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Detail Assessment of Natural Drainage Flow Pattern in Federal University Otuoke and its Environs using Digitized Topographic Information

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Abstract

Regional and local flooding have always been a menace in Bayelsa state, this could well be attributed to poor knowledge and design of drainage system and erection of illegal structure across the water way. The aim of this study therefore, is to ascertain the natural drainage pattern that exit at Federal University Otuoke and its environs by taking advantage of topographic information. To achieve this, digitize information of latitude, longitude and elevation were extracted from an imagery map and developed into 3D surfaces. The results have shown that Federal University Otuoke and its environs is located in an environment where the average elevation above mean sea level is about 18 m. The highest elevation within the survey area is 27 m, while the lowest elevation is 7 m. Using the Faculty building as a reference point the results have shown that all future drainages that will be designed and constructed within Federal University Otuoke and its environs should be directed from North East, South East, North West, South west towards the Otuoke river. The results have also revealed that the present land mass of Federal University Otuoke and where it will expand into in future is located within a region where the average elevation is about 22 m above mean sea level, which is an indication that it will not be subjected to regional flooding like that of 2012. However the possibility of local flooding cannot be ruled out, if the drainages pattern is not tailored in the right direction.

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Introduction

This research was carried out to ascertain the nature of topography in Federal University Otuoke and its environs. Topography is known to affect and control the natural flow pattern. Water will naturally move from region of high pressure to a region of low pressure under the influence of gravity. This research work became necessary in other to avert the menace of flooding that took place in 2012 (Figure 1).

According to Ebipade 2013, Bayelsa would continue to experience flood, owing to the vulnerability of the topography. The devastation of last year's flood (2012 flooding) cannot be quantified, as it brought poverty, developmental challenges, lives were lost, and institutions (Federal University, Otuoke) shut down, amongst others. Collins, 2014, has earlier stated that "detail survey should be carried out to ascertain the local topography and the drainage pattern before the design and construction of any drainage system in any part of Bayelsa State".

Federal University Otuoke was established in 2011, and being a young University the need to carefully study and plan the drainage pattern cannot be over emphasised. This factor will determine the road network, the building style and areas where prominent structures are to be located, to completely avoid building along water ways. The instrument used for this research work includes; Global positioning system, Google Earth imagery Map and dedicated geo software for 3D surface modeling.

Materials and methods

Location of the study area

The study area is Federal University Otuoke and its environs as shown in Figure 2. Otuoke is a community in Bayelsa state, located within the rich oil Niger Delta of southern Nigeria. The survey area is bounded by Latitude 4° 51′ 05.23″ N, Longitude 6° 20′ 14.2″ E and Latitude 4° 43′ 48.69″ N, Longitude 6° 20′ 19.84″E.

Figure 1: Flooded school premises (www.iformationng.com, 2012)

International Journal of Basic Science and Technology October 2015, Volume 1, Number 1, Pages 43 - 48

Geology of the study area

The study area is Federal University Otuoke and its environs in Bayelsa state, and it lies within the fresh water and meander belt geomorphic unit of the Niger Delta, (Okiongbo and Douglas, 2013). The formation of the present Niger Delta started during Early Paleocene as a result of the built up of fine grained sediments eroded and transported to the area by the River Niger and its tributaries. The regional geology of the Niger Delta consists of three lithostratigraphic units, Akata, Agbada and Benin Formations, overlain by various types of Quaternary Deposits (Short and Stauble, 1967; Wright *et al.*, 1985; Kogbe, 1989).

These Quaternary Sediments, according to Osakuni and Abam (2004) are largely alluvial and hydromorphic soils and lacustrine sediments of Pleistocene age.

Data acquisition

The data acquisition started by using the Global Positioning System (GPS) Equipment to collect the initial data (Latitude, Longitude and Elevation). This baseline data collected in strategic positions by standing with the GPS, were used to locate and digitalize location points of the survey area on the imagery map. The digitization was done along rectangular flight lines (Figure 3) at an interval of 500 m.

