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UTILITY OF GEOGRAPHIC INFORMATION SYSTEM IN THE ASSESSMENT AND MAPPING OF THE VULNERABILITY OF SOILS IN IMO STATE TO GULLY EROSION HAZARD

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Abstract

This study is on assessment and mapping of the vulnerability of soils in Imo state to gully erosion hazard using geographic information system. The main objectives of the study are to assess the vulnerability of some parts of Imo State to gully erosion hazard using geographic information system. The specific objectives are, to use field sampling to map soil properties and soil erodibility of Imo State with a view to depicting the spatial distribution of gully erosion hotspots in Imo State. The results, among other things showed that the hill shading concur with that of slope above depicting that 87% of the area shaded fall within the highest heights of 176 – 187m and above whereas the remaining part (13%) fall within heights lower than 176m. Results of the elevation and drainage analysis follow the previous trend depicting that 78% of the entire land area representing 3833 $Km^{2\ fall}$ within less to moderately vulnerable erodibility class. The results of soil analysis showed that all the soils exhibited very high dispersion ratios ranging from 58-82%. As expected, the dispersion ratios were affected by the type of underlying parent material. The highest dispersion ratios were found in Nneato (82%) and Ihube (78%) representing sites in Upper Coal measures. Oguta site representing Alluvium (Lacustrine Deposit) had a dispersion ratio of 71% whereas Oforola Owerri site representing Coastal Plain Sands and Arondizogu representing Clay Shale had dispersion ratios of 63 and 58 % respectively. Soils having dispersion ratio greater than 15% are vulnerable to erosion in nature. Since most soils in the study area have high dispersion rates, depicting high vulnerability to soil erosion and 84% of the entire landscape fall into slightly to less vulnerable to erosion with a slope class between 1 – 4% slope, it then follows that high rates of erosion recorded for the area may be due to land use and management as light vegetation, cultivation and built areas cover 73% of the land area and classified as moderately to extremely vulnerable to erosion. The result at landscape and plot scale varies. Therefore, it was recommended that a control system should be put in place using GIS Control measures based on engineering structures is required, which includes the construction of terraces, waterways, concrete structures and porous barriers.

Keywords: mapping, vulnerability of soils, gully erosion hazard, geographic information system

Introduction

Going by the current trend and recent findings, Soil erosion is a worldwide natural disaster and a number of studies had been undertaken with a view to grasp a clear understanding of its origin, processes, factors, effects, and control. Experimental studies have been done through simulated rainfall conditions to assess the influence of certain factors and processes of soil erodibility under ambient and controlled conditions. The review may not be complete without considering the soil genesis and classification, soil properties and the geomorphic/climatic influences and the three facets of soil erosion. This becomes indispensable since Biological and Engineering control measures are based on soil classification, properties which in turn have climatic influences. As opined by Igbokwe (2004) time state factor for soil formation comprises: climate, organisms, soil, relief, parent material and time. The nature of organic and inorganic colloidal material and resultant cohesive forces binding the soil particles into aggregates are among other factors that contribute to soil erosion. As opined by Ayeni, Nwilo, and Badejo (2004) time factor could be supplemented by an additional factor and that is the degree of weathering and soil formation. The factor and sub-factor involved are primarily controlled by climate and parent rock or parent material. The behavior of soils as an open system where loss and reception of material and energy take place at the boundaries (Hughes *et al*2001). Many studies have come out with results or intricacies of soil formation processes, including overlapping activities. However, a number of events may take place simultaneously or in sequence to mutually reinforce or contradict each other (Igbokwe et al (2003), Egboka (2004). As opined by Egboka (2004) Soil formation processes comprises organic and mineral material addition to the soil as solid, liquids and gases, losses of these from the soil, translocation of materials from one point to another within the soil and transformation of mineral and organic substances within the soil. Akamigbo and Asadu (1983) opined that the parent rocks (parent materials) of sedimentary soils of South-eastern Nigeria tend to influence strongly the texture, soil reaction, acidity, basicity, soil depth, colour, coarse material content and profile drainage**.**

Furthermore, as opined by Lal, (2001) factors such as land use, soil management, farming/cropping system, land tenure, marketing and industrial support has the high value of importance among anthropogenic factors. Not only development factors influence the soil erosion, but also lack of development and poverty also contribute to soil erosion. Soil degradation interacts dynamically with poverty, and can cause more vulnerable environmental situation and serious problems on soil management for subsistence agriculture (Majid, Azlin and Said 2012). Geographic Information System (GIS) technologies played important role in enhancement of the soil erosion models. For example, use of spatial images and Digital Elevation Model (DEM) under these techniques and technologies help practitioners to acquire the model’s data requirements (Majid, Azlin and Said 2012).

