NATIONAL OPEN UNIVERSITY OF NIGERIA

ESM 407

Geographic Information System

Module 2

ESM 407 Geographic Information Systems Module 2

Course Developer/Writer
Dr. N. O. Uluocha, University of Lagos

Course Coordinator
Mrs. Cecilia Medupin, National Open University of Nigeria

Programme Leader
Prof. K. T. Obidairo, National Open University of Nigeria

Credits of cover-photo: Henry Ude, National Open University of Nigeria

National Open University of Nigeria - University Village, 91 Cadastral Zone, Nnamdi Azikiwe Express Way, Jabi Abuja, Nigeria

www.nou.edu.ng centralinfo@nou.edu.ng
oer.nou.edu.ng oerunit@noun.edu.ng OER repository
Published in 2021, by the National Open University of Nigeria

How to re-use and attribute this content

Module 2 Components of GIS

Unit 1 GIS Hardware

1.0 Introduction

There are many specialized hardware associated with GIS operations. Hardware comprises the physical electronic equipment needed to support the many activities of GIS ranging from data collection to data analysis and output. In this unit, we will look at the computer, data input devices, data storage devices, data output devices, and other related hardware devices.

2.0 Objectives

At the end of this unit, you should be able to:
- identify the hardware components of a typical GIS
- discuss the functions of each of the hardware devices.

3.0 Main Content

3.1 Computer

This consists of the computer system on which the GIS software will run. The computer forms the backbone of the GIS hardware. The central piece of equipment is the workstation, which runs the GIS software and is the attachment point for ancillary equipment. The choice of hardware system ranges from 300MHz personal computers (PCs) to multi-user supercomputers having capability in Tera FLOPS. The computer contains the processor, which is used to manage and manipulate the database based on certain rules and commands.

3.2 Input Devices

The input devices are used to capture or enter data into the computer. There are two broad categories that are usually handled in a GIS environment namely; spatial data and non-spatial (attribute or descriptive) data. The spatial data can be entered into the computer with the aid of a digitiser or a scanner. A digitizer is a flat electronic board used for vectorization of a given map objects.

In other words, a digitizer is used for conversion of the drawings on an analogue or hard copy map to digital data. On the other hand, a scanner converts an analogue image or picture into a digital image for further processing. The image data acquired via a scanner can be stored in many formats e.g. TIFF, BMP, JPG etc. The use of handheld field technology is also becoming an important data collection tool in GIS. For instance, data collection efforts can also require the use of a Global Positioning System (GPS) data logger to collect data in the field (Figure 2.1). The attribute (statistical or non-spatial data) used in GIS are keyed into the computer using the keyboard.

Fig. 2.1: A Trimble Handheld GPS Receiver

(http://www.mightygps.com/Trimble/geoxm.html)

3.3 Storage Devices

The storage devices include various media such as optical hard disk, magnetic tape, compact disc (CD), flash drive.

3.4 Output Devices

Output devices are used to obtain the hardcopy versions of processed data. Printers and plotters are the most common output devices for a GIS hardware setup. Presently, printers can only be used to obtain print-outs on paper as large as A3, whereas there are plotters that can draft on paper as large as A0.

3.5 Others

With the advent of Web-enabled GIS, Web servers have also become an important piece of equipment for GIS.

4.0 Conclusion

In a typical GIS environment various digital hardware devices are used. Some of the devices such as GPS, digitiser, and plotter are rather peculiar to GIS and similar systems, which handle geographical data. The capabilities of these devices can make or mar the success of GIS operations.

5.0 Summary

The hardware components of GIS are the physical electronic devices used in performing GIS operations. The hardware devices include the CPU and allied accessories used in various data handling functions such as data capture/entry, storage, manipulation, output, and distribution. The devices are usually of varying capacities; however, owing to the characteristically voluminous and largely graphic nature of geospatial data, robust and high calibre devices are often preferably required for their handling.

