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BASELINE ASSESSMENT OF GULLY EROSION OF SELECTED LOCATIONS IN SOUTH-EAST, NIGERIA

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ABSTRACT

Changes on the structure and physical characteristics of the earth surface are inevitable due to factors ranging from physiochemical effects, human activities, geological changes and such like. These changes are evident in various dimensions in our immediate environment. The case of gully and coastal erosion is predominant in the South-South and South-East region of Nigeria with its attendant impacts and consequences in both human and material resources. The challenge is not the presence of this environmental phenomenon (gully erosion) particularly in the South-East region, but the absence of a regular geospatial assessment of the extent and impact of gully erosion on the environment. It is therefore the aim of this paper to highlight the relevance of the geospatial baseline assessment of the extent and impact of gully erosion and geological changes within and around the study area. The objective hereto is to map the gully corridors and profile, determine gully geometry through the provision of spatial information to serve as a baseline to determine gully system dimension and its changing pattern. We deployed Global Navigation Satellite System (GNSS) techniques to generate spatial data for the different section of the gully impacted areas. The study areas of Nkpor axis and Obosi axis were 6.965hectares and 22.485 hectares respectively as at the year 2018. We further determined the spatial information of 1397 and 3755 points along the gully corridor and associated profile for Nkpor and Obosi axes respectively. The profile map and 3-dimensional representation of the extent of the gully demonstrate the need to provide the associated information for the purpose of mitigating the devastating effect within and around the study area. (Keywords: Gully erosion, geological, spatial data, earth surface, GNSS)

Keywords: Gully Erosion, Baseline, Assessment, GNSS, Map

1.0 INTRODUCTION

Gully erosion is an ecological issue of great concern in the south-south region of Nigeria in general and Anambra State in particular. Erosion problems arise mainly from natural causes but their extent and severity are increasingly being attributed to man's ignorance and unintentional actions (Enabor and Sagua, 1988). According to Ofomata (2009), Gully erosion, which is simply a systematic removal of soil, including plant nutrients, from the land surface by the various agents of denudation occurs in several parts of Nigeria under different geological, climatic and soil conditions. Gully erosion is a dynamic geomorphic event operating on the landscape (Ojo and Johnson, 2010). In spite of technological advancement, erosion menace still remains a major problem in Nigeria (especially in South East and South-South Nigeria). The yearly heavy rainfall has very adverse impacts altering existing landscape and forms. Such landforms create deep gullies that cut into the soil. The gullies spread and grow until the soil is removed from the sloping ground. Gully erosion when formed expand rapidly coupled with exceptional storm or torrential rain down the stream by head-ward erosion gulping up arable lands, economic trees, homes, lives, and sacking of families and valuable properties that are worth millions of naira (Umudu, 2008). Gully erosion is the process in which soil is removed according to the concentration of surface water and subsurface water in narrow flow paths, resulting in the formation of incised channels that may grow into gullies deeper than 30 cm over short time periods (Luffman, I. E., et al, 2015). This cause significant soil loss and soil degradation, and it is generally considered as an indicator of desertification and land degradation (Poesen, J., et al, 2003). Despite being a natural process, gully erosion is generally initiated and accelerated by inappropriate agricultural and human activities (Kakembo, V., et al, 2003). Gully erosion mapping is a crucial step to monitor land degradation and study its current and future local impacts.

To date, numerous gully erosion studies have been performed at different scales and with different objectives (Gomez-Gutierrez, A. et al, 2015). For instance, gully location maps at the national scale (Roux, N.M., et al, 2012) and gully risk map at regional scale have been obtained (Eustace, A. H., et al, 2011) the effect of topography on gully distributions (Zhang, s., et al, 2015) and the spatial variations of gully distributions over a large scale have been analyzed (Yan, Y. C., et al, 2006) gully networks have been defined for small catchments at a medium scale (Perroy, R. L., et al, 2010), and gully head cut retreat rates at a small scale have been estimated (Wu, Y., et al, 2008). Various techniques have been applied for measuring, mapping and monitoring gully erosion accordingly. Compared with conventional techniques (e.g., ruler, tape, micro topographic profilers (Casali, J., et al, 2006), poles, total stations (Castillo, C., 2012) pins (Ionita, I., 2006) which are time-consuming for achieving high accuracy in field surveys at a small scale, the development of Global Navigation Satellite System (GNSS) techniques has provided an efficient method to obtain spatially continuous gully information over large scales for different time periods.

