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# TERRAIN ANALYSIS ALONG MAJOR ROADS IN UNIVERSITY OF LAGOS CAMPUS

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**Abstract**

Investigation into surface level is an exercise that provides the required data for lasting solutions to environmental and engineering problems. Flooding is a major environmental problem that causes unquantifiable damages and requires engineering solutions. University of Lagos is located close to the Lagoon making many areas within the University to be susceptible to flooding. Investigation into the surface level on the major roads of the University of Lagos will provide information for a better understanding of flooding on campus. This study, therefore, carried out the terrain analysis of major roads within the University of Lagos to identifying flood prone areas along the road. Automatic level was used in a levelling exercise along the roads. Observations were taking at every 25 meter intervals at the two sides of the roads as well as the center lines of the roads. Observed data were processed and accuracy obtained agrees with a second order levelling. Results were presented in longitudinal sections using the central road data observations. Contour lines and flow direction map were also produced using both center line and road side observations. A Digital Terrain Model of the major roads was produced and a 3D wireframe that shows the terrain formation along the major roads. Analysis of the results revealed flood prone spots. It was concluded that another study of the entire University of Lagos as well as the analysis of the drainage system in the immediate vicinity of the campus is required to proffer a lasting solution to flooding on the campus.

***Keywords**: Terrain, Flood, Road Network, Analysis, University of Lagos*

## 1.0 INTRODUCTION

The use of the term slope within the Surveying and Geomatics parlance refers to element of the solid earth's surface, which includes the terrestrial and underwater surfaces. It therefore serves as an interface between lithosphere and the aggregates of earth's water generally denoted as the hydrosphere or the layers of gases that enveloped the solid earth generally denoted as the atmosphere (Qin et al., 2020). Elements of slope may be in different shapes and configuration. It describes the angle of inclination of a surface with respect to a predetermined or assumed surface and the slope so established may be upward or downward. The aggregation of the downward,

upward or level surface defines the terrain of the surface. Terrain analysis can be carried out for the purposes of Engineering work, erosion analysis, building layout plan, military purposes and many more (Tukura et al., 2022).

Terrain analysis of the major roads in the University's main campus is important for many reasons. The University of Lagos Akoka (main) campus is situated close to the Lagos lagoon. This has resulted in occasional flooding on the campus after any slight rainfall. While most of these roads were designed as part of the master plan of the University, there have been tremendous changes in the landscape of the University between the inceptions of the University till date. Flooding has therefore increased in recent times with many parts of the major roads flooded after every rainfall both on campus and in Lagos generally (Ndimele et al., 2024). An example of flooding along the road in University of Lagos is a flooded portion of Oduduwa drive, leading from Faculty of Engineering through the Lagoon front to the Vice-Chancellor's lodge as shown in Figure 1. It could be observed that water has taken over this portion of the road and some parts of Faculty of Engineering workshop.



Figure 1: Typical flood along Oduduwa road by Faculty of Engineering workshop after rainfall.

This trend of flooding calls for proper investigation to identify the portions of the roads within the University that may be affected by flooding and then analyze possible alternative to the existing

drainage system for the purpose of ameliorating the flood currently being experienced. Apart from the issues of flooding, the University is nursing the possibility of using only electric vehicles as a means of intra-campus transportation services. This is to reduce the emission of greenhouse gasses into the atmosphere thereby contributing to the reduction of the impact of climate change on the environment (Madalsa et al., 2024). Since the electric vehicle is being designed for the University of Lagos as a starting point, terrain analysis of the network of roads within the University will serve as input in the determination of energy consumption of the vehicle. Based on these reasons and for many other purposes that terrain analysis can serve, the study of the terrain of the major roads in the University of Lagos main campus is the focus of this study.

There have been previous studies carried out about the topography of University of Lagos. Previous studies include the assessment of the accuracy of UAV-based orthophotos of part of University of Lagos main campus (Daramola et al., 2017). The focus of the study was to determine the accuracy of orthophotos derived from UAV acquired images by comparing the geometric positions selected locations obtained from the orthophoto with geometric positions the same location obtained by a second order ground control method. The study concluded that UAV-Based orthophotos can be used for the compilation of large scale maps in an inaccessible area. Another was conducted where the authors examine the use of UAV-based images for the production of a 3D map of the University of Lagos main campus (Abiodun et al., 2020). The study presented a Digital Terrain Model (DTM), Digital Surface Model (DSM) and the contour map of the University. There was however, no particular attention paid to the road and the study may not produce the much needed results that may be useful for the purposes of flooding on the road as well as slope analysis for the determination of energy consumption by an electric vehicle plying the roads. Yet another study conducted, was a UAV-based survey of University of Lagos for a 3D mapping and change detection analysis of the University (Gbopa et al., 2021). Apart from the 3D map of the University produced by the authors, the study also reported an increase of 16,306.7 $m^2$ in the area occupied by buildings between 2015 and 2019.