In a nutshell, the major hardware-related elements essential for effective GIS operations could be summarised as follows (Burrough, 1986):

- the presence of a processor with sufficient power to run the software
- sufficient memory for the storage of large volumes of data
- a good quality, high-resolution colour graphics screen
- data input and output devices (for example, digitisers, scanners, keyboard, printers and plotters).

6.0 Self-Assessment Exercise

Identify the hardware components of a typical GIS.

References/Further Reading

Burrough, P. A. (1986). *Principles of Geographical Information Systems for Land Resources Assessment*. New York: Oxford University Press.

Burrogh, P. A. & McDonnell, R. A. (1998). *Principles of Geographical Information Systems*. New York: Oxford University Press.

Clarke, K. C. (1995). *Getting Started with Geographic Information Systems*. (3rd ed.). New Jersey: Prentice Hall.

Heywood *et al* (1998). *An Introduction to Geographical Information Systems*. New York: Addison Wesley Longman Limited.

Uluocha, N. O. (2007). *Elements of Geographic Information Systems*. Lagos: Sam Iroanusi Publications.

Unit 2 GIS Software

1.0 Introduction

In computing, the software is the component that drives the hardware and data using certain methods and rules. There are a number of software packages that are used in GIS operations. GIS software packages are designed to handle geographical or spatial data. In this unit, you will learn about the nature as well as types of GIS software.

2.0 Objectives

At the end of this unit, you should be able to:

- explain what GIS software is
- identify different types/makers of GIS software.

3.0 Main Content

3.1 What is GIS Software?

Generally, software is a digital language comprising of set(s) of rules, commands, algorithms or programs, logically and systematically written to perform certain tasks. The software elements allow the user to input, store, manage, transform, analyse and output data (Heywood, Cornelius, and Carver, 1998).

Basically, GIS software is a package of programs, rules or commands used to perform certain GIS operations such as the input, storage, retrieval, editing, querying, analysis, manipulation, update, display and output of geographic data, in a computer environment (Uluocha, 2007).

GIS software encompasses a broad range of applications, all of which involve the use of some combination of digital maps and geo-referenced data. In the main, GIS software provides the functions and tools needed to store, analyze, and display geographic information. Different software packages are important for GIS. Central to this is the GIS application package. Such software is essential for creating, editing and analyzing spatial and attributes data; therefore these packages contain a myriad of GIS functions inherent to them. Extensions or add-ons are software that extends the capabilities of the GIS software package.

Component GIS software is the opposite of application software. Component GIS seeks to build software applications that meet a specific purpose and thus are limited in their spatial analysis capabilities. Utilities are stand-alone programs that perform a specific function. For example, a file format utility that converts from one type of GIS file to another. There is also Web GIS softwaree that helps serve data through Internet browsers.

Typical GIS software consists of four distinct but interrelated subsystems or modules. These are:

- Data input software subsystem (used for e.g. digitizing or scanning, checking, editing, topology building, etc.).
- Data storage and retrieval software subsystem.
- Data manipulation and analysis software subsystem (e.g. for querying, sorting or indexing, overlay operations, buffer creation, etc.)
- Data output software subsystem (e.g. for screen display, page set-up formatting, hard copy generation, etc.)

3.2 Types of GIS Software

Numerous GIS software packages are nowadays available which cover all sectors of geospatial data handling. However, the GIS software systems can be sorted into different categories. (For example, the Wikipedia Web link listed in the references section of this unit). Presented below is a list of some notable GIS software packages. It should be noted that some of the packages mentioned are also used for digital cartographic (map-making), CAD, and remote sensing (image processing) operations. (For more details on GIS software packages and their manufacturers, see Uluocha, 2007).

GRASS GIS: Originally developed by the U.S. Army Corps of Engineers, open source: a complete GIS.

SAGA GIS (System for Automated Geo-scientific Analysis): hybrid GIS software. SAGA has a unique Application Programming Interface (API) and a fast growing set of geo-scientific methods, bundled in exchangeable Module Libraries.

Quantum GIS: QGIS is an Open Source GIS that runs on Linux, UNIX, Mac OS X, and Windows.