In consideration of the available information and contributions as documented by authors acknowledged above, it is therefore the intention of this research to document findings on the assessment and mapping of gully erosion hazard using geographical information system in Imo State.

Statement of the Problem

Inspite of technological advancement, erosion menace still remains a major problem in Nigeria, especially in South Eastern Nigeria.In order to protect the environment and the natural resources for the future generations, it is important to assess and map areas of Imo State that are vulnerable to gully erosion. Furthermore, in order to plan for a better environment with appropriate decision-making policy, the evaluation of this environmental hazard is important; hence the decision to carry out this research.

Objective

To use field sampling to map soil properties and soil erodibility with a view to depicting the spatial distribution of gully erosion hotspots in Imo State.

LITERATURE REVIEW

Geographic Information System (GIS)

According to Odujoko (2001) technological advancements have brought about new ways through which large volumes of geographic information can be analyzed and displayed faster and better. Thereby, producing a system with 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. This system is known as Geographic Information System (GIS). The term Geographic Information System (GIS) has come to mean a tool, a product, a technology and a science. As such, the term involves difference perceptions depending on whether the viewpoint is that of the software developer, the system marketer, the data provider, the application specialist or the academic researcher, among others. A newcomer to the field is likely to be bewildered by the multiple uses of the same terms. One of the many definitions of Geographic Information System is stated below. Geographic Information System is a computerized tool for capturing, storing, checking, integrating, manipulating, analyzing and displaying data, which are spatially referenced to the earth. It is normally considered to involve a spatially referenced and structured digital database and appropriate application's software, (*Department of Environment, 1987, Kufoniyi, 1998).*

Whatever way Geographic Information System is defined they reveal that:-

(1) It is a computer based system

(2) Uses spatially referenced or geographic data, and

(3) That it carries out various management and analysis task on these data, including their input and output.

Geographic Information System can be viewed as a software package, the component being the various tools used to enter, manipulate, analyze and output data. The component of a Geographic Information System include: the computer system (hardware and operating system), the software, spatial data, data management and analysis procedure and the people to operate the Geographic Information Systems. *(Ian Heywood, Sarah Cornelius and Steve Carver, 1998)* One of the best ways to introduce Geographic Information System is to consider the generic types of questions it has been designed to answer. These include questions about location, patterns, trends and conditions:

Where are particular features found? What geographical pattern exists? Where have changes occurred over a given time period? Where do certain conditions apply? What will the spatial implications be if an organization takes certain actions?

The Department of the Environment (1987) list the capabilities that a well-designed Geographic Information System should be able to provide:

(1) Quick and easy access to large volumes of data.

(2) The ability to: Select detail by area or theme; Link or merge one data set; Analyze spatial characteristic of data; Search for particular characteristic or features in an area; Update data quickly and cheaply; Model data and assess alternatives.

(3) Output capabilities (maps, graphs, address list and summary statistics) tailored to meet particular needs.

In short, Geographic Information System can be used to add value to spatial data. By allowing data to be organized and viewed efficiently, by integrating them with other data, by analysis and by the creation of new data that can be operated on in turn, Geographic Information System creates useful information to help decision making. Some authors consider that there are important elements of a Geographic Information System in addition to those common to the definition above.

