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APPLICATION OF DIGITAL TERRAIN MODEL AS A TOOL FOR FUTURE INFRASTRUCTURAL DEVELOPMENT

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Abstract

The aim of this research is to produce digital elevation model (DEM) for environmental sustainability. The procedure adopted for this research comprises of field reconnaissance, in which the boundary stations were selected and monumented. Ground surveying method was adopted in carryout the field

Keywords: *Digital Terrain Model, Interpolation, Earth configuration, Spatial Coordinates, Analysis and Accuracy.*

INTRODUCTION

Digital Elevation Model is the continuous representation of elevation values over a topographic surface by a regular array of z-values, referenced to a common datum. Digital Elevation Models (DEMs) are useful in many geo-science applications, such as topographic mapping, earth's deformation, hydrological and biological studies. DEM is an array representation of squared cells (pixels) with an elevation value associated to each pixel. DEMs can be obtained from contour lines, topographic maps, field surveys, photogrammetry techniques, radar interferometry, and laser altimetry (Manuel, 2004). Different interpolation

observation. The instrument was setup on an existing control with a beacon number SC/BA 500 which was used for connection. The coordinate of the point was collected from the Department of Surveying and Geo-informatics, Federal Polytechnic Bauchi. The spatial data were obtained from the field using Global positioning system (GPS). The data obtained was exported in to ArcGIS 10.3 version for production of digital terrain model (DTM). The DTMs generated were analyzed for future infrastructural development. The generated DTM is found to be sensitive to height interpolation Methods as well as the terrain nature. The DEM portrayed the actual terrain configuration which will serve as a tool for future development.

Methods applied over the same data sources may result in different results and hence it is required to evaluate the comparative suitability of these techniques. Interpolation techniques are based on the principles of spatial autocorrelation, which assumes that closer points are more similar compared to farther ones (Ashraf 2012). Interpolation methods include Inverse Distance Weighting (IDW), Local Polynomial Method, Nearest Neighbor (NN), Natural Neighbor, Radial Basis Functions (RBFs), Kriging, spine, global polynomial interpolation, Empirical Bayesian kriging and diffusion interpolation with barrier. The Kriging tool fits a mathematical function to a specified number of points, or all points within a specified radius, to determine the output value for each location. Kriging is a multistep process; it includes exploratory statistical analysis of the data, variogram modeling, creating the surface, and (optionally) exploring a variance surface. Interpolation is the process of using points with known values or sample points to estimate values at unknown points. It can be used to predict unknown values for any geographical point data, such as elevation, rainfall, chemical concentrations, noise levels, and so on. The aim of this research is to analyze different DEM interpolation methods. The objectives includes; to generate DEM using various interpolation methods and to compare different methods of DEM interpolation (Clarke, 2003).

Marina et al (2016), described the process of creating digital terrain models (DTM) using different interpolation methods. The analysis shows the accuracy of the DTM obtained from topographic maps at different scales and using different interpolation methods. The quality and accuracy

of DTM depends on the complexity of the terrain, data sources, and methods of height interpolation. Zahraa (2016), Digital Elevation Model represents a very important geospatial data type in the analysis and modeling of different hydrological and ecological phenomenon which are required in preserving our immediate environment. DEMs are typically used to represent terrain relief. DEMs are particularly relevant for many applications such as lake and water volumes estimation, soil erosion volumes calculations, flood estimate, quantification of earth materials to be moved for channels, roads, dams, embankment etc. (Davidovic, 2015), provides a review of spatial interpolation methods for environmental science and categorized the methods into three as non-geostatistical methods, geostatistical methods and combined methods. Prior to the physical development, it is paramount that the nature of the terrain be taken in to account. This research portray the terrain configuration in order to solve the problem of environmental monitory and planning of engineering/building project, an accurate and up to date Digital terrain model (DTM) and contour map is needed (Rayburg, 2009).. On other hand, different researchers compared two or three DEM interpolation method and came up with their respective results but there is no single research that compared more than four DEM interpolation methods. If all the methods of DEM interpolation in ArcGIS is put under consideration, the most accurate method would be determined and use for terrain modeling. Terrain information is very vital for most of the human settlement and used for monitory of physical development. The research is targeted toward planning and monitory of environment for sustainable development. The major problems that prompted this project research includes lack of accurate DEM of the study area, in availability of digital data set for decision making pertaining terrain configuration and difficulties in choosing appropriate accurate interpolation model. The research might be used in civil engineering work such as preparation of road project, exaction filling of related volume calculations land stratification studies, and drainage construction work.it is very vital in building construction and environmental planning. The scope of the research covers the entire Bauchi metropolis.

