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Geographic Information System (GIS) in Cadastral Management

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Abstract: **Geographic Information System is a modern tool that is employed in virtually all disciplines including Surveying and Geoinformatics. However, cadastral management reguired adequate, accurate and up-to-date data to continue to perform. The paper examines the adoption of Geographic information system(GIS) in Cadastral management. It x-rays the survey methods in order to confirm their efficiency and effectiveness in the adoption of Geographic information system (GIS) as a potent tool in Cadastral management. It highlights some challenges associated with its adoption. However, for an effective Cadastral management it is opines that Geographic information system (GIS) should be incorporated into its management system.**

Keywords: **Cadastral, Management, Geographic, Information.**

1. INTRODUCTION

According to the International Federation of Surveyors (FIG 1995), in Stig and Hans (1999), defined cadastre as:

> *"a parcel based and up-to-date information system containing a record of interests in land (e.g. rights, restrictions, and responsibilities). It usually includes a geometric description of land parcels linked to other records describing the nature of interests and ownership or control of those interests and often the value of the parcel and its improvements".*

Odedare (2001) described three main aspects of cadastre as first, the Fiscal aspect, which is concerned primarily with generating revenue for constitutional authority. The second is the legal aspect, which binds the interests of the land attached to a particular person or group of people and lastly, the technical aspect that spells out the method of demarcation survey and preparation of plans for the plots. The technical aspect is powered by a cadastral system.

More succinctly, a cadastral system consists of collection, recording and storage of all information related to individual land parcels. Cadastral surveying is that which establish and record the location, boundaries of features thereon and ownership of land and property. This is one of the data sources in Geographic Information System.

According to Nwilo, e tal (2010), GIS is a system for capturing, storing, manipulating, analyzing and presenting geographically referenced data. It is a multidisciplinary concept because it cuts across virtually every profession. They, however, stressed further that basically a GIS consists of a set of tools that professionals in various disciplines use to improve the way they work. GIS allow many different types of data to be geographically viewed, organized and analyzed. This information can be used to computerize Cadastral register. According to Stig and Hars (ibid), the computerization of the old analogue cadastral maps were done, the automatic linkage between the subsystems is achieved by establishing the cross reference register, which contains all key identifications with each of the subsystems (e.g. the parcel number, its building number, the address, etc) and the cross-reference between these identifications. This means that it is possible to obtain all available information on a specific property or building by knowing only one of the keys. Furthermore the identification-keys are linked into the relevant physical element represented in the digital maps e.g the parcel, the building. The main feature of this concept is that the daily running of the individual subsystems should, whenever possible, be decentralized and the maintenance should relay on an integration of the data-collection within the administrative routines.

The responsibility for the vitalization of the systems should rest with those (custodians) who need the data and therefore care for the updating procedures and the applications as part of their daily administration routines. The digital cadastral system is designed for application into this GIS – Concept (Stig and Hars, 1999).

Cadastral operation and management is one of the foremost front-runners among the numerous disciplines in the application and/or use of GIS. The source of information for Cadastral documents is majorly through conventional surveying and mapping, which is the scientific collection of Cadastral data/information.

2. CADASTRAL DATA ACQUISITION

The creation of database for Cadastral Surveying involves the collection of both spatial and non-spatial data. Primary data acquisition method by land surveying is good for capturing spatial (geometric) data, while attribute data can be obtained through social surveys and personal contact. The major source of data for geo-information system are the classical surveying methods, aerial images, satellite images, topographic maps, statistical data, historical data, and descriptive data. Data collection is the most expensive part of a spatial information automation project. If GIS is all about the management of spatial and attribute data, the acquisition of the data therefore, is paramount and of immeasurable value in its GIS operation; because without sufficient and accurate data there can be no GIS (Ayeni, 2001). Hence, the availability of relevant and current data is of valued interest to a GIS operator. According to Iyiola (2006), the backbone of any GIS is good and reliable data. Inaccurate data will generate inaccurate models and maps.