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These studies are not adequate for the purpose of flood analysis on the road because they were produced on a relatively small scale thereby making a detailed analysis impossible. There is therefore the need for a separate study that will concentrate on the analysis of the terrain surface along the major roads in University of Lagos for flood analysis on the road and the estimation of energy consumption of an electric vehicle on the roads. The current study therefore will take height observations along the road at every 25 meters interval for the purpose of surface analysis for flood monitoring and control.

## 2.0 STUDY AREA

The University of Lagos is located in the mainland area of Lagos. The University is almost encircled by the Lagoon as it is bounded to the North, East and South by the Lagos Lagoon. It is bounded to the West by the Iwaya community and the North-West by Abule Oja and Akoka communities in Lagos Mainland Local Government Area of Lagos State. The study area lies between Latitude and Longitude 06 ° 31 ' 07 " N and 03 ° 23 ' 17 " E respectively at North, Latitude and Longitude 06 ° 30 52 " N and 03 ° 23 ' 16 " E respectively at South. The study area is as shown in Figure 2.

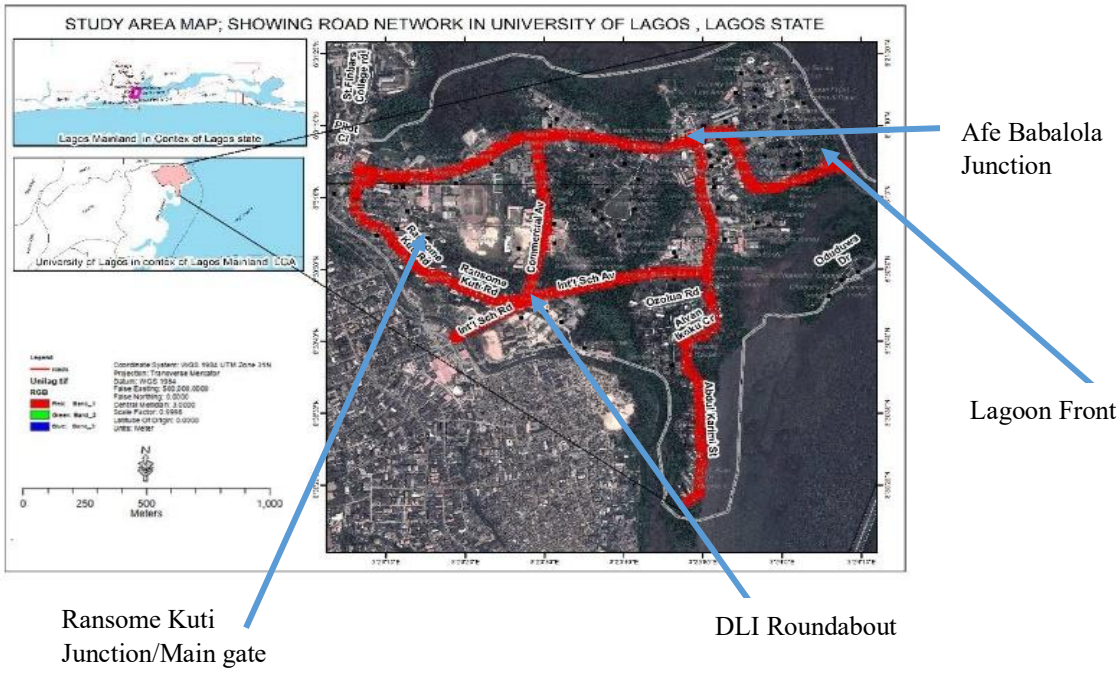


Figure 2: Google map showing major roads within University of Lagos.

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## 3.0 MATERIALS AND METHODS

Height data was acquired for this study using an automatic level. Two peg test was carried out on the level to ascertain that the instrument is in good order and that results are reliable. Essentially, if level instrument is properly level, it makes the instrument compensator to create horizontal line of sight, which enables correct readings to be taken on a graduated leveling staff, from which height difference between points can be determined/known (Atinc & Ramazan, 2018). Results of two-peg test in this study reveal an error of 0.002m. This shows that the instrument meets the first and second order standards (FGCC, 1984). The main control used were ED 011 located at the Lagoon front, CR 06 located in front of Afe Babalola Auditorium and XST 347 located at Distance Learning Institute (DLI) roundabout. The location of these controls are contained in Table 1. Observations commenced from XST 347 control. On every road, observations were taken at every interval of 25m. At every interval, observations were taken at both sides of the road as well as the middle of the road.

