Topographic Information System (TIS): A Critique to Sustainable Physical Development and Decision Making

I. C. Onuigbo[1], N. Zitta[2], A. M. Gbedu[3], I.O. Pius[4] and H. A. Samaila-Ijah[5]
Department of Surveying and Geoinformatics
Federal University of Technology Minna
Niger State, Nigeria
Correspondence email: anyi.onuigbo@futminna.edu.ng

***Abstract*—This paper examines topographic information system [TIS] as a tool to sustainable physical development. A part of Federal University of Technology (FUT) Minna, Niger state, Nigeria was used for the study. A total station (leica product) was used to acquire the data (x y z) coordinates within the study area. The usefulness of the Topographic information generated was highlighted and map revealed the true configuration of study site and vacant areas for future development. A digital terrain model [DTM] was created to enhance further analysis on slope, aspect, hill shade and view shed analysis in addition; a vector map of the study site was also generated. of the area. The information is also available for query that will assist in the physical planning of the area under investigation. The study concludes that Topographic Information System is essential for physical planning and accurate decision making because it allows easy updating and quick retrieval of information for better planning and environmental management.**

Keywords—Topographic information system (TIS), Digital Terrain Model (DTM), decision making, physical planning

1.0 Introduction

Land surveying is the first point of reference in any meaningful development projects. 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.

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, geo-magnetic data and geo-chemical data. Topographical surveying involves the acquisition of topographic data of the features on the earth's surface, both man-made 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 employment of the analytical capabilities of geographic information system [GIS].

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 the creation of new data that can be operated on 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. The objective of this paper is to create topographic information system for adequate management of immediate physical environment in FUT Minna.

1.1 Topographic Information System (TIS)

Digital technology was successfully introduced in the field of mapping in late 1960's as means of speeding up map production. [Perera and Shanta, 2002] with the change in technology in the last two decades and the growth in the number of spatial information systems, the concept of topographic data base has been introduced in several mapping-surveying organization in the world, in order to deliver more geo-information to the user community.

A TIS 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. TIS can be explained as the combination of human effort and computer based tools for 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. Encyclopaedia, 1989

In view of this, it is necessary to create TIS 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:-

a) Possibility of fast amendment and dynamic updating of data

b) Fast capturing of data with total stations or GPS

c) Analysis of many important spatial problems

d) Versatility in integrating data collected from various sources

e) Flexibility output possibilities

f) Provides bases for additional information with relative ease for production of maps.

1.2 The Study Area

The Federal University of Technology, Minna, Gidan kwano Campus, situated in Bosso Local Government Area of Niger state, Nigeria. The campus is located between longitude 09° 31’ 30’N and 09°32’ 15’’N and latitude 06° 26’ I4’’E and 06° 27’ 33’E respectively.