The thrust of the research therefore is to highlight the relevance of the geospatial baseline assessment of the extent and impact of gully erosion and geological changes within and around the study area, which was achieved with the aid of Global Navigation Satellite System (GNSS) techniques to generate spatial data for the different section of the gully impacted area. Specifically, the objectives of the present study are: to map the gully corridors and profile, and determine gully geometry through the provision of spatial information to serve as a baseline to determine gully system dimension and its changing pattern.

1.2 STUDY AREA

This paper documents a GNSS positioning techniques for the establishment of a geospatial baseline that can be used to assess, monitor, and determine the impacts of the gully erosion.

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The geospatial baseline assessment survey was carried out at two different locations Nkpor and Obosi in Anambra State, Nigeria. Nkpor is a town in Idemili North local government area of Anambra state, southeastern Nigeria. The town of Nkpor had an estimated population of 109,377 in 2007. It is attached to the much larger city of Onitsha to the west, Oze to the north west, Ogidi to the north, Umuoji to the north east and Obosi to the south.

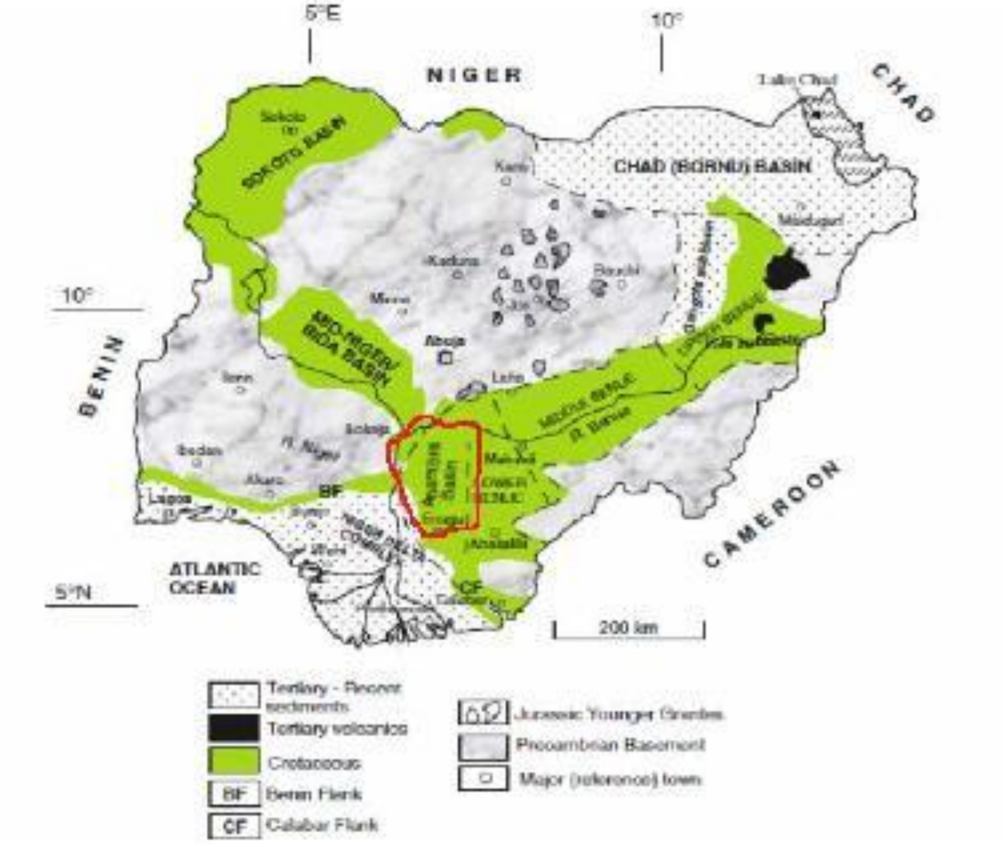

Figure 1. Geological Map of Nigeria (Obaje, 2009)

1.3 METHODOLOGY

The geospatial baseline map was done using the Global Navigation Satellite System (GNSS) on the real time kinematics mode. RTK surveying is a carrier phase based relative positioning technique that employs two (or more) receivers simultaneously tracking the same satellites. This method is suitable when: (1) the survey involves a large number of unknown points located in the vicinity (i.e., within up to about 10-15km) of a known point; (2) the coordinates of the unknown points are required in real time; and (3) the line of sight, the propagation path, is relatively unobstructed (Langley, R. B., 1996). Because of its ease of use as well as

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its capability to determine the coordinates in real time, this method is the preferred method for the mapping of gully erosion.