**Table 1**: Location of the three controls used for the study

| ID | Control | Coordinate (m) | | Location |
|---|---|---|---|---|
| | | Northings | Eastings | |
| a | XST 347 | 719894.220 | 543235.430 | DLI roundabout, in front of First Bank |
| d | GME 05 | 720627.896 | 544028.926 | At the front of Afe Babalola Auditorium |
| e | UNILAG 01 | 720458.060 | 544479.214 | At the Lagoon front, along Oduduwa drive |

Observations were divided into different sections of the road network. The various sections used in the observation shown in Figure 3. According to Figure 3, observations were made on lines A, B, C, D, E and F.

Table 2 is a further description of the leveling operation based on Figure 3.

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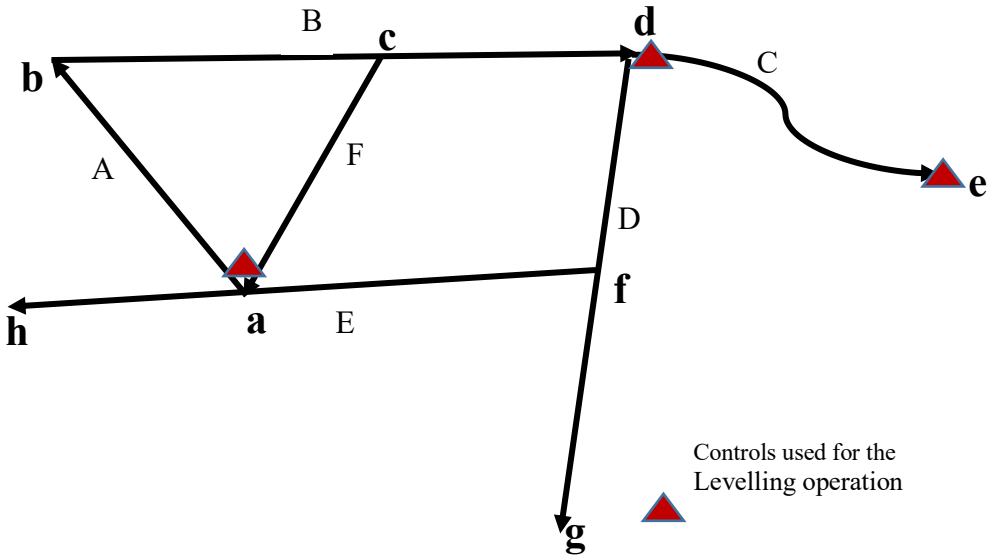


Figure 3: Levelling network adopted for the study.

Observations that took off from point "*a*" ended on point "*e*". Thereafter, a flight levelling operation was carried out back to point "*a*" from the levelling operations took started. The total distance of the entire levelling operation was determined as 6.910km. The last observation recorded on point "*a*" at the close of the levelling operations was used to determine the accuracy of the survey. The known coordinate of point "*a*" and the final coordinate at the close of the levelling operation are as contained in Table 3.

**Table 2:** Location of the three controls used for the study

| Section | Nodes | Road names | Description |
|---|---|---|---|
| A | a, b | Ransome Kuti Road | From First Bank at DLI junction, through Ransome Kuti road to intersection with Usman Danfodio at Faculty of Education |
| B | b, d | Usman Danfodio | From main gate, along Usman Danfodio road to the intersection with Oduduwa drive front of Senate House |
| C | d, e | Oduduwa Drive | From the intersection of Usman Danfodio and Oduduwa at Senate House through Oduduwa road to the Lagoon front. |

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| | | | |
|---|---|---|---|
| D | d, g | Tafawa Balewa Road, Alvan Ikoku cresent and Abdul Karimi Street | From Intersection of Danfodio and Tafawa Balewa road in front of Afe Babalola auditorium, through Tafawa Balewa road, Alvan Ikoku cresent and Abdul Karimi Street to High Rise Buildings |
| E | f, h | International School Avenue | From Second gate through ISL Intersection of ISL road and Tafawa Balewa road (in front of medical centre) through ISL road to secong gate |
| F | c, a | Commercial Road | Along Commercial road, From Access bank to First Bank at DLI junction |

**Table 3:** Comparison of the observed and known parameters of point a (XST 347).

| Station | Northing (m) | Easting (m) | Height (m) | Remarks |
|---|---|---|---|---|
| XST 347 | 719894.220 | 543235.430 | 4.701 | Known |
| XST 347 | 719894.195 | 543235.700 | 4.642 | Observed |
| | + 0.025 | - 0.270 | + 0.059 | Difference |

Linear accuracy was determined by Equation 1 while the maximum allowable vertical misclosure was determined by Equation 2 (Abubakar et al., 2020).

