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# Spatial Cadastral Information System and topographic mapping of a new residential layout

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***Abstract:*** *The purpose of this paper is to produce a spatial Cadastral Information System (CIS) and a topographic feature of the CIS of a new residential layout. Differential GPS has been used to collect 3D coordinates which are later used to geo-reference the base map prior to digitization. The CIS shows equally-spaced resident parcels with area of 1.2 hectares and an undulating hill to the east. Attribute information of individual parcels suggests the possibility of incorporating different government institutions into a single computer system for proper management. This could be useful in enhancing tenement rate, tax identification and collection as well as utility management without missing or duplicating entries. The possibility of updating and retrieving at will any information about any parcel such as parcels with Certificate of Occupancy could be improved. It is recommended prior to establishment of any government layout, Digital Elevation Models (DEM) and its contingents such as slope and flow direction be first made to allow ways of leveling of steep slopes. This will control water flow in case of flood.*
***Keywords:*** *Cadastral Information System, Mapping, Database, DGPS, Planning*

## I. Introduction

The establishment of Cadastral Information System (CIS) has been at the forefront of all applications of Geographic Information Science in Nigeria since the year 2000. Making CIS mandatory in Abuja, the federal capital through the establishment of Abuja Geographic Information Systems (AGIS) let to the advancement of land administration throughout the country. Analogue cadastres are consequentially converted into digital format, solving the problems of duplication of titles and delay in conveyance of Certificate of Occupancy (C of O). With the advancement in the data collection method, and the implementation of CIS in the country, digital mapping has now come to stay, whereby field data are collected, uploaded into a computer system, plotted, mapped, saved and retrieved at will electronically. These maps can be easily edited and also eliminates the cumbersome procedure of handling paper maps.

Although, digital cadastral maps provide a view of plots and their adjoining boundaries, a spatial database is needed to form a complete CIS. Of course, the primary function of CIS is to produce maps that give accurate presentations of a particular area and detailing all features of interest that would be valuable to a user. This database design is the process by which a collection of spatial data from a location is compiled and formatted in to virtual image (Babalola and Kardam, 2011). It is an organized integrated collection of non-redundant data stored so as to be capable of use by relevant applications with the data being accessed through different logical paths, by multiple users and same time access. Digital database can be created in the form of a table of segments, polygons and points using the Structured Query Language (SQL) model of a database software. An interface is then used to link both graphic and attribute component of the database. Systematic queries are then framed and executed. The graphic and attribute result of queries show the elegance of GIS database technology (Kufuniyi, 1998). A complete CIS with topographic maps provide us with the structures for storing geographical knowledge and experience, without which we would find it difficult to orient ourselves in a large environment (Diaz, 2006). To this respect, this study focuses on incorporation of topographic mapping onto the spatial CIS. It is also worth mentioning here that the study area is flood-prone, and hence the topographic mapping could give an idea of the terrain as prerequisite information for construction of drainage channels during planning and maintenance purposes.

Topographic maps represent all physical features and their locations as contour lines, shapes and elevations that include- valleys, mountains, plains, lakes, boundaries, transmission lines and major buildings and other facilities. The wide range of information provided by topographic maps make them highly useful to professional and recreational map users alike. These maps are used for defense purposes, engineering, energy exploration, natural resources conservation, environmental management, public works design, commercial and residential planning and outdoor activities like hiking, camping and fishing. These maps are also very vital in identifying areas vulnerable to flood and erosion. The advantage of having a 3D coordinate of a terrain and then recording the presence of man-made and natural features make it essential for management of land resources. Generally, for us to be able to comprehend physical features on land, the topographic map becomes an essential tool (Bannister, 2006).

There are various techniques used in collecting data for topographic maps. These include tacheometry, an optical instrument process such as theodolites and levels, aerial photography, use of Global Positioning System (GPS), Total Station instrument and mapping using satellite radar (Muhammed et al, 2014). However, the practice of modern surveying is undergoing rapid change due to availability of electronically controlled instruments, the widespread adoption of the Global positioning systems (GPS), and the proliferation of various Geographic and Land Information Systems (GIS/LIS) (Agajelu, 1994; Heinz and Scherer, 1997). Therefore, it is also possible to model topological relationships of various earth surface entities and analysis be performed to predict future trends, and that assist decision makers to facilitate working on spatial environment. Administrative authorities could create a spatial data instruction by which the database may easily be exchanged (Konecny, 2001; Diaz, 2006).

Although, most government layouts in the Yola city and the suburbs have had CIS produced, Shuwari settlement has not being considered yet. This study is aimed at creating a Spatial Cadastral Information System and topographic mapping of a new settlement layout for proper planning and management purposes. The outcome of this research will be valuable to planning, tenement rate collections, utility and flood management.

