NATIONAL OPEN UNIVERSITY OF NIGERIA

ESM 407

Geographic Information System

Module 1

ESM 407 Geographic Information Systems Module 1

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Module 1 Introduction to GIS

Unit 1 Overview of Geographic Information Systems

1.0 Introduction

This course is basically aimed at introducing you to the science, art and technology of Geographic Information Systems (GIS). Some of the basic concepts, components, functions and application of GIS will be introduced to you in this unit.

2.0 Objectives

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

- describe Geographic Information Systems
- analyze the roles of science, art and technology in Geographic Information Systems.

3.0 Main Content

3.1 Overview of GIS

Since its inception in the early 1960s, Geographical Information Systems (GIS), as we know it today, has been growing by leaps and bounds. Originally developed by geographers, GIS has become a powerful tool useful to all and sundry who handle geospatial data.

Traditionally, we have long used maps as a method of storing and disseminating spatial data as well as exploring the earth and locating natural and cultural resources. In fact, the origins of GIS are rooted as far back as several millennia ago, when the early man drew cave paintings of the animals they hunted along with crude maps depicting migration trails. While the cave paintings only vaguely resemble today's advanced geographic information systems, they contain the same basic data as modern systems namely, geographic data linked with spatially dependent attributes (descriptive) information.

Modern geographic information system is a computer based information system used to digitally represent and analyze the geographic features and events on the Earth' surface and the non-spatial attributes linked to the geography under study. This way, the GIS has proved itself as a robust and reliable technology for managing spatial data and as a decision support tool. Indeed GIS is rather revolutionizing the way we collect, store, visualize, analyze and use geographical data.

Owing to its versatility, many disciplines can benefit from GIS technology. An active GIS market has resulted in lower costs and continual improvements in the hardware and software components of GIS. These developments will, in turn, result in a much wider use of the technology throughout science, government, business, and industry, with applications including real estate, public health, crime mapping, national defense, sustainable development, natural resources, landscape architecture, archaeology, regional and community planning, transportation and logistics.

GIS is also diverging into location-based services (LBS). LBS allows GPS enabled mobile devices to display their locations in relation to fixed assets (nearest restaurant, gas station, fire hydrant), mobile assets (friends, children, police car) or to relay their position back to a central server for display or other processing. These services continue to develop with the increased integration of Global Positioning System (GPS) functionality with increasingly powerful mobile electronics (cell phones, PDAs, laptops) coupled with Web-enabled operations.

4.0 Conclusion

GIS is a relatively new technology, at least within the Nigerian context. You should, therefore, be ready to learn some new terminologies, concepts and methods of managing spatial data in a computer environment. Importantly, you should pay particular attention to the peculiarities and potentialities and, hence, practical applications of the powerful GIS technology.

5.0 Summary

In this unit, we have discussed the origin of GIS, its meaning and effects in information system. We also learnt that an active GIS market has resulted in lower costs and continual improvements in the hardware and software components of GIS. These developments has, in turn result in a much wider use of the technology throughout science, government, business, and industry, with applications including real estate, public health, crime mapping, national defence, sustainable development, natural resources, landscape architecture, archaeology, regional and community planning, transportation and logistics.

6.0 Self-Assessment Exercise

Explain how advent of GIS is revolutionising data collection, storage and analysis.

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Unit 2 Definitions of Geographic Information Systems

1.0 Introduction

There are several definitions of GIS in existence. However, none of such definitions is universally accepted. It is difficult to agree on a single definition for GIS for the simple reason that various kinds of GIS exist, each made for different purposes and for different types of decision making. As we will see shortly in the range of definitions presented below, people offer definitions of GIS with different emphasis on various aspects of GIS.

2.0 Objectives

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

- define GIS
- highlight the essential features of GIS
- outline some of the spatial questions that GIS can answer easily.