Map Window GIS: Free, open source GIS desktop application and programming component.

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

gvSIG: Open source GIS written in Java.

JUMP GIS/OpenJUMP: (Open) Java Unified Mapping Platform (the desktop GIS OpenJUMP, SkyJUMP, deeJUMP and Kosmo emerged from JUMP).

Whitebox GAT: Open source and transparent GIS software.

Kalypso (software): Kalypso is an Open Source GIS (Java, GML3) and focuses mainly on numerical simulations in water management.

TerraView: GIS desktop that handles vector and raster data stored in a relational or geo-relational database, i.e. a frontend for TerraLib.

Capaware: Capaware is also an Open Source GIS, an incredible fast C++ 3D GIS Framework with multiple plug-in architecture for geographic graphical analysis and visualization.

Falcon View: Falcon View is a mapping system created by the Georgia Tech Research Institute for the Windows family of operating systems. A free, open source version is available.

PostGIS: Spatial extensions for the open source PostgreSQL database, allowing geospatial queries.

MySQL Spatial

TerraLib is a spatial DBMS and also provides advanced functions for GIS analysis.

Spatialite: Spatial extensions for the open source SQLite database, allowing geospatial queries.

GeoNetwork open source: A catalog application to manage spatially referenced resources.

Chameleon: Environments for building applications with MapServer.

MapPoint, a technology ("MapPoint Web Service," previously known as MapPoint .NET) and a specific software program created by Microsoft that allows users to view, edit and integrate maps.

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, 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.

Cadcorp: Products include Cadcorp SIS, GeognoSIS, mSIS and developer kits.

Caliper: Products include Maptitude, TransModeler and TransCAD.

ENVI: Utilised for image analysis, exploitation, and hyperspectral analysis.

Manifold System: GIS software package.

Netcad**:** Desktop and Web based GIS products developed by Ulusal CAD ve GIS Çözümleri A.Ş.

Dragon/ips: Remote sensing software with some GIS capabilities.

Field-Map : GIS tool designed for computer aided field data collection, used mainly for mapping of forest ecosystems.

VISIONLABS: Products - VISION Enterprise GIS Suite earlier named VISION MapMaker, Complete 2D/3D mapping - Installations in Indian Government and Defence.

Regio Graph by GfK GeoMarketing: GIS software for business planning and analyses; company also provides compatible maps and market data.

IDRISI: GIS and Image Processing product developed by Clark Labs at Clark University. Affordable and robust, it is used for both operations and education.

Boeing's Spatial Query Server spatially enables Sybase ASE.

DB2: Allows spatial querying and storing of most spatial data types.

Informix: Allows spatial querying and storing of most spatial data types.

Microsoft SQL Server 2008: The latest player in the market of storing and querying spatial data. At this stage only some GIS products such as MapInfo and Cadcorp SIS can read and edit this data while ESRI and others are expected to be able to read and edit this data within the next few months.

Oracle Spatial: Product allows users to perform complex geographic operations and store common spatial data types in a native Oracle environment. Most commercial GIS packages can read and edit spatial data stored in this way.

PostGIS: a spatial database based on the free PostgreSQL database

Safe Software: Spatial ETL products including FME Desktop, FME Server and the ArcGIS Data Interoperability Extension.

Mapnik: C++/Python library for rendering - used by Open StreetMap

GeoServer.

MapGuide Open Source : Web-based mapping server.

MapServer: Web-based mapping server, developed by the University of Minnesota.

MapLarge: Web-based mapping server for large datasets.

Software Development Frameworks and Libraries (for Web Applications)

Open Layers: open source AJAX library for accessing geographic data layers of all kinds, originally developed and sponsored by MetaCarta.

Map Fish.

Geo Base (Telogis GIS software): Geospatial mapping software available as a Software development kit, which performs various functions including address lookup, mapping, routing, reverse geocoding, and navigation. Suited for high transaction enterprise environments.

4.0 Conclusion

Not all that are called GIS software actually have the full range of GIS functionalities. Whereas some packages are general-purpose in nature, some others are thematic or dedicated to performing some specific, usually limited, tasks. Full-fledged GIS software are relatively few.