As opined by Tasneem Abbasi and S.A Abbasi (2012) Geographic Information System is a computer based information system which attaches a variety of qualities and characteristics to geographical location and helps in planning and decision making. *Maguire (1991)* offers a list of 11 different definitions. This variety can be explained, as *Pickles (1995)* suggests, by the fact that any definition of Geographic Information System will depend on who is giving it and their background and viewpoint. Pickles also considered that definition of Geographic Information System are likely to change quickly as technology and application develop further. Some of the shorter definitions give an idea of what a Geographic Information System is albeit in a superficial way. For example, *Rhind (1989)* proposed that Geographic Information System is a computer system that can hold and use data describing places on the earth's surface. *Burroughs (1986)* suggests that Geographic Information System have three main elements, computer hardware, application software modules and a proper organizational context. Others such as *Maguire (1989),* stress that data are the most important part of Geographic Information System. Paul A. Longley (2011) revealed that Geographic information system (GIS) are a special class of information systems that keep track not only of events, activities, and things, but also of where these events, activities, and things happens or exist. In practice, none of the main elements (the computer system, data processing tools) will function as a Geographic Information System in isolation, so all might be considered of equal importance. However, it is perhaps the nature of the data used and the attention given to the processing and interpretation of these data that should lie at the center of any definition of Geographic Information System (GIS). The functions that Geographic Information System can perform include: input, storage, management, query and analysis, manipulation and visualizations of voluminous geographic data. There are a few industries that are realizing the value of Geographic Information Systems. They include: Agriculture, Banking, Education, Environment, Management, Federal Government, Forestry, Health, Insurance, Law enforcement, Logistics/Vehicle Management, Mining, Public Safety, Real Estate, Retail Business, State and Local Government, Telecommunications, Transportation, Utilities *(ESRI, 1999*).

Basic functions of Geographic Information System (GIS)

There are three basic functions of every Geographic Information System package, they are;

- To store and manage geographic information comprehensively and effectively.
- To display geographic information depending on the purpose of use.
- To execute query, analysis and evaluation of geographic information effectively.

Benefits of a Geographic Information System (GIS)

A very good and properly designed Geographic Information System package has the capability of providing new and flexible forms of output such as customized maps in both digital and analogue formats, reports, address lists, etc. It should be able to support quick and easy access to large volume of data, to select terrain detail from the database by area or theme, to merge one data set with another, to analyze spatial characteristics of data, to search for particular characteristics or features in an area, to update data quickly and be able to answer to complex land-related questions, (Mitasova, *et al* 1996).

A Geographic Information System has five basic components that work together so as to meet our various or composite needs. They are hardware, software, data, procedure and expertise.

Geographic Information System as an Information and Decision Support System

Information refers to a data element of some kind which is useful for a particular application such as decision making process. Information and communication technologies are generally a new industrial revaluation already as significant and far - reaching as those in the past. This revolution has added new capacities to human intelligence and consequently changed the way we work, the way we live together and the way decisions are made.

An information system is defined as computer based tools for the collection, storage, analyses and retrieval of various kinds of data for decision making. Geographic Information System is thus a special type of an information system.

Relationship between information system and GIS

GIS	INFORMATION SYSTEM
User + Other GIS DBMS + Application Software Spatial Database Procedure	Environment Information Processor Information Base Grammar

Source: Relationship between information system & GIS (Pullar & Springer, 2000).

In a decision making process, inadequate or insufficient information limits the options available to the decision matter *(Philip, 2004*). This is the problem to which a Geographic Information System is tailored to solve. Its ability to link spatial and a spatial data makes it perfect for the generation of more complete information for decision making.

Development and Implementation of a Geographic Information System (GIS)

Derby (2004) identified three issues involved in the development and implementation of a Geographic Information System (GIS) package. They are;

1. Planning as well as budgetary considerations

2. Availability of appropriate graphical and descriptive data types, minimum standards, and management skills.

3. Constant communication among the development teams, stakeholders and potential users.

Thus, in the design of a Geographic Information System package, the entire system is developed around current and future applications that need to be supported by the system. The design involves two major steps, they are;

i. Planning and organization
ii. Design and implementation

In the planning and organization stage, input are gotten from users such as decision makers, management staffs and the public through direct interviews or indirectly through survey and questionnaires. Data collected on user's activities and resources determines and of course forms a framework for the design and implementation of the proposed Geographic Information System (GIS) system. The analysis of the data identifies the data types needed as well as their optimum resolution and required accuracy, their structure and the required capacity of the system to support the activities of multiple users. This information is very important for developing a Geographic Information System (GIS) system with a functional database structure and content, efficient institutional support for implementation and in infrastructure that would be able to handle both current and future Geographic Information System information needs.

The design and implementation stage involves conceptual database design, establishment of minimal accuracy standard for graphical database and definition of minimum capability requirements for hardware, software networking and data communications. Most times the numbers of Geographic Information System application increases over times, thus Geographic Information System should be designed to accommodate new data and perform more complex analysis. This implies that data should be structured in a way which ensures easy expansion of the database and facilities for the addition of new data.