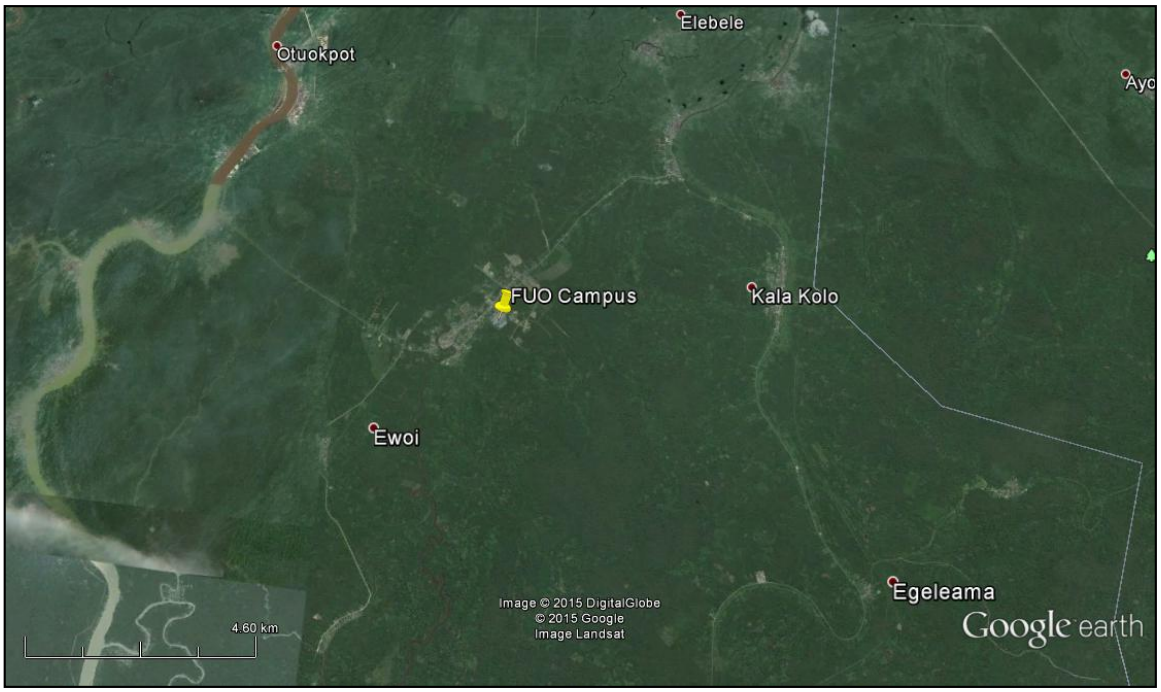

Figure 2: Imagery map of the survey area, adapted from Google Earth (2014)