3.0 Main Content

3.1 Definitions of GIS

Geographic Information System (GIS) has been defined in various ways by different authorities. A typical GIS can be understood by looking at its various definitions. In this section, we present different definitions (or descriptions) of GIS that have been offered by people.

Burrough (1986) defines GIS as a "set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes".

In his own definition, Arnoff (1989) defines GIS as "a computer based system that provides four sets of capabilities to handle geo-referenced data: data input, data management (data storage and retrieval), manipulation and analysis, and data output."

"A geographic information system (GIS) is a computer-based tool for mapping and analysing things that exist and events that happen on earth. GIS technology integrates common database operations such as query and statistical analysis with the unique visualisation and geographic analysis benefits offered by maps" (ESRI, 1990).

". . . The purpose of a traditional GIS is first and foremost spatial analysis. Therefore, capabilities may have limited data capture and cartographic output. Capabilities of analyses typically support decision making for specific projects and/or limited geographic areas. The map data-base characteristics (accuracy, continuity, completeness, etc.) are typically appropriate for small-scale map output. Vector and raster data interfaces may be available. However, topology is usually the sole underlying data structure for spatial analyses" (Huxhold, 1991 p.27).

"A geographic information system is a facility for preparing, presenting, and interpreting facts that pertain to the surface of the earth. This is a broad definition . . . a considerably narrower definition, however, is more often employed. In common parlance, a geographic information system or GIS is a configuration of computer hardware and software specifically designed for the acquisition, maintenance, and use of cartographic data" (Tomlin, 1990 p xi).

"A geographic information system (GIS) is an information system that is designed to work with data referenced by spatial or geographic coordinates. In other words, a GIS is both a database system with specific capabilities for spatially-reference data, as well as a set of operations for working with data . . . In a sense, a GIS may be thought of as a higher-order map" (Star and Estes, 1990, pp. 2-3).

A GIS is "an organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information" (ESRI, 1990, pp. 1-2).

“A Geographic Information System (GIS) is a collection of computer hardware, software and geographic data used to analyze and display geographically referenced information” (URL1).

“A GIS is a computer system capable of capturing, storing, analysing, and displaying geographically referenced information; that is, data identified according to location. (Some GIS) practitioners also define a GIS as including the procedures, operating personnel, and spatial data that go into the system” (URL2).

“In the strictest sense, a GIS is a computer system capable of assembling, storing, manipulating, and displaying geographically referenced information, i.e. data identified according to their locations. GIS practitioners also regard the total GIS as including operating personnel and the data that go into the system” (URL2).

“GIS is an integrated system of computer hardware, software, and trained personnel linking topographic, demographic, utility, facility, image and other resource data that is geographically referenced” (URL3).

A list of additional definitions of GIS can be found in Longley *et al* (2001). By way of summary, GIS can be considered to be a computer-based system comprising hardware, software, geographically-referenced data, personnel and procedures put together for the input, storage, retrieval, analysis, manipulation, query, update and output of geographical data.

3.2 Essential Features of GIS

From the foregoing, it is obvious that a geographic information system (GIS) is a computer-based tool that combines the visual appeal of conventional maps with database operations and statistical analysis. It is used for mapping and analyzing things that exist and happen on the surface of the Earth by classifying the information into "layers", making it easy for users to distinguish each element separately. The speed and accuracy of a GIS provide an invaluable service to organizations, by explaining events, predicting outcomes and planning future strategies.

Irrespective of the definition one is giving or adopting, it must be realized that GIS is a peculiar technology with the essential features of spatial references and data analysis. Hence, the true power of GIS lies in its ability to integrate information and to help in making decisions.

A GIS integrates hardware, software, and data for capturing, managing, analysing, and displaying all forms of geographically referenced information. GIS allows 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 is a technological field that incorporates geographical features with tabular data in order to map, analyze, and assess real-world problems. The key word to this technology is Geography – this means that the data (or at least some portion of the data) is spatial, in other words, data that is in some way referenced to locations on the earth. Attribute data can be generally defined as additional information about each of the spatial features. An example of this would be schools. The actual location of the schools is the spatial data.