GIS in Soil Erosion Assessment

The conventional methods proved to be too costly and time consuming for generating this input data. Besides with the powerful spatial processing capabilities of Geographic Information System (GIS) and its compatibility with remote sensing data, the soil erosion modelling approaches have become more comprehensive and robust. Multi-temporal satellite images provide valuable information related to seasonal land use dynamics. Satellite data can be used for studying erosional features, such as gullies, rainfall interception by vegetation and vegetation cover factor. DEM (Digital Elevation Model) one of the vital inputs required for soil erosion modelling can be created by analysis of stereoscopic optical and microwave (SAR) remote sensing data.

Geographic Information System (GIS) has emerged as a powerful tool for handling spatial and non-spatial geo-referenced data for preparation and visualization of input and output, and for interaction with models. There is considerable potential for the use of GIS technology as an aid to the soil erosion inventory with reference to soil erosion modelling and erosion risk assessment. A GIS can be used to scale up to regional levels and to quantify the differences in soil loss estimates produced by different scales of soil mapping used as a data layer in the model. The integrated use of remote sensing and GIS could help to assess quantitative soil loss at various scales and also to identify areas that are at potential risk of soil erosion. (Saha *et al.*, 1992). Several studies showed the potential utility of GIS technique for quantitatively assessing soil erosion hazard based on various models (Saha et al, 1992, Shrestha, 1997, Suresh Kumar and Sharma, 2005). Considering the inaccessibility of the hilly terrain if it is extensive area, RS is essential to accommodate spatial variability and information. Spatial modelling involves the use of GIS for representation of the conceptual model and performance of simple mathematical computations on the stored GIS object attributes for displaying the results spatially.

RESEARCH METHODOLOGY

Study Area

Imo State is one of the 36 states of Nigeria and lies in the south eastern part of Nigeria with Owerri as its capital and largest city. Imo State came into existence in 1976 along with other new states created under the leadership of the late military ruler of Nigeria, Murtala Muhammad, having been previously part of East-Central State. The state is named after the Imo River. Part of it was split off in 1991 as Abia State, and another part became Ebonyi State. The main cities in Imo State are Owerri, Orlu and Okigwe. The Orashi River has its source in this state. The local language is Igbo and Christianity is the predominant religion, its citizens are predominantly farmers and artisan.

Imo State derives its name from Imo River, which takes its course from the Okigwe/Awka upland. It lies within latitudes 4°45'N and 7°15'N, and longitude 6°50'E and 7°25'E. It occupies the area between the lower River Niger and the upper and middle Imo River. Imo State occupies the area between the lower River Niger and the upper and middle Imo River. Imo State is bounded on the east by Abia State, on the west by the River Niger and Delta State; and on the north by Anambra State, while Rivers State lies to the south. Imo State covers an area of about 5,100sq km.

Climate and Vegetation

Rainfall: Rainfall is an important element of far reaching consequences to the problem of soil erosion. The period for rainy season is between April and October. The average annual rainfall of the study area is about 2300mm.

Sunshine: Maximum sunshine hours are usually recorded in the dry months of January to April and November to December, when the mean monthly maximum is about 6 hours. Lower values of about 2 hours are recorded for the wet months of May to October.

Temperature and Evaporation: Owerri West L.G.A have tropically dry and wet climate. Average daily minimum temperature is about 19^{o}C. Evapotranspiration is estimated at 1450mm per year.

Relative Humidity: Relative humidity is lower in the dry period of January to March and November to December with values of about 95% for wet periods, the value increases up to 97% or more.

Population:

According to 2006, National Population Commission Census (NPC) the population of Imo State is 4,800,000 million and using the population estimate of 2.5% annual increase the population of the area at the end of 2014 will be 4,920,000 million with a population density varies from 230-1, 400 people / sq. km. its population makes up 2.8% of Nigeria’s total population.

Research Design

The design of a study defines the study type (descriptive, correlational, semi-experimental, experimental, review, and meta-analytic). In our present study we would use the experimental design.

Data Acquisition

The data collected for the study are classified into primary and secondary data. The primary data are coordinates of already existing gully sites obtained from GPS observations during reconnaissance survey of Imo State. Secondary data source includes information on rainfall distribution from January to December, 1982-2008 collected from records of NIMET. Existing road network, settlement distribution, administrative map, drainage patterns and vegetation/land use was obtained from ASTAL Uyo whereas geology, rainfall, relief, and soil maps printed and published by ministry of lands, survey and urban planning, Owerri, Imo state from 1980-date were collected. The elevation data (DEM) and contour map of Imo State for 2014 was derived from Advanced Space borne Thermal Emission and Reflection (ASTER).Available paper maps were scanned to digital/raster image. The scanned maps were geo-referenced and digitized in ArcGIS software environment.

