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Applying Geospatial Information and Communication Technology (GeoICT) System: research on Locations of Federal Universities in Nigeria

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Abstract: There is need for a comprehensive system with visual representation that would identify and show the absolute locations of Federal Universities in Nigeria. This will create solutions in admissions prospecting by candidates and decision making by the government agencies for education management in Nigeria. Leveraging the roles of Geospatial Information and Communication Technology (GeoICT) in applied computing can be of great benefit. In this research, a broad study of GIS is made as it relates to the building of a geodatabase system that would show the absolute longitudinal and latitudinal locations of the Federal Universities in Nigeria and enable users appreciate any institution of choice. The techniques used are Structured System Analysis and Design Methodology (SSADM) from which a blend of seven (7) programming tools is employed to implement the system. The achieved result is that a functional Geospatial Information and Communication Technology system that mapped Federal Universities in Nigeria has been developed.

Keywords: GeoICT; GIS; Federal Universities; SSADM; GPS; ARCGIS; Geodatabase

I. INTRODUCTION

There are three (3) types of Universities currently existing in Nigeria today under the auspices of the National Universities Commission (NUC) Abuja. They include the Federal Universities, State Universities and Private Universities. There were twenty seven (27) Federal Universities in Nigeria until recently, the Federal government created nine (9) additional Federal Universities to cover the six geopolitical zones in Nigeria. This good development was an "imperative to creating more access to University education in view of the large number of qualified candidates who are annually stranded" according to the Minister of Education [19]. These Federal Universities are categorized as illustrated in Table III into Conventional Universities, Universities of Technology, Universities of Agriculture, and Specialized Universities. It is obvious that most of the research work in Nigeria happens in the Universities (especially the Federal Universities) and there is a huge demand for faculty members and academic staff; also the rate of admissions into Universities is on the increase. This emergence of many Universities, academic/non-academic staffing needs and prospective students has created a high need for a decision-making tool with visual representation and guidance. A GeoICT System can readily provide this representation for the general public in Nigeria.

The concept of GeoICT is to integrate the Geospatial technology into the mainstream of Information and Communication Technology (ICT). ICT and GeoICT are rapidly gaining momentum as an indispensable research methodology in geography, environmental science, etc [2]. The different parts of geospatial data management which includes data acquisition, data assimilation, data analysis, information generation, decision support, and information dissemination can be unified in GeoICT [1]. It has recently emerged as an interdisciplinary technology that requires the integration of Geographic Information System (GIS), Remote Sensing (RS), Global Positioning System (GPS), Satellite Communication System, Mapping and Web Technologies. References [2, 6] considered GIS as part of GeoICT adding that it provides even broader applications that traditional GIS may have not addressed well. This is also seen in the use of position tracking (an application of GPS) in the implementation of this research. The benefits and applications are broadly seen in other researches. Adinarayana et al [8] listed the advantages of GeoICT as follows: centralized control over data and model, global and easy accessibility, interconnectivity, model propagation, education platform, and more importantly interconnectivity, coordination, or flexibility in decision making/participatory decision making. Acharya [1] listed the application areas among others to include forestry, environment, urban development, land administration, hydrology, topography, police, emergency response, tax assessment, education, utility services and other economic development sectors.

Reviewing the development of the GeoICT in the international scene, the Geo ICT Lab at York University [7] positioned that GeoICT is an enabling technology that is stemmed from the integration of geospatial information and imaging technologies with ICT. It is considered as a core emerging technology that forms a basis for spatial decision making, geo-computation and Location Based Services (LBS). It contributes significantly to the emerging markets and applications like Spatial Data Infrastructure (SDI), digital earth, Location-based Commerce (L-Commerce), Mobile Commerce (M-Commerce), E-Commerce and E-Government. Also, Tao, the founder of GeoICT Lab in Canada stated that an important notion for GeoICT is that location becomes a key that links to the geospatial technology and the ICT applications [6]. LBS or Location Intelligence (LI) as he called it is a typical GeoICT application while traditional GIS may have other trends, such as better handling the social aspects of GIS and more advanced spatial analysis. He added that Web services based mapping and LI are very promising as Location-based Microsoft MapPoint services, ESRI ArcWeb services, and OGC spatial web services will become a catalyst to the GeoICT market. Apart from the Lab in Canada, other renowned International groups working in this area are the Spatial Information Processing Lab, University of Tokyo, and Spatial Information and Research Group, Australia [6, 21]. Nigeria as well has been making good progress in the development of GeoICT. Okeke, in the Geospatial Network Newsletter [9] reported the launch of Digital Mapping Project by Lagos state government of Nigeria, procurement of Satellite Imagery and Production of Digital Township Mapping Paraphernalia of selected towns in Nasarawa state and digital GIS for Land Administration in Ogun state. ProxyCAD 1.1 by Proxy Logics Nigeria is Nigeria's first home-made GIS software which imports CAD data formats in ArcGIS geodatabase seamlessly. Also, the contributions of National Space Research and Development Agency (NSRDA) and Regional Centre for Training in Aerospace Surveys (RECTAS), both in Ile-Ife, Nigeria cannot be overemphasized.

From Scholten et al, in the International Workshop on Geo-ICT and the Role of Location within Science [4], participant scientists discussed three key frameworks as effective ways of applying GeoICT in science. These frameworks include:

1) Geodatabase-framework: Location was identified as a specific component in the databases (e.g. Oracle Spatial)

2) Geomap-framework: Includes both visualisation and map-making; e.g. one would notice that a GIS generated map must be drawn from a geodatabase.