Additional data such as the school name, level of education taught, student capacity would make up the attribute data. It is the partnership of these two data types that enables GIS to be such an effective problem solving tool through spatial analysis. GIS operates on many levels. On the most basic level, GIS is used as computer cartography, i.e. mapping. The real power in GIS is through using 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.

A GIS is an information system designed to work with data referenced by spatial/geographical coordinates. In other words, GIS is both a database system with specific capabilities for spatially referenced data as well as a set of operations for working with the data. It may also be considered as a higher order map.

GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies (ESRI, 1990).

Many professionals, such as foresters, urban planners, and geologists, have recognized the importance of spatial dimensions in organizing and analyzing information. Whether a discipline is concerned with the very practical aspects of business, or is concerned with purely academic research, geographic information system can introduce a perspective, which can provide valuable insights as:

70% of the information has geographic location as its denominator making spatial analysis an essential tool.

- Ability to assimilate divergent sources of data both spatial and non-spatial (attribute data).
- Visualization impact.
- Analytical capability.
- Sharing of information.

In a nutshell, GIS is a special-purpose digital database in which a common spatial coordinate system is the primary means of reference. A full-fledged, comprehensive GIS has dedicated facilities or subsystems for:

- data input, from maps, aerial photos, satellites, surveys, and other sources

- data storage, retrieval, and query
- data transformation, analysis, and modeling, including spatial statistics
- data reporting, such as maps, reports, and plans.

3.3 Questions GIS can Answer

We can gain a deeper understanding of GIS by looking at the type of questions the technology can (or should be able to) answer. GIS can be used to address concerns relating to location, condition, trends, patterns, modeling, spatial questions, as well as non-spatial questions. Basically, we can identify five broad types of questions that a sophisticated GIS can answer (URL4).

Location: What is at…………?

This question seeks to find out what exists at a particular location. A location can be described in many ways, using, for example, a place name, post code, or geographic reference such as longitude/latitude or x/y.

Condition: Where is it…………?

In this question, instead of seeking to identify what exists at a given location, one may wish to find location(s) where certain conditions are satisfied (e.g., all rentable 3-bed room apartments in a neighborhood, sites suitable for the construction of a cement industry, an unforested section of at least 2000 square meters in size, within 100 meters of road, and with soils suitable for supporting buildings)

Trends: What has changed since…………..?

This question involves seeking to know what has changed over a given period of time, as well as the magnitude and spatial pattern of such a change (e.g. change in land use or elevation over time).

Patterns: What spatial patterns exist…………..?

This question is more sophisticated. One might ask this question to determine whether, for instance, landslides are mostly occurring near streams. It might be just as important to know how many anomalies are there, those who do not fit the pattern and where they are located.

Modeling: What if……………..?

"What if…" questions are posed to determine what happens, for example, if a new road is added to a network or if a toxic substance seeps into the local ground water supply. Answering this type of question requires both geographic and other information (as well as specific models). GIS permits spatial operations.

Non-spatial Questions

"What's the average number of people working as Estate Surveyors and Agents in each location?" is a non-spatial question - the answer to which does not require the stored value of latitude and longitude; nor does it describe where the places are in relation with each other.

Spatial Questions

"How many people work with estate firms in the major urban centers of Lagos metropolis?" OR "Which centre lie within 10 Km of each other? ", OR "What is the shortest route passing through all these centers". These are spatial questions that can only be answered using latitude and longitude data and other information such as the radius of earth. Geographic Information Systems can answer such questions.

4.0 Conclusion

GIS is basically a computer-based system comprising hardware, software, geographically-referenced data, people and procedures logically arranged to store, retrieve, manipulate, analyse, update and output data (as information), for decision making. This way, GIS should be rightly seen as a powerful decision support system (DSS).