5.0 Summary

The GIS technology runs on software – a set of logically related rules, commands, algorithm and programs. Some of the software elements are designed to perform a single broad task while some are multi-purpose and multi-functional. The choice of software to install and run on a GIS platform, therefore, depends on the intended use of such a system. By and large, care must be taken to select software that can conveniently perform any of the four major tasks of GIS software identified above.

6.0 Self-Assessment Exercise

Identify six types of GIS software.

7.0 References/Further Reading

Heywood *et al.* (1998). *An Introduction to Geographical Information Systems.* New York: Addison Wesley Longman Limited.

Steiniger, S. & Weibel R. (2008). "*GIS Software - A Description in 1000 Words*". Retrieved from http://www.geo.unizh.ch/publications/sstein/gissoftware_steiniger2008.pdf

Steiniger, S. & Bocher (2011). *An Overview on Current Free and Open Source Desktop GIS Developments - Steiniger and Bocher. On* http://www.spatialserver.net/osgis. (Retrieved 20/7/11).

Uluocha, N. O. (2007). *Elements of Geographic Information Systems*. Lagos: Sam Iroanusi

http://en.wikipedia.org/wiki/List_of_geographic_information_systems_software (Retrieved on 28/5/11).

Unit 3 Data used in GIS

1.0 Introduction

Data is the core of any GIS. There are two primary types of data that are used in GIS namely, spatial (or geographic) data and aspatial (attribute or descriptive) data. Documentation of GIS datasets is known as metadata. Metadata contains such information as the coordinate system, when the data was created, when it was last updated, who created it and how to contact them and definitions for any of the coded attribute data.

Geographic data and related tabular data can be collected in-house or purchased from a commercial data provider. A GIS will integrate spatial data with other data resources and can even use a DBMS, used by most organization to maintain their data, to manage spatial data. This unit aims at introducing both spatial and attributes data.

2.0 Objectives

At the end of this unit, you should be able to:

- differentiate between spatial and aspatial types of data
- explain the meaning of metadata
- analyse attribute data.

3.0 Main Content

3.1 Spatial Data

Spatial data are used to graphically represent some real world features. The features could be material (visible), e.g. road, building, water body; or they could also be abstract (invisible) e.g. geopolitical boundaries, language, and temperature. Similarly, spatial data can be obtained from primary or secondary sources. The primary data are obtained first-hand by the user while secondary data are obtained from already existing sources.

The digital map forms the basic data input for GIS. The map is an abstraction or model of some aspect of reality. As shown in Figure 2.2 and Table 2.1 geographical features are abstracted into four spatial entities namely *point* (0-dimensional), *line* (1-dimensional), *area* (2-dimensional), and *volume* (3-dimensional). (See Unit 4 of Module 1).

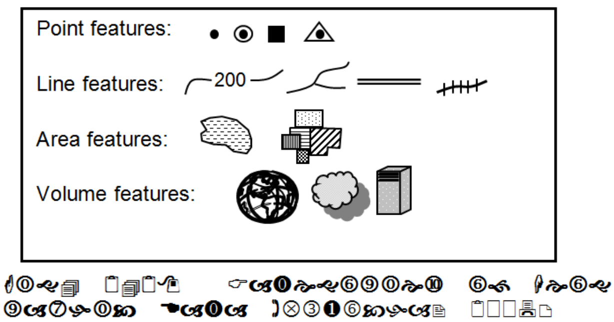


Fig. 2.2: In practice, however, the first three entities (point, line and area) are commonly used.

Table 2.1: Geographical Feature Categories and Examples

Feature Category	Examples
Point	Borehole, benchmark, bus stop
Line	Road, river, railway, coastline
Area	Farmland, lake, forest reserve, boundary
Volume	Population, traffic, air mass.