3) Geomodel-framework: Location was also idenfied as a key variable in the explanatory models (e.g. distance between objects).

It was observed that within each of these frameworks, location is an important feature or even the starting point for scientific investigations. In this research, we fully agree with this observation as location-based services (e.g. GPS) and locational data display for decision making cannot be overemphasized in in any GIS development. The resultant system from this research is derived from a blend of GIS, GPS and Web Technologies. The tools employed is tabulated in Table II. Generally, because GeoICT is an emerging technology, it is often referred to as GIS, but as this research shows, it is more than that.

A GIS is generally a tool that enables information that has an earth-based reference to be stored in a logical fashion. It will allow a user to accurately map areas and to store information that is pertinent to that map to be linked to the digital map. The development of a GIS has relative flexibility [5]. A GIS must know the spatial relationship of one object in relation to all of those other objects surrounding it. Thus geographical information systems are computer technologies for organizing spatially related data. GIS is often defined not for what it is but for want it can do [11]. This functional definition is very revealing about the use of GIS, because it shows the set of capabilities that a GIS is expected to have. These capabilities can be grouped into data capture, data storage, data management, data retrieval, data analysis, and data display – the major parts of geospatial data management that can also be extended in GeoICT [1]. A GIS can be seen as a system of hardware, software and procedures (tools) designed to capture, manage, manipulate, analyse, model, and display spatial or geo-referenced data for solving complex planning and management problems. Harmon et al [15] further illustrated these with the diagram in Figure 1, stating that a GIS is composed of five main componets – People, Applications, Data, Software and Hardware:

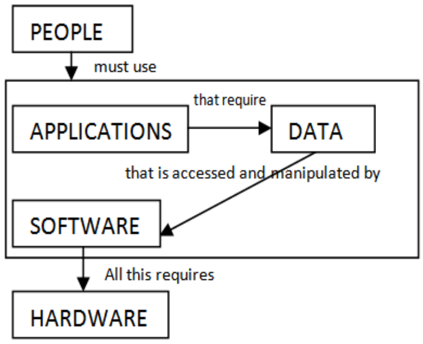


Figure 1. Five main components of a GIS.

According to Huebner et al [13], A GIS can be viewed in three ways:

A. *Database View*

A GIS is a unique kind of database of the world—a geographic database (geodatabase). It is an "Information System for Geography." Fundamentally, a GIS is based on a structured database that describes the world in geographic terms.

B. *Map View*

A GIS is a set of intelligent maps and other views that show features and feature relationships on the earth's surface. Maps of the underlying geographic information can be constructed and used as "windows into the database" to support queries, analysis, and editing of the information.

C. *Model View*

A GIS is a set of information transformation tools that derive new geographic datasets from existing datasets. These geoprocessing functions take information from existing datasets, apply analytic functions, and write results into new derived datasets.

These three views are critical parts of an intelligent GIS and are used at varying levels in all GIS applications. These views together with applications of GPS shall be used to study, design and implement the system for mapping the locations of Federal Universities in Nigeria. It is obvious that the study of GeoICT and GIS in particular is all encompassing, with specific examples of distributed systems in web-based GIS, Mobile GIS, Corporate GIS and GRID computing but in this research, we are restricted to build a standalone GIS that will be integrated or hosted on the web to achieve the objectives outlined in section II. We will review the design of geospatial model in section III which will help us in defining a coordinate system in section IV and building of a geodatabase in section V. Section VI presents the methodology applied while section VII enumerates the benefits of the system. Finally, we will discuss the results and conclusion in sections VIII and IX respectively.

II. RESEARCH OBJECTIVES

The overall objectives of this research are to build a geodatabase system that would show the locations of the Federal Universities in Nigeria through an interactive clickable location-based map and analyze the spatial distribution of Nigerian Federal Universities to help prospecting students, associated bodies and the general public in decision making.

Specifically, the objectives include:

- Design and implement an interactive clickable location-based map of Federal Universities.
- Show the absolute locations of the Federal Universities in Nigeria.
- Analyze the spatial distribution of Nigerian Federal Universities in relation to states educational development, types and generations of Federal Universities
- Help prospecting students (undergraduate, graduate and postgraduate) to make preference about an institution, its resources and environment before making a choice for admissions.
- Help government education agencies (National Universities Commission, Ministry of Education, etc) in locational or spatial decision making.

III. GEOSPATIAL MODEL DESIGN

Before a geodatabase system could be built, a geospatial model must first be designed. There are two phases that are required to derive a geospatial model; they include: the design phase and the construction phase as represented in the Figure 2.

A. The Design Phase

The design phase includes all the abstraction processes ranging from the conceptual design, the logical design, to the physical design. Relating the concepts in Figure 2 to this research, the main view of reality (or the study area) is the Federal Universities in Nigeria.