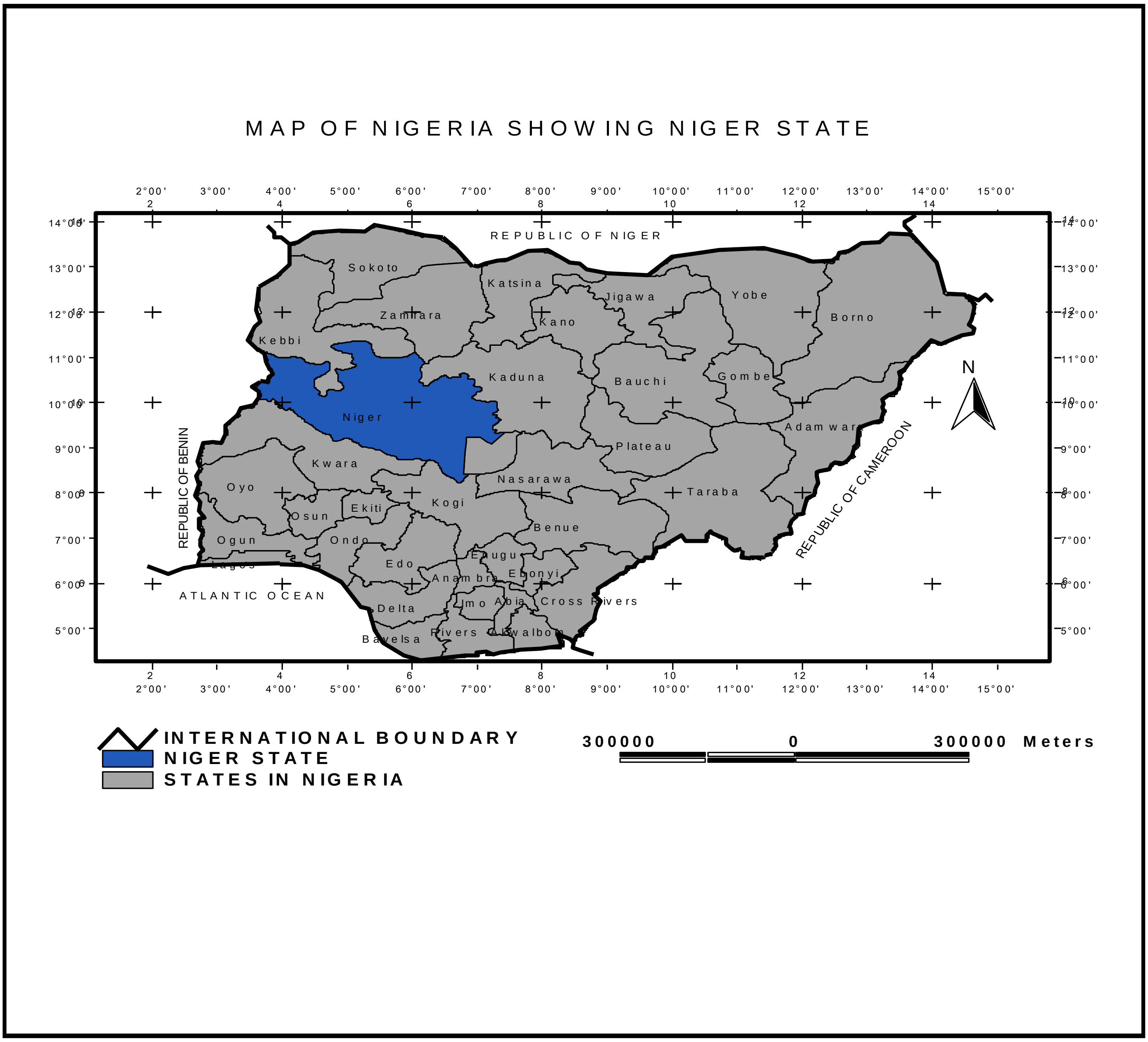

Figure 1.0: Map of Nigeria showing Niger state, Minna.

