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TOPOGRAPHIC INFORMATION SYSTEM FOR EFFECTIVE AND SUSTAINABLE MANAGEMENT OF ENVIROMENT

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Abstract

The need for the production of Topographic Information System (TIS) of Bauchi Metropolis arose due to the non-availability of Topographic Information System for proper planning of Bauchi town. Therefore, TIS was carried out with the aim of producing a tool for effective planning and land management of Bauchi metropolis. Field and office reconnaissance were carried out in order to be familiar with the terrain and do proper planning on the methodology and equipment to be used for the acquisition and assembling of spatial. The geometric (spatial) data were acquired by ground survey method using Dual Frequency Receiver through the process of traversing and spot heights which were carried out simultaneously. The data

Introduction

Surveying has been described as an essential element in every human developmental activity since the beginning of recorded history. It has been discovered to be an imperative requirement in the planning and execution of every forms of meaning development (Bannister et al., 1986). Provision of infrastructure; planning of towns and cities; management of hazardous natural events and human actions such as erosion, flooding, earthquakes and subsidence; coastal management; exploration and exploitation of minerals; sitting of industries; resources exploitation on the land and on the sea are dependent on land surveying products (E.O. Oriola, and Asonibare S.O, 2011). The demand for topographic information for various needs and applications by numerous users is on the increase. From a global point of view, there is

processing was adequately and effectively done using GNSS Solution and the data were downloaded to the computer. ArcGIS 10.3 version was used in generating the Digital Terrain Model (DTM), Contour map, Aspect map, hill shade and flow directional map. The interpretation of the maps supports decision making policy needed by the Land surveyors, Architects, Engineers, Urban and Regional planners to plan, design and execute vital infrastructural projects in Bauchi town. It was recommended that TIS should become a lasting tool for decision making and management of land and its resources for effective and sustainable development.

***Keywords**: Mapping, Topography, Geographic Information System, Interpolation, digital Terrain Model.*

No meaningful development embarked upon by an individual, government and agencies without information about the topography of the area to be developed. In recent past, classical and conventional techniques were used to produce topographical maps, whereas the configuration of the terrain can be shown in form of contour lines (Jimoh, 2014). Topography is generally known as the study of earth surface, and its features and shape. It also gives the description of the features (such as surface, shapes, vegetation cover & elevations), depicted in maps. In essence, topography mainly concerned with local details such as vegetative and man-made features including local history and culture. More specifically, topographic surveying involves gathering information on terrain, three dimensional details of the surface including recognizing the specific landforms. In modern terms, it is the generation of data digitally or electronically. The outcome of topographic survey is the graphic representation of a given land parcel on a map using several techniques such as contour lines, Hypsometric tints and relief shading (i.e. topographic maps). There are varieties of methods used in topographic surveying. Topography of an area describes the surface characteristics of relief features of such area as depicted by hills, valleys and plains. It can be used to study and represent as a surface, any characteristic that has a continuously changing value other than elevation, for instance, population, geomagnetic data and geochemical data(Musa A.A. 2014). Topographical surveying involves the acquisition of topographic data of the features on the earth‘s surface, both manmade and

natural in three-dimension (x y z). This employs the techniques of plane surveying and other special techniques to establish horizontal and vertical controls. The implications of the above is that no meaningful development can be embarked upon by an individual, government and any other agencies without information about the topography of the area where such development is to take place. Topographic information system can be derived from the topographic data with the implementation of the analytical capabilities of geographic information system [GIS].

Geographic Information System (GIS) evolved as a new technology in surveying. It combines geographic data (location) and attribute data about object feature on the earth's surface with cartographic representation in order to perform spatial decision making using spatial analysis. According to Burrough [1986], GIS is a tool for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes. In short, GIS can be used to add value to spatial data (Sharma et al, 2006). This is by allowing data to be organized and viewed effectively, by integrating them with other data, by analysis and by creation of new data that can be operated in turn to create useful information that can help decision making. GIS is unique in its ability to integrate data from variety of sources. A GIS can thus be described as a form of spatial decision support system. A digital terrain model (DTM) is a topographic model of the terrain relief that can be manipulated by computer programs (Ndukwe, 2001). The data files contain the spatial elevation of the terrain in digital format which are usually represented as a rectangular grid. Vegetation, buildings and other man made (artificial) features are removed leaving only the underlying terrain. Modeling terrain relief using DTM is a powerful tool in GIS analysis and visualization. DTM can be stored in GIS database in several ways: As a set of contour vectors, a rectangular grid of equal spaced corner/point height or an irregularly spaced set of point connected in triangles (TIN-Triangular Irregular Network). The aim of this project is to create topographic information system for adequate management of immediate physical environment.