5.0 Summary

Modern computer-based GIS is both a database system with specific capabilities for spatially referenced data as well as a set of operations for working with the data. It may also be considered as a higher order map. GIS can be used to address concerns relating to location, condition, trends, patterns, modelling, spatial questions, as well as non-spatial questions. GIS is a digital technology that combines the visual appeal of conventional maps with database operations and statistical analysis.

6.0 Self-Assessment Exercise

1. According to three authorities, define GIS.
2. Highlight the essential features of GIS.
3. Explain three types of question GIS can answer.

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Unit 3 History of GIS Development

1.0 Introduction

Man has always used geographical information. Geographical features and data gathering form part of our everyday lives. Indeed, most of the decisions we make on a daily basis are influenced by some aspects of geography. Hence, one would be right to say that, generally speaking, geographical information system is as old as man himself. However, in this unit our focus is on modern geographical information system. We will briefly look at the emergence and growth of GIS as well as the underlying factors.

2.0 Objectives

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

- trace the historical evolution of GIS
- highlight the factors responsible for the growth of GIS.

3.0 Main Content

3.1 History of Development

It is commonly believed that the more sophisticated modern GIS can be traced back to John Snow's 1854 map of the distribution of incidences of cholera in 19th century London. While it is only a fairly basic 2-dimensional rendering, Snow's map is a useful tool to demonstrate the data analysis possibilities of GIS.

When viewed in isolation, a list of cholera cases suggests nothing as to the origin of the outbreak. When that same data is translated into a GIS map, the data takes on new meaning, allowing the analyst to track down the outbreak to an infected water pump (the Broad Street Pump) in the centre of a cluster. When the pump's handle was disconnected the outbreak was terminated, giving the authorities the opportunity to curtail the cholera outbreak and save lives.

While the basic elements of topography and theme existed previously in cartography, the John Snow map was unique, using cartographic methods not only to depict but also to analyze clusters of geographically dependent phenomena for the first time.

The early 20th century saw the development of photolithography, by which maps were separated into layers. Computer hardware development led to general-purpose computer "mapping" applications by the early 1960s.

Work on GIS began in late 1950s. Canada was the pioneer in the development of GIS as a result of innovations dating back to late 1950s and early 1960s. Much of the credit for the early development of GIS goes to Dr. Roger Tomlinson. The year 1962 saw the development of the world's first true operational GIS in Ottawa, Ontario, Canada by the Federal Department of Forestry and Rural Development.

Developed by Tomlinson and his team, it was called the "Canada Geographic Information System" (CGIS) and was used to store, analyse, and manipulate data collected for the Canada Land Inventory (CLI) – an effort to determine the land capability for rural Canada by mapping information about soils, agriculture, recreation, wildlife, waterfowl, forestry, and land use at a scale of 1:50,000. A rating classification factor was also added to permit analysis.

CGIS was the world's first such system and an improvement over "mapping" applications as it provided capabilities for overlay, measurement, and digitizing/scanning. It supported a national coordinate system that spanned the North American continent, coded lines as "arcs" having a true embedded topology, and it stored the attribute and location information in separate files.

As a result of this, Tomlinson has become known as the "father of GIS," particularly for his use of overlays in promoting the spatial analysis of convergent geographic data. CGIS lasted into the 1990s and built a large digital land resource database in Canada. It was developed as a mainframe computer-based system in support of federal and provincial resource planning and management. Its strength was continent-wide analysis of complex datasets. The CGIS, however, was never available in a commercial form.

In 1964, Howard T. Fisher formed the Laboratory for Computer Graphics and Spatial Analysis at the Harvard Graduate School of Design (LCGSA 1965-1991), where a number of important theoretical concepts in spatial data handling were developed, and which by the 1970s had distributed seminal software code and systems, such as 'SYMAP', 'GRID', and 'ODYSSEY' - which served as literal and inspirational sources for subsequent commercial development - to universities, research centers, and corporations worldwide.