Source: Ministry of Land and Survey, Minna

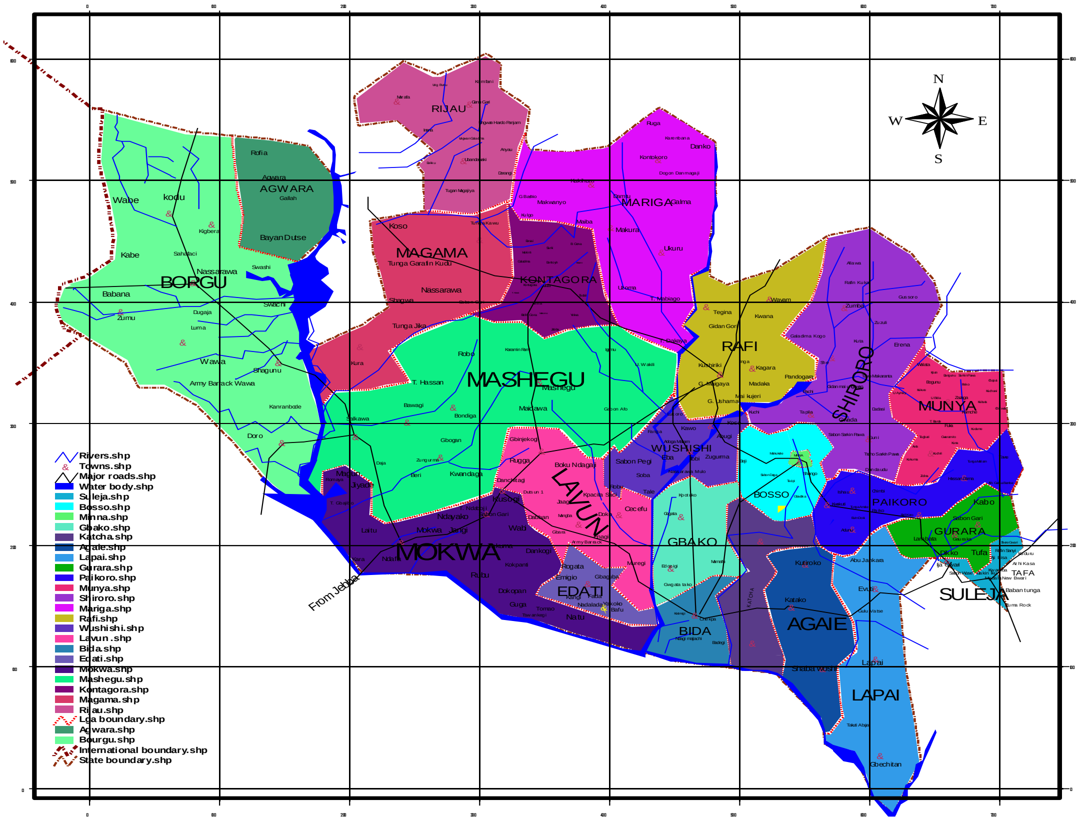

Figure 1.1: Map of Niger state showing Bosso LGA, Minna.

Source: Ministry of Land and Survey, Minna

Figure1.2: Google image of FUT Minna, Gidan-Kwano Campus

2.0 Materials and Methods

For this study, the following data were collected from both primary and secondary sources: previous analogue map covering the area, previous control points at the vicinity of the project area and a streamed google earth image.

Vector approach of data acquisition was used that is, x, y, coordinates of the objects of interest work acquired using total station which is a computerized electronic instrument having a combination of EDM and theodolite was used for measuring distances, angle, fixing of details and determination of coordinates or points.

It is a basic rule in surveying that for a new area; references must be made to old existing controls by way of connecting the new survey to the existing one. The principle of ''Working from Whole to Part'' was upheld. This is the basis for carrying out perimeter traverse first before the detailing and spot heightening. Heights of instrument and target were measured and stored in the memory of the instrument after the perimeter traversing which started from the control point FUT GPS 25 and closed back on another control point FUT GPS 21. All the detailing and spot heightening were done by orienting with the coordinate boundary marks/ stations.

3.0 Results and Discussion

The major characteristic that differentiates GIS from other information system is the spatial analytical capabilities especially overlay operation, buffering, spatial search, topographic operation, and neighbourhood and connectivity operations. GIS uses this spatial analytical capability to answer fundamental generic question of location, condition, trend, routing, pattern and modelling by manipulation and analysis of input data. The major analysis performed in this project were overlay operations, topographic operation and spatial search

3.1 Overlay operation

In this study the contour map was overlaid on detailed map of the study area to produce the topographic map of the area, which shows the relationship that exists between the various spatial entities in the study area. This result can be used to determine area that need access road to the structure or other facilities.

The contour map of the study area is shown in Fig 2.0. This map assists in planning and control of erosion in the study area [FUT Minna], while the detailed map of the area under investigation can be used to ascertain area that are available for future developments.