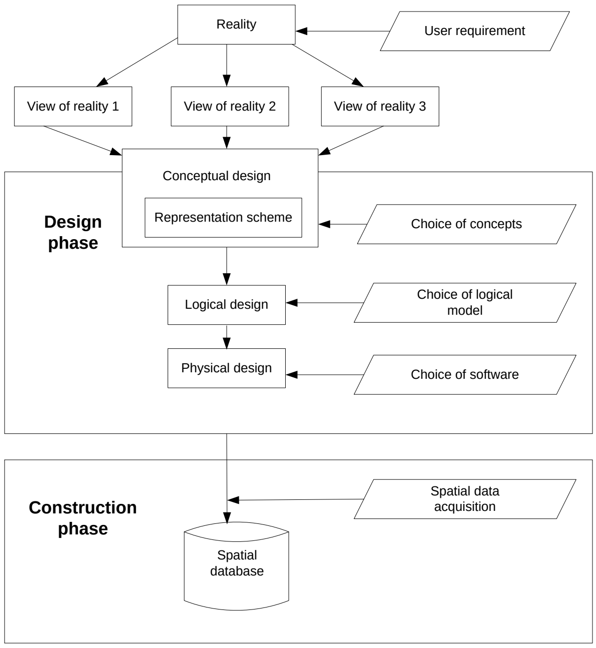
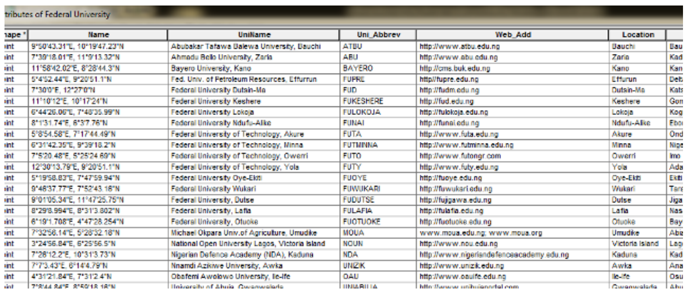


Figure 2. A diagrammatical representation of a geospatial data model (Adapted from Kufoniyi, 1998)

The requirement is to determine the locations of the various views of reality which is the present patterns of distribution of Universities in the study area. The process of design for these views of reality follows:

1) The Conceptual design: This comprises of a general scheme describing what should be included in the GIS. The result of a conceptual design is usually the conceptual model [12]. An improvement on the conceptual model is the entity-relationship (ER) model or diagram which shows the entities participating in a relationship and the extent of such participation from an individual entity to the relationship. This is referred to as cardinality constraint [14]. The ER diagram highlights the relationship types by illustrating whether it is a 1: n (one to many), 1:1 (one to one), 1:0 (one to zero) relationship or vice versa. For instance, the extent of association between states containing University could be said to be 1: n since a single state can contain many Universities. The ER model is also said to be a summary for the conceptual model of a database.

2) The Logical design: This sets out all the elements needed for the construction of the database, without stating any software specific implementation process for the model. The logical design states how the representation of one object is distinguished from another. This is done by assigning a unique identifier to objects. The result of a logical design is usually a logical model [12]. Figure 3 shows the logical model for this research.



tributes of Federal University

hape *	Name	UniName	Uni_Abbrev	Web_Add	Location	
int	9°50'43.31"E, 10°19'47.23"N	Abubakar Tafawa Balewa University, Bauchi	ATBU	http://www.atbu.edu.ng	Bauchi	Bau
int	7°39'18.01"E, 11°9'13.32"N	Ahmadu Bello University, Zaria	ABU	http://www.abu.edu.ng	Zaria	Kad
int	11°58'42.02"E, 8°28'44.3"N	Bayero University, Kano	BAYERO	http://cms.buk.edu.ng	Kano	Kan
int	5°4'52.44"E, 9°20'51.1"N	Fed. Univ. of Petroleum Resources, Effurun	FUPRE	http//fupre.edu.ng	Effurun	Deb
int	7°30'0"E, 12°27'0"N	Federal University Dutsin-Ma	FUD	http://fudm.edu.ng	Dutsin-Ma	Kats
int	11°10'12"E, 10°17'24"N	Federal University Keshere	FUKESHERE	http://fud.edu.ng	Keshere	Gom
int	6°44'26.06"E, 7°48'35.99"N	Federal University Lokoja	FULOKOJA	http://fulokoja.edu.ng	Lokoja	Kog
int	8°1'31.74"E, 6°3'7.76"N	Federal University Ndufu-Alike	FUNAI	http://funai.edu.ng	Ndufu-Alike	Ebo
int	5°8'54.58"E, 7°17'44.49"N	Federal University of Technology, Akure	FUTA	http://www.futa.edu.ng	Akure	Ond
int	6°31'42.35"E, 9°39'18.2"N	Federal University of Technology, Minna	FUTMINNA	http://www.futminna.edu.ng	Minna	Nige
int	7°5'20.48"E, 5°25'24.69"N	Federal University of Technology, Owerri	FUTO	http://www.futongr.com	Owerri	Imo
int	12°30'13.79"E, 9°20'51.1"N	Federal University of Technology, Yola	FUTY	http://www.futy.edu.ng	Yola	Ada
int	5°19'58.83"E, 7°47'59.94"N	Federal University Oye-Ekiti	FUOYE	http://fuoye.edu.ng	Oye-Ekiti	Ekiti
int	9°46'37.77"E, 7°52'43.16"N	Federal University Wukari	FUWUKARI	http://fuwukari.edu.ng	Wukari	Tara
int	9°01'05.34"E, 11°47'25.75"N	Federal University, Dutse	FUDUTSE	http://fujigawa.edu.ng	Dutse	Jiga
int	8°29'8.994"E, 8°31'3.802"N	Federal University, Lafia	FULAFIA	http://fulafia.edu.ng	Lafia	Nas
int	6°19'1.708"E, 4°47'28.254"N	Federal University, Otuoke	FUOTUOKE	http://fuotuoke.edu.ng	Otuoke	Bay
int	7°32'58.14"E, 5°28'32.18"N	Michael Okpara Univ.of Agriculture, Umudike	MOUA	www.moua.edu.ng; www.moua.org	Umudike	Abia
int	3°24'56.84"E, 6°25'56.5"N	National Open University Lagos, Victoria Island	NOUN	http://www.nou.edu.ng	Victoria Island	Lag
int	7°28'12.2"E, 10°31'3.73"N	Nigerian Defence Academy (NDA), Kaduna	NDA	http://www.nigeriandefenceacademy.edu.ng	Kaduna	Kad
int	7°7'3.43"E, 6°14'4.79"N	Nnamdi Azikiwe University, Awka	UNIZIK	http://www.unizik.edu.ng	Awka	Ana
int	4°31'21.84"E, 7°31'2.4"N	Obafemi Awolowo University, Ile-Ife	OAU	http://www.oauife.edu.ng	Ile-Ife	Osu
int	7°8'44.84"E, 8°59'18.18"N	University of Abuja, Gwagwalada	UNIABUJA	[illegible]	Gwagwalada	Abu

