CHAPTER 3: GEOGRAPHIC INFORMATION SYSTEM TECHNOLOGY

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A. Definition and Significance of GIS

Geographic information system (GIS) is a collection of computer hardware, software, geographic data, and personnel assembled to capture, store, retrieve, update, manipulate, analyze, and display geographically referenced information. Basically, the information in the GIS would allow users to answer where things are or what is located at a given area.

Operationally, the GIS can link different data sets together. Hence land use planners, development practitioners, and local communities are using GIS because the system assists in visualizing, analyzing, and interpreting data collected to understand relationships, patterns, and trends affecting community life. GIS data is saved as shapefile (.shp) which can be shared with others using GIS software. GIS mapping enables better decision-making, improved communication, greater efficiency, and better record-keeping.

In recent years, there has been a growing movement towards securing the formal legal recognition of land rights for indigenous peoples, landless farmers, and local communities. The relationship between community land rights and human rights is important as land and natural resources are fundamental to the existence, livelihood, identity, and opportunities for rural communities.

Mapping of land and natural resources are valuable inputs to the development of frameworks for sustainable management of the lands, territories, and resources of the local people. Natural resources are essential to the growth of local economies because of the raw materials, food, medicine, and energy that these provide to various industries. Sadly, these resources are being depleted globally. In this light, GIS mapping provides a tool for indigenous peoples and other stakeholders to manage their natural resources, by producing a variety of maps related to land cover, vegetation, soil, geology, habitat, and resource use, among others. Natural resource information is critical in the development of sustainable resource management plans, and for the process of decision-making to ensure effective management practices are put in place.

The rural communities and indigenous peoples are estimated to hold as much as 65 percent of the world's land area under traditional and customary systems, yet many governments formally recognize their rights to only a fraction of those lands. This is a major source of conflict, environmental degradation, and cultural extinction. Securing rights to land and resources enable people to exercise their traditional knowledge and management systems, manage external threats, and govern their territories as stewards towards sustainable human development.

B. Advantages of Using GIS

a) Find geographic features. Users can search a GIS database to find point, line, area, and surface features by their descriptions or measurements.

b) Measure geographic features. Users can measure lengths, widths, areas, and volumes, and compare sizes from one feature to another.

c) ***Characterize distributions.*** Users can group geographic features and define their distributions based on how much space they use, how close they are to each other, and where they are relative to other features.

d) ***Summarize geographic data.*** Users can calculate all sorts of statistics on their geographic features from the simplest descriptive statistics (for example, mean, median, and mode) to very complex spatial statistics.

e) ***Work with networks.*** Users can find routes based on time, distance, or other factors. For instance, scheduling bus routes to reach the maximum number of people and use population density information to locate stores near potential customers.

f) ***Compare map layers.*** Users can compare the locations of features from one map layer (or theme) to another. This powerful feature helps users to "overlay" the layers, and shows the relative location of features from one layer to another.

g) ***Perform surface analysis.*** Users can work on the many surfaces available in GIS and use mathematical methods (such as interpolation) to find missing values and perform other analyses.

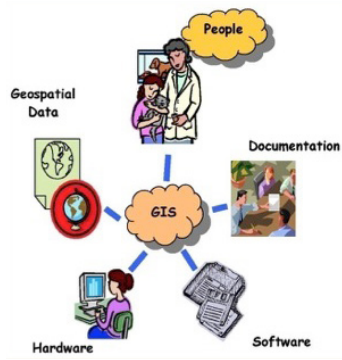
Source: *De Mers, M., GIS for Dummies*

C. Components of GIS

Basically, there are four interrelated components of GIS to function effectively and efficiently, as shown on the following page:

Components

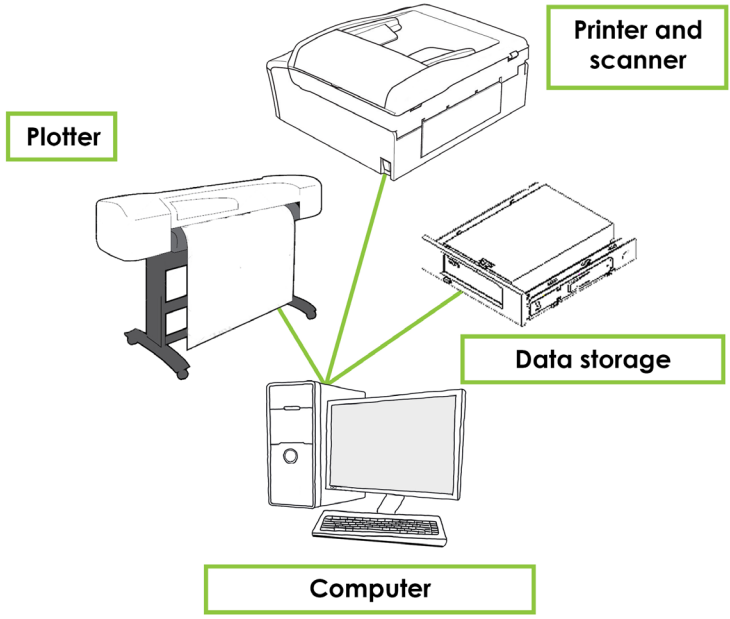
- **Hardware**
- **Software**
- **Geospatial data**
- **Documentation of procedures**
- **People, organizations and institutional arrangements**



Source: *Geographic Information Systems (powerpoint presentation by PAFID).*

1) **People trained to use GIS supported by an organization.** People are the most important component for the GIS to function effectively and efficiently. The people using GIS must be familiar with all its functionalities. Motivated and well-trained personnel composed of project leaders, researchers/enumerators, data encoders, and professional consultants are the key players for the successful implementation of a computerized mapping project.

2) **Appropriate hardware.** Users need a computer desktop or a laptop with sufficient memory, video capacity, and hard disk drives to run the GIS program effectively and efficiently. The GIS hardware components include a control processing unit which is linked to mass storage units such as hard disk drives and tape drives, digitizer/ scanner, printer or plotter, and Visual Display Unit (VDU), as shown below:



Source: *GIS Components (M. Anji Reddy, 2008)*

3) **Appropriate software.** GIS software ranges from simple "viewers" to "map-creation using software" that displays a small number of layers, to powerful applications that can handle and display enormous amounts of data. Some software can create and display GIS maps from a website, making them accessible to many users. Other types of software are non-GIS software programs yet it can use the data stored in them to create GIS maps. The software depends on the technical requirements of the GIS project, how much budget, and how important it is to the over-all functioning of the concerned agency.

Operationally, an effective GIS map-creation software should include:

a. The ability to enter and work with geographic and location information – street names, political boundaries, etc.

b. A database management system to organize and manage information. The GIS software package consists of four basic technical modules:
   (i) data input and verification;
   (ii) data storage and database management;
   (iii) data transformation and manipulation; and,
   (iv) data output and presentation.
c. A map creator easily viewed and simple to interpret and analyze.
d. A simple and usable graphical user interface (GUI) with various toolbars and controls.

4) Necessary Data. GIS software cannot create a map unless it has the information to do so. This comes from the five types of data that the software has to use, to wit:

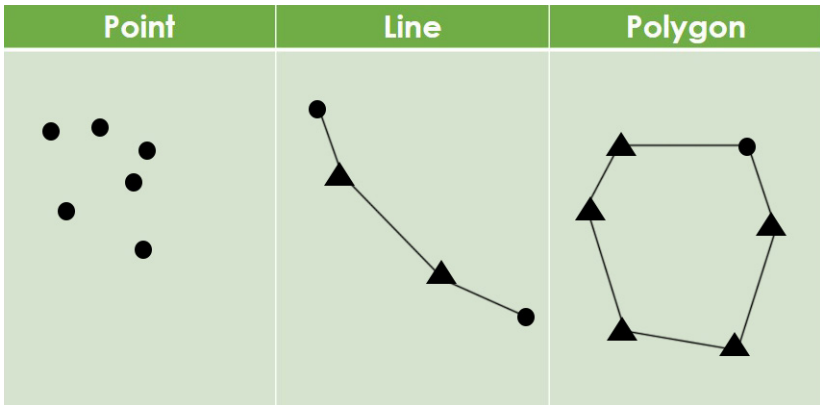
Spatial data refers to information about the location, dimensions, shape, and the relationships among geographic features. In GIS, spatial data are technically classified as points, lines, areas, and raster grids.