By the early 1980s, M&S Computing (later Intergraph), Environmental Systems Research Institute (ESRI), CARIS (Computer Aided Resource Information System) and ERDAS emerged as commercial vendors of GIS software, successfully incorporating many of the CGIS features, combining the first generation approach to separation of spatial and attribute information with a second generation approach to organizing attribute data into database structures.

In parallel, the development of two public domain systems began in the late 1970s and early 1980s. The Map Overlay and Statistical System (MOSS) project started in 1977 in Fort Collins, Colorado under the auspices of the Western Energy and Land Use Team (WELUT) and the U.S. Fish and Wildlife Service. GRASS GIS was begun in 1982 by the U.S. Army Corps of Engineering Research Laboratory (USA-CERL) in Champaign, Illinois, a branch of the U.S. Army Corps of Engineers to meet the need of the U.S. military for software for land management and environmental planning.

The later 1980s and 1990s industry growth were spurred on by the growing use of GIS on Unix workstations and the personal computer. By the end of the 20th century, the rapid growth in various systems had been consolidated and standardised on relatively few platforms, and users were beginning to export the concept of viewing GIS data over the Internet, requiring data format and transfer standards.

More recently, a growing number of free, open source GIS packages run on a range of operating systems and can be customised to perform specific tasks. Increasingly geospatial data and mapping applications are being made available via the World Wide Web.

Computerized mapping and spatial analysis have been developed simultaneously in several related fields. The present status of GIS would not have been achieved without close interaction between various fields such as utility networks, cadastral mapping, topographic mapping, thematic cartography, surveying and photogrammetric remote sensing, image processing, computer science, rural and urban planning, earth science, and geography.

3.2 Factors Aiding the Rise of GIS

Certain developments over the centuries have been cumulatively instrumental to the emergence and subsequent growth of the GIS technology. Such factors include:

- Revolution in Information Technology
- Computer Technology
- Remote Sensing
- Global Positioning System
- Communication technology
- Rapidly declining cost of computer hardware, and at the same time, exponential growth of operational speed of computers
- Enhanced functionality of software and their user-friendliness
- Visualizing impact of GIS corroborating the Chinese proverb "a picture is worth a thousand words."

4.0 Conclusion

The management of geographical data has a long and rich history. Modern sophisticated computer-based GIS, is a relatively new innovation. Nonetheless, since its formal inception in the early 1960s the GIS industry has been growing by leaps and bounds. Advancements in the field of GIS have been taking place faster than anticipated. The technology is steadily making great inroads into virtually every facet of human endeavour.

5.0 Summary

Present day GIS technology made its debut in the second half of the 20th century. Over the years, this technology has been witnessing tremendous transformations in hardware and software engineering, as well as in the manner in which geospatial data are acquired, processed and used.

Basically, GIS is a contemporary technology for digitally handling the data acquisition, manipulation and analytical operations commonly associated with traditional geography. This technology has been experiencing unprecedented growth, which is encouraged by developments in allied fields (especially ICT) as well as the new impetus given to information (particularly geo-referenced information) as a key infrastructure for sustainable socio-economic development and environmental management.

6.0 Self-Assessment Exercise

1. Highlight and discuss factors responsible for the growth of GIS.
2. Trace the history of modern geographic information system.

7.0 References/Further Reading

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Unit 4 Understanding Geographical Data

1.0 Introduction

GIS is used to manage data. In fact, the ultimate essence of using a GIS is to provide the user with information that can be used to make sound decision and solve some real-world problems. But our concern here is primarily with geographical data or geographical information. Hence, to properly understand and appreciate the workings of GIS and how it is used to handle data, there is need for us to first comprehend the nature and importance of that data.

2.0 Objectives

At the end of this unit, you should be able to:
- define geographical data
- explain the nature/characteristics of geographical data
- identify the types/classes of geographical data
- highlight the value of geographical data.