Figure 3. Logical Model of FedUniMapping

3) The Physical design: The physical design specifies the actual size and type of each element of the model for the implementation of the geospatial model. This phase yields an internal model and software specific steps for eventual implementation of the model. This is where a choice of software is made. For this research, the GIS software is the ArcGIS 9.3 with applications in ArcCartlog for integrated and unified view of data, files and database; and also with applications in ArcMap 9.3 for mapping, editing, query, and analysis of data in the database.

B. The Construction Phase

The construction phase is actual implementation of the geospatial model. A major input of this phase is spatial data collection using the technology of GPS. It delivers the spatial database with the chosen software. A spatial database is a collection of spatially referenced data that acts as a model of reality. It stores georeferenced data for example, Universities with their absolute x, y locations.

IV. GPS AND COORDINATE SYSTEM IN ARCGIS

A coordinate system is a reference system used to represent the locations of geographic features, imagery, and observations such as GPS locations within a common geographic framework. Coordinate systems enable geographic datasets to use common locations for integration. According to ARCGIS help file [20], there are two common types of coordinate systems used in GIS:

- A global or spherical coordinate system such as latitude–longitude. These are often referred to as *geographic coordinate systems.*
- A projected coordinate system based on a map projection such as transverse Mercator, Albers equal area, or Robinson, all of which (along with numerous other map projection models) provide various mechanisms to project maps of the earth's spherical surface onto a two dimensional Cartesian coordinate plane. Projected coordinate systems are sometimes referred to as *map projections.*

Coordinate systems (either geographic or projected) provide a framework for defining real-world locations [3]. These locations must first be collected using a GPS device. In ArcGIS, the coordinate system is used as the method to automatically integrate the geographic locations from different datasets into a common coordinate framework for display and analysis. ArcGIS automatically integrates datasets whose coordinate systems are known. If your datasets have a well-defined coordinate system, then ArcGIS can automatically integrate your datasets with others by projecting your data on the fly into the appropriate framework—for mapping, 3D visualization, analysis, and so forth. If your datasets do not have a spatial reference, they cannot be easily integrated. You need to define a coordinate system before you can use your data effectively in ArcGIS [16].

A. GEOREFERENCING

A spatial reference in ArcGIS is a series of parameters that define the coordinate system and other spatial properties for each dataset in the geodatabase. It is typical that all datasets for the same area (and in the same geodatabase) use a common spatial reference definition. After the geospatial model has been created, a common spatial reference is specified for all elements in the geodatabase. The process of doing this is known as georeferencing. Georeferencing involves relating all elements in the geodatabase to a specific geographic location to the extent that enables them to be located on or near the earth's surface [17]. In this study, the Geographical projected WGS 1984 coordinate system was adopted for all elements modeled in the study area. The Geographical projection is a standard map projection for all Countries in which individual Countries are zoned with more than 1 zone to minimize scale distortion [14]. Hence, it was adopted for this study since it is suitable for local area mapping.

B. DIGITIZING

Another process needed for building the geodatabase is Digitizing. Digitizing in this study involved converting the raster map features which were in raster format into vector format that fits the structure of the geodatabase. First, features on raster map were visually interpreted based on their shape, size, and tone. States were digitized as polygon and University as point based on the scale needed to visualize the output. Consequently, the geodatabase was populated simultaneously for subsequent analysis.

V. ARCGIS AND GEODATABASE DESIGN

Just as the design of a geospatial model, the design of the GIS database will include three major elements alongside [18]:

A. Conceptual design

Basically laying down the application requirements and specifying the end-utilization of the database. The conceptual design is independent of hardware and software and could be a wish-list of utilization goals.

B. Logical design

Logical design, which is the specification of the database vis-a-vis a particular GIS package. This design sets out the logical structure of the database elements determined by the GIS package.

C. Physical design

Physical design, which pertains to the hardware and software characteristics and requires consideration of file structure, memory and disk space, access and speed etc.

Each stage is interrelated to the next stage of the design and impacts the organization in a major way. For example, if the concepts are clearly defined, the logical design is easier done and if the logical design is clear the physical design is also easy.

Geodatabase designers must ensure the inclusion of three fundamental dataset types regardless of the system they use. They'll have a set of feature classes (much like a folder full of ESRI shapefiles), they'll have a number of attribute tables (such as dBase files, Microsoft Access tables, Excel spreadsheets, DBMSs, and so forth), and most of the time, they'll also have a large set of imagery and raster datasets to work with [16]. This is illustrated in Figure 4.