$$Linear\ accuracy = \frac{1}{\frac{\sqrt{(\Delta E)^2+(\Delta N)^2}}{Total\ Distance}} \quad (1)$$

$$Maximum\ misclosure = 24mm\sqrt{k} \quad (2)$$

Where

$\Delta E$ is the difference in the eastings, $\Delta N$ is the difference in the northings and $k$ is the is the total distance in Kilometers (6.910km)

Linear accuracy obtained from the traverse operations as calculated by Equation 1 is 1:25,483.615. Therefore the accuracy obtained is approximately 1:25,000. Based on Table 3 above, the difference between the known and observed height is 59mm. A maximum of 63.09mm is permitted based on Equation 2. This shows that the misclosure in the levelling observation falls within the permissible error. Accuracy results revealed that the study meets the standard required for a third order Survey. The height data obtained from the observations were used to produce a longitudinal section of each of the roads based on the sections enumerated in Table 2. In this study, the longitudinal section of the six roads covered are presented according to the sections presented

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in Table 2. Contour map was produced for the entire network to show the terrain configuration that covers the width of the roads. Another map that shows the direction of flow based on the terrain was also presented. The study also presented a Digital Terrain Model (DTM) of the entire road network covered in this study. Finally the study also produced a wireframe which shows the actual terrain of the road network.

## 4.0 RESULTS AND DISCUSSIONS

The first set of results presented in this study are the longitudinal section of the road network based on the sections highlighted in Table 2. Section A of the network covers Ransome Kuti road. The longitudinal section of Ransome Kuti road is as presented in Figure 4. This road takes its root from the DLI roundabout and passes through Ransome road to Ransome Kuti junction at the University main gate, a distance of approximately 1,000 metres. It was observed that the route consistently shows a steep slope just after DLI junction and then rises just before Ransome Kuti junction.

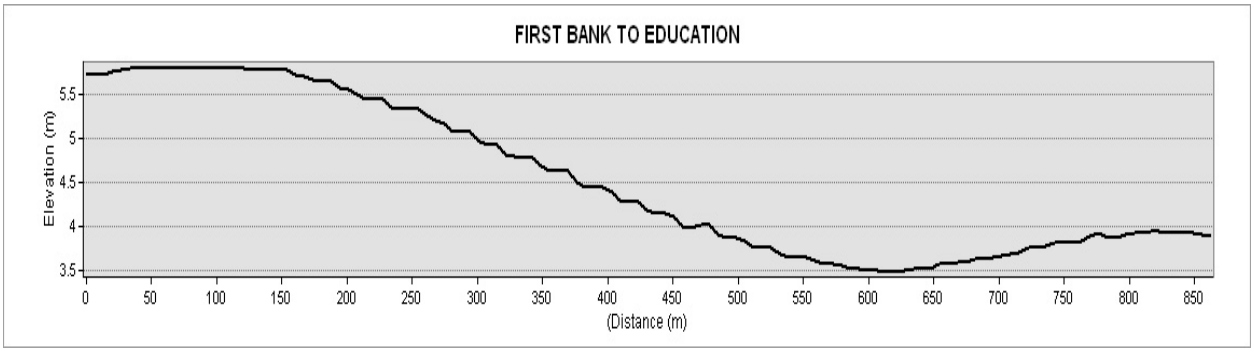


Figure 4: Shows Elevation profile along First Bank to Education in the University of Lagos

The next longitudinal results presented here is for section B of the level network which takes off from University main gate through Usman Danfodio Boulevard to senate building, a distance of about 1.5Km. As the results shows in Figure 5, the elevation of the boulevard reveals of the three sharp deeps. The first can be noted around chainage 200m, the second at chainage 500m and the third at chainage 900m. Elevation however is generally higher when compared with profile of section A.

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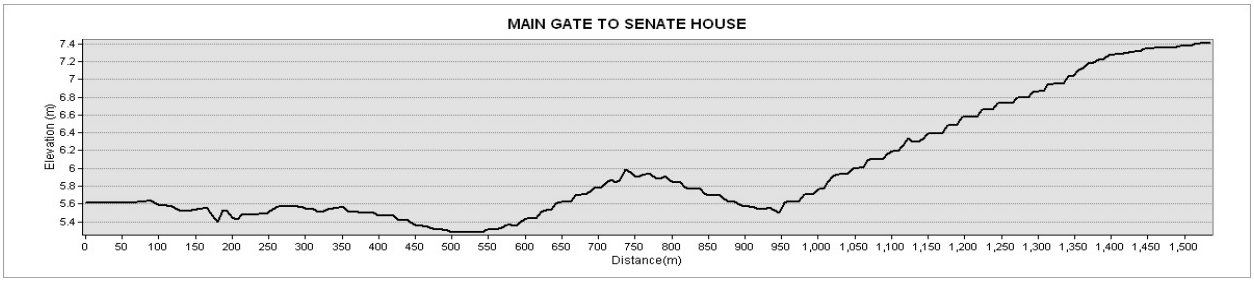