In this method, the base receiver remains stationary over the known point and is attached to a radio transmitter. The rover receiver is normally carried in a backpack and is attached to a radio receiver. Similar to the conventional kinematic GPS method, a data rate as high as 1Hz (one sample per second) is required. The base receiver measurements and coordinates are transmitted to the rover receiver through the communication (radio) link. The built-in software in a rover receiver combines and processes the GPS measurements collected at both the base and the rover receivers to obtain the rover coordinates.

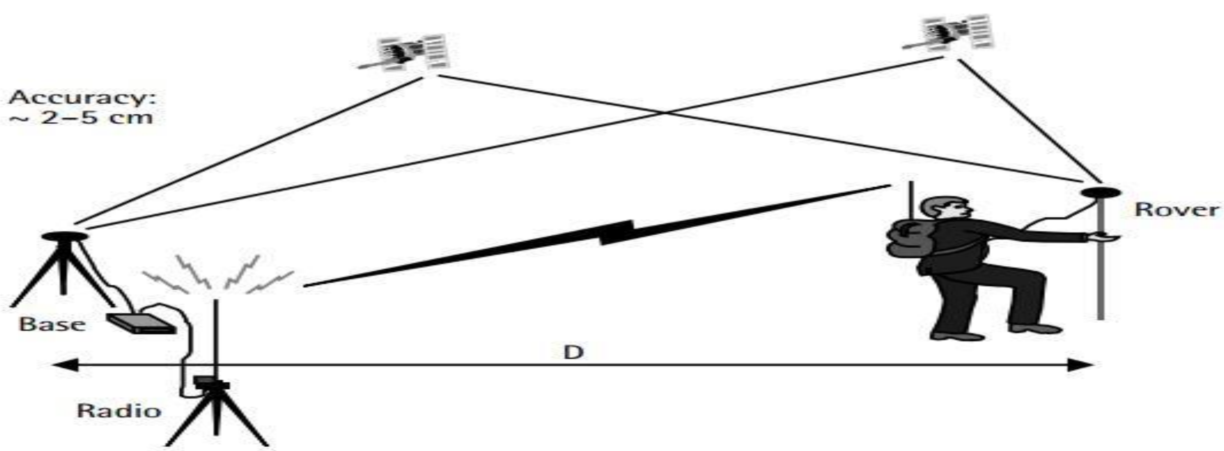

Figure 2: Diagrammatic Representation of GPS Receiver (Source: EL-Rabbany A., (2002); Introduction to GPS)

During field work, one of the GPS receivers (Base Receiver) was set up on an existing GPS control point (Figure 2a) ascontinuously‘basereceivestation’visualsatellitesignal towhile the other receivers (Rover) was used in collecting field data along the gully corridors and the interiors. Field observations were carried out between 8am and 4pm when the signals from satellites were guaranteed. Also a distance range less than 30 km (manufacturer specification) was maintained for better accuracy. The coordinates in Digital Train Model (DTM) format was obtained in real time and stored in the pocket display adapter. The obtain data was later downloaded from the pocket adapter to a personal computer (PC) where the data was arranged and sorted using micro soft excel. The suffer software version 8.2 was used to plot the contour, and other models as shown in the result.

Figure 3: Pictures of the Gully Data Acquisition Exercise (Hart and Basil, 2018)

1.4 IMPACT OF GULLY EROSION AND GEOLOGICAL CHANGES

The buildings and other allied structures within and around the study area are greatly impacted by the effect of the gully erosion. Figures 4 and 5 depicts the impact on residential buildings with partial collapse and structural cracks on the buildings. Furthermore, the geological impact underpins the non-usable characteristics of the environment in terms of agriculture or other economic ventures. In the same vein, the affected area becomes prone to various hazard and unsafe conditions for human and allied activities.