3.0 Main Content

3.1 What is Geographical Data?

Geographical data (also known as spatial data) can be defined as any data that has location or positional identity with respect to the surface of the earth. In other words, geographical data gives us some information about a geographical object or event.

Simply put, a geographical object or feature is anything, anywhere. Anything that exists on or in relation to the Earth's surface is a geographical object; similarly, any event that takes place on or in relation to the Earth's surface is a geographical event. So, facts and figures that help us to identify the location and other spatial dimensions of any geographical phenomenon are geographical data.

3.2 Characteristics of Geographical Features

Geographical features have some characteristics which the GIS technology uses to manipulate geographical data. The major characteristics are:

Location: Every geographical phenomenon has a location or positional identity which can be used to know exactly where it is on or in relation to the surface of the earth. The relative location of an object can be defined using geographical coordinates (latitude and longitude) or some other form of position identification.

Size: There is a great variety in the magnitude of geographical phenomena. Some are comparably small in size e.g. trees, boreholes, etc., while some are quite gigantic e.g. mountains, oceans, settlements, etc.

Dimensions: Every geographical feature has some geometric dimension(s). Hence each feature can be identified as a point, linear, areal, or volumetric feature. (See the sub-section on types/classes of geographical objects).

Shape: Geographical objects have shape. Natural features commonly have irregular shapes while most of the man-made features have regular shapes.

Distributed: Geographical phenomena are distributed over space. Some features are highly dispersed while some are clustered together. Similarly, while some features, especially natural features, are more randomly distributed, some others, especially man-made features, tend to be more evenly or regularly distributed.

Some geographical objects are considered to be discrete in their distribution; they are not found everywhere, instead they exist at distinct locations e.g. bus stops, boreholes, lakes, etc. On the other hand, some other geographical features are ubiquitous in their distribution; they cover a vast area at varying degrees, e.g. population, temperature, rainfall, soil, etc.

Relationship: No geographical feature exists in isolation; in various ways and degrees, they relate and interact with one another. A geographical feature can be located close to or far away from another feature. Also a feature can be located to the north, east, south, or west of another; just as it could be on the left or right side of another feature. Features could be adjacent to each other; they could also be contiguous to one another in which case they share common boundaries; they can also be widely separated.

Similar features could intersect, just as one feature could lie completely inside another feature. The spatial relationships mentioned above are the key to all GIS-based analysis.

3.3 Types/Classes of Geographical Features

There is a wide range of geographical features in existence. Traditionally, however, all geographical features are grouped into four namely, point, linear, areal (polygon), and volumetric features. This grouping is done based on the geometric dimensions of the features:

Point features: These are features that exist at a single spot without appreciable length and breadth. Hence, point features are considered to be zero dimensional (0-dimensional or 0-D) in nature. Examples include boreholes, bus stops, electrical transformers, etc.

Line or linear features: They are considered to be one dimensional (1-dimensional or 1-D) in nature; it is the length of such features that is usually taken into account. Examples are roads, rivers, railways, etc.

Areal or polygonal features: These are features that occupy a considerably large expanse of space. Both the length and breadth dimensions of such features are usually considered in their measurement; hence they are treated as two dimensional (2-dimensional or 2-D) features. Examples are lakes, farmlands, local government areas, etc.

Volumetric features: these are three dimensional (3-dimensional or 3-D) features. Their length, breadth and height (depth, or quantity as the case may be) are usually measured. Examples include mountains, population, vehicular traffic, and air mass.

3.4 The Value of Geographical Data

About 80% or more of the data man uses on a daily basis is geographical in nature. In other words, the decisions and actions we take daily are largely based on information that has geographical content. This should not really be quite surprising, especially when we realise that virtually every activity of man takes place in geographical space. Geographical data or information helps us to understand our environment and, hence, to exploit the available resources in the most productive, sustainable and beneficial manner.