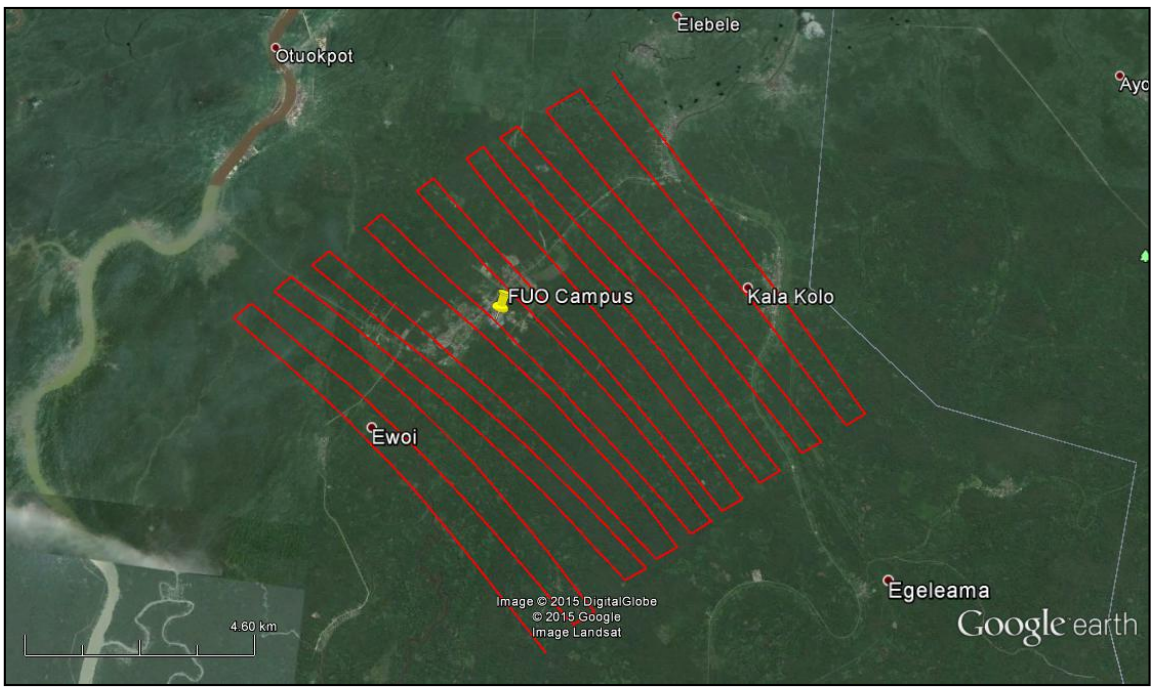

Figure 3: Imagery map showing the digitized sample point for the survey area

International Journal of Basic Science and Technology October 2015, Volume 1, Number 1, Pages 43 - 48

Table 1: Part of the raw data digitized from the imagery map

Degree N	Minutes N	Seconds N	Degree E	Minutes E	Seconds E	Elevation
4	51	5.23	6	20	14.12	16
4	50	52.8	6	20	24.03	15
4	50	40.41	6	20	34.76	14

Among the data collected include Latitude, Longitude and elevation. Part of the raw data digitized from the imagery map is shown in Table 1. A total of 356 data points were digitized to cover the entire sub region. A total of 188 data points covering Federal University Otuoke and the adjoining Otuoke town were also extracted from the 356 data point that covers the entire sub region of interest.

Data processing

The data processing started with the conversion of the latitude and longitude values recorded in minutes and seconds into degrees. The converted values in degrees were arranged in three columns, longitude, latitude and elevation, in the form of x, y, z coordinates, as shown in Table 2. These tables were exported into a processing software where it was grided and converted into 3D surfaces. The 3D surfaces were covered in a shade of colours with a colour bar attached for easy of interpretation. The 3D surface vector map which will indicate the flow pattern was generated. Elevation profile analysis was also carried out to determine the lowest, the average and the highest elevation of the survey area.

Results and Interpretations

The results of the elevation profile analysis are shown in Figure 4 and 5. All elevation quoted here are with reference to mid-sea level. Figure 4 shows the highest elevation in the survey area which stands at 27 m, while Figure 5 shows the least elevation in the survey area which stands at 7 m. The elevation analysis has also shown that the average elevation in the survey area is 18 m.

The 3D surface that was developed to depict the survey area is displayed in shades of colour (Figure 6), with a coloured scale bar attached for easy of interpretation. Prominent areas within the survey area were labeled on the 3D surface for ease of visualization. A close examination of the 3D model, which represented the regional view of the survey area revealed that the range of elevation was between 7 m to 27 m above sea level, and the average elevation from the coloured scaled bar is about 18 m, which confirm the result of elevation analysis on the imagery map of Figure 4 and 5. Taking the Faculty of Science of the Federal University Otuoke as a reference point in the 3D model of Figure 6, it becomes very obvious that the north eastern and the south eastern part of the survey area have higher elevations than the north western and and south western part of the survey area. The survey area could be described as having a depression at the center, flanked by high elevation on both side.

The extracted 188 data points covering Federal University Otuoke and the adjoining Otuoke town only were contoured into 3D surfaces (Fig. 7), to get a good detail view of part of the survey area that is of major point of interest.