Topographic Information System

Topographic Information System is very crucial in this present age in other to be able to update maps and retrieve necessary data at any given time with

minimal efforts. Topographic Information System can be explained as the combination of human effort and computer-based tools for the collection, storage, analysis, manipulation and retrieval of various kinds of data relating to geographic features (man-made and natural) on the surface of the earth (Lexicon Universal Encyclopedia ,1989). In view of this, it is necessary to create Topographic Information System for different locations because the information generated from such system can be used for various purposes in physical planning and decision making in such locations. Some of the usefulness and advantages of this digital database for such system over the conventional maps include: Possibility of fast amendment and dynamic updating of data, Fast capturing of data with Total Stations or GPS, Analysis of many important spatial problems, Versatility in integrating data collected from various sources, Flexibility, output possibilities and Provides bases for additional information with relative ease for production of maps.

Study Area

The study area is Bauchi metropolis located in Bauchi state, with maximum and minimum temperature of about 41^{o}c at day time and 23^{o}c at night. Bauchi state is located between latitudes 09^{0} 30' N and 09^{0} 50' N, north of the equator and longitudes 09^{0} 50' E and 10^{0} 20' E, east of the Greenwich meridian. The total population of Bauchi state is 4,653,066 as at 2006 with the population density 95/km^{2} (250/sq mi) (National Population Commission of Nigeria, 2006).

Materials and Methods

For the purpose of this research study, three control points was used for connection after in-situ was properly checked. Data were collected from primary source which includes; coordinates of points at the vicinity of the research area. Vector approach of data acquisition was used, that is, x, y, z coordinates of the objects of interest were acquired using Dual Frequency Receiver. The GPS Receiver was used in static mode. The x, y, z coordinates of 856 points randomly distributed within the area were determined. GNSS solution was the software used for data processing. The points were exported to ArcGIS 10.3 version which was used for the generation of Digital Terrain Model (DTM). The DTM was used in the production of contour map, 3D, hill shade map, aspect/direction map and curvature map of the study area.

Results and Discussion

The major characteristic that differentiates GIS from other information systems is the spatial analytical capability; especially overlay operation, buffering, spatial search, topographic operation, and neighborhood and connectivity operations. GIS uses this spatial analytical capability to answer fundamental generic question of location, condition, trend, routing, pattern and modeling by the manipulation and analysis of input data. The major tasks performed in this research were production of Digital Terrain Model (DTM), Contour map, Aspect map, hill shade and direction map. The earth is a three dimensional, most GIS applications include some element of 3 dimensional analyses of which topographic operations and analysis of surface terrain becomes paramount. Figure 1 is the contour map of Bauchi metropolis which was interpolated from raster DEM. The contour map portrayed the configuration of the each surface. The contour lines are represented in brown color using 10 meters contour interval. The grid lines in the map are 2 minutes separation in both the northing and easting coordinates. The lowest point has an elevation of 640 meters and the highest point has an elevation of 880 meters. Figure 2 shows the three dimensional model of the study area, which also portrayed the terrain configuration.