Statement of Problem

Lack of an up to date Elevation Model of the study area makes the assessment of the configuration of the terrain impossible, hence imposed difficulties in terrain analysis. Problems associated to pipe lying, drainage and other Engineering constructions are persistent due to the non

availability of an elevation model which serves as a basis for the design and construction of Engineering projects in which the relative heights of the terrain is the factor of prime concern. Effort were being made by the school management to install Internet and other communication mast but till today the total campus coverage was not achieve, one of the factors is the non-cognizance of the nature of the terrain in the campus. There is therefore the need for an Up to date elevation Model that can give an idea about the plate on which all the construction is to be sited.

Aim and Objectives

The aim of this study is to produce a Digital Elevation Model DEM of The Federal Polytechnic Bauchi using GIS and remote sensing Techniques for future infrastructural development.

The objectives of this study are:

1. To generate spot heights of the study area
2. To generate a contour map of the area under study
3. To produce a Digital Elevation model.

Scope of Study

It is important to note that, the accurate production of DEM requires many components. Therefore, this study would be restricted to two main categories; viz: Digital Elevation Model and Database management

Study Area

The study area is Bauchi metropolis, Bauchi state, Nigeria. Bauchi State has a maximum and minimum temperature of about 41^{o}c during the daytime and 23^{o}c at night and a population of about 4,653,066 people.

Fig.1 Map of the Study Area

Material and Methods

The Method adopted for this project research comprises of field reconnaissance, in which the boundary station were selected and monumented and a recce diagram was produced. An existing control with a beacon number SC/BA 500 was used to setup the instrument on the control point for connection. The coordinate of the point was collected from the department of surveying and Geo-informatics, Federal Polytechnic Bauchi. Spatial data were obtained from the field using DGPS receiver. The data obtained was exported to ArcGIS 10.3 version for the production of the DTM. The DTMs generated were compared and analyzed for further discussion and presentation.

Result and Discussion

The software used in carrying out the digital terrain model (DTM) is ArcGIS 10.1. These are different methods for generating DTM. These includes: Diffusion Interpolation Barrier, Inverse Distance Weighting, Empirical Bayesian Kriging, Kriging, Spline, Global Polynomial Interpolation, Local Polynomial Interpolation, Radial Basic Function, Natural Neighbor, and Kernel Interpolation with Barriers. The method used in this research is Kriging.

Kriging: The result of the interpolation generated using this method has a mean spot height of 636.07451 and standard deviation of 1.81857. The accuracy of the result was defined base on the standard deviation extracted. This method was found to be the forth method based the result extracted. The raster DTM is shown in Figure 1.

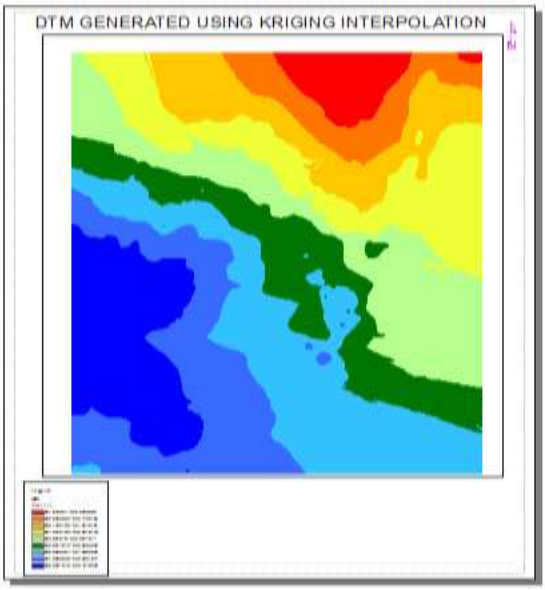

Fig 1: DTM generated using Kriging (Source: Author Lab.)

Conclusions

It is concluded that based on this research, the best method of interpolation is inverse distance weighting.

Recommendation

It is recommended that DEM should be adopted for effective and sustainable environmental management.

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