common GIS tools

Using the GIS tools and the methodologies, data models are developed by GIS users. The data models are also varied from organization to organization. They can be just as extensive as the number of tools which is available in the standard GIS software. An example of a data model that was generated in ArcGIS software is shown in Figure 4. It is a data model that updates a cadastral data set using a set of rules.
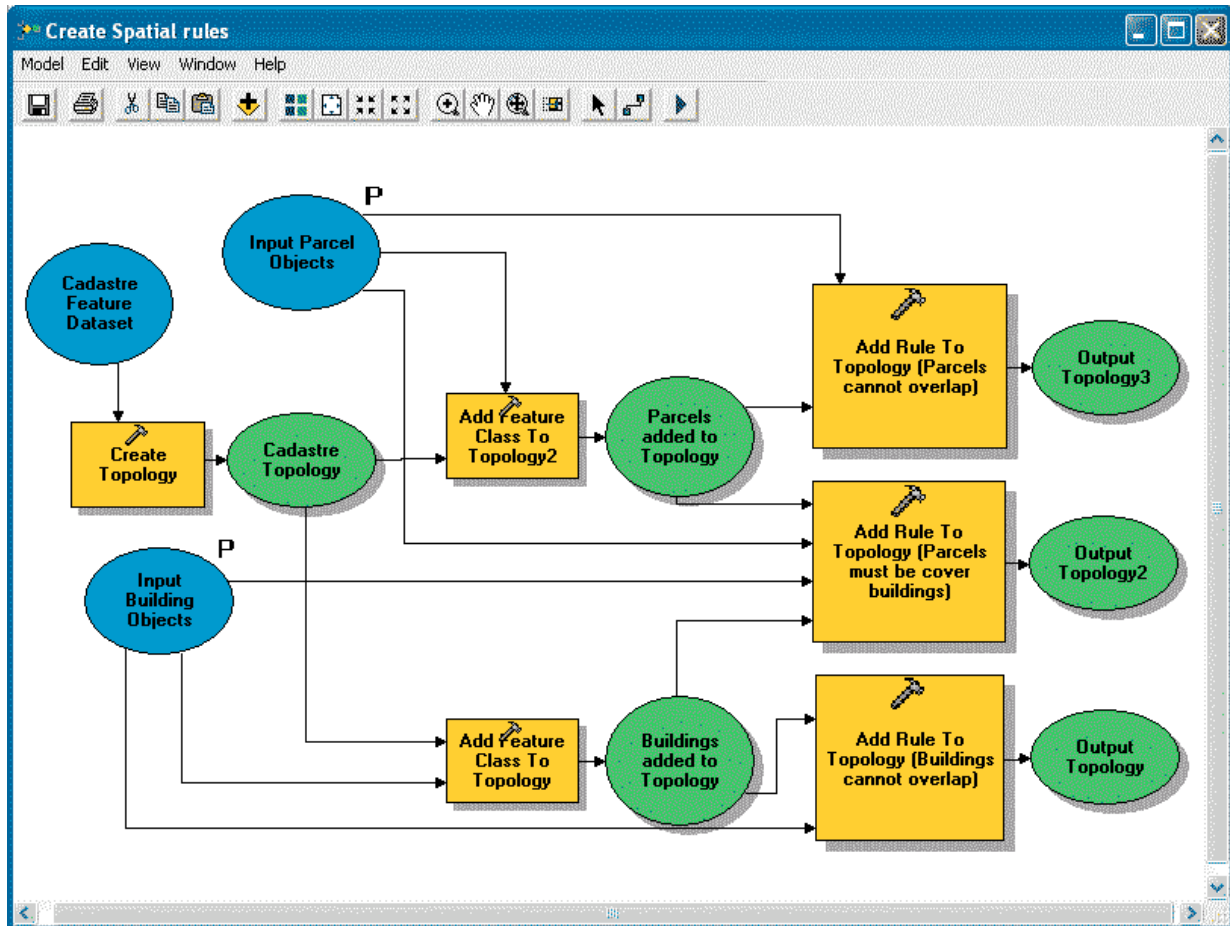
Figure 4: Example of a Cadastral data model[18]

The Internet has certainly assisted in making GIS a popular technology across the various professions. Now, GIS is extended to having the ability to share data and also share data models. The problem still remains, of overlaying data from different sources. The reason for this originates from the definition of the data, in particular, the coordinate system.

2.   Projections and Coordinate Systems

A map projection is one of many methods used to represent the 3-dimensional surface of the earth or other round body on a 2-dimensional plane in cartography. This process is typically, but not necessarily, a mathematical procedure. The creation of a map projection involves three steps in which information is lost in each step:

1. Selection of a model for the shape of the earth or round body (choosing between a sphere or ellipsoid).

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[18] http://www.ncad.net/Gi/gi1.htm

2. Transformation of geographic coordinates (longitude and latitude) to plane coordinates (eastings and northings).
3. Reduction of the scale (in manual cartography this step came second, in digital cartography it comes last).