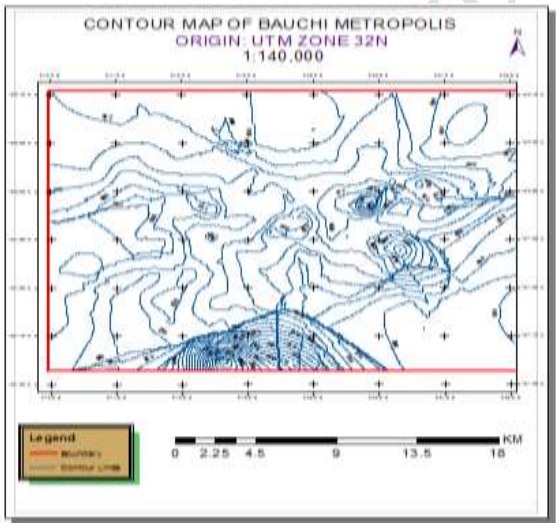

Figure 1: Contour Map of Bauchi Metropolis

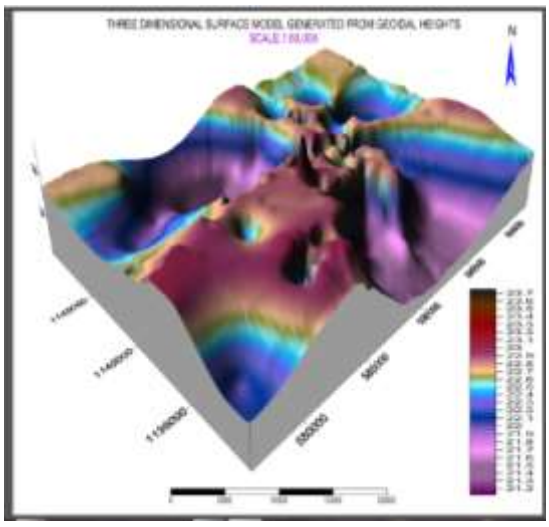

Figure 2: 3D of Bauchi Metropolis

Figure 3 shows the aspect map of Bauchi metropolis at a scale of 1:140,000. The lowest color ramp has a range of value of -1 to 0.000001 whereas the

highest color ramp has a range of value of 337.500 to 360 which is represented in dark blue color. Each color ramp represents different elevation