More so, geographical information enables us to navigate our environment in an intelligent way. Questions relating to the spatial location, distribution, relationship and accessibility of various phenomena are best answered using geographical information. In other words, geographical knowledge helps us erase location ignorance by affording us the opportunity of identifying events and features within a spatial frame. Geographical features and data describing them are part of our everyday lives. Most of our daily decisions are influenced by some aspect of geography.

4.0 Conclusion

GIS makes use of geo-referenced data to function. An understanding of the peculiar nature of geographical data, therefore, is critical to proper handling of the data in a GIS environment. Before entering a piece of geo-data into a GIS environment, the type or class of the data has to be defined; similarly, the type of analysis it would be used for has to be known.

Unless a piece of data is given a geographical identity in a GIS environment it will be almost impossible to process the data to yield the desired result. It therefore behoves a potential user of the GIS technology to sufficiently understand the true nature of geographical data; this will help the user in knowing how to handle the data in GIS.

5.0 Summary

Geographical data are facts about geographical features. A geographical feature is anything anywhere. Geographical features could be classified as point, line, areal, or volumetric. The location, geometric and relational facts, figures, or statistics relating to geographical features are captured and communicated as geographical data. Geographical data/information is quite essential to the everyday intelligent functioning and decision-making of man.

6.0 Self-Assessment Exercise

1. Briefly identify classes of geographical data.
2. Explain the nature/characteristics of geographical data.

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Unit 5 GIS versus Allied Technologies

1.0 Introduction

There are so many terms and technologies that are related to GIS. The use of many acronyms, synonyms, and terms with related meaning to GIS can actually cause some confusion. This unit is therefore aimed at assisting you to know some of the various terms and technologies that are allied to GIS and to know the similarities and dissimilarities between GIS and those other technologies.

2.0 Objectives

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

- highlight some acronyms, synonyms and terms related to GIS
- identify some information technologies that are related to GIS
- differentiate between GIS and other related technologies.

3.0 Main Content

3.1 Related Terms: Acronyms, Synonyms, and More

As noted earlier, one reason it can be difficult to agree on a single definition for GIS is that various kinds of GIS exist, each made for different purposes and for different types of decision making. A variety of names have been applied to different types of GIS to distinguish their functions and roles.

Some of the most widely used related terms include:

- AGIS (Automated Geographic Information System)
- AM/FM (Automated Mapping and Facilities Management): AM/FM is designed specifically for infrastructure management. Automated mapping by itself allows storage and manipulation of map information. AM/FM systems add the ability to link stores of information about the features mapped. However, AM/FM is not used for spatial analysis, and it lacks the topological data structures of GIS.
- CAD (Computer-Assisted Drafting): These systems were designed for drafting and design. They handle spatial data as graphics rather than as information. While they can produce high-quality maps, generally they are less able to perform complex spatial analyses.
- CAM (Computer-Assisted Mapping, or Manufacturing).
- Computerized GIS.
- Environmental Information System.
- GIS (Geographic Information System).
- Geographically Referenced Information System.

- Geo-Information System.
- Image-Based Information System.
- LIS (Land Information System).
- Land Management System.
- Land Record System.
- Land Resources Information System.
- Multipurpose Cadastre.
- Multipurpose Geographic Data System.
- Multipurpose Land Record System.
- Natural Resources Inventory System.
- Natural Resources Management Information System.
- Planning Information System.
- Resource Information System.
- Spatial Data Handling System.
- Spatial Database.
- Spatial Information System.

3.2 GIS and Related Systems

There are some systems that are similar in both function and name to GIS. Nevertheless such systems are not really geographic information systems as defined above. Broadly, these similar systems do not share GIS's ability to perform complex analysis. Computer-Aided Drafting (CAD) systems, for example, are sometimes confused with GIS.

