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VIEWSHED ANALYSIS OF FEDERAL UNIVERSITY OF TECHNOLOGY YOLA, WIRELESS INTERNET NETWORK

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ABSTRACT

This paper is concerned with rectilinear propagation of radio signals utilized by wireless internet platform. The topographic map covering the study area was scanned and saved as JPEG image on the computer. It was then exported to ILWIS environment where the segment map and the Digital Elevation Model (DEM) were created. The DEM was then exported to IDRISI 32 for line-of-sight and viewshed analysis. Viewpoints were selected on both high and lowland areas of the study area and the results compared. The results showed that viewpoints on high peaks produced remarkable visibility than on lowlands in the line-of-sight and viewshed analyses. It was recommended that Boaster transmitters be installed at locations where the height of the wireless signal tower be increased beyond the 30m average to improve signal coverage.

KEYWORDS: Viewshed, Digital, Elevation, Wireless, Propagation

INTRODUCTION

A viewshed refers to the portion of land surface that is visible from one or more view points and the process of deriving viewshed is called viewshed or visibility analysis. The viewshed analysis requires two input data set, a point layer that contains one or more view points and the second input is a Digital Elevation Model (DEM) (i.e. an elevation raster) (Kang-tsung, 2008). Wireless network radio signals obey the Law of rectilinear propagation and thus need unobstructed visibility to get to the intended destinations with optimal strength. This requires careful network design and planning for sites to guarantee inter-visibility and hence communication Wikipedia (2010). Wireless internet signal and strength are very good and fast around the Administrative Building of the Federal University of Technology Yola, (study area), where the server is located, other schools and some departments which fall within the coverage, have very poor or no internet signal at all. This is the major source of concern within the University community.

Wireless internet signals can be affected by a number of factors such as; temperature, humidity, fog, pressure, scattering, sefraction, reflection. etc.

Atmospheric conditions are favourable at some times and thus do not pose constant problem to wireless network signal. Features such as trees, topography, building, mountains between transmitter and receiver are some of the main barriers to signal propagation. The fact that good reception of wireless signals is available at some locations, mainly at high peaks, suggest that geographic and not atmospheric factors have negative effect on the line-of-sight and hence poor wireless signals at lowland areas.

The research is borne out of the concern to provide a platform that would guarantee extensive wireless internet signals within the university community, and is aimed at demonstrating the use of viewshed analysis in improving wireless internet signal reception. It will be done by defining the optimal site from where signals can be received. It will also determine areas of maximum signal reach as a precursor to the installation of booster stations, Finally, data collected would be made available to service providers who might wish to improve signal coverage for the university community.

This study is concerned with the determination of optimal sites for wireless network communication facilities for improving signal reception. The concept of passing message or signals from a location to another was developed right from the ancient times using various instruments and techniques. Gary *et al.* (1996) enumerated the importance of communication to include safety concerns, economic, social interaction, etc. In every effective voice or no voice communication, the platform or location of two points, the transmitter and receiver as well as inter-visibility are significant factors and must be carefully considered. Li (2005) also enumerated factors affecting good radio or wireless signal reception as distance between transmitters and receiver, refraction, scattering, reflection, transmission and diffraction. While reflection in radio signals is similar to optical wave propagation, Li (2005) explained the transmission is as a result of interaction of radio waves with an obstacle which to some extent is transparent, e.g. glass to visible light.

Refraction on the other hand is as a result of lack of constant refractive index of the atmosphere thereby causing the radio waves to change course.

Davin, (2006) considered two points to be inter-visible only if a straight line can be drawn between the points without intersecting any part of the terrain surface between them. This is the concept of line-of-sight and viewshed analysis; while the line-of-sight (LOS) is the process of determining visibility between an observer point and a target, viewshed analysis is the process of determining the region of visibility observable from one or more view points. Viewshed analysis considers a given region and regards every cell within the DEM of

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the given region as target. Viewshed maps has wide range of applications such as location of security towers, GSM mast, radio and television mast, wildlife management, archaeological research, position of watch towers, etc.