3.2 Topographic operation

This operation was performed from digital elevation model generated using Arcview 3.2a version. The earth is 3-dimensional, most GIS applications include some element of 3-dimensional analysis of which topographic operations and analysis of surface terrain becomes paramount. Slope, aspect and other DTM generations are considered as the most common uses in application of terrain model use in GIS. Further analysis using Arc view 3.2a could generate products such as Hill shade map, Aspect map, Slope map etc, to further enhance sustainable physical development of the study area.

3.3 Query and presentation of analysis

The most fundamental of all tools provided by a GIS are those involved with database query and its ability to perform complex spatial analysis and modelling operations in support of environmental management planning and mapping. Queries may be simple or multiple.

Based on the Database created for this study, it is easy to query for land use/land cover, its size; show building and use [bungalow and lecture room].

4.0 Application of Topographic Information System [TIS] Products.

The various products generated in the study can be very useful for planning purposes and decision making. The topographical map of the Federal University of Technology, Minna, shows all features as they exist on the ground and other available areas for future development. Some of the products that could be generated include slope, aspect and hill shade maps. These are maps that are very essential for taking good decision on environmental issues.

a) 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.

b) 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].

c) Viewshed analysis: TIS is 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.

e) Other products generated from the query can be used for physical planning, decision making, and solution of some spatial problems of FUTMX. These products are all very essential for environmental management and easy analysis of our physical environment.

5.0 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 analyse many important spatial problems in the area, produce output that is flexible and supply data for producing interactive maps of the area.

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APPENDIX 1; PRODUCT OF THE TOPOGRAPHICAL MAPPING OF FUT MINNA (TOPOGRAPHIC INFORMATION SYSTEM)

CONTOUR MAP OF FUTMX;