The professional surveyor's primary assignment in GIS application for Cadastral management is the scientific acquisition, processing and logical presentation of Cadastral data/information. Prior to the development of GIS, analogue equipment was the order of the day but with the coming of GIS and the advancement in Information Communication Technology (ICT), there had been severe paradigm shift in the Surveyor's tools and methods. Data capturing entails all the field procedures, methods and operation carried out so as to obtain the require data from reality. Care has to be taken to ensure that the data are accurately acquired because these data are to be used to build up database for various applications.

2.1 Equipment:

The ability to locate objects on the earth surface and its presentation in form of map or plan are now being influenced to a considerable extent by developments in the fields of electronic and information technology. Measuring, which means determining the position of objects in a reference system, becomes a fully automated processes with the use of the following major equipment like

i. Electronic Theodolites
ii. Digital level
iii. Total Station
iv. Global Positioning System (GPS)
v. Digital Camera
vi. Satellite
vii. Unmanned Aerial Vehicle (UAV)
viii. Smart Stations etc

2.1.1 Total Station (Electronic Tacheometer):

The Total Stations are advanced brands of Digital Theodolite. It measures and compute distances and bearings at each station, it has a higher storage capacity for storing acquired data. It has an internal processing capacity to compute coordinates. Electronic Total Station is an integrated computerized surveying equipment which incorporated both digital theodolite and Electromagnetic Distance Measurement (EDM) equipment. It is equipped with software, which make it possible to process and compute data in real time (Abubakar, 2001).

2.1.2 Digital Level:

A digital level is an electronic version of optical level. It is a level with digital electronic processor for determining heights, distances and recording the results automatically. During measurement procedure the whole of that part of the bar code is visible in the field of view and it is captured as the measurement signal by an infrared sensitive line detector. This measurement signal is then correlated with the reference signal while the staff reading and the horizontal distance are displayed as the result. This instrument can assist in determining height of points on the earth surface (Abubakar, 2001).

2.1.3 Global Positioning System (GPS):

The Global Positioning system (GPS) equipment is one of the recent data acquisition system. It observes and determines location and position (coordinates) of points on the earth surface directly. Its reference is satellites in space, and this made it very easy and fast in data acquisition. It is based on a constellation of twenty-four satellites which act as reference point

from which records triangulate in them to the ground position. Based on the travel time of signals transmitted from the satellite, a GPS receiver on the ground can determine its distance from these satellites. With distance measured from four different satellites, the receiver can calculate its latitude, longitude and height (Abubakar, 2001).

2.1.4 Other Equipment:

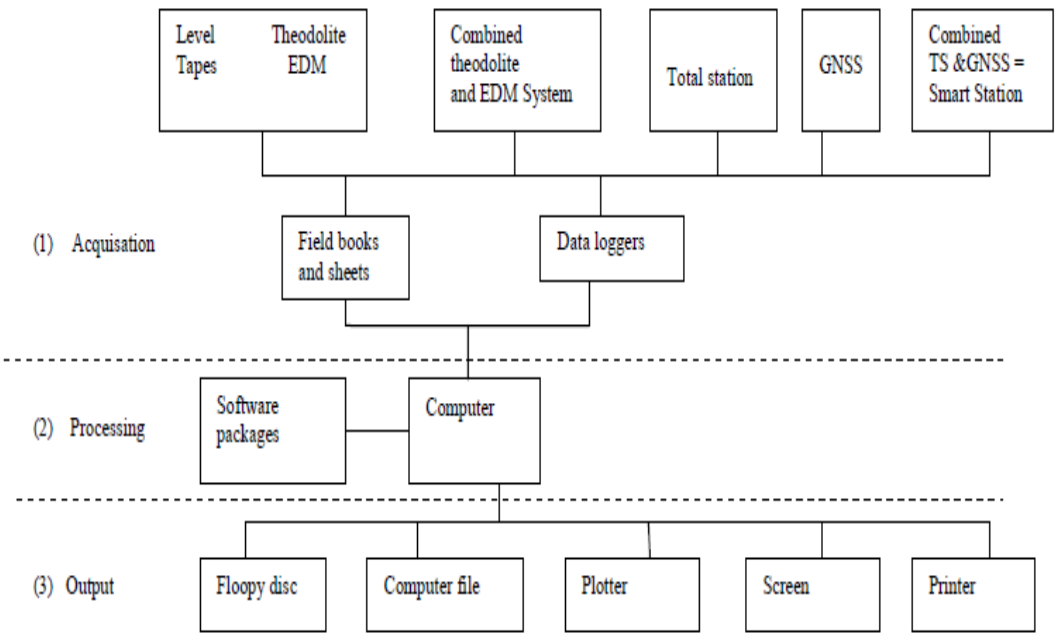
The second categories of equipment are those that acquire pictoral information of objects in space. They include Digital Cameras of which smaller ones could be used on land and the bigger and more sophisticated ones are mounted on Airplanes called Mapping (photo) planes for aerial photography of the earth's surface. The information so acquired can be processed to produce a two or three-dimensional spatial view of objects on the earth surface at different scales of presentation. It has the advantage of very high resolution (Akinyede, 2004).