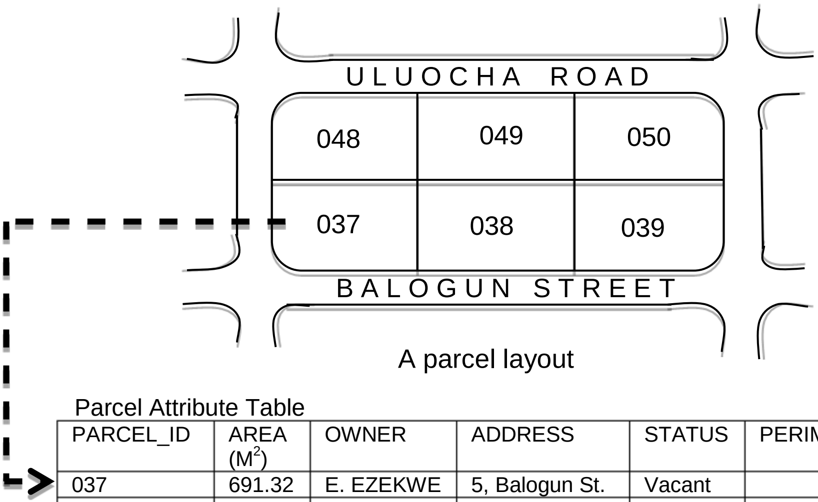
Spatial data in GIS are usually held in a database. A geodatabase is a type of database that is in some way referenced to locations on the earth. Geodatabases are grouped into two different types: vector and raster. Vector data is spatial data represented as points, lines and polygons. Raster data is cell-based data such as aerial imagery and digital elevation models. The vector and raster models are discussed in greater detail in Unit 2, Module 4.

3.2 Aspatial (Attribute) Data

Geographic data is usually known as aspatial or attribute data. Attribute data is generally defined as additional information about each spatial feature. An attribute data gives descriptive information about some aspect of a geographical entity. Every geographical feature has some attributes. For example, a person is a geographical object located somewhere and occupying space.

However, this person also has some attributes with which they can be identified e.g. name, age, complexion, height, tribal/ethnic affiliation, religion, occupation, educational level, hobby, etc. Similarly, a school is a geographical entity having various attributes such as name, address, year of establishment, owner, facilities available (e.g. classrooms, playground, library, laboratory, weather station, hostels), etc.

In a GIS environment, attribute data is usually housed in tabular format. This tabular database related to the map objects can also be attached or linked to the digital spatial database (Figure 2.3).



Parcel Attribute Table

PARCEL_ID	AREA (M^2)	OWNER	ADDRESS	STATUS	PERIMETER
037	691.32	E. EZEKWE	5, Balogun St.	Vacant	

Fig. 2.3: Linking a Geographic File with an Attribute Table
Source: (Uluocha, 2007)

4.0 Conclusion

To successfully implement GIS, data is a critical element. Data is the raw material that GIS processes to yield a highly sort after product namely, information. In a sense, data is the element that keeps the engine of GIS running. However, care must always be taken to ensure that the right data is fed into the system. Creating GIS databases could be herculean task; yet once in place and routinely updated, the databases are an invaluable asset to the users.

5.0Summary

Data is a major component of GIS. However, the data to be used for GIS operations must be geographically or spatially referenced. In other words, operating GIS presupposes the availability of a reliable and comprehensive geospatial database coupled with an equally robust attribute database. Without data the GIS cannot work. But before entering any piece of spatial data into GIS it has to be properly classified as either point, linear or areal data. Besides, the attribute database should be properly linked with the spatial database.

6.0 Self-Assessment Exercise

1. Analyze spatial data.
2. Differentiate between spatial and attribute data.

7.0 References/Further Reading

Balogun, O. Y. (2001). "Representation of Geographical Data." In: N. O. Uluocha & G. N. Nsofor (Eds). *Cartography and GIS in Nation Building*. Lagos: Nigerian Cartographic Association. pp. 25-47.

ESRI (1991). *A Glossary of GIS and ARC/INFO Terms*. Redlands: Environmental Systems Research Institute Inc.