Spatial Analysis using GIS

Operations

Map Overlay- combination of two separate spatial data sets (points, lines or polygons) to create a new output vector data set.

Spatial Query- a query was built by choosing a Field, then an Operator, then a Value.

Feature Identification on GIS - each layer in an Arc Map has a table storing attributes about the geographic features it contains.

Buffering- a geographic buffer is the area that contains all features that are closer or equal to a specified buffer distance from the boundary of a feature or set of features. This was used to buffer towns affected by erosion and next affected town putting in mind rate of erosion runoff.

Nearest Neighbor Statistics- the average nearest neighbor distance tool was used to measures the distance between each feature centroid and its nearest neighbor's centroid location. It then averages all of these nearest neighbor distances. If the average distance is less than the average for a hypothetical random distribution, the distribution of the features being analyzed are considered clustered. If the average distance is greater than for a hypothetical random distribution, the features are considered dispersed. The index is expressed as the ratio of the observed distance divided by the expected distance (Expected distance is based on a hypothetical random distribution with the same number of features, covering the same total area). Hence if the index is less than 1, the pattern exhibits clustering; if the index is greater than 1, the trend is toward dispersion. This was to examine the distribution points in the study area (Imo state).

Geostatistics is a point-pattern analysis that produces field predictions from data points. It is a way of looking at the statistical properties of those spatial data. The Geostatistics wizard was used to produce prediction map (using ordinary Rigging) Erosion hazard map (in the study area).

Fieldwork

A reconnaissance survey was carried out in the study area to identify sampling points. Sampling points were chosen in each selected site using free survey technique (observation points that are representative of the site are chosen by the surveyors based on personal judgment and experience) (Mulla and McBratrey, 2000).

The 5 soil groups representing soils formed over alluvium, coastal plain sands, Imo shale clay, and upper coal measures were selected. Three auger and three core samples were collected from 0-20 cm depth in each of the site. The auger samples were composited and its sub-samples used for analysis whereas the core samples were analyzed separately and mean results computed and used for statistical analysis. Differences in management practices and edaphoclimatic properties of the soils influenced the choice of the different sites.

Laboratory analyses

Soil samples were air-dried and sieved using 2-mm mesh sieve before laboratory determinations. Particle size distribution was determined in both distilled water and calgon by hydrometer method (Gee and Bauder, 1986). Thereafter dispersion ratio, used as indirect measures of erodibility was computed as follows:

Erosion index (EI) DR

% clay/ ½ WHC

Where DR = dispersion ratio

WHC = Water holding capacity

Dispersion ratio (DR) % silt + % clay (H^20)

% silt + % clay (calgon)

Particle size distribution (textures) was obtained by the hydrometer method (Gee and Or, 2002). Soil water holding capacity was determined on undisturbed samples as the difference

Location	Co-ordinates Latitude Longitude	Elevation (Meters)	Parent material	Dispersion Ratio (%)	Remarks
Nneato	6^0 2' 53''N 7°37'23''E	330	Upper Coal measures	82	Highly Erodible
Ihube	5^0 48' 46''N 7°35'54''E	300	Upper Coal measures	78	Highly Erodible
Oforola Owerri	5^0 43' 14''N 7°37'34''E	67	Coastal Plain Sands	63	Highly Erodible
Arondizogu	5^0 59' 58''N 7°34'37''E	294	Clay Shale	58	Highly Erodible
Oguta	5^0 53' 16''N 7°20'32''E	66	Alluvium(Lacustrine Deposit)	71	Highly Erodible

of water contents at –0.03 MPa determined by pressure plate and water content at –1.5 MPa determined by pressure membrane (Dane and Hopmans, 2002).

Erodibility Classes

For the purpose of this study, five erodibility classes were used to depict the vulnerability of the soil to erosion as follows;

1. Extremely vulnerable
2. Highly vulnerable
3. Moderately vulnerable
4. Slightly vulnerable
5. Less vulnerable

Results and Discussion

Soil Properties

The major soil class found in Imo State is Ultisols. However, several different types of Ultisols are found in different places at lower classification levels and that infers that each of these has properties that affect soil degradation differently. Soils vary in their resistance to erosion partly based on texture and amount of organic matter. The resistance also depends on soil condition and depth. Soils high in silt and low in clay and sand are highly erodible (Nill et al. 1996). The high erodibility of silty soils is explained by their weak structural stability. They rapidly form surface seals upon the impact of rain drops. Erosion is less on clayey soils due to better aggregation and on sandy soils due to the non-sealing surface. Most of the differences in soil characteristics highly depend on the type of parent material found in the study area.