Young *et al.* (2004) agreed that, some application areas of viewshed analysis include, location of telecommunication towers, radio and television mast, locating wind turbines evaluation, urban environmental planning and optimal path routes planning.

Stance (2005) other application areas are least cost path analysis to determine routes for military transportation with minimal exposure to danger, scenic routes design, facility location in visually sensitive areas such as national parks, reconnaissance facility site location. Musa (2007) explained how by line-of-sight analysis, the US Army needed to add only 15.2m to the height of a proposed radar tower for optimal vision, thus preventing further clearing of 486.10m of trees after clearing 304m radius without achieving the required result.

The planning and design of wireless network base stations using viewshed analysis has become the norm in developed countries. This is still far from the truth in underdeveloped countries. The demonstration of how this can be achieved successfully is the gap this research study intends to fill.

The research would be very important to both lecturers and students that use wireless network for teaching and research. The improvement on the network coverage would be of importance to those who, for reasons of no or poor network, have to travel to town for similar facility.

Hence, the study will provide adequate information to policy makers who would like to invest in the wireless communication business. Existing wireless network service providers can use this information to re-assess their network policies with a view to increasing outreach. The result can also be used to design an efficient triangulation network.

METHODOLOGY

The research study is based on the use of Geographic Information System (GIS) in solving environmental problems.

Data Acquisition

i. A topographic map of the study area which was used to create the DEM for viewshed analysis.
ii. Coordinates (Latitude, Longitude) of some selected prominent points in the study area. The coordinate were transformed to UTM grid.

INSTRUMENTS:

Software used.

i. CorelDraw XII for manipulation of graphics
ii. ILWIS (Integrated Land and Water Information System) 3.2 Academic, for creation of DEM.
iii. IDRISI 32: for line-of-sight and viewshed analysis.

Hardware:

i. HP Scanner; to scan the topographic map of the study area.
ii. Laptop computer (HP dv6)
iii. Hand held Garmin 12 GPS receiver; to obtain the coordinates of some selected points within the study area
iv. Printer (HP DeskJet 2050 series)

Methodology and Data Processing

The result obtained in transforming the polar coordinates of selected points to UTM grid coordinates is shown in table 1. DEM generated through any of the following techniques; point interpolation techniques and interpolation of contour lines. The interpolation of contur line techniques were used for this study.

The topographic map was scanned and saved as JPEG image, later the contour lines were digitized and interpolated to generate the DEM. In creating the coordinate system and georeferencing of the points, the tie points were entered on the base map to the GPS ground observation points.

By clicking on a designated point, a tie point dialog box appear with rows, columns, the x y coordinates are entered. The process was repeated to enter all the tie points, thus creating a georeference map of the study area. Ten tie points using projective transformation were entered with at least two in each quadrant of the study area.

The segment map was created in order to obtain digital line features. At the segment editor map window, on screen digitization of the contour lines was carried out. Georeference corner was used during rasterized operation or as a North-oriented georefenence for re-sampling raster maps. Contour interpolation in ILWIS software was carried out; the procedure used involves first the rasterized contour lines of a segment map with values domain and next values for pixels in the segment not covered using linear interpolation was calculated.

Re-sampling the Digital Elevation Model

The nearest neighbor re-sampling method was used and the DEM was re-sampled to a spatial resolution of 20m with 534rows and 482 columns a total of 257388 cells. The re-sampled DEM was exported to IDRISI, since ILWIS Academic 3.0 could not provide the functionality for viewshed analysis. The created DEM was exported to IDRISI 32 environment, the object was converted to IDRISI 32 object.

A viewshed map is intended to identify and represent both visible and invisible points of the study area from chosen view points. Every raster cell within the DEM is considered a target, they are observed and all cells that are visible were coded as O, to produce a binary map or viewshed map.

Initialization of DEM

This process creates a non-zero image of the input image (DEM) that is required in the first stage of creating the viewpoint image input for viewshed calculation. Viewpoints where chosen bearing in mind that high peaks command wider view than low land. A vector point file was created for viewshed determination. To perform viewshed analysis, two objects were required surface image (DEM) and viewpoint image of the study area. The vector object create forms the basis for view point image. Since the DEM is a raster object, the vector object created needs to be rasterized to be compatible for viewshed calculation.