## II. Study Area

The study area is called Shuwari New Settlement: designed, implemented and managed by the Yola South Local Government of Admawa State, Nigeria. It is located along Yola-Furofe road, and lies between latitude [$9^{O}$ 35' 32" and $9^{O}$ 33' 07" N], and longitude [$12^{O}$ 21' 28" and $12^{O}$ 22' 10" E] of the Greenwich

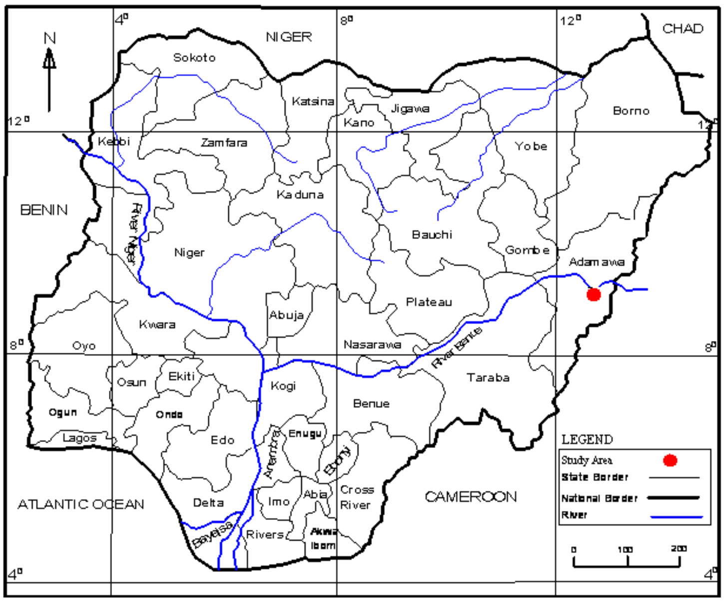


**Figure 1:** Map of Nigeria showing the study Area.

meridian (figure 1). It shares boundaries with Fufore Local Government Area to the east, Mayo Belwa, Demsa to the west Girei and Yola North Local Governments areas to the north. The relief of the study area is generally low from 152.40m (500ft) to 215.70m (707.68ft) above the mean sea level. Some parts of Yola South are located at a fairly flat terrain such as Njoboli village in the east, while other parts are on undulating rough terrains e.g. Eastern and Southern part of the Local Government such as Bole, Rugange and Njoboliyo which are located on the gentle slope of Sedimentary rocks escapement from the bank of the river Benue which forms the boundary from east reaching Njoboliyo.

The climate of the study area is generally temperate. The average monthly temperature fluctuates between 18°c around December and January (coldest months) to 45°c around April (hottest month) which is the peak of the maximum temperature. The average annual precipitation in the study area is about 960 mm. There are two distinct seasons; the dry season which commences from the month of November and ends in April and the rainy season starts from May to October with a higher rainfall recorded during the months of August and

September when the intensity assumes over 25% of the annual value (Muhammed et al., 2014). The dry months are January and February with an average humidity of about 28%. The relative humidity starts increasing gradually from April and reaches the peak (80%) in August and September from it where it starts declining in October to the minimum following the cessation of rains (NIMA, 2004). This paper is organized as follows: 1) Introduction, 2) Study Area, 3) Materials and Methods, 4) Results and Discussion, 5) Summary and Conclusion.

## III. materials and methods

To achieve the aim of this research, differential GPS (DGPS) was used to obtain high precision 3D coordinates (x, y, z). For cadastral mapping, only DGPS can give meaningful results by placing boundaries to their right locations. The reason is that operating the GPS in differential mode improves the accuracy of the GPS by over 65% for both horizontal and vertical coordinates. The GPS used is Promak III, and software used is ESRIS's ArcGIS Desktop 10.1. Transferring the data to the computer is relatively easy compared to optical surveying instruments.

This research uses two forms of data: 1) Primary data, that involves field observations of relevant coordinates of both natural and artificial features such as trees, buildings, drainages, roads, footpaths, electric pole, transformer and spot heights. 2) Secondary data, that include existing maps and plans of the area, coordinates of existing controls, benchmark etc. These are sourced from the Ministry of Lands and Survey, Yola.

Reconnaissance survey was conducted and taken in to account the important features and the inter-visibility between points so that obstacles could be avoided. This also entails the identification of existing controls amongst other factors. In the office, cross checking of existing coordinates and testing their inter-visibility was conducted.