A total of seven (7) different parent materials were found in the study area. As earlier mentioned, five sites representing four of the seven parent materials were identified in the study area and soil samples and field measurements taken from the sites to complement GIS studies. The results showed that all the soils exhibited very high dispersion ratios ranging from 58-82%. As expected, the dispersion ratios were affected by the type of underlying parent material. The highest dispersion ratios were found in Nneato (82%) and Ihube (78%) representing sites in Upper Coal measures. Oguta site representing Alluvium (Lacustrine Deposit) had a dispersion ratio of 71% whereas Oforola Owerri site representing Coastal Plain Sands and Arondizogu representing Clay Shale had dispersion ratios of 63 and 58 % respectively. According to Middleton (1930) soils having dispersion ratio greater than 15% are erodible in nature.

Summary of Findings

Results show that most of the soils in the study (79.9 %) are classified as highly to moderately vulnerable to erosion based on the RUSLE soil erodibility classification. This means that the combined effect of cultivation (33%), light vegetation (37.2%) and human settlements (9.1%) combine to expose the soils to greater risk of gully erosion. Thus 80% of the soil of Imo State will be classified as highly vulnerable to erosion. Moreover, changes in precipitation volume and intensity caused by climate changes may increase the energy available in rainfall for detaching and carrying sediments. According to Yang et al. (2003), the global average soil erosion is projected to increase approximately 9% by 2090 due to climate changes.

Although soil erosion is a natural and inevitable process, the accelerated rates of soil loss, caused by the factors mentioned above, represent a serious environmental problem. For instance, increased rates of soil erosion are directly associated with nutrient loss, which may reduce agricultural productivity (Bakker et al., 2007) and cause water bodies' eutrophication (Istvánovics, 2009). In some cases, advanced stages of soil erosion, such as rill and gully erosions, can devastate entire areas, turning them unusable for agricultural purposes (Valentin et al., 2005; Kirkby and Bracken, 2009).

Conclusion

Technological advancements in the world today have led to better, efficient and effective techniques of information management. From time to time a lot of information is being generated about earth resources and effect of human activities on these resources, thus creating a need for managing and planning. The use of GIS will help greatly in the acquisition, organization, management and analysis of these large volumes of data, allowing for better understanding of natural disasters and the importance of record keeping for future use.

From the deduction of the analysis performed it is evident that these gullies are a continuous process and occur due to the geographical surface of the state (the heights), nature of the soil in the state and high population density of the state; soil runoff which takes place after rainfall. And also excavation is becoming a major treat to erosion in the state and there is a need to control these gullies in order to reduce runoff. This project has provided a GIS Gully hotspot database for Imo state using Arc view GIS version 3.2a The project is coming at a time when there is need for the improvement on the methods of acquisition, organization, presentation, manipulation, interpretation, management and analysis of spatial information about ecological hazards and how to tackle them in Imo Sate thereby helping to give planning, development, management authorities there necessary assistance for decision making. The use of GIS technologies will offer better and relevant ways through which geographic information can be presented.

Recommendations

Due to the disastrous nature of Gullies, it should be controlled. With the application of GIS a control system should be put in place. There are certain requirements that are necessary in order to have a good and functional GIS for Imo State.

Firstly, there must be the establishment of a GIS Database Unit at strategic locations in Imo state. It shall be responsible for the acquisition of all data to be included in the Imo State Database from time to time.

Secondly, there must be adequate education on the use, relevance and need of GIStechnologies. This will also involve training (and practical exposure) of officers of this unit and other relevant government departments / Establishments on the advantage of GIS from time to time. The training will involve diverse methods of acquisition, organization, presentation, manipulation, interpretation, management and analysis of spatial information for use in Imo State.

Thirdly, there must be provision of software, hardware-personal computers (PCs) with standard GIS requirements and other relevant equipment for the use of the unit. The acquisition of appropriate texts and useful materials to help the development of these individuals is also recommended. All these would require upgrading / updating from time to time to measure up to increase functions.

Finally, a web site for the GIS erosion database for Imo State should be created.

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