Heywood *et al.* (1998). *An Introduction to Geographical Information Systems*. New York: Addison Wesley Longman Limited.

Uluocha, N. O. (2007). *Elements of Geographic Information Systems*. Lagos: Sam Iroanusi Publications.

Unit 4 GIS Personnel

1.0 Introduction

Effective development and use of the GIS technology requires the involvement of a number of people performing different tasks. In a GIS environment, the people are fittingly referred to as the *humanware* or *liveware*.

Well-trained people knowledgeable in spatial analysis and skilled in using GIS software are essential to the GIS process. The humanware coordinates and controls all the other components of GIS. GIS personnel range from technical specialists (who design and maintain the system) to those who use it to help them perform their everyday work.

There are three factors to the people component: education, career path, and networking. The right education is key; taking the right combination of classes. Selecting the right type of GIS job is important. A person highly skilled in GIS analysis should not seek a job as a GIS developer if they have not taken the necessary programming classes. Finally, continuous networking with other GIS professionals is essential for the exchange of ideas as well as a support community.

2.0 Objectives

At the end of this unit, you should be able to:

- identify the various groups of GIS personnel
- state the functions of GIS personnel.

3.0 Main Content

3.1 Engineers (Hardware and Software)

This has to do with the crop of technical specialists who design and maintain the system. They include the hardware engineers who fashion various GIS hardware such as the computers (CPU) and accessories like visual display units (VDUs), digitisers, scanners, disk drives, tape drives, plotters, printers and other hardware components associated with the GIS technology. On the other hand, GIS software engineers specialise in churning out computer programs and programming languages containing a set of rules (or algorithms) for solving certain spatially defined problems.

3.2 Data Providers

Data providers are those who collect and/or market spatial/non-spatial data for GIS operations. The data could be acquired through field observation, land survey, GPS, aerial photography, remote sensing technique, socio-economic surveys, and so on. In Nigeria, some of the vendors of data that could be used in GIS projects are the Federal and State Survey Departments; the National Space Research and Development Agency (NASRDA); the Federal Office of Statistics (FOS); the Nigerian Meteorological Agency (NIMET); private surveying/mapping outfits; the Ministry of Environment; Geological Surveys of Nigeria; the

National Population Commission (NPC); Centre for Satellite Technology Development, Abuja; National Centre for Remote Sensing, Jos; and so on.

3.3 Digitizers

These are the CAD/GIS operators whose work is to create the database; they vectorise the map objects. In other words, they are basically involved in data capturing, and conversion from analogue to digital or from binary to image and vector.

3.4 Programmers and Analysts

These are the GIS experts who use vectorized data to perform query, analysis or any other work. Their ultimate task is to generate information useful for decision making.

3.5 Managers

The GIS managers undertake administrative functions necessary for the successful implementation of the GIS technology in an organisation. They also make useful decisions based on the available geo-referenced information.

4.0 Conclusion

A team of experts is usually required to successfully install and run a GIS outfit. The quality of personnel involved in the implementation of a GIS project can make or mar the initiative. Hence, concerted effort should be made to ensure that the right calibres of personnel are used. Personnel are the most valuable asset required in the implementation of any GIS programme.

5.0 Summary

GIS personnel are those involved in the provision of the hardware and software, acquisition and handling of data, as well as decision making and implementation.

6.0 Self-Assessment Exercise

Identify and explain function of GIS personnel.

7.0 References/Further Reading

Adeoye, A. A. (2001). *Geographic Information Systems: Operations and Management*. Lagos: Information Management Consultants.

Aronoff, S. (1995). *Geographic Information Systems: A Management Perspective*. (4th ed.). Ottawa: WDL Publications.

Burrogh, P. A. & McDonnell, R. A. (1998). *Principles of Geographical Information Systems*. Oxford: Oxford University Press.

Uluocha, N. O. (2007). *Elements of Geographic Information Systems*. Lagos: Sam Iroanusi Publications.