**Figure 5:** Shows Elevation profile along main gate to senate house in the University of Lagos.

The next results presented is section C of the levelling network along Oduduwa road which passes through the Lagoon front. Although this levelling operation stops at the Lagoon front, the road to the Vice-Chancellor's lodge. The levelled section of the road covers a total distance of 625 metres. The longitudinal profile of the road shows sharp steepness right from the beginning of the road. The lowest point observed along this road appear between the 300m and 350m chainages. This point is the lowest point in all of the observations taken along all the routes in the levelling exercise. Longitudinal section of section D of the levelling network takes off from Afe Babalola/Bookshop junction to high rise building. Detail description of the section is as presented in Table 2. The profile of the road is as presented in Figure 7. The highest point along this route is at the beginning of the route. There is a sharp slope at about the chainage 200m, the elevation rises again and reached a peak at about the chainage 400m form where it starts to consistently slope down until the end of the section. The end of this section is very low, similar to the lowest point of section C of the network, although, this point on section D is still a little higher than the lowest point of section C.

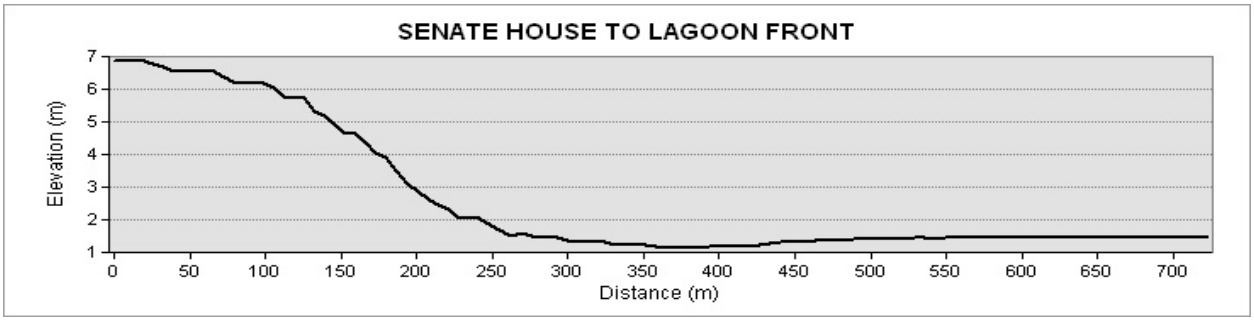


**Figure 6:** Shows Elevation profile along Senate House to Lagoon Front in the University of Lagos.

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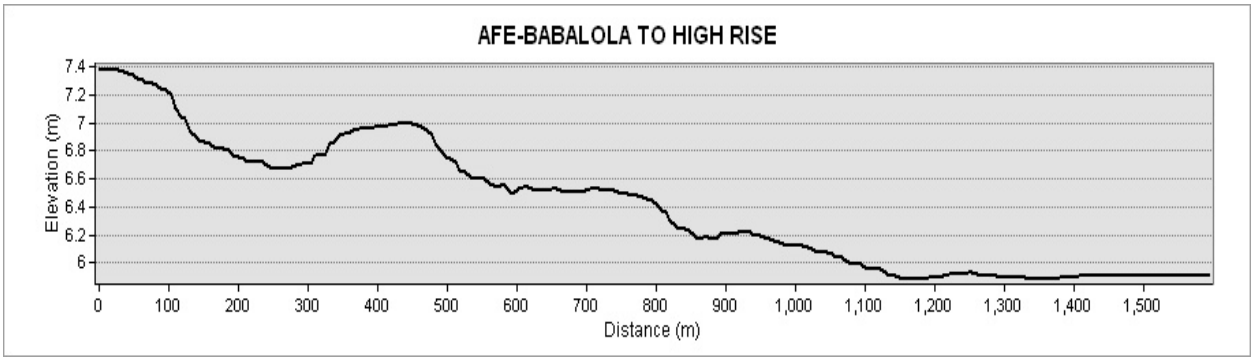


**Figure7:** Shows Elevation profile along Afe-Babalola to High Rise in the University of Lagos

Section E of the network takes off from the University Second gate to University medical center and the longitudinal section is as presented in Figure 8. The longitudinal section shows a fairly level surface from the second gate with a gentle rise around chainage 350m. Thereafter, there was a downward slope to chainage 700m where the lowest point of the route can be found. From this lowest point, a consistent rise in elevation is observed and the highest point along this route is at the end of the route located at the junction with section D (along Tafawa Balewa road in front of medical center).

The last section of this study is route F along the levelling network as shown in Table 2 and Figure 3. The entire route is about 700m long. The longitudinal section of the route as presented in Figure 9 shows that the highest point along the route is the take-off point at the intersection of the route with route B which is along Usman Danfodio Boulevard. The lowest point on this route is between chainages 450m and 500m. Thereafter, there is a gentle rise up to the end of the route at the DLI junction.