Viewshed Processing

The following information was used for viewshed processing; surface image, viewpoint image, output image, viewer height (height of selected cell/viewpoint including height of internet wireless transmitting mast) search distance. Three-dimensional (3D) Illumination image of the study area was created, an illuminated image is intended to create a deeper perspective and a better appreciation of the topography. The illuminated three-dimensional view of the terrain was generated in IDRISI environment by combing the Hue/Saturation, the input plate and the created DEM to produce a resulting output which was finally draped on the DEM in an automatic and simultaneous process to generate the 3D illuminated image of the study area.

Analysis of Results

Table 1 shows the position of the points observed with the hand held GPS; this shows the result of the viewshed analysis spanning from the creation of the segment map of the viewshed or binary map of the study area.

Table 1: Location of some observed viewpoints

S/No	Location	X(m)	Y(m)	Height Above Sea Level (m)
1	PBAA 438	226944	1036816	250.96
2	Admin	225824	1033718	237.55
3	SPAS Junction	225965	1034282	232.41
4	School field	226277	1033850	232.89
5	Staff quarters	226010	1034597	217.09
6	CEMIT	225948	1034041	241.01
7	Kabiru Umar Hall	225348	1034428	229.28
8	SMIT	225284	1034096	227.88

PBAA 348: as the reference point

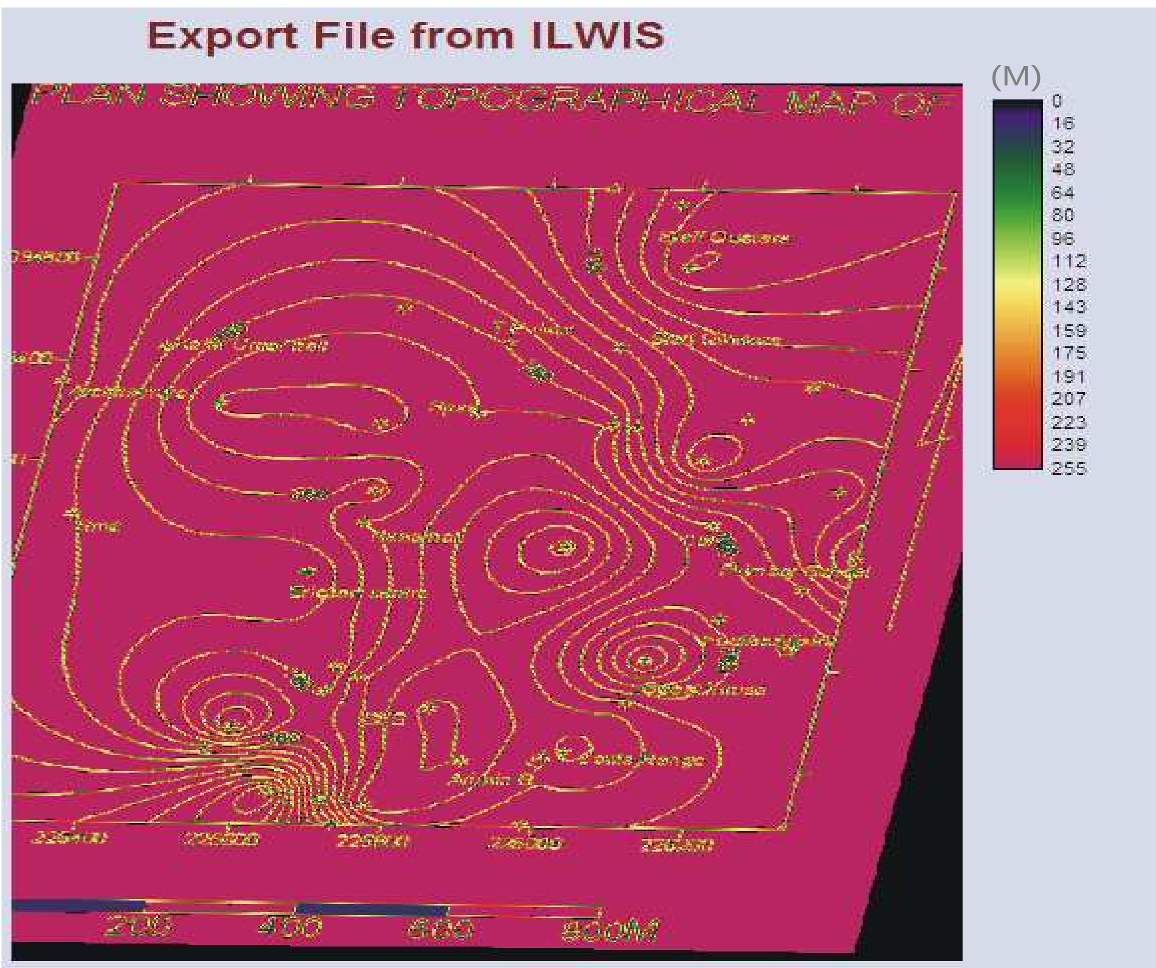

Fig.1: Contour Map of the Study Area (FUT. Yola)

Figure 1 shows the representation of the contour map of the study area. This was obtained from the observed height.