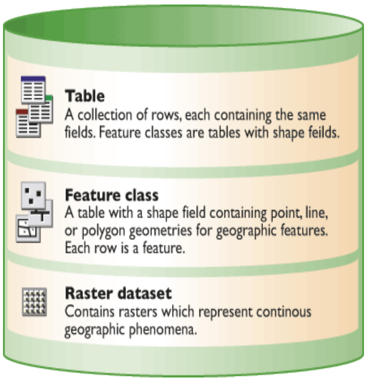


Figure 4. Three elements of a geodatabase (Source: http://webhelp.esri.com/)

Fundamentally, all geodatabases will contain this same kind of content. This collection of datasets can be thought of as the universal starting point for your GIS database design. All three fundamental datasets in the geodatabase (feature classes, attribute tables, and raster datasets) as well as other geodatabase elements are stored using tables [16]. ArcGIS implements the geodatabase either as a collection of files in a file system or as a collection of tables within a relational database management system (RDBMS). Typically, geodatabases are scalable, that is, they are systems that does not show negative effects when its size or complexity grows greater. However, there are various types of geodatabases as tabulated in Table I with their scalable capacities.

Table I. Comparing types of scalable geodatabase

Properties and functions	***Scalable geodatabases***		
	Enterprise Geodatabase	***Workgroup Geodatabase***	***Desktop Geodatabase***
Supported RDBMS	DB2, Informix, Oracle, PostgreSQL, SQL Server	SQL Server Express	SQL Server Express
Management Interface	ArcCatalog, RDBMS, ArcSDE command line	ArcCatalog	ArcCatalog
Storage Capacity	Depends on the server	4 GB	4 GB
Licensing Availability	ArcGIS Server Enterprise	ArcGIS Server Workgroup	ArcInfo or ArcEditor
Supported OS Platform	Any platform	Windows	Windows
Number of Users	Unlimited editors and readers—concurrent	10 editors and readers—concurrent	1 editor and 3 readers—concurrent
Network Application	Intranet and Internet	Intranet and Internet	Desktop use

VI. METHODOLOGY

Having taken a concise study of the development of GeoICT involving GIS and GPS, we adopted a design methodology in Computer Science called Structured System Analysis and Design Methodology (SSADM) with emphasis on parallel development (illustrated in Figure 5) to implement the system. Using SSADM, a general design for the whole system is achieved, and then the project is divided into a series of distinct subprojects that can be designed and implemented analogously [10]. When all these distinct subprojects are complete, there is a final integration of the separate pieces, and the system is delivered.

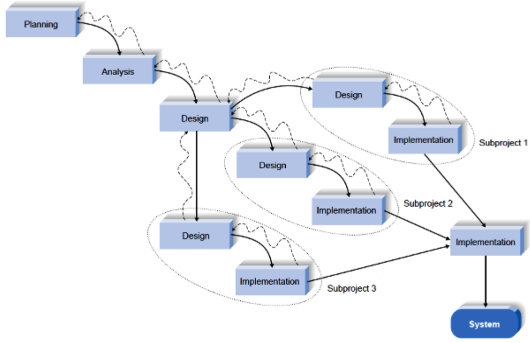


Figure 5. Parallel development methodology

SSADM is an internally accepted method for Software Engineering design. The following steps as it relates to this research are employed:

1) Problem Identification: A statement of scope and objectives was written stating the objectives of the reaserch (as contained in section II of this paper), the overall cost of the project which is set by the researchers and the key selection criteria which is to help the system provide reliability and dependability

2) Feasibility Study: The basic issue that shall pose an obstacle to the project was identified; such as governmental policies, financial implications, and technological advancement. Many GIS users face the problem of acquiring accurate and timely data at a cost effective price. Also, GIS data may be outdated, inaccurate, prohibitively expensive, or all three. These pose the real limitations of any GIS or geodatabase in operation and this research is not an exception.

3) Requirement Analysis: The requirements for the execution of the project was analyzed and itemized as follows:

a) The analog/digital administrative map of the Federal Republic of Nigeria: This is required as raster/vector dataset to implement the system.

b) GPS device: This positioning device is needed for collection of GPS Points (x, y) of the locations of the Federal Universities.

c) Software programming tools: ArcGIS 9.3, Dreamweaver 8.0, Google Earth, etc as identified in Table II with their specific uses.

Table II. The Software Tools Used

S/N	***Software***	***Uses***
1.	Microsoft Visio	Used to design the flow diagram
2.	ArcGIS 9.3	Used for creating the geo-database, geo-referencing and visualization.
3.	Dreamweaver	To write scripts and create interface for the interactive location-based map.
4.	Acrobat Macromedia/Acrobat Flash	To create supported animations for the internet based location map
5.	ENVI 4.3	Used for all raster operations which include images
6.	KLM	Used to extract raster dataset from Google Earth
7.	Google Earth	To provide needed raster dataset for the work

d) System Analyst: The researchers serve in this capacity for overall work flow in design and construction of the system.

e) Transportation: The researchers travelled to all the locations of the Federal Universities in Nigeria for collection of the GPS Points.

f) Hardware and Software requirements: The software will require any of Windows 2000, XP, Vista and 7 operating system with a windows compatible browser e.g. Internet Explorer, Mozilla Firefox, etc. The tools presented in Table II are also required.

4) Detailed System Analysis And Design: The system data dictionary, the subsystems and program modules, input/output screen design, overall workflow diagram and system algorithm for the various operations were designed. Figure 6 shows the output screen design of the complete system.