Attribute data are information about who lives where, locations of different commercial and industrial establishments, land uses, demographics of the population (e.g. income, employment, education, crime rates), trends, and changes over time (e.g. tracing the conversion of farmlands to real estate developments for over 10 years).

Data Layers are the results of combining spatial and attribute data – essentially adding the attribute database to the spatial location.

Layer Types refer to the way spatial and attribute information are connected. There are three major layer types or models, to wit:

a. ***Vector*** **-** represents real-world features such as points, lines, and polygons.



Source: *GIS Components (M. Anji Reddy, 2008)*

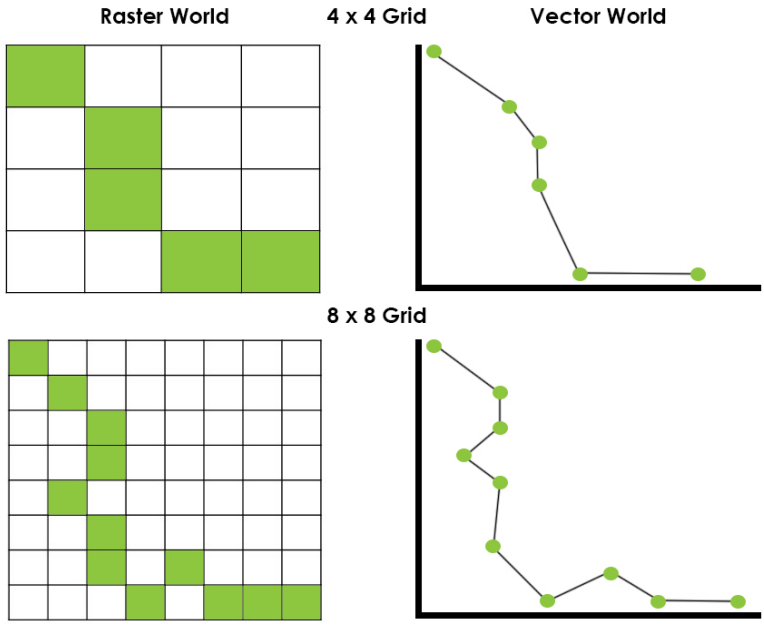
- A point is represented in a computer database by x, y coordinates.

- A line is a sequence of x, y coordinates, whereby the end points are usually called nodes and the intermediate points are termed vertices.

- Polygons are represented by a closed series of lines such that the first point equals the last point of the loop. Points may be used to represent houses and lines as roads and rivers.

b. ***Raster*** **-** divides space into a regular array of rows and columns. A cell in this array or grid is sometimes called a pixel, which stands for a picture element and reveals the origin of this data model. In most raster systems, the attribute value at a given location is stored in the corresponding cell of the raster. The raster database of elevation is a long string of elevation numbers.

c. ***Topography*** **-** information on how geographic features are related to one another, and where they are in