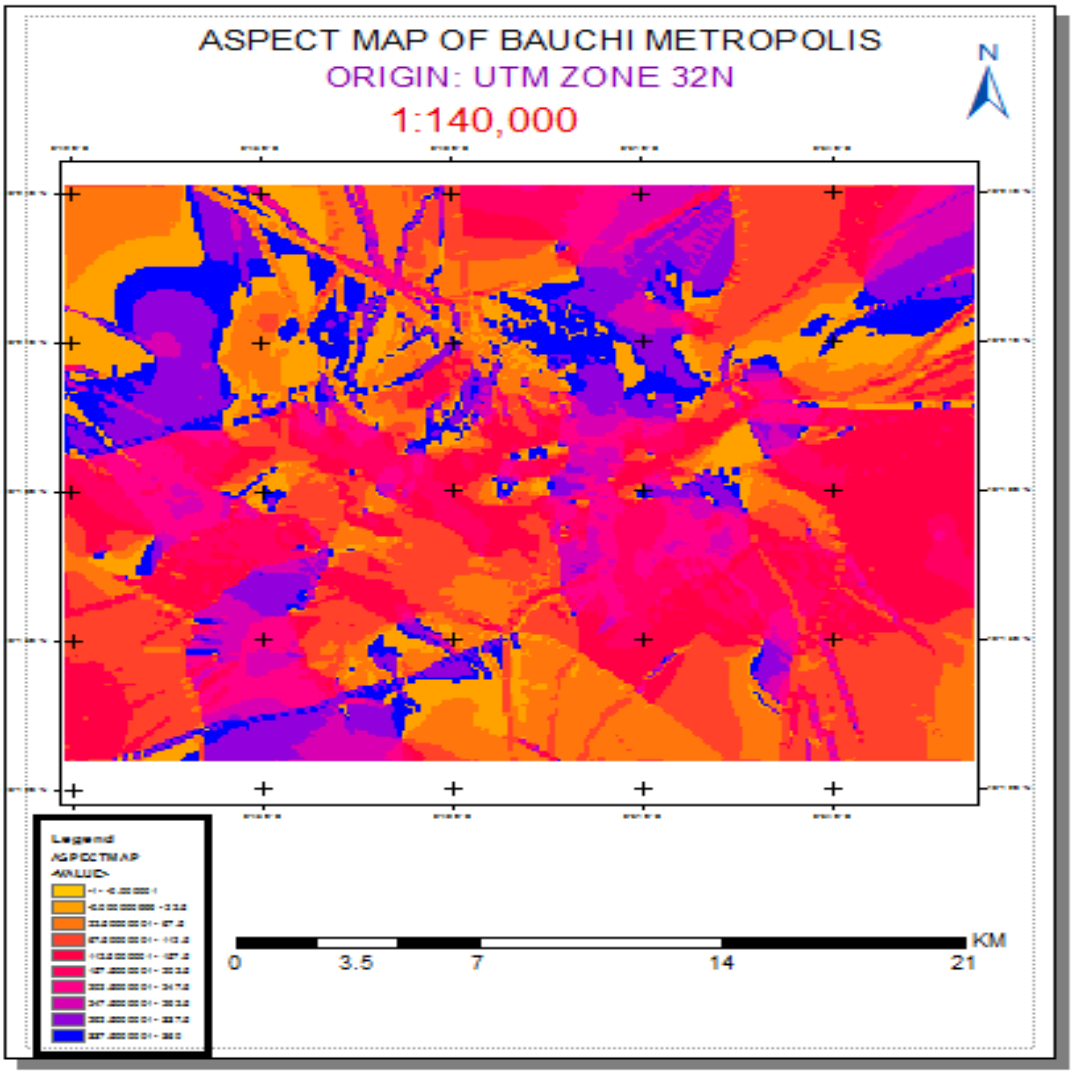

Figure 3: Aspect Map of Bauchi Metropolis

Figure 4 shows the flow direction map of Bauchi metropolis at a scale of 1:140,000. The lowest color ramp has a range of value of 576.184 to 611.027 whereas the highest color ramp has a range of value of 854.928 to 889.771. Each color ramp represents different elevation. This aspect slope map simultaneously shows the aspect (direction) and degree (steepness) of slope for the configuration of the study area. Aspect map is useful for identifying landscape features and prediction of fire risk area within the study area.

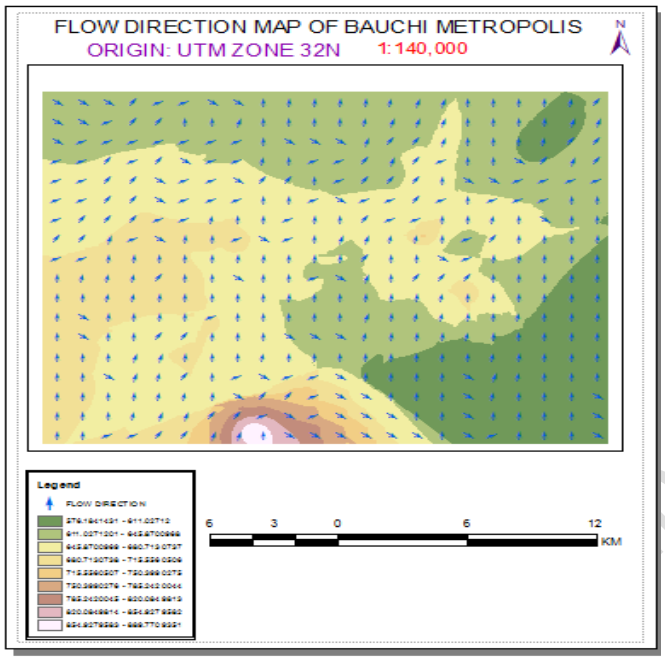

Figure 4: Flow Direction Map of Bauchi Metropolis

Figure 5 shows the hill shade map of the study area. Hill shade is a technique used to visualized terrain as shaded relief, illuminating it with a hypothetical light source. The lowest color ramp has a range of value of 149 to 168 whereas the highest color ramp has a range of value of 220 to 234 portraying different elevation.