Choosing a projection surface is important and needs special consideration. When a surface can be transformed onto another surface without stretching, tearing, or shrinking, then the surface is said to be an applicable surface. The sphere or ellipsoid is not applicable with a plane surface so any projection that attempts to project them on a flat sheet will have to distort the image. A surface that can be unfolded or unrolled into a flat plane or sheet without stretching, tearing or shrinking is called a 'developable surface'. The **cylinder**, **cone** and the **plane** are all developable surfaces since they can be unfolded into a flat sheet without distorting the projected image. The different types of developable surfaces are shown in Figure 5.
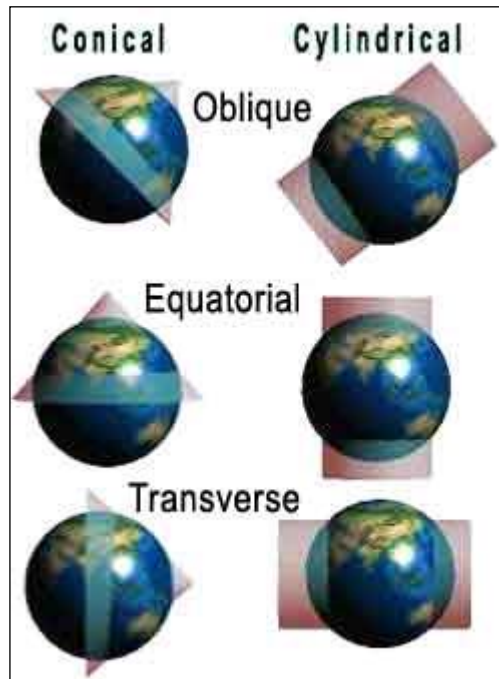

Figure 5: Developable map projection surfaces

In order to transform from one map projection to another, a map projection transformation is required. No map projection transformation can maintain scale everywhere. Angles, areas, distances and directions will be altered in the planar representation of the ellipsoidal earth. The distortions created during the map projection transformation may be analyzed using a measure of distortion. Therefore, all data sets must have a projection system for it to be transformed to another map projection. Data sets with no map projection are un-useable and will be required to be geo-referenced. Examples of map projections are shown in Figure 6.
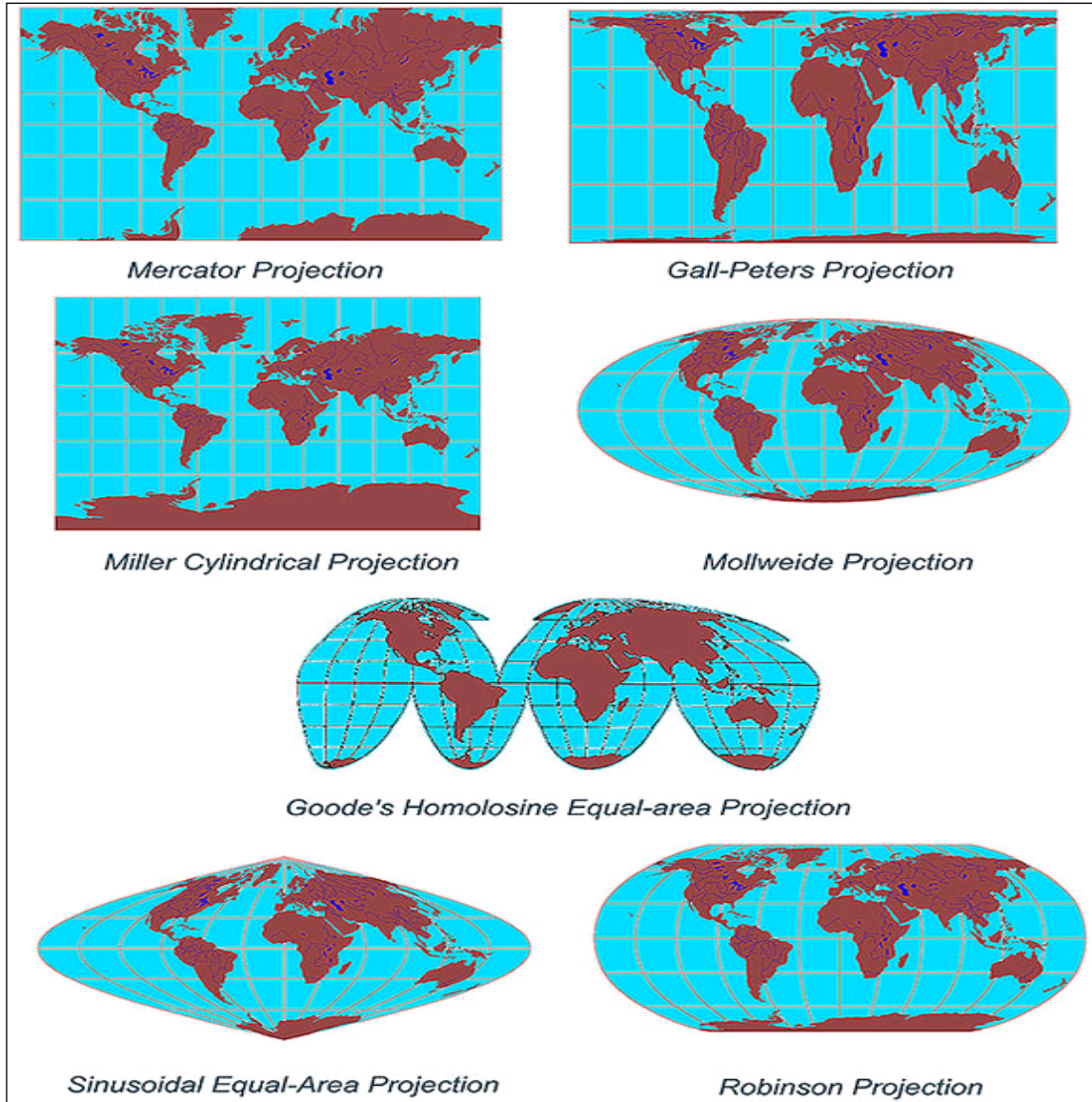
Figure 6: Examples of map projections

3.   Common GIS data types

The data which is available on the Internet is varied and comprised of different data types. GIS technology utilizes two basic types of data. These are:

- **Spatial data:** describes the absolute and relative location of geographic features.
- **Attribute data:** describes characteristics of the spatial features. These characteristics can be quantitative and/or qualitative in nature. Attribute data is often referred to as tabular data.