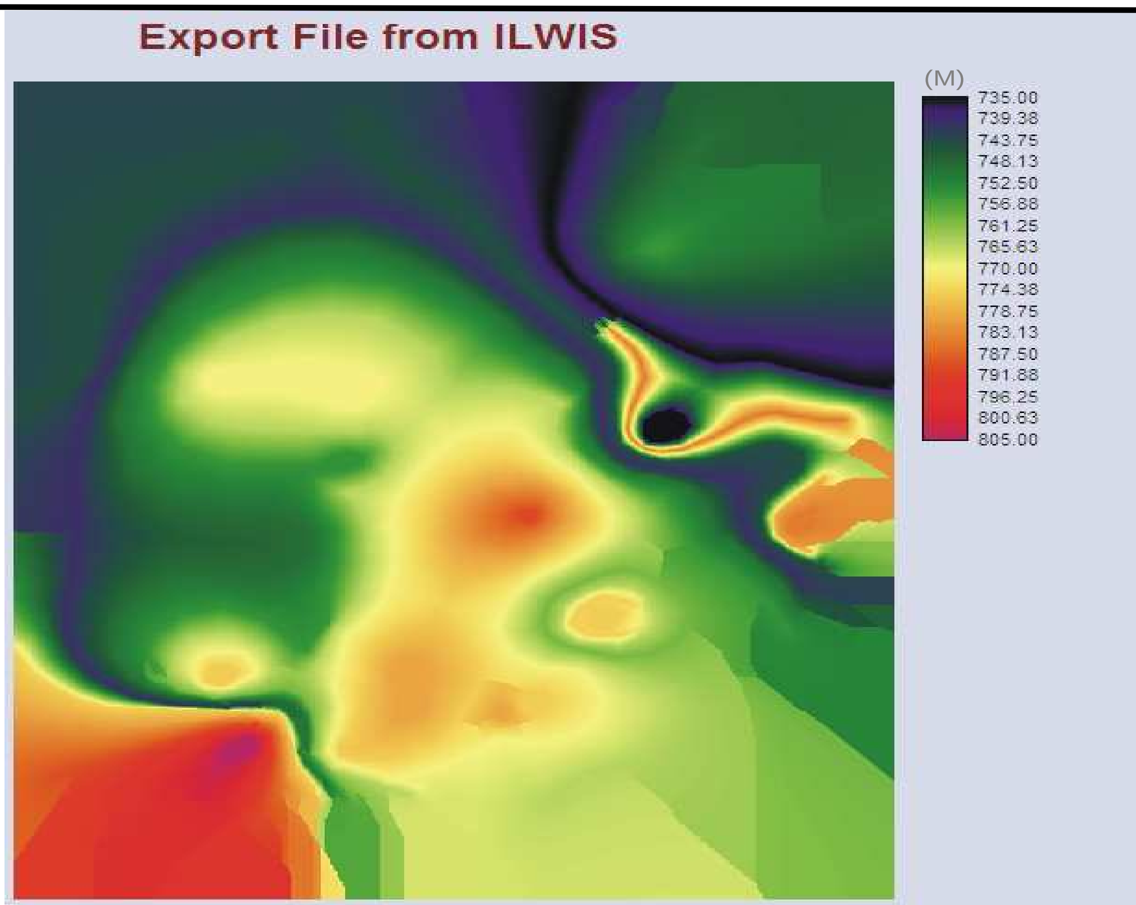

Fig. 2: Digital Elevation Model of FUT, Yola

The Digital elevation model of the study area created and