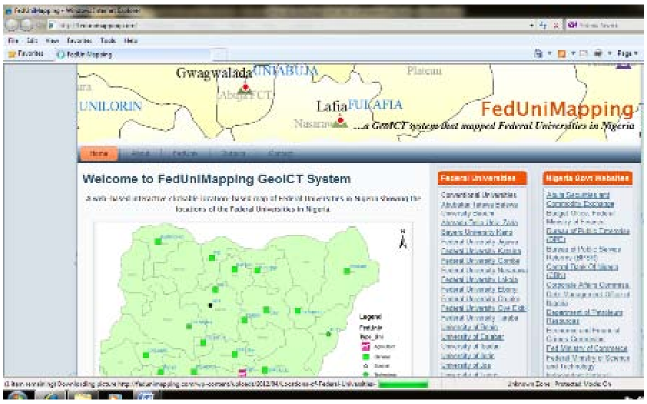


Figure 6. Display of final System Outputs on a browser (Source: http://fedunimapping.com)

5) Software Design: The main menu, the submenus (one per subsystem) and the system drivers were designed; the algorithm (*Pseudo-code*) is presented next:

Begin
Logon browser;
Input URL;
If URL is correct then
Display main menu else
Quit system;
Select Main Menu option;
If option = Home then
Display clickable map of all Federal Univ. In Nigeria
If option = Institution then
Display (all Federal Universities' profiles)
If option = Location then
Display (the location-based clickable map of Nigeria)
Select any point of choice and view to (Google maps)
If option = Analysis then
Display all the buffer section
If option = Background Information then
Display Website Information of each University
Endif
End

6) Software Coding: On a one-on-one basis, each of the software design realized in item 5 is coded with the programming tools identified in the software requirement analysis in item 3 above.

7) Software Testing And Integration: The program modules which make up the subsystems are tested one by one. These are integrated and the subsystem drivers are tested on them; finally, the subsystems are put together and the main system driver is tested on them.

8) Implementation: At this stage, user training and conversion/handover were done. The system is hosted online for users in education management and prospective students in Nigeria.

9) Maintenance: This final step deals with ensuring the operation of the system after implemenataion. The researchers ensure the running of the hosting and periodic update of the database for functional changes as progress is made in educational sector in Nigeria.

Finally, the figure 7 below illustrates the overall workflow diagram in the system design and implementation using the SSADM methodology.

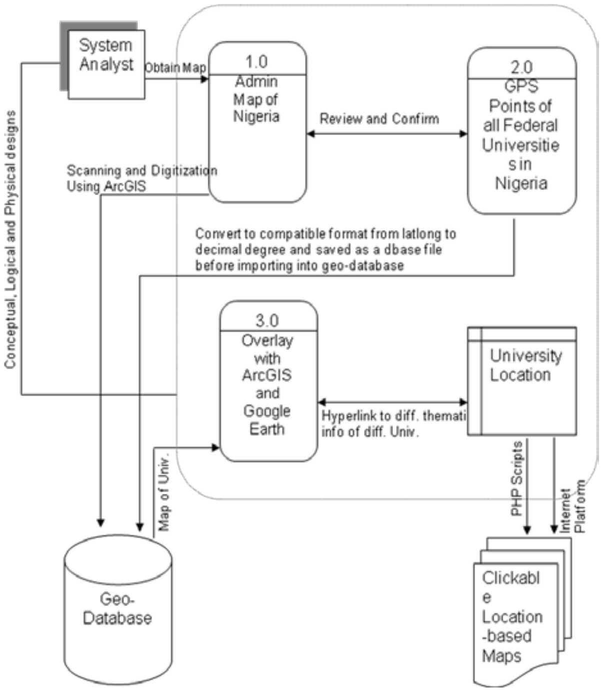


Figure 7. Overall Workflow Diagram

VII. BENEFITS OF THE FEDUNIMAPPING SYSTEM

There are many glaring benefits of the system for admissions prospecting students and government agencies in education management in Nigeria. They are as follows:

A. For Prospecting Students

1. Comparison: A candidate can easily see other Universities in Nigeria in various towns/cities offering the same course and will be able to compare the facilities they possess for delivering excellence.
2. Accessibility: A full map view to enable the candidate locate the University of choice easily
3. Proximity: A candidate can easily identify which institution is far or near from the convenience of his/her home.
4. Search-ability: It becomes easy to search for a University, its location and direction

5. Demographic friendliness: A candidate can easily determine how many individuals of certain ethnicity live in a given location where an institution is located
6. Digital form: A candidate can easily make queries for basic information about the University without spending extra money and time to travel physically to the location.

B. *For Government Agencies in Education*

1. Makes management decision-making easier
2. Determine the less educational developed states in Nigeria easily
3. Following the analysis pattern, enable creation of new institutions or merging of some institutions
4. Aid the dissemination of useful information to a targeted University or city/town

Table III. Types, Locations and GPS Points of the Federal Universities in Nigeria