Table 2: Converted values in degrees arranged in three columns, longitude, latitude and elevation

East (Degree)	North (Degree)	Elevation (m)
6.337255556	4.851452778	16
6.340008333	4.848000000	15
6.342988889	4.844558333	14

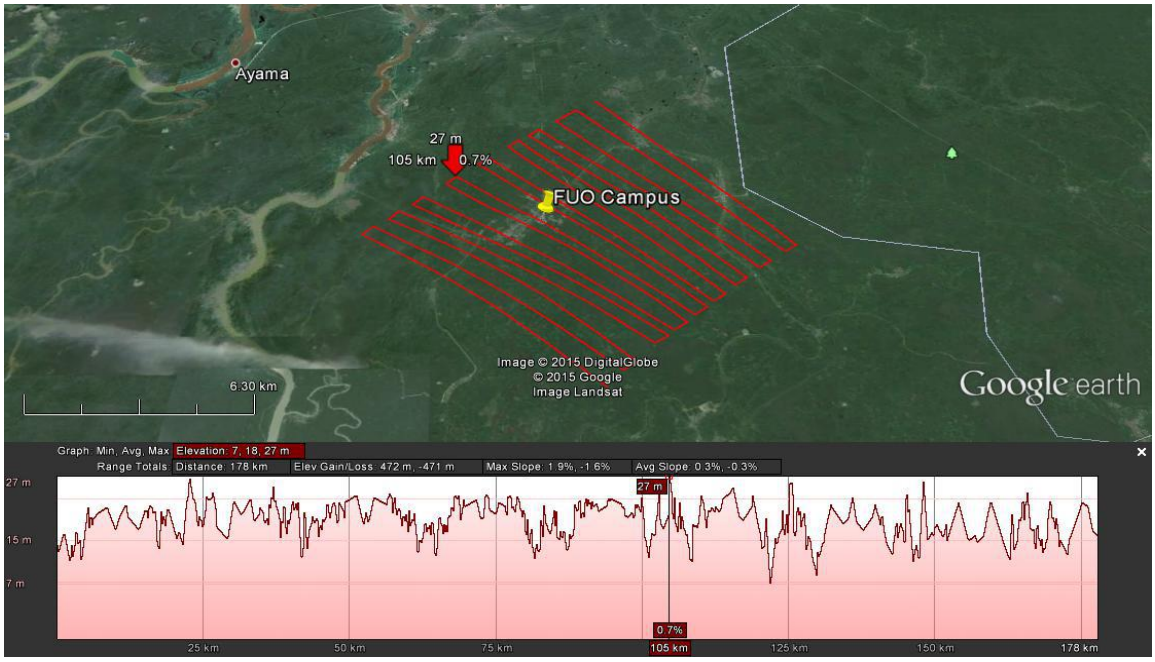

Figure 4: Elevation profile analysis for the highest point in the survey area

International Journal of Basic Science and Technology October 2015, Volume 1, Number 1, Pages 43 - 48