re-sampled on the georeference corners.

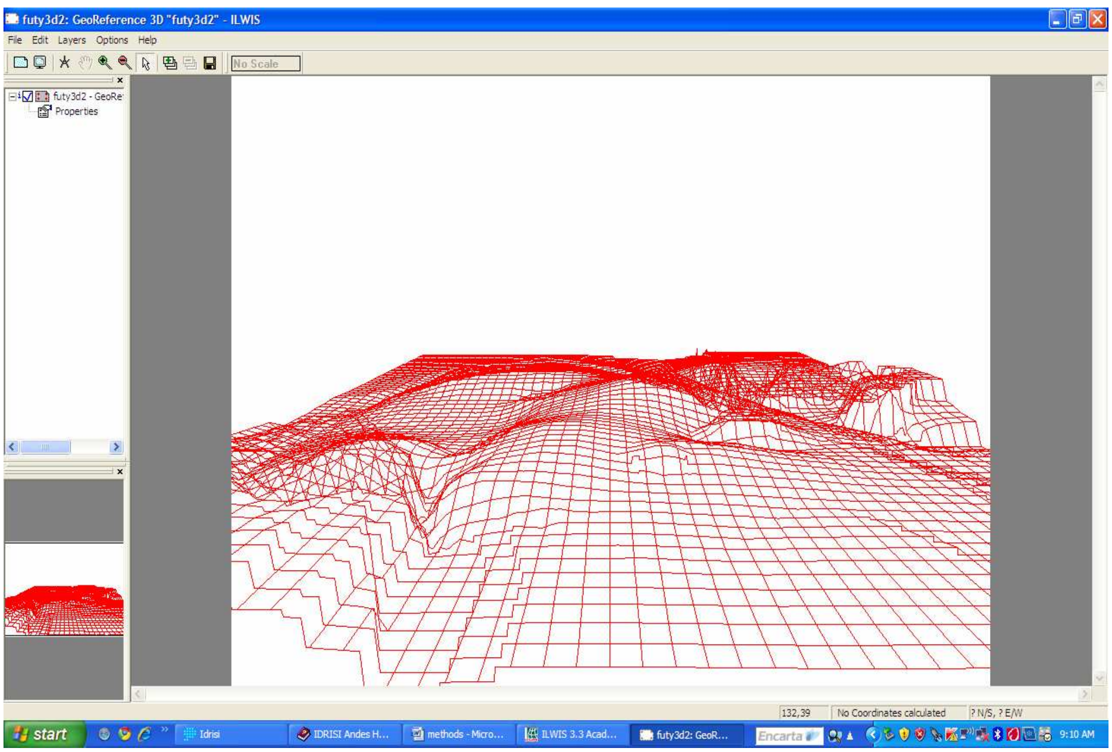

Fig. 3: Illuminated (3-D view) of the study area (FUT, Yola)