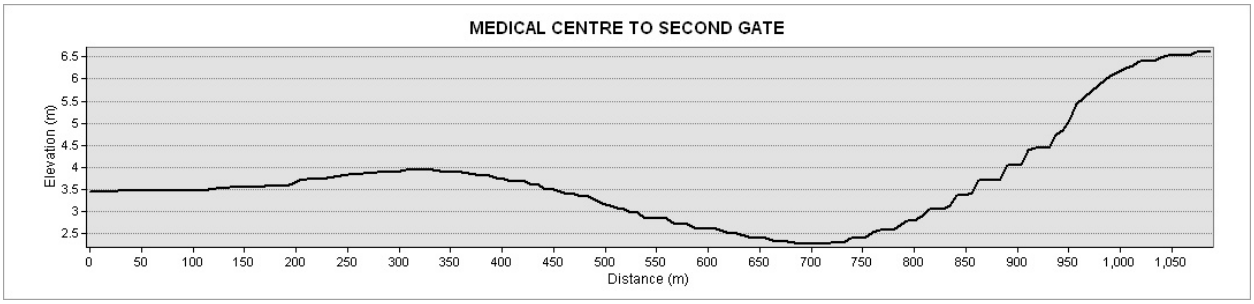


**Figure 8**: Shows Elevation profile along medical center to second gate in the University of Lagos

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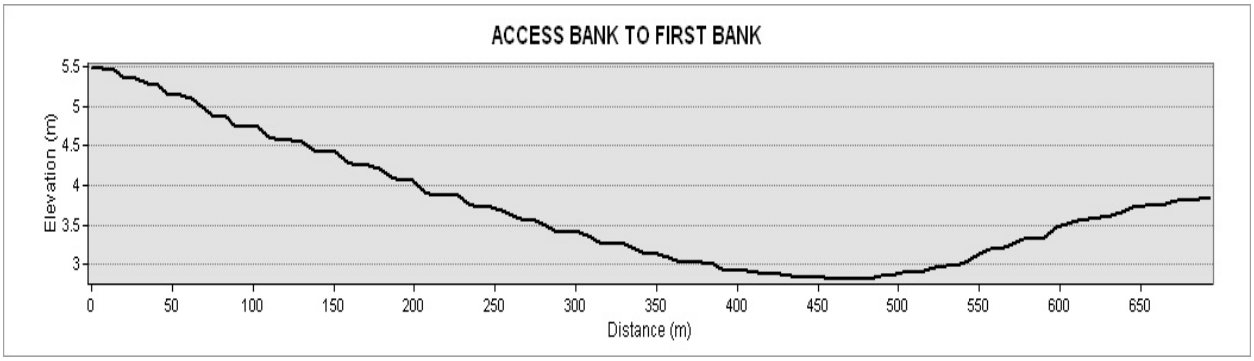


**Figure 9:** Shows Elevation profile along Access Bank to First Bank in the University of Lagos

A contour map of the road network was produced as shown in Figure 10. The contour map revealed spots that are relatively high. Along Usman Danfodio Boulevard, the main gate area and shortly before kosoko drive junction are relatively high. Along commercial road, around the intersection with the Usman Danfodio is relatively high. Along Tafawa Balewa road, around the intersection with Usman Danfodio Boulevard is equally high. Apart from the locations mentioned above, other areas along the road network are relatively plain with some spots of lower elevation. The flow direction map presented in Figure 11 agrees with the information presented in Figure 10. Flow direction map shows that there is flow outward of the areas identified to be relatively higher than others. It also assist to identify areas where there could be flooding problem in case of heavy rainfall. All the areas marked in green circle in Figure 11 shows points where water can accumulate in case of flooding. Careful observation of these spot revealed that flow moves away from the road especially the two spots along Usman Danfodio road and the only spot along Tafawa Balewa road, which suggests that there is a drainage that takes water away from the road. The other three spots will most likely have flooding problem after heavy downpour.