Unit 5 GIS Method/Procedure

1.0 Introduction

Every task follows some laid down procedure or method; and GIS tasks are no exceptions. But the method of doing things may vary from one task to another and also from one organisation to another. In any case, it is always imperative to understand the peculiar method that applies in any given situation. Unless a good understanding of the working procedure in an organisation is attained, implementing GIS in that organisation may as well be an exercise in futility. Hence, in this unit we will examine the concept of *method* as an element of GIS.

2.0 Objectives

At the end of this unit, you should be able to:

- underscore the need of understanding method or procedure as a major component of GIS
- highlight the need to link GIS procedure with the general business of the company.

3.0 Main Content

3.1 GIS Method/Procedure

Simply put, procedure or method has to do with the ways of getting a job done in an organisation. But with particular reference to GIS, method could be understood to include a well-designed GIS implementation plan in addition to business rules, which are the models and operating practices unique to each organisation (Buckley, *URL*). Method may vary from one organisation to another, depending on the objectives as well as *modus operandi* of each individual organisation (Uluocha, 2007). The way an estate surveyor/valuer would use the GIS facility, for instance, will differ from how a geologist would use it – since their goals and functions also differ.

The essence of adopting the GIS technology in any organisation is to assist the organisation to attain its goals. GIS is normally used to meet the information need of an organisation, which is quite crucial to decision-making. But for GIS to successfully operate in an organisation, it has to be appropriately integrated into the business strategy and operations of that organisation. Thus, GIS should be a functional part of the entire method of data acquisition, input, storage, sorting, indexing, retrieval, analysis, output and updating, along with the process of decision-making.

GIS could be implemented to simply automate (fully or partially) the methods of executing certain jobs, which hitherto were manually done. This may not involve any major change in procedure except that the job is now done digitally instead of manually.

Nonetheless, the adoption of GIS in an organization may necessitate a significant shift in procedure, which could see the organization adopting some entirely new methods of executing some conventional jobs (Uluocha, 2007). For instance, in a GIS environment, there are various techniques used for map creation and further usage for any project. The map creation can either be done through automated raster-to-vector conversion or it can be manually vectorized on-screen using the scanned images. The source of these digital maps can be either map prepared by any survey agency or satellite imagery. An organization should be able to decide on which suitable procedure of GIS operations to adopt.

Method or procedure is usually tied to the business of the company. This means before recommending and implementing GIS in a company, the various units of the establishment and the linkages amongst them coupled with the operations/tasks that are carried out must be properly understood.

In other words, the method of GIS operation in a company should be dependent on the components of the company, tasks executed, the type of data/information used, the pattern of information flow, the information output (product) required, and the general *modus operandi* of the company.

In discussing or determining the GIS procedure in any organisation the following should be taken into consideration:

- the nature of the company's business (what does the company do?)
- spatial data requirements of the company; that is, the types of geospatial data used by the company for its various activity modules
- how the company collects, converts, stores, and processes its spatial database
- the pattern of information flow in the company
- data accessibility policy of the company
- geospatial data handling facilities available
- the cartographic (map) and allied products (outputs) required by the company.

4.0 Conclusion

Before implementing a GIS in an organization, the procedure for the use of the technology should be clearly defined in line with the aim and aspirations of the organization. A successful GIS operates according to a well-designed plan and business rules.

5.0 Summary

Method or procedure is one of the five major components of GIS. It has to do with the way data (i.e. geo-referenced data), is managed and used in an organisation, in a GIS environment. The process of data handling varies from one organisation to another. It is, therefore, important that before introducing GIS into the business of an organisation, its general *modus operandi,* spatial data needs, method of data processing, pattern of information flow, and the use of geo-information in the decision-making process must all be properly understood and incorporated in the GIS implementation programme.

6.0 Self-Assessment Exercise

Understanding method or procedure is a major component of GIS. Discuss.

7.0 References/Further Reading

Buckley, D. J. (*URL*). *The GIS Primer: An Introduction to Geographic Information Systems.* www.innovativegis.com/education/primer/primer.html

Uluocha, N. O. (2007). *Elements of Geographic Information Systems*. Lagos: Sam Iroanusi Publications.