S/N	*FEDERAL UNIVERSITIES*	*LOCATION*	*NORTH*	*EAST*
Conventional (General)				
1	Abubakar Tafawa Balewa University	Bauchi	10°19'47.23"	9°50'43.31"
2	Ahmadu Bello University	Zaria	11°9'13.32"	7°39'18.01"
3	Bayero University	Kano	11°58'42.02"	8°28'44.30"
4	Federal University Nasarawa State	Lafia	8°29'8.994"	8°31'3.802"
5	Federal University Bayelsa	Otuoke	4°47'28.254"	6°19'1.708"
6	Federal University Jigawa State	Dutse	11°47'25.75"	9°01'.05.34"
7	Federal University Katsina	Dutsin-Ma	12º26'37.741"	7º29'1.181"
8	Federal University Gombe State	Keshere	10°17'24"	11°10'12"
9	Federal University Kogi State	Lokoja	7°48’35.99"	6°44'26.06"
10	Federal University Ebonyi State	Ndufu-Alike	6°03'07.76"	8°01'31.74"
11	Federal University Ekiti State	Oye-Ekiti	7°47'59.94"	5°19'58.83"
12	Federal University Taraba State	Wukari	7°52'43.16"	9°46’37.77"
13	University of Benin	Benin-city	6º23'59.02"	5º36'34.77"
14	University of Calabar	Calabar	4º57'8.15"	8º20'24.38"
15	University of Ibadan	Ibadan	7°25'59.68"	3°54'5.79"
16	University of Ilorin	Ilorin	8°29'37.90"	4°40'57.67"
17	University of Jos	Jos	9°54'48.65"	8°53'34.97"
18	University of Lagos	Akoka	6°30'57.15"	3°23'30.73"
19	University of Maiduguri	Maiduguri	11°54'49.44"	13°17'19.836"
20	University of Nigeria	Nsukka	6°42'36.928"	7°17'0.673"
21	University of Port-Harcourt	Port-Harcourt	4°54'9.69"	6°55'13.65"
22	University of Uyo	Uyo	5°2'27.36"	7°58'36.81"
23	Usuman Danfodiyo University	Sokoto	13°7'37.93"	5°12'15.51"
24	Nnamdi Azikiwe University	Awka	6°14'4.79"	7°7'3.43"
25	University of Abuja	Gwagwalada	8°59'18.16"	7°8'44.84"
26	Obafemi Awolowo University	Ile-Ife	7°31'2.40"	4°31'21.84"
Technology				
27	Federal University of Technology	Yola	9°20'51.10"	12°30'13.79"
28	Federal University of Technology	Akure	7°17'44.49"	5°8'54.58"
29	Federal University of Technology	Minna	9°39'18.20"	6°31'42.35"
30	Federal University of Technology	Owerri	5°25'24.69"	7°5'20.48"
Agriculture				
31	Michael Okpara Univ. of Agriculture	Umudike	5°28'32.18"	7°32'56.14"
32	University of Agriculture	Abeokuta	7°13'50.85"	3°26'11.53"
33	University of Agriculture	Makurdi	7°43'0.594"	8°49'8.3"
Special				
34	National Open University Lagos	Victoria Island	6°25'56.50"	3°24'56.84"
35	Nigerian Defense Academy (NDA)	Kaduna	10°31'3.73"	7°26'12.20"
36	Fed. Univ. of Petroleum Resources	Effurun	9°20'51.10"	5°4'52.44"

(Table III Description: For example, NDA, a special University is absolutely located 10°31'3.73" North (read 10 degree, 31 minutes and 3.73 seconds north) and 7°26'12.20" East)

VIII. RESULTS AND DISCUSSION

The results of this research can be accessed publicly by any user on the following procedures:

- Launch any browser of choice and logon to http://www.fedunimapping.com
- Select the Output menu and follow the Subscriber registration function to enable you access the current outputs from the system
- Select the About menu for a brief description of each of the Universities, number of faculties/courses, etc
- To view other advanced features like the resources of each University, follow the link on the front-page which leads to the clickable location-based maps
- Select the right pane of the front-page to visit any of the thirty-six Federal Universities' websites for institution specific further information. Also over fifty governmental agencies' websites of the Federal Republic of Nigeria are presented on the subsequent pane.
- Once a User is registered, she/he may request for additional outputs for any analysis or decision making which will be generated from the developed geodatabase. Note that the geodatabase is spatial, that is, location-based, hence it cannot be moved onto the web but is housed on a standalone (ARCGIS) computer.

In this paper, we presented five outputs for discussion in the Figures that follow next. Figure 12 can guide the Ministry of Education and the Federal government towards the creation of additional three Universities to cover these states without the presence of a Federal University. Figure 11 shows a dense distribution of not only Federal Universities but State and Privates Universities (as well as Polytechnics) in the western and eastern regions of Nigeria thus making them more educationally developed than the northern and southern regions. This shows the region that requires the attention of government for further education development. Figure 10 mapped the towns in which these Federal Universities are located while Figure 9 shows the distribution of their types in those towns. Finally, Figure 8 illustrates the generations of the Universities from first to fourth generation following the year they were founded. There are many decisions making and choices one may deduce from these illustrations as also discussed in section VII above.