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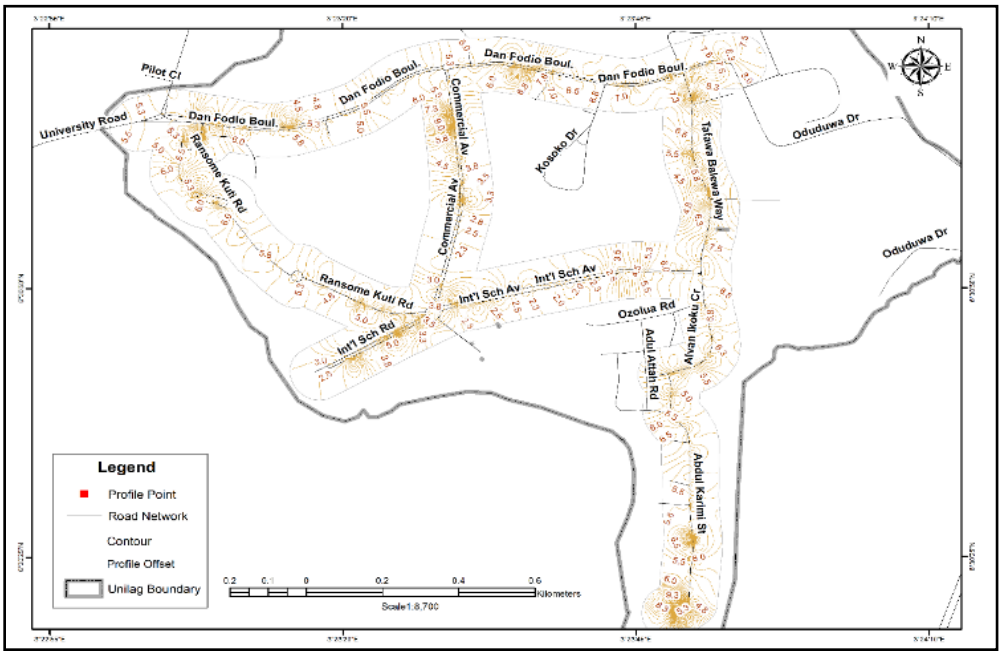


**Figure 10:** Contour map of the road network in University of Lagos Campus

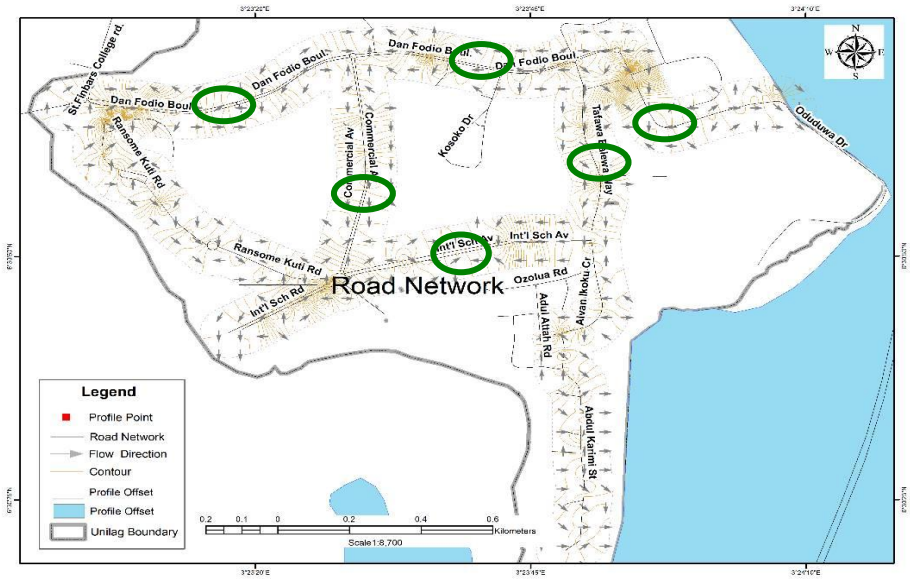


**Figure 11:** Flow Direction map of the road network in University of Lagos Campus

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The Digital Terrain Model of the area presented in Figure 12 presented more clearly the areas that are liable to flooding. Figure 12 shows that although DLI junction is relatively high, there are low elevation areas while moving away from DLI junction in all of the available roads. The two locations identified to be liable to flooding along Usman Danfodio Boulevard and Tafawa Balewa road are actually on a relatively high land. Since water will find its way to low land, these three areas might not experience serious flooding. Figure 12 also shows that the lowland along commercial road may not experience as much flooding as International School Avenue and Oduduwa way. The one along International School Avenue on top of a bridge, there is still a canal under the bridge. It may be necessary to examine the drainage system in this area to see that water get easily off the bridge to the canal. It may even be necessary to clear the canal which is presently covered by thick bush. The one along Oduduwa way may be more serious since it is on a longer stretch of the road. Since most of the surrounding areas are higher, it may be necessary to channel the excess water here to the Lagoon. However, before this is done, it may be necessary to determine water level at the Lagoon front so that water will not flow back to the land at high water.