The paper map of the study is scanned and geo-referenced using four control points to allow proper image registration based on the projected coordinate system of UTM WGS84 zone 33N. Having collected sparse coordinates randomly within and outside the study area, it is important to delineate the study area to make it a full entity. To achieve this, the polygon feature in ArcMap was used to extract the study area. The map is then digitized to produce a digital format of the original map. Layout fabrics were then created using points, lines and polygons to represent discrete features such as electric posts, streets and parcels respectively.

Two forms of databases were finally produced. These include: the object-based database which in its formation in a geo-database can be considered as spatial data of plots comprising of Shape ID, Perimeter, and Shape Area. The other is the attribute data of the plots built in a separate file, which are the information on the owners. Basically the entity relationship approach was used in the design of the database for parcels. Here the entity relationship requires that the various entities must have been determined before the commencement of the design. The attribute table was also designed. It is important to note that all the houses are for residential purposes.

Finally, the spatial and attribute databases are related through a query facility in the ArcGIS. Both of these are essential constituents for CIS. The ability to query and obtain information is central in any database.

The spatial analyses extension of the ArcGIS is now used to create contours. The Kridge interpolator made it possible to align contours properly even though the 3D coordinates were not equally spaced. These contours are overlaid on the spatial map, indicating variations of spot heights around the parcels and streets.

## IV. Results And Discussion

A spatial cadastral information system is produced (Figure 2), showing the existing parcels and the streets, as well as query information comprising query table and information about a parcel. The layout appears to have a good road network and having a boundary to the north with the main highway leading to Fufore town. On average, each residential plot is about 1.2 hectares.

The contour map shows lines joining spot heights of equal value. Close to the centre of the layout and to the east lies upper ground while to the south-west is lower ground. By implication, this has given us a view that higher grounds are safer zones during floods. Areas with sparse contours to the south-west are more likely vulnerable to flood.