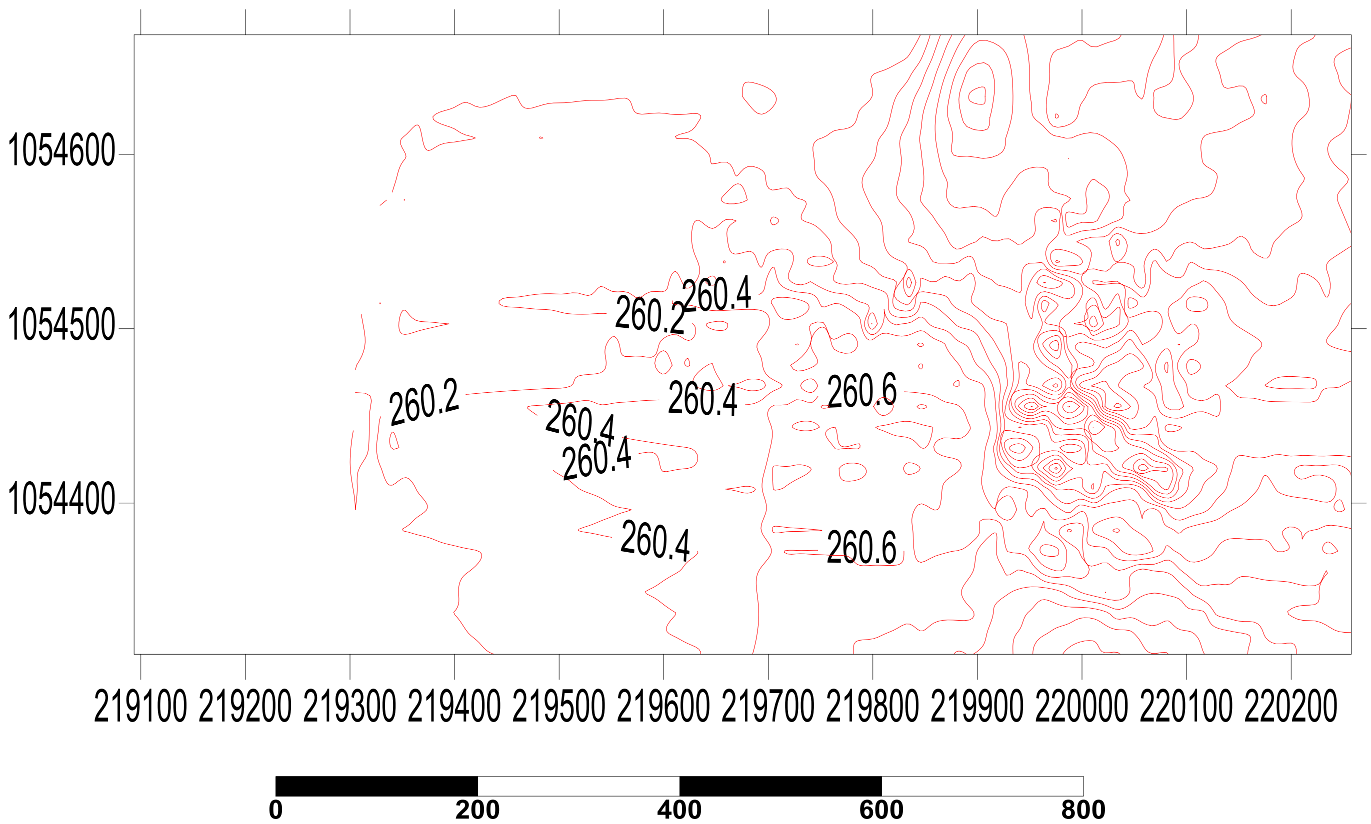

Figure 2.0: Contour map of FUT Minna.