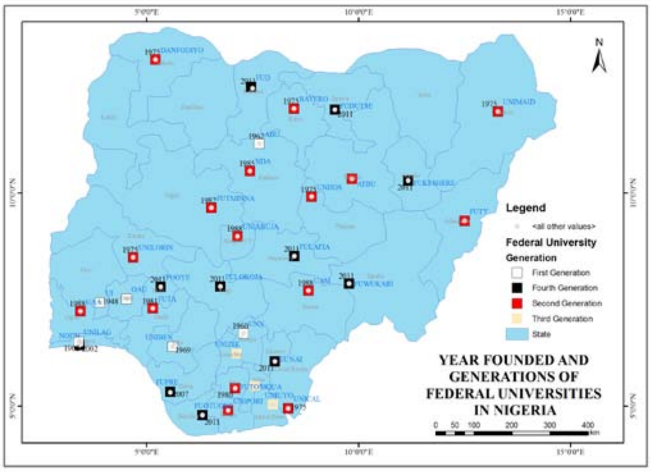


Figure 8. Generations of Federal Universities

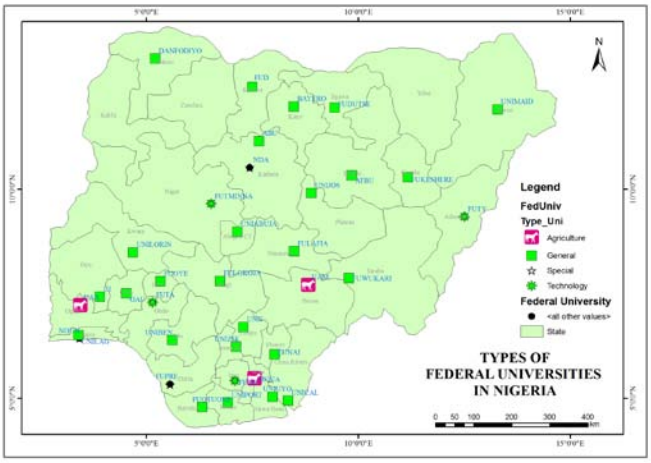


Figure 9. Types of Federal Universities

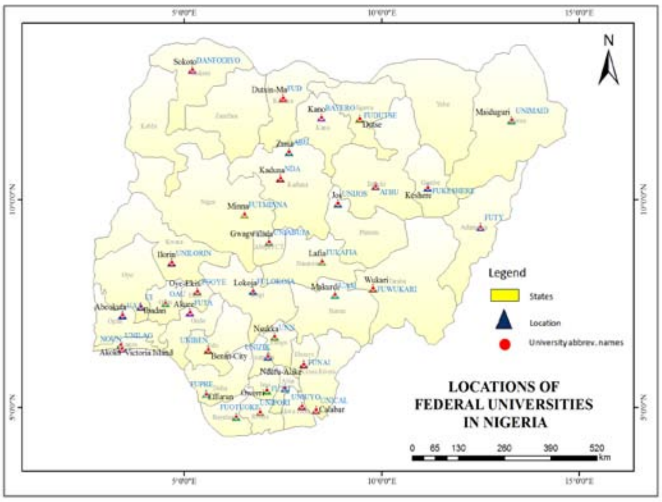


Figure 10. Locations of Federal Universities

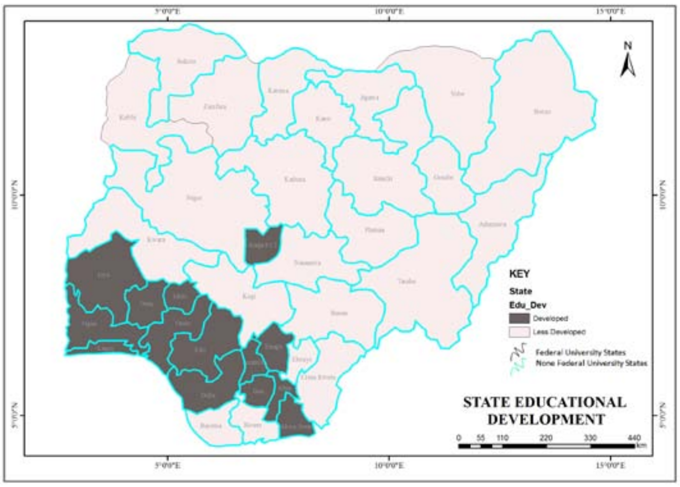


Figure 11. Educationally developed/less developed States

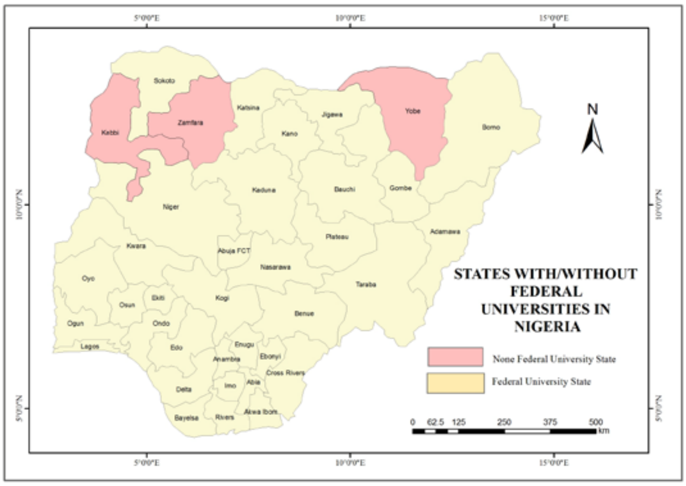


Figure 12. States without Federal Universities

IX. CONCLUSIONS

We are able to adopt the emerging technology of GeoICT with emphasis on GIS, GPS and Web Technologies to study, design and implement a geodatabase system using ARCGIS 9.3 that would show an interactive clickable location-based map of all Federal Universities in Nigeria. Users can analyze the spatial distribution of Nigerian Federal Universities in relation to developed and less developed educational states. The advantages of this system shall enable candidates to compare, access a graphical map view, and search for or select an institution of choice with ease and the associated agencies in education management shall be able to make decision making clearer. The capabilities of this system can be extended or applied in other nations of the world for location-based studies using the same methodologies, tools and techniques well-designed in this research.

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