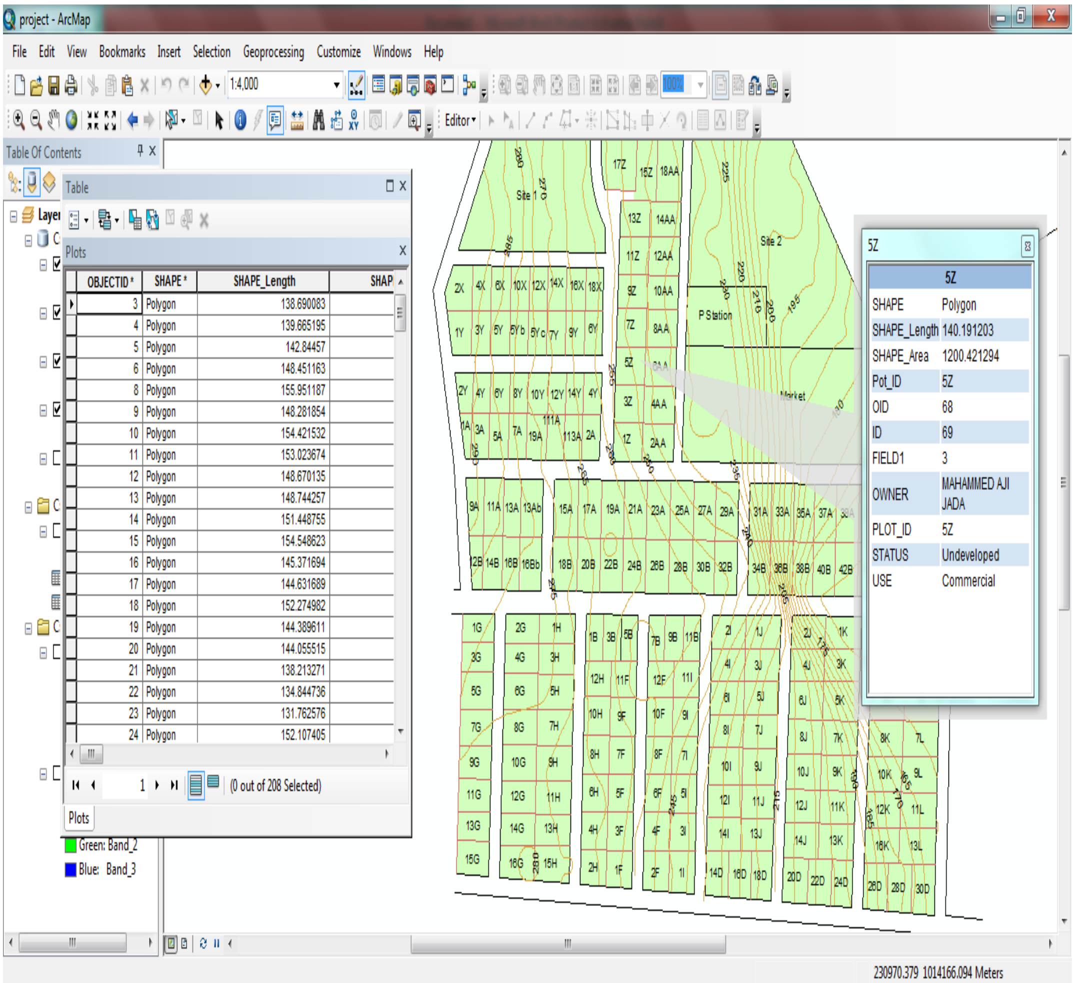


**Figure 2:** Digital map of the study area, contour overlay with attribute table and information about a parcel

Land use is an important aspect of CIS, and figure 3 shows various land uses consisting of residential, public and commercial. As was noted earlier, the layout is purposely residential; however, there is a need for social facilities for the inhabitants. Hence, commercial areas are used for local shopping malls and public areas are used for recreational purposes. The commercial facilities are in a better location for transport of goods and services, having an easy access to the highway Yola-Fufore road to the north. It was observed that only about 5% of the layout was developed (not shown). This is one of the reasons why GPS fixes give proper boundary locations.

Technically, successful management of government layouts depend on a complete understanding and identification of needs, and the coming together of various government establishments. For example, tenement rate collection, tax collection, utility management all should have a one computerised system to be able to properly manage any estate. Estate occupants would also have services rendered to them on timely basis that could also be much more affordable. Therefore, an integrated approach is urgently needed and these should incorporate both local and state governments.

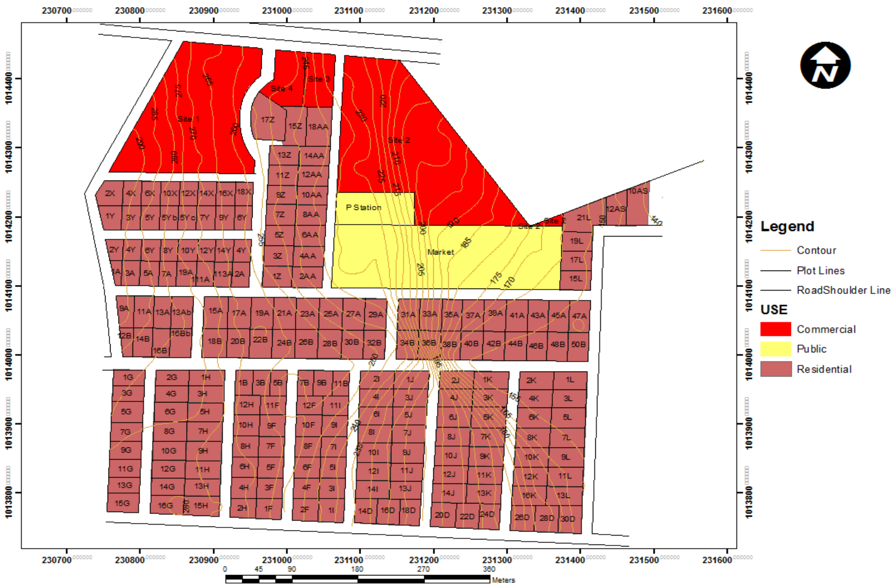


**Figure 3:** Digital map of the study area with contours showing land use pattern.

## V. Summary And Conclusion

The differential GPS has been used in conjunction with layout map that served as a base map to produce spatial Cadastral Information System (CIS). Detailed GPS mapping was conducted, following proper survey guidance to arrive at the results. Existing control stations were used to geo-reference the scanned map prior to digitization. The 3D coordinates of the entire study area, including the boundary points were used to generate contours that are overlaid on the cadastral map. To establish quality of field work, carefulness by the observer was ensued. The position of the observation also matters, because GPS instruments tend not to give correct values when there are biased fixes. In other words, GPS resection on only one side of the horizon gives a biased result. Observations were therefore made while getting correct position fixing. The advantage of this is that there are very few trees and only about 5% of the plots have been developed.

The integration of local and state governments in managing estates will play a key role in proper management for the benefit of both government and residents. These can be in the form of single computerized system that can be accessed by utility managers and the like to harness income and ensure continuity in income flow.

Producing DEM and its contingent such as watershed, slope and aspect prior to layout development could assist further in explaining proper direction of flow when constructing drainages. In addition, if software developers could produce much user-friendly software with Graphic User Interfaces (GUIs) that can accept ArcGIS output into a database would be an added advantage. This is because ArcGIS is more of scientific tool, and less technical personnel should be able to painlessly use the outcome of the tool.

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