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Figure 4: Impact on Residential Buildings in the Study Area (Hart & Basil, 2018)

Figure 5: Impact on Geological Changes in part of the Study Area (Hart & Basil, 2018)

1.5 RESULTS AND DISCUSSION

The spatial information of the study area which covers the Obosi and Nkpor gully sites are represented in terms of the projected coordinates and ellipsoidal heights of points along the gully corridors and interior location. Table 1, depicts the specimen coordinate listing for the

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Obosi gully location with the relative ellipsoidal height ranging between 40.471 to 104.102 meters. These values were used to obtain the elevation model and contour of the affected location. Similarly, table 2, highlights the coordinates of points in the Nkpor gully location with approximate ellipsoidal height as 106.550 meters, the data analysis reveals the area of Nkpor axis and Obosi axis as 6.965 hectares and 22.485 hectares respectively as at the year 2018. The spatial information of 1397 and 3755 discrete points along the gully corridor and associated profile for Nkpor and Obosi axes respectively were obtained for analysis. However, these points are not monumented due to the dynamic nature resulting from the physiochemical effects, human activities, geological change and other activities associated with the study area. The values were also used to obtain the necessary geospatial models as required.

Table1: Specimen of Coordinate Listing of Obosi Gully Site (2018)

Point I	Easting	Northing	Height
Obosi D	259653.3	676342.	104.01
Obosi D	259654.1	676341.	103.67
Obosi D	259664.7	676349.	104.01
Obosi D	259665.5	676349.	103.98
Obosi D	259665.5	676348.	103.00
Obosi D	259665.1	676349.	102.99
Obosi D	259660.0	676358.	104.09
Obosi D	259632.7	676342.	103.99
Obosi D	259637.3	676332.	103.84
Obosi D	259637.6	676331.	103.86
Obosi D	259637.4	676331.	102.87
Obosi D	259637.8	676331.	102.86
Obosi D	259651.6	676339.	103.55
Obosi D	259650.9	676340.	103.71
Obosi D	259651.2	676340.	102.53
Obosi D	259651.7	676339.	102.58
Obosi D	259653.5	676341.	102.60
Obosi D	259654.0	676340.	102.99
Obosi D	259653.5	676341.	102.24

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Table2: Specimen Coordinate Listing of Nkpor Gully Site (2018)

Point ID	Eastings (m)	Northings (m)	Height(m)
NKpor rd2	259761.564	680577.569	106.55
NKpor DTop	259748.573	680589.979	99.169
NKpor DTop2	259736.048	680589.066	97.837
NKpor DInvert1	259735.935	680588.799	97.277
NKpor DInvert2	259735.997	680588.017	97.29
NKpor DInvert3	259736.235	680587.293	97.326
NKpor DTop	259713.036	680586.389	96.474
NKpor Dinv	259713.131	680586.385	95.873
NKpor Dinv1	259713.205	680585.514	95.866
NKpor Dinv2	259713.361	680584.653	95.856
NKpor DTop4	259713.267	680584.665	96.402
NKpor DTop5	259692.444	680585.307	94.666
NKpor Dinv5	259692.466	680585.175	94.067
NKpor Dinv6	259692.579	680584.293	94.111
NKpor Dinv7	259692.731	680583.473	94.149
NKpor Dtop7	259692.878	680583.428	94.72
NKpor DInv9	259693.74	680581.171	95.014

The 3D-Model of the Ire Obosi Gully as shown in figure 3 depicts the two channels of the gully with its unique geometry which converge and empty into the Idemili river. The scale at the left corner shows the depth (in meters) in term of color variation of the Gully. Similarly, figures 4a and b shows the contour and image characteristics of the obosi axis gully site. In this same vein, figure 5 further shows the relief map of the gully site demonstrating the spatial properties of the affected location.

Figures 6, 7 and 8 shows also the spatial representation of the gully site in the Obosi axis of the study area in terms of the contour, 3-dimensional view, and relief representation as applicable.

These representations are as at 2018 which forms the basis of geospatial baseline analysis of the corresponding effects and impact within and around the study area.