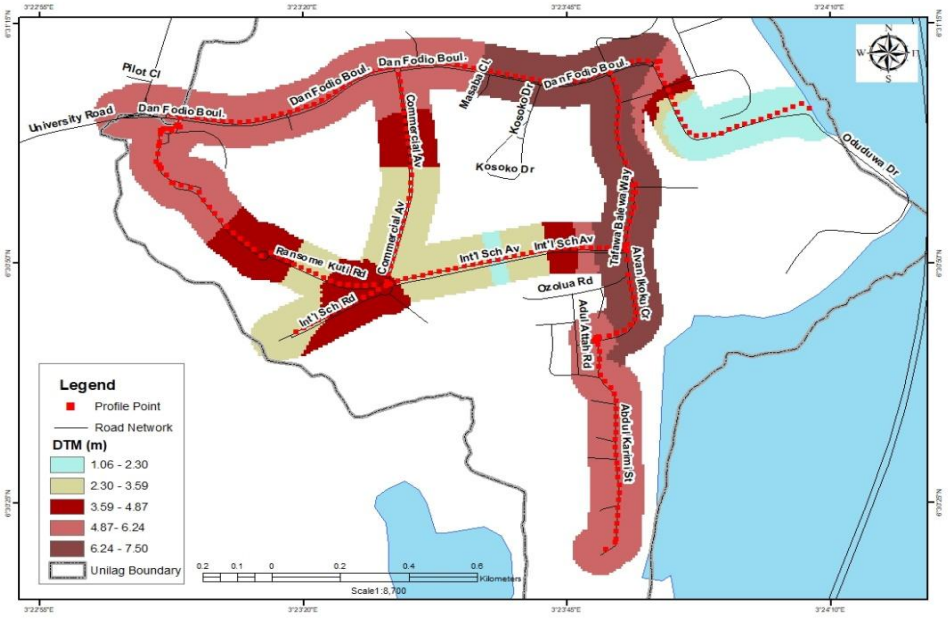


**Figure 12:** The Digital Terrain Model of the selected roads within the University of Lagos.

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The wireframe model presented in Figure 13 is a three dimensional presentation of the landscape along the entire road network. The two locations highlighted in green circle in Figure 13 are the points mentioned earlier to be prone to flooding. Figure 13 therefore confirmed initial submission that these areas are liable to serious flooding in the instance of heavy rain. Having identified flood prone areas, it is necessary to study how these can be solved. There is therefore the need for further study on the terrain of the entire University vis-a-vis the drainage system in the immediate environment of the campus so as to understand how this flooding can be channeled away from these flood prone spots.

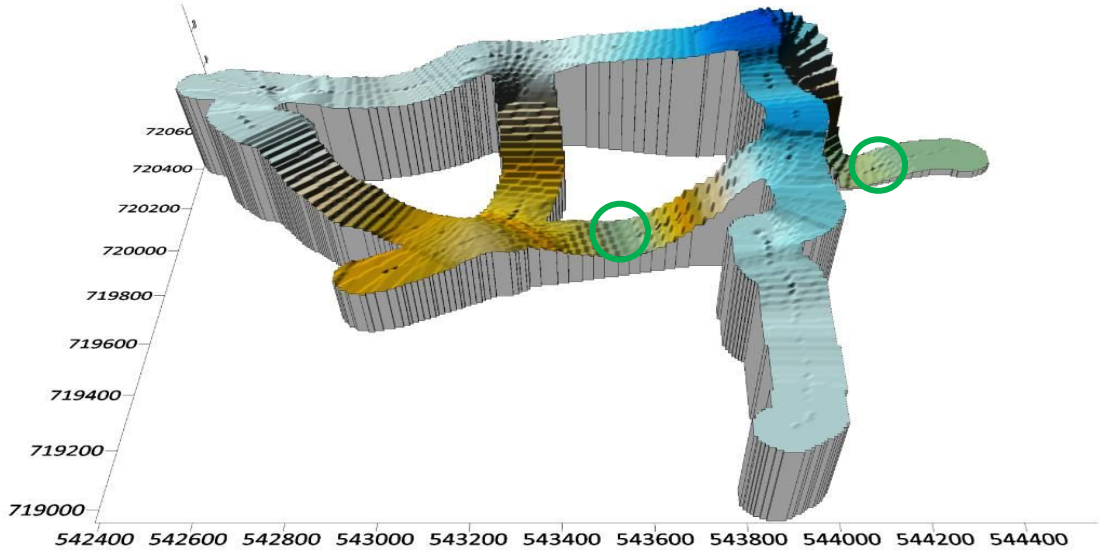


**Figure 13:** The wireframe model of the road network within the University of Lagos

## 5.0 CONCLUSION

This study conducted a thorough investigation into the road network terrain within the University of Lagos campus. Results from the study reveal locations that are susceptible to flooding along the road in the event of heavy flooding. The study therefore recommends further study on the drainage system along these roads as well comprehensive study of the landscape in the neighborhood of the locations identified with flooding. It is believed that the proposed study will complement previous and current efforts at proffering a lasting solution to the problem of flooding in University of Lagos.

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