Another method of spatial data acquisition is the use of satellites to acquire satellite imageries through Remote Sensing technique and observes the pictorial view of the earth's surface as can be captured from the satellite. The satellite imageries can then be processed to obtain two or three-dimensional spatial information (Akinyede, 2004).

3. PRESENTATION OF RESULTS IN FORM OF MAPS OR PLANS

The traditional method of survey plans or maps production is by hand. The process of analogue survey plans is extremely time consuming and very often, the Surveyor does not have the ability to achieve the required high standard of presentation in inked work but needed someone skilled in hand draughting techniques for tracing and annotating (Uren & Price, 1994).

In the presentation of the surveying results, the production of maps or plans is being replaced by the ability to create digital model. With the utilization of information management technologies, the surveying and mapping processes have changed substantially. Computer Aided Design (CAD) is now widely used as an important tool to improve the performance of cadastral system. CAD is designed for construction industry professionals, and takes advantages of high-level drafting technology, cartographic and plotting functions e.g. Autocad, Microstation, etc. The AutoCAD is an ideal software for management of cadastral records. The use of CAD is now wide spread in the surveying and mapping industry particularly in automation of cadastral records. Therefore, the need for further research to the development in the CAD skills is an important veritable tool for sustainable development (Iyiola, 2006). It involved three stages, acquisition of raw data, input into the computer, and output.



(Source: J.Uren & W.F. Price, 1994)

Fig. 1: Computer Aided Plotting System

3.1 GEOGRAPHIC INFORMATION SYSTEM AND CONCEPTS OF GEO-INFORMATION:

Any observed feature or phenomenon exits in space and time and therefore has a spatial (geometric) and a temporal extent. Thus, information has to be related to a specific location on earth while the system refers to anything that has component which are interrelated and work together to perform certain functions bordering on decision making. The central theme of Geographic information system is spatial object which has three main components namely;

(i) Geometric component

(ii) Temporal component

(iii) Attribute component

The Geometric component represents the locational (co-ordinates) information while the temporal and attribute form the non-spatial information. Spatial information is a type of information which includes a reference to an n-dimensional position in space as one of its attributes. A geographic information is any information which can be related to a location on earth, particularly information on natural phenomenon, cultural and human spatial information.

3.2 BASE MAP:

A veritable component that is highly essential is Base map. Base map can be described as a collaborative effort to create a widely available source of basic geographic data. It provides the most common data themes geographic data users need, as well as an environment to support the development and use of these data (Afolayan, 2008). He stressed further that base map data provide general base mapping information that people can use to derive additional geographic information that supports their own project requirements. However, the two categories of information earlier mentioned are not in themselves sufficient for GIS operation when they are not combined together. The process of combining the locational (coordinates) and the spatial (capriconia) information of objects in space is called Geo-Referencing (Nnabugwu, 2007). However, (Kasianchuk and Taggart, 2004) simply put Geo-referencing as the process of establishing a relation between the data displayed in your GIS software and its real – world location. These two are processed together to produce Digital Base Maps which forms the basis for GIS operation. Any GIS project requires input of relevant data (spatial and non-spatial data) in digital form and this depends on the available data type. Good and accurate data must be entered in the system before you can get reliable results from GIS analyses.