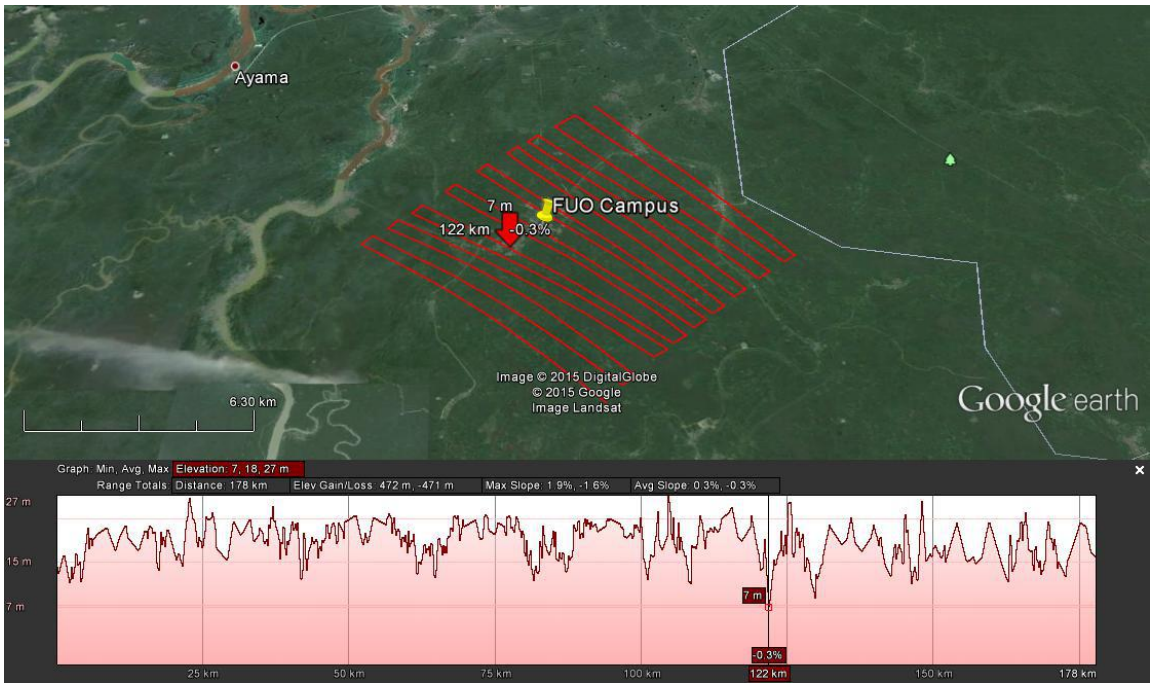

Figure 5: Elevation profile analysis for the lowest point in the survey area

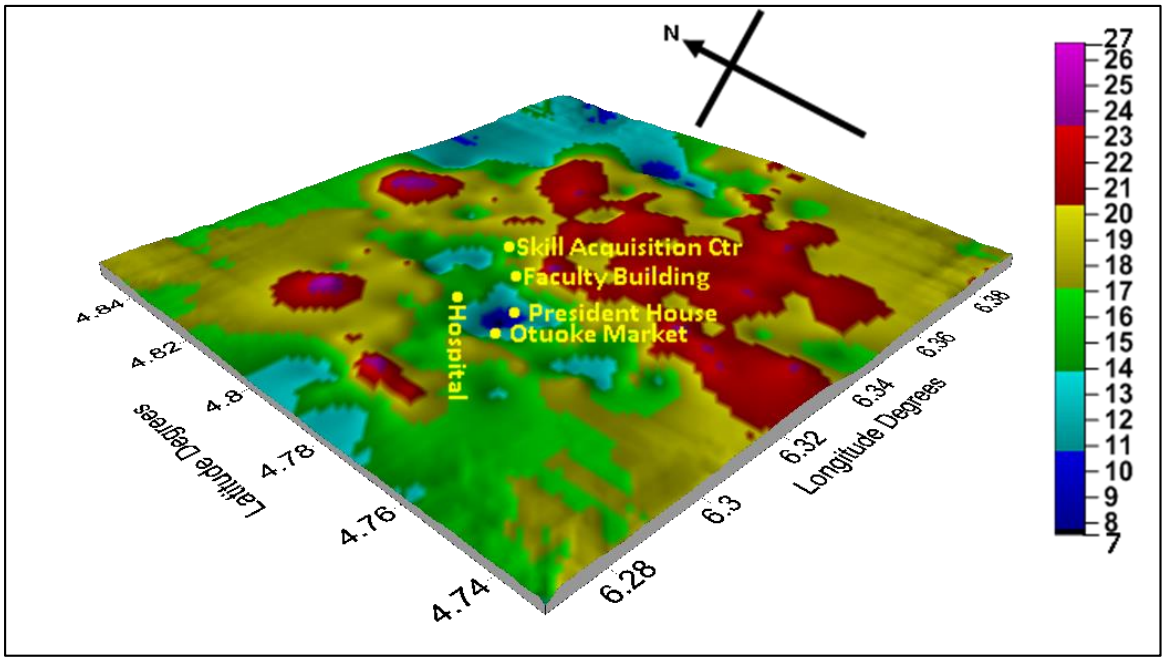

Figure 6: 3D Surface of the survey area showing the regional topography

The 3D surface is displayed in shade of colours with a coloured scale bar attached to the model. The elevation above sea level ranges from 7 m to 28 m. The average elevation in this particular region stands at 17 m. A close examination of the 3D surface shows that the north eastern and south eastern part of this region have a higher elevation which stands at 18 m to 27 m above the mean sea level, compared to the north western part of the region. A close assessment of the 3D surface topography showed that the "President's residential area" has the least elevation which stand at 7 m above sea level. Places like Faculty building of Science, and Skill acquisition center of Federal University Otuoke stand at 16 m above sea level.