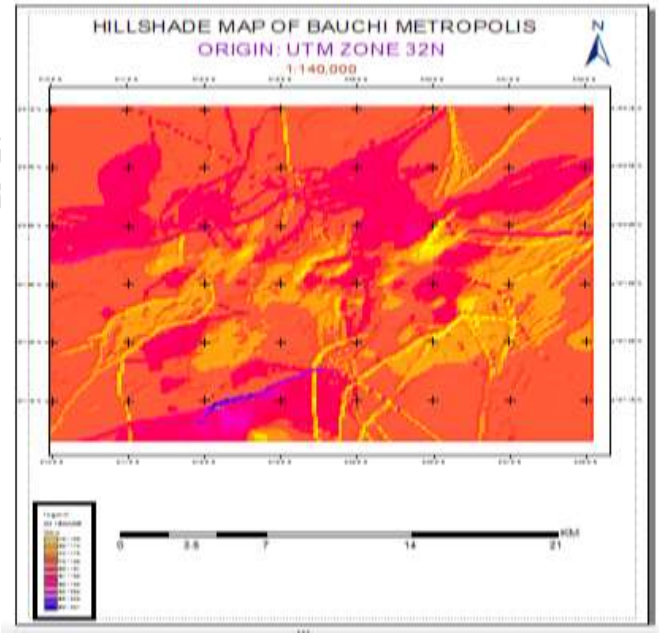

Figure 5: Hill shade Map of Bauchi Metropolis

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Figure 6 shows curvature map of Bauchi metropolis. The lowest color ramp has a range of value of -1.538 to -0.772 whereas the highest color ramp has a range of value of 0.845 to 1.562

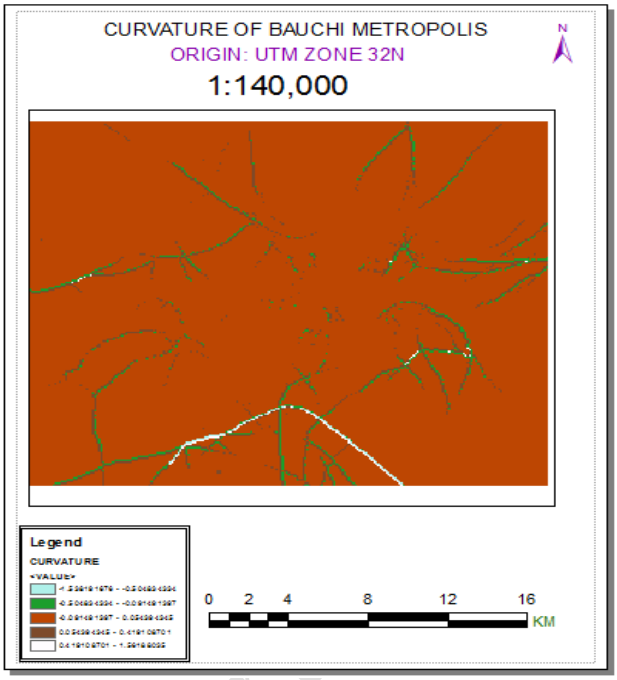

Figure 6: Curvature Map of Bauchi Metropolis

Application of Topographic Information System (TIS) Products

The various products generated in the study can be very useful for planning purposes and decision making. Some of the products that were generated include slope, aspect and hill shade maps. These are maps are very essential for taking good decision on environmental issues. Aspect map shows the direction the surfaces faces. It is very useful in building construction and agricultural management. Aspect map is useful for drainage network. Its usefulness is pronounced in the laying of pipes where direction of flow is prominent. Hill shade map is like aspect map, it shows how rugged the landform is. It is used in hilly area to determine the amount of sunlight that will be received in a given area. It can be used to determine the vest part of farmland to reserve for drying of crops after harvesting. In fact, hill shade is used to portray relief difference and terrain morphology in hilly and mountains area. The colour tones in a hill shade raster represent the amount of reflected light in each location, depending on its orientation relative to the

illumination source. This illumination source is usually chosen at an angle of 45° above the horizon in the north-west direction (Oriola, 2011). TIS are useful in visibility studies, that is, determining what is visible on a surface from a set of one or more location. d) TIS are also use in the evaluation of land use land cover for effective appraisal of the environment. These products are all very essential for environmental management and easy analysis of our physical environment.

Conclusion

In conclusion, this paper has been able to showcase topographic information system (TIS) as a necessary tool for managing environmental issues and abate some environment related challenges. With this system, it is now possible to amend and update data in the system, quickly analyze many important spatial problems in the area, produce output that is flexible and supply data for producing interactive maps of the area. Conclusively, having arrived at the allowable degree of accuracy, it was concluded that the aims and objectives of the research were achieved.

Recommendation

It was recommended that TIS should become a lasting tool for decision making and management of land and its resources for effective and sustainable development.

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