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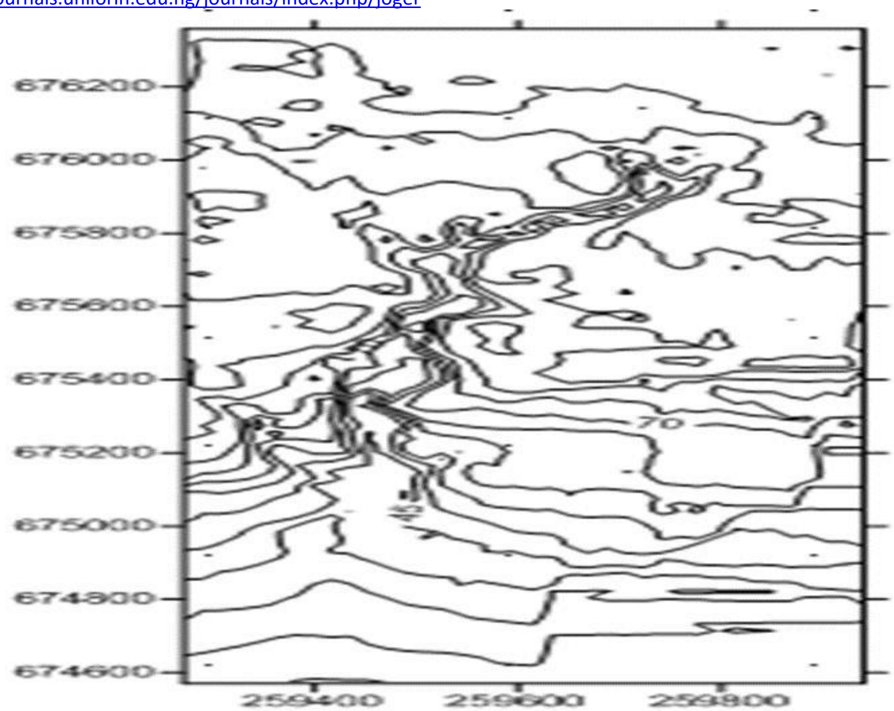