To ascertain the drainage pattern of the 3D surface models, vector map analysis was carried out as shown in figure 8. The directions of the arrows on the 3D surface indicate the direction water-will flow on the surface when it moves freely under the influence of gravitational force.

A detailed assessment of the 3D surface indicate that water will naturally flow from north east toward the south west, and from the south west toward the north east to converge at Otuoke river (which flows north south) , as shown by the two large arrows, arrows 1 and 3. Within this region also, water will flow from south east toward north west and from northwest toward the south east to also converge at Otuoke River, as indicated by arrows 2 and 4.

Taking the Faculty building of Federal University Otuoke as a reference point, drainages constructed within this region should be directed from north east as indicated by arrow 1 toward south west, and also from the south west toward the north east, as indicated by arrow 3, to empty into Otuoke River which runs North-South. Similarly drainages, constructed within this region with the same reference point (Faculty building of Federal University Otuoke) should be directed from the South-East toward the North-West as indicated by arrow 2, and from the North-West on the other side

International Journal of Basic Science and Technology October 2015, Volume 1, Number 1, Pages 43 - 48

toward the South-East as indicated by arrow 4, both to empty into River Otuoke which flow North-South.

A general assessment of Federal University Otuoke present land mass and where it will expand into in future (North East and South East) has shown that it is lucky to have been sited at very good high elevation with an average height of 22 m above sea level, where it will not be prone to flood. However local flooding of the environment could result if the drainage system is not well designed from the onset. Still taking reference with Faculty building of Federal University Otuoke, any drainage directed eastward away from Otuoke River is going to result in severe local flooding of the environment, except it is redirected back through curve channels. This research work will serve as a reference document to the town planner in designing the drainage pattern to prevent flooding.