APPENDIX 2; 3D VIEW OF THE STUDY AREA

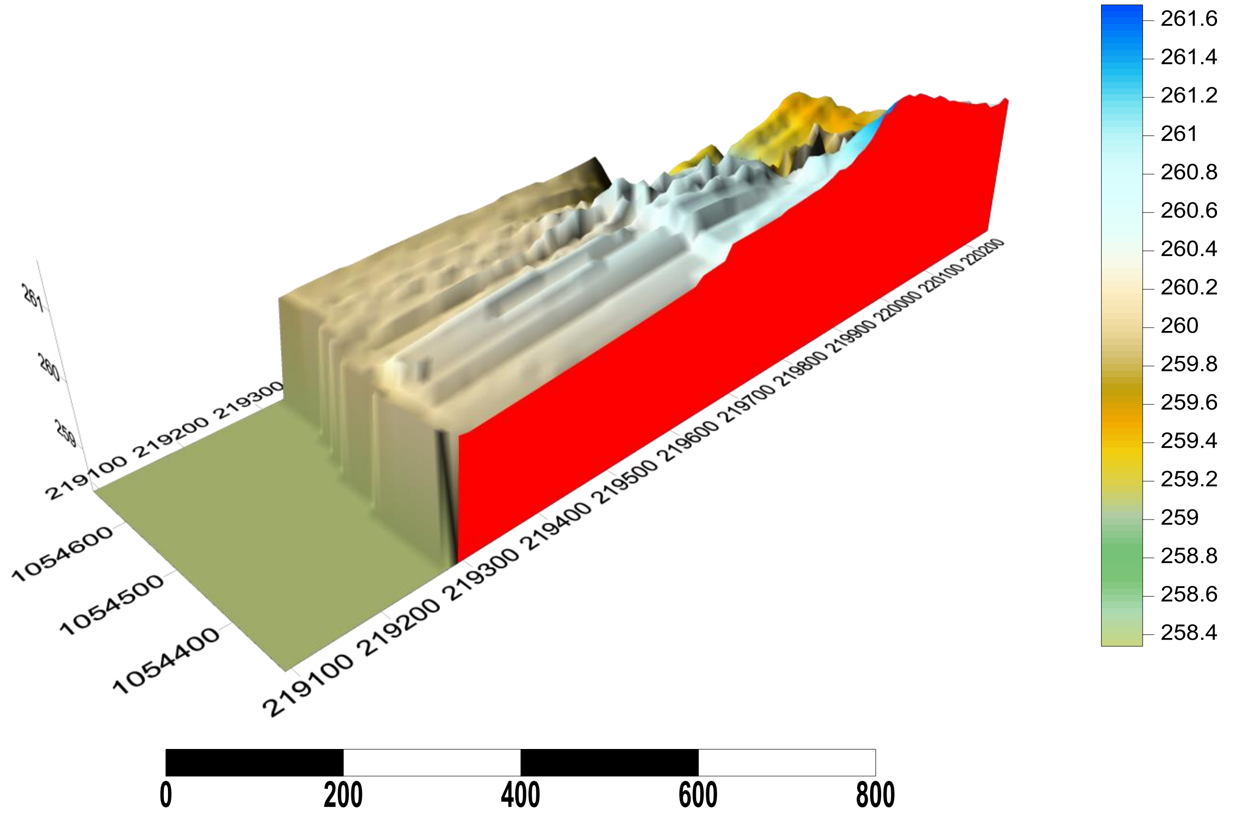

Figure 2.1: 3 DIMENSIONAL MAP OF FUTMINNA.

APPENDIX 3;