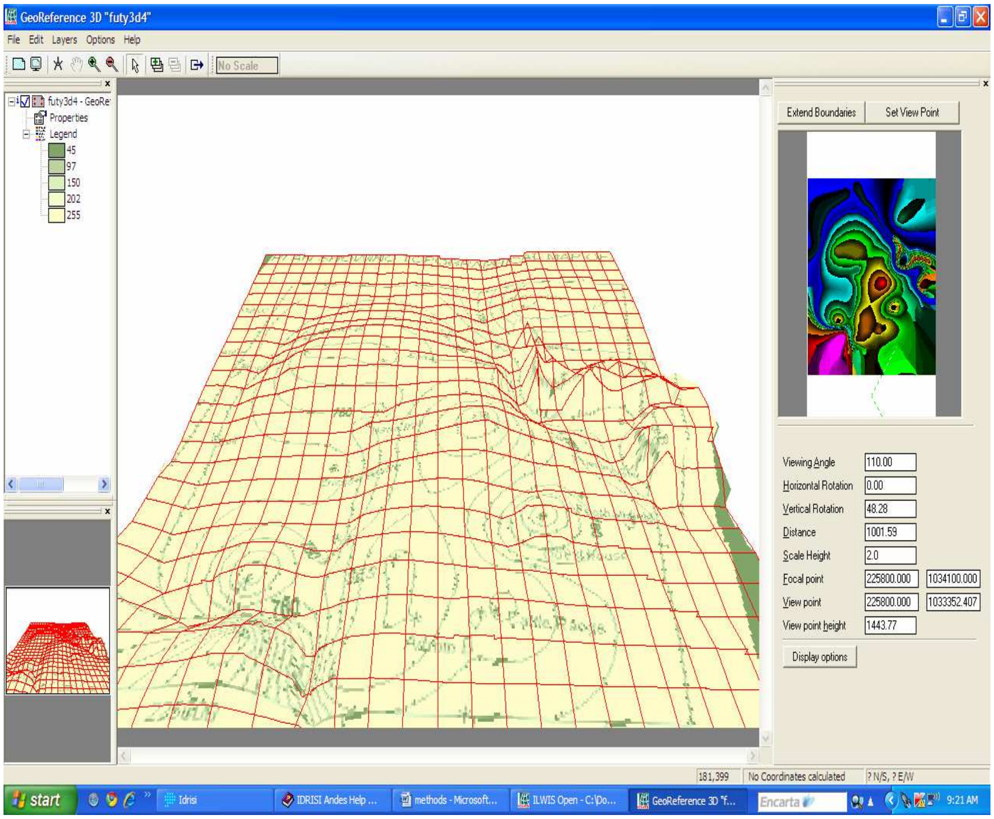

Fig 4: shows the Georeferenced 3-D image of the study area.