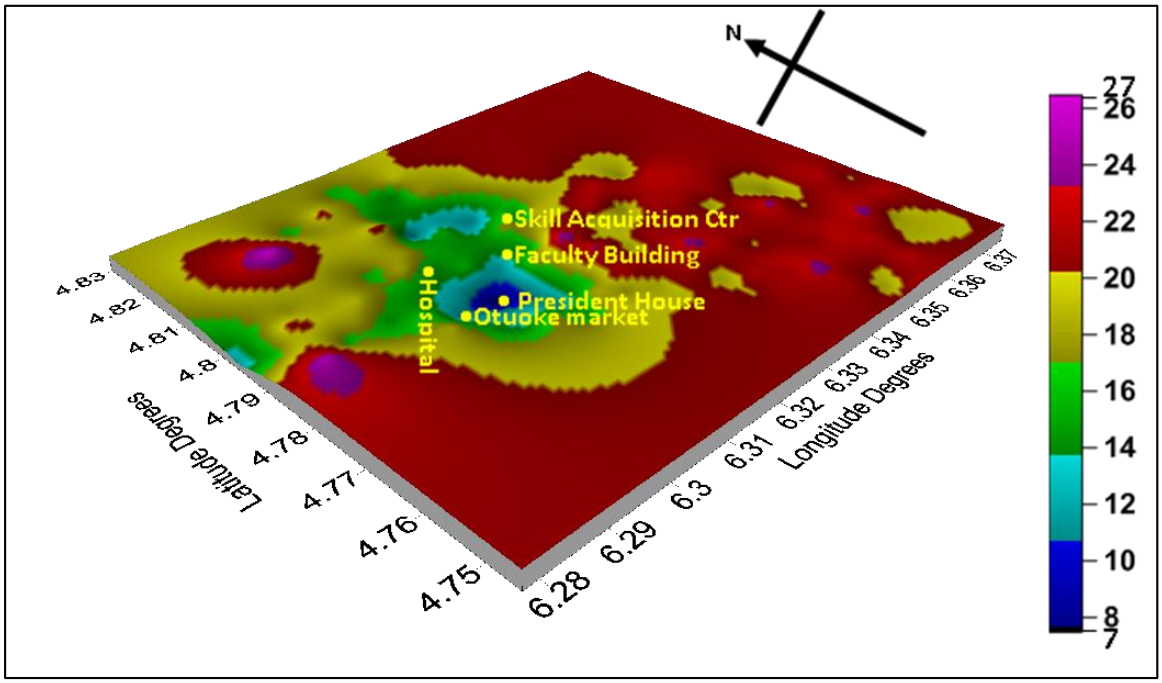

Figure 7: Extracted 3D surface from the regional survey to get clearer details

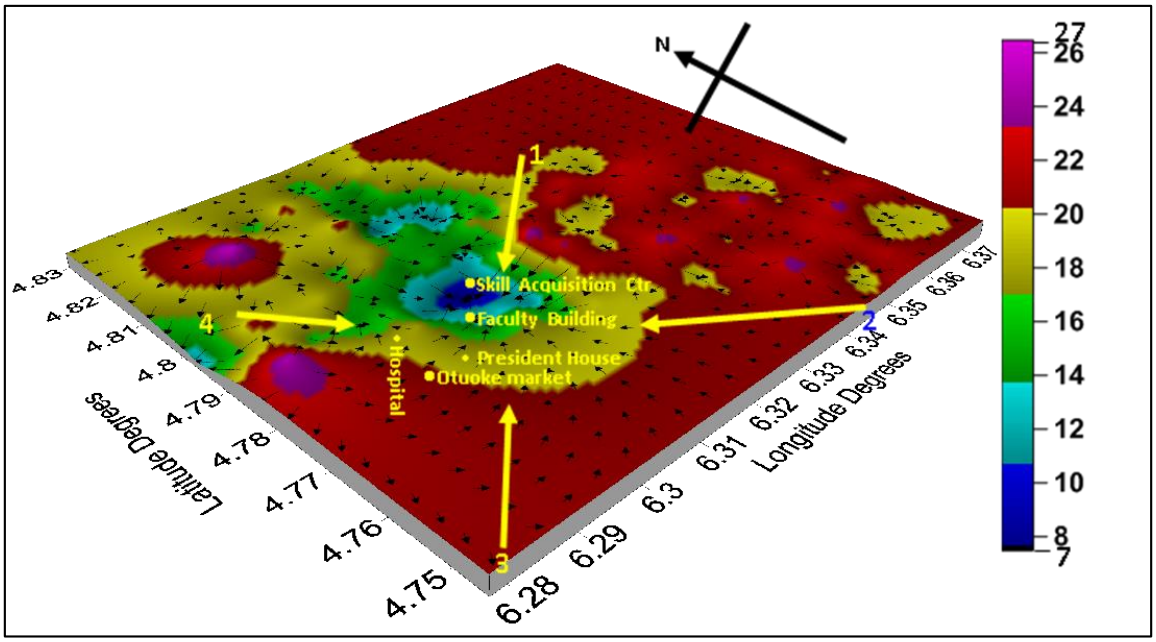

Figure 8: 3D surface showing vector analysis, which indicate flow pattern

Conclusion

It has been established that the average elevation within the study area stands at about 18 above mean sea level. The highest elevation was estimated to be 27 m and the lowest elevation to 7 m above mean sea level. The major drainage system should be channeled from the North-East, South-East, North-West and South-West toward the Otuoke River. It has also been established that Federal University Otuoke will expand in the future into a land mass with an average elevation of 22 m above mean sea level

International Journal of Basic Science and Technology October 2015, Volume 1, Number 1, Pages 43 - 48

where it will relatively be immune to regional flood, however local flooding could result if the drainage system are not properly planned and implemented.

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