Figure 6: Contour Map of Obosi Gully

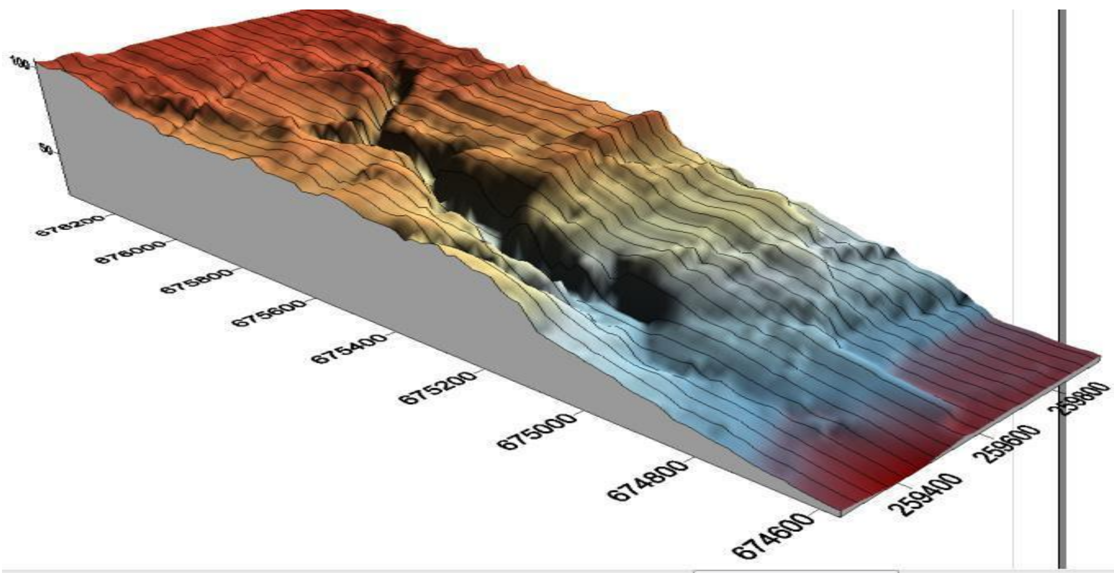

Figure 7: 3D-Model of the Ire Obosi Gully

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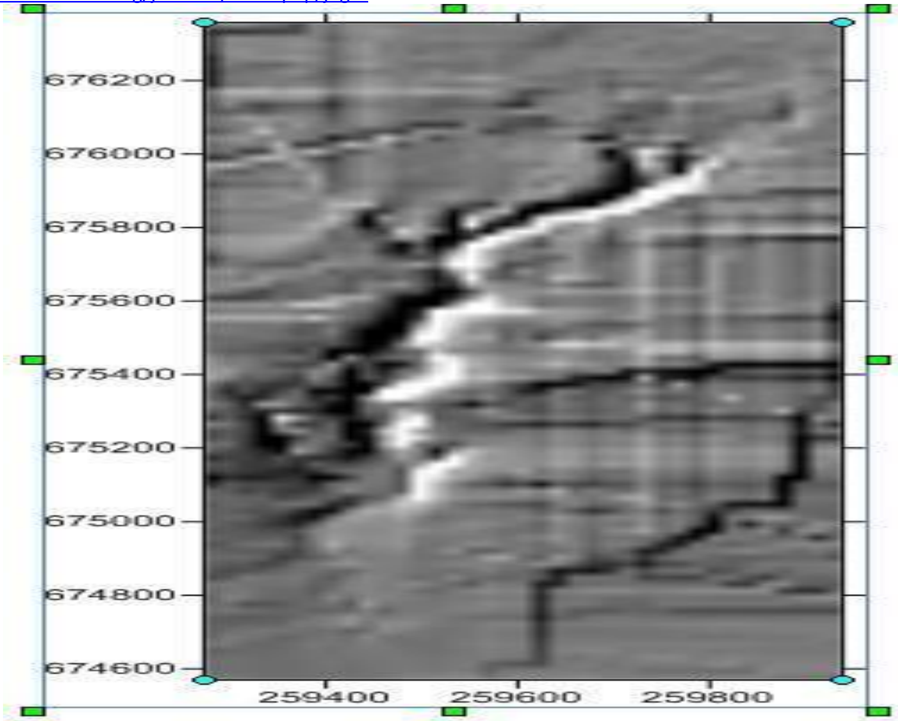

Figure 8: Shaded Relief Map of Obosi Axis Gully (2018)

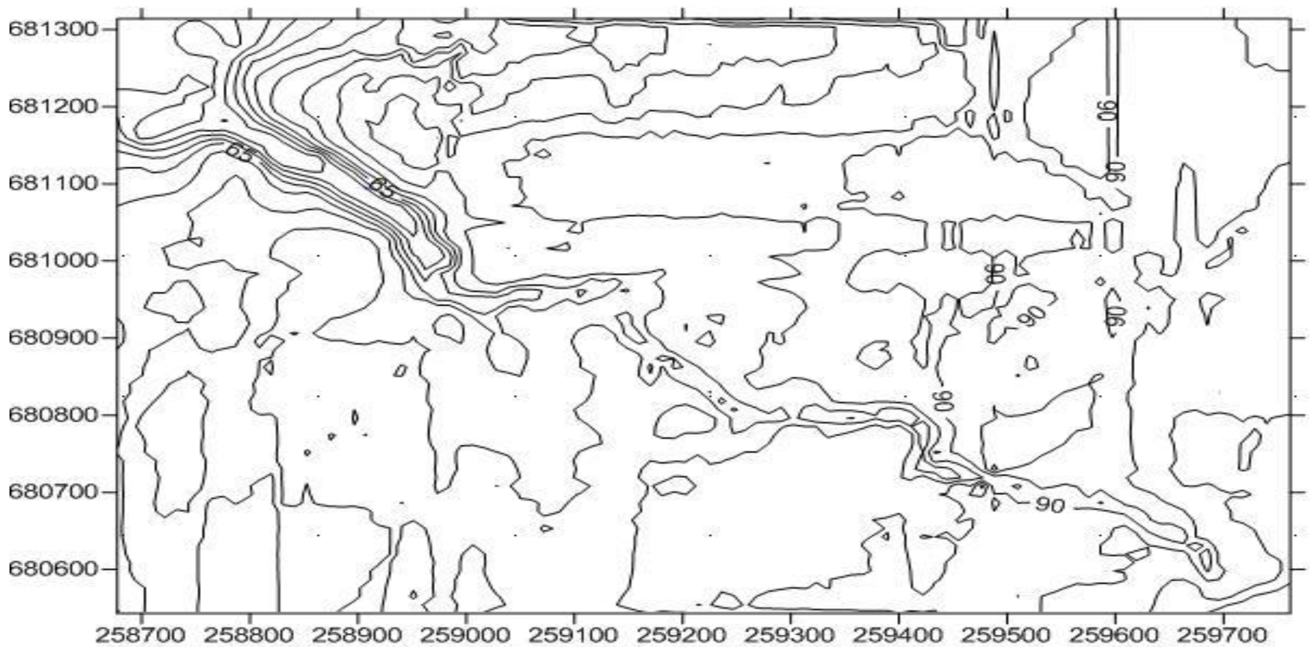

Figure 9: Contour Map of Nkpor Axis Gully (2018).

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