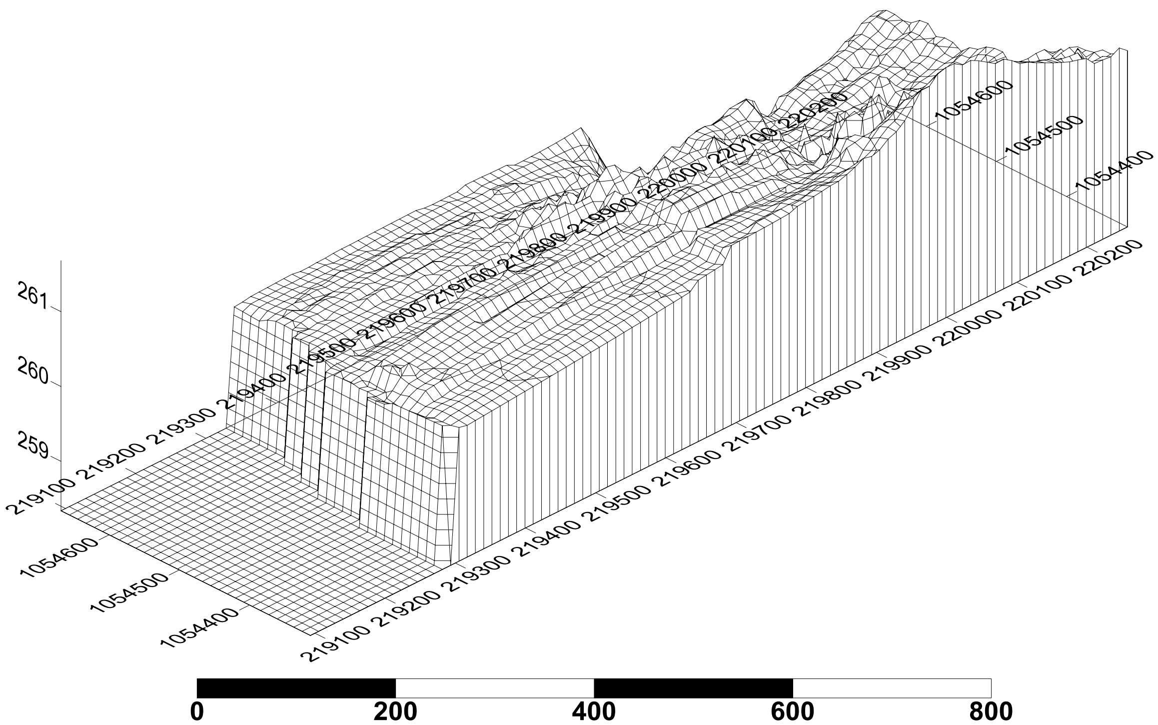

FIGURE 2.1a: Wire frame/DTM of Gidan Kwano Campus FUTMx

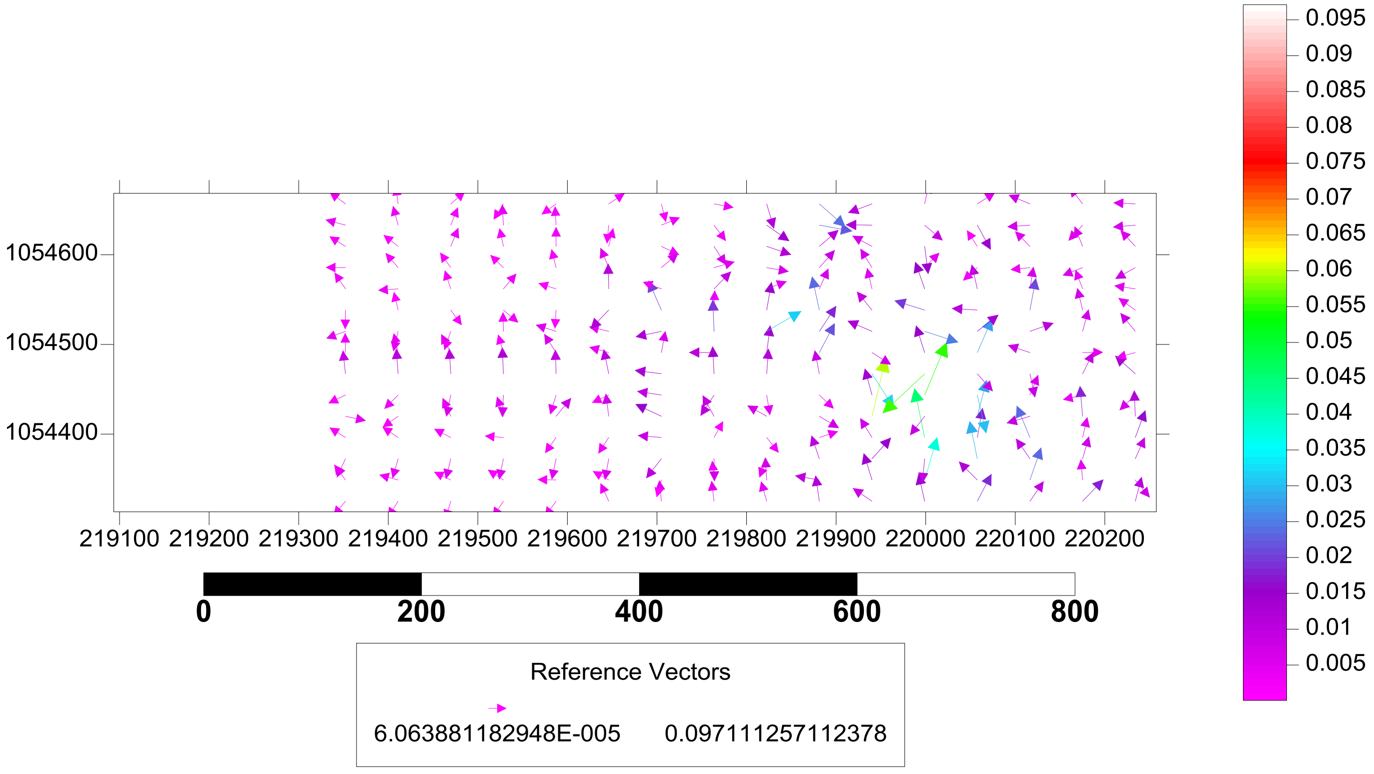

Figure 2.1b: Vector map of gidan kwano campus futmx