Not long ago, a major distinction existed between GIS and CAD, but their differences are beginning to disappear. CAD systems are used mainly for the precise drafting required by engineers and architects; they are also capable of producing maps though not designed for that purpose. However, CAD originally lacked coordinate systems and did not provide for map projections. Also, initially CAD systems were not linked to data bases, an essential feature of GIS. These features have been added to recent CAD systems, but geographic information systems still offer a richer array of geographic functions.

Uluocha (2007) has identified the similarities and differences between GIS and CAD. Such similarities and differences will be discussed thus.

Similarities between GIS and CAD

1. Both systems have similar requirements for capturing, storing and displaying graphic images interactively.
2. Interactive commands for entering lines or symbols and for editing, moving, modifying and deleting features are required for both applications.

3. Existing (analogue) maps (in the case of GIS) and drawings (in the case of CAD), must be digitised.
4. Both applications require capabilities for operations such as annotation, labelling, calculation of length, distance and area.
5. Both types of systems require similar computer hardware devices such as processor, disk, tape, workstation, digitizer, scanner, and plotter.
6. Both have requirements for the linking of attribute data with their graphic entities.

Differences between GIS and CAD

1. GIS makes use of maps ranging from large to small scales whereas engineering drawings used in CAD applications usually have very large scales.
2. GIS applications unlike their CAD counterpart, generally require complex and large volume of attribute data.
3. GIS operations involve complex geographic analysis and modelling of geographic features, CAD applications deal with sophisticated engineering calculations and modelling of engineering structures.
4. GIS makes use of standard map projections while CAD does not. Simple local plane coordinates are usually enough for engineering drawings.
5. GIS has powerful facilities for numerous attribute data processing operations; CAD, on the other hand, has limited attribute processing capabilities.
6. GIS handles many spatial features such as soil, vegetation, elevation, boundaries, population and infrastructural facilities like roads, sewers, electricity, water, and so on; and also covers a wide geographic area like city, local government, state, country or even the entire earth. On the other hand, CAD applications deal with a specific or single project like the engineering design of a road segment, water or sewer line, electrical wiring, and so on. Such designs are usually done at a very large scale hence they cover very small geographic area.
7. GIS applications use topological data structure that allows for the geographic analysis of the data based on the spatial relationships among map elements. CAD applications do not require a topological data structure.
8. A GIS can be used to perform geographic analytical tasks such as polygon overlay analysis, network tracing and routing, buffering and delineation of service area, district, ecological zone, and so on. A CAD on the other hand, is used for carrying out engineering analysis and calculation functions.
9. GIS is usually used for constant updating of map features, which are known to change frequently. On the other hand, engineering drawings (and structures) hardly change. However, if a major change should occur which may necessitate altering the original concept or structure, an entirely new drawing is produced rather than updating the original drawing.

4.0 Conclusion

There are many digital data processing systems that use geo-referenced data. However, it is not every computer-based system that utilises geospatial data that can be considered to be a geographical information system. There are notable similarities as well as differences between GIS and some allied technologies. What distinguish the GIS system from other information systems are its spatial analysis functions. The analysis functions in GIS use the spatial and non-spatial attributes in the database to answer questions about the real world.

5.0 Summary

GIS is used to manage spatial data. Other information systems that can be used to handle spatial data equally exist. However, there are clear similarities and differences between GIS and other related information systems. Unlike most other systems, a typical GIS is a combination of database management system, mapping or graphics system and geo-statistical processing/analysis; no other system can boast of such a robust combination.

Moreover, whereas other systems are tailored towards handling certain specific and limited tasks, the GIS technology is quite versatile, multifunctional and multipurpose in nature.

6.0 Self-Assessment Exercise

1. Differentiate between GIS and other related technologies.
2. Briefly discuss the relationship of other information technologies with GIS.

7.0 References/Further Reading

Cowen, D. J. (1990). "GIS versus CAD versus DBMS: What are the Differences." In: D. J. Peuquet & D. F. Marble (Eds). *Introductory Readings in Geographic Information Systems*. New York: Taylor & Francis. Pp. 52-61.

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

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