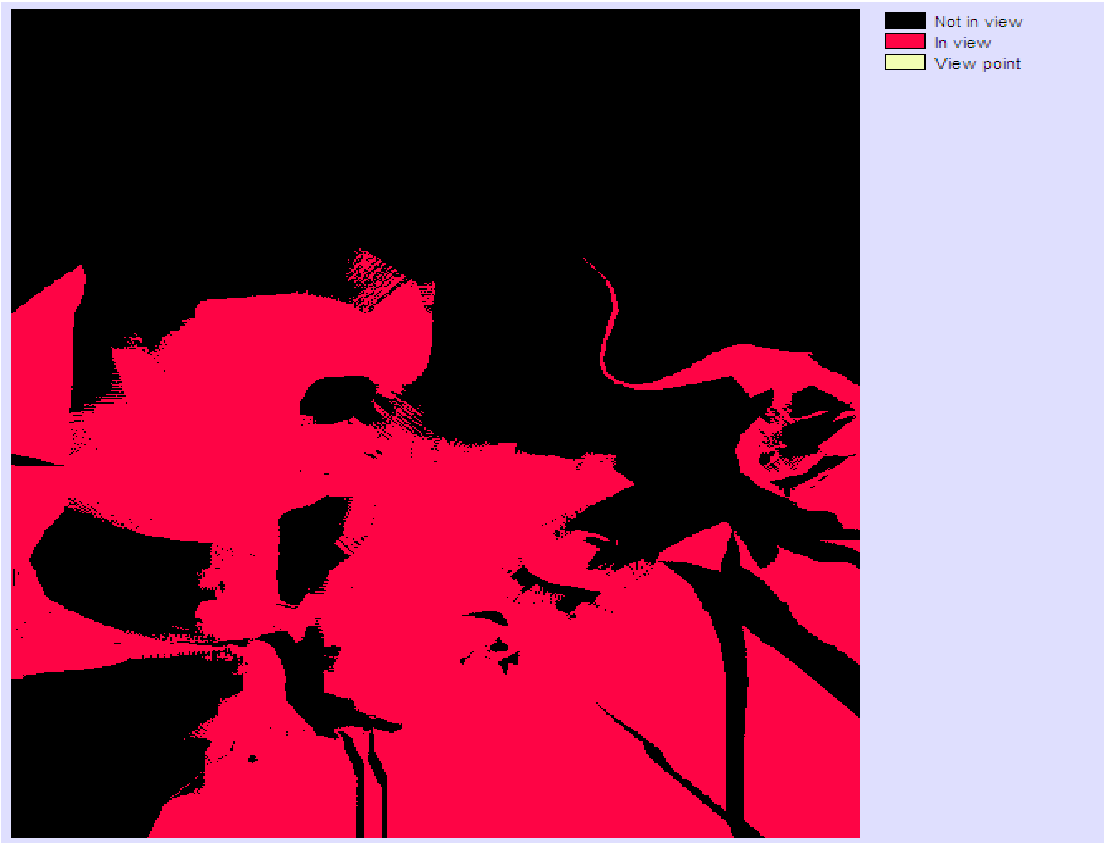

Fig 5: Representation of viewshed map of the study area
"in visible areas" against O and red for "visible areas" as against I

RESULT AND DISCUSSION

The contour map of the study area is being represented in fig. 1. This was obtained from the observed height represented in table 1. Interpolation of the contour line technique was employed, scanning of the topographic map and digitization was used to generate the Digital Elevation Model (DEM) which is shown in firg.2. Fig.3shows the illuminated 3-D view of the study area, while fig.4 shows the georeferenced 3-D image of the study area. The viewshed map was created in idrisi32 environment based on Boolean theory; the representation of the image is black for a single viewpoint located at Admin with mast height of 30m was used to produce the coverage area as seen in figure 5. As can be observed in figure 3, 4 and 5 the topographic feature that possibly constitute an obstruct to the line-of-sight within the study area are the surrounding hills and mountains which descends gently across the line-of-sight, this is responsible for the lack of signal in points of depression in the study area. In figure 5, the viewshed image of the study area shows the part of the university community that can receive signal from the wireless transmitting mast effectively and those that have no or poor signal. The 3-D view image of the study area gives a clue to this; line-of-sight and viewshed analysis using low viewpoints showed limited coverage as geographic features, such as mountains and hills block the line-of-sight hence limiting coverage in those parts of the study area.

The result of the research findings shows that:

a) The location from which the wireless signals are being transmitted is in a low area, surrounded by mountains hence; the poor signal being experiences in most parts of the study area.
b) High peaks provide more extensive area coverage than low peaks.
c) Geographic features, such as hills, mountains and high buildings constitute obstruction to the line-of-sight and hence the poor quality of network being experienced in most parts of the study area.
d) Some of the non visible areas, such as library and some lecture halls location in the southern part of the university can become visible by increasing the height of the view part cells.

CONCLUSION AND RECOMMENDATION

The viewshed analysis has shown that the present location of the server “ADMIN” for the wireless network signal is a suitable platform for extensive signal coverage within the study area, since the signal is not received in most of the locations in the university. The study also showed that the internet wireless signal coverage in the study area is limited by some geographic features such as buildings and the high ground between the buildings and lecture halls. However, extensive signal coverage is possible and obtainable at high peaks, ridges and by increasing the height of the wireless service transmitting tower by 20m. Multiple sites can also be use to improve signal coverage as is used in mobile phone communication GSM transmitters and in radio/television transmission where boaster inter-station are used to improve area coverage.

The following recommendations were made base on the findings and results obtained.

i. Viewshed analysis is recommended for determination of optimal sites for optimal signal outreach.
ii. Boaster transmitters be installed at locations were unobstructed line-of-sight exist between optimal sites and the visible boundaries of the study area to increase signal coverage.
iii. Height of the wireless signal tower be increased beyond the 30m average used in this study to improve signal coverage in FUT, Yola.
iv. Multiple viewpoints should be used by operations of wireless service to improve signal coverage in the study area.

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