4. GIS AND MAPPING

The availability of specific and functional maps is paramount in Cadastral management, because the manipulation of Cartographic data (map) together with attribute data (Cadastral Records) is the major feature of GIS. Hence the first stage in Cadastral management is the availability of functional and up-to-date or current maps. As aforementioned, this is an area where the professional surveyor is of immeasurable value to the implementation of GIS in every facet of life.

Digital maps can be produced directly nowadays with the use of the aforementioned various digital methods of field data acquisition. But this is rather very expensive. It is sad to know that State Governments talk less of Local Governments, don't dabble into it in Nigeria while the Federal Government approaches it cautiously. For this reason, most GIS projects resort to Digital Map Creation from existing Analog maps. There are two methods for converting existing maps into digital formats, namely scanning and digitizing.

Digitizing is the process of redrawing existing maps by using digitizing tables; while scanning is the conversion of existing map through a raster to vector using an optical scanner. This can be done by three different methods such as; interactive, which is the use of software command to trace over the image with appropriate objects such as lines, arcs and polylines; Semi-Automatic, the conversion is automatic through CAD overlay LFX from softdesk, and Automatic, which involves automatic programs software such as RxVectory, Ivector, GTXRaster CAD plus, Transcribe Plus and Draftsman Plus (Iyiola, 2006). The process is much faster than digitizing but each system has its advantages and disadvantages. With an existing Digital Base map several other purpose specific functional maps like Cadastral, Thematic, Utility, Land use, Geocode, Demographic etc. can be created with slight updating and the use of GIS application (Afolayan, 2008).

4.1 Importance of Digital Map:

Digital base map produced are very useful to various end users such as Planners, Property Managers, City Engineers, Building Inspectors, Tax Assessors/Collectors, Traffic Engineers, Election Commission, Population Commission,

Community Development, Ministry of Health, The Police, Fire Brigades, Tourists, Water works, for Planning, policy implementation and development, Easy population count, Social security service, Police information system and crime prevention and control, Interstate and local government boundaries demarcation, Utility information system, Inventory management, Easy revenue collection, Easy development control, Easy land use management, Forest and tree preservation, Easy management of certificate of occupancy, Easy property evaluation and assessment (Afolayan, 2008).

5. CADASTRAL DATABASE CREATION AND MANAGEMENT

Database is an organized integrated collection of non-redundant data capable of use by relevant application. Database creation distinguishes GIS from Computer Assisted Mapping (CAM) or Computer Assisted Cartography (CAC). With the advent of computer system, the role of maps as data storage has been taken over by databases. What remain are the visualization functions of maps. Database management system is a collection of software in organizing information in a database. It contains routines in data input, verification, storage and retrieval. Location identifiers are used to process and display the attribute data about features on the map (Ajibade, 1999).

The basic object of interest in the database is the land parcel having technical, legal and fiscal components together with some related datasets (Kufoniyi, 2002). The boundaries of each parcel in the database must be accurately demarcated and surveyed based on the national geodetic framework. For each parcel of land, the following data among others are kept in addition to the geometric data parcel identification and size, real entitled person (owner), real right, date obtained and of alienation of the parcel, price and year of purchase, identification number of water control board, etc. When properly designed and implemented, Cadastral database will supply information on land to various agencies and individuals.

The development of cadastral database for various needs and application to solve our numerous land related problems is a *sine quo non* to the nation's sustainable development. However, it appears that the Federal and State Surveys departments and the private sectors survey firms have not fully accepted and adopted the initiative. A cadastral database system may be seen as a combination of human and technical resources with a set of organized procedure that result in the collection, storage, retrieval, dissemination and use of land information in a systemic way.

6. CONCLUSION

It is an established fact that information, in whatever form, is not an end to itself but a means to an end. Digital base map is important for decision making in all facets of life. The challenges of Information Management in cadastral management is systematically being addressed by application of Geographic Information System. However, the need for proper funding of surveying and mapping sector is a right step in the right direction to be able to actualize these action plans. The benefits to be derived by the provision of timely and up to date cadastral records through surveying and mapping information in all sectors of the economy are enormous and essential for sustainable development in the 21st century. All this information can be packaged as cadastral database for the country. This Cadastral database can provide the essential geospatial information that will facilitate a rapid improvement of our national economy including an efficient management of the nation's natural resources and environment.

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