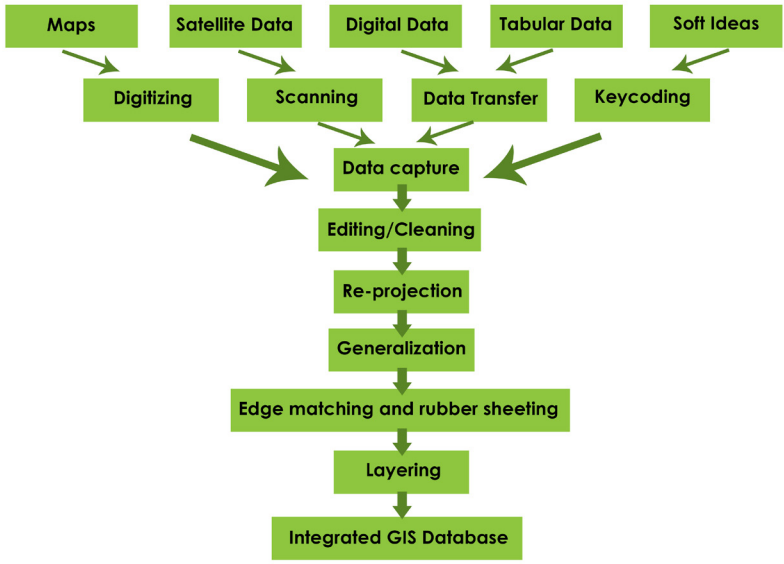


relation to one another. Topology is the critical element that distinguishes a GIS from a graphics or automated cartography system. The GIS has the ability to employ spatial relationships and manipulate geographic relationships.

Essentially, the GIS links different data sets together. The data to be inputted, stored, and saved for a GIS database integrated system are acquired in various ways. Data are entered using a keyboard, by digitizing, or scanning. Data encoding and editing is called Data Stream as shown on the next page.

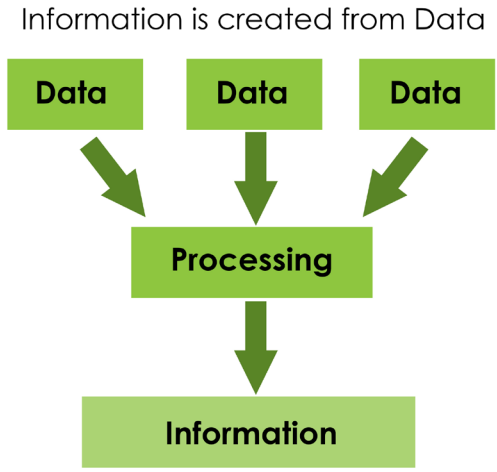
D. GIS Work Flow

GIS is a set of tools that allow for the processing of spatial and attribute data into information. To elaborate, data refers to raw, unorganized facts that need to be processed. Data can be something simple or randomly arranged. Unless organized, data is meaningless. When data is processed, organized, structured,



Source: *Conceptual view of GIS Data Stream (M. Anji Reddy, 2008)*

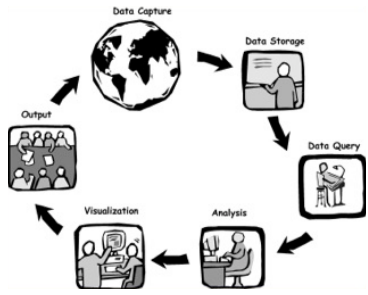
or presented in a logical manner and within a given context, it is called information as shown below:



Basically, there are five essential elements that a GIS must contain. These are data acquisition, pre-processing, data management, manipulation, and analysis; as well as product generation (M. Anji Reddy, 2008). These elements as interrelated as shown below:

Functions

- **Data capture**
- **Data management**
- **Data query – database operations**
- **Analysis – perform spatial operations**
- **Visualization – display**
- **Outputs – reports**



Collection, inputting, and correction operations function with receiving data into the system that include manual digitizing, scanning, keyboard entry of attribute information, and online retrieval from other database systems. At this stage, a digital map is first constructed. The essential pre-processing includes (a) format conversion, (b) data reduction and generalization, (c) error detection and editing, (d) merging of points into lines, and lines into polygons, (e) edge matching and tiling, (f) rectification/ registration, (g) interpolation, and (h) interpretation.

Database management provides consistent methods for data entry, updating, deletion, and retrieval. Modern database management systems isolate the users from the details of data

storage. A modern Database Management System (DBMS) is used to create the GIS database.

Storage and retrieval mechanisms include the control of physical storage of data in memory, disk, or other mechanisms for its retrieval to serve the other three components. This module includes the software structures used to organize spatial data into models of geographic reality. The development of new derived data layers, which may form the input to further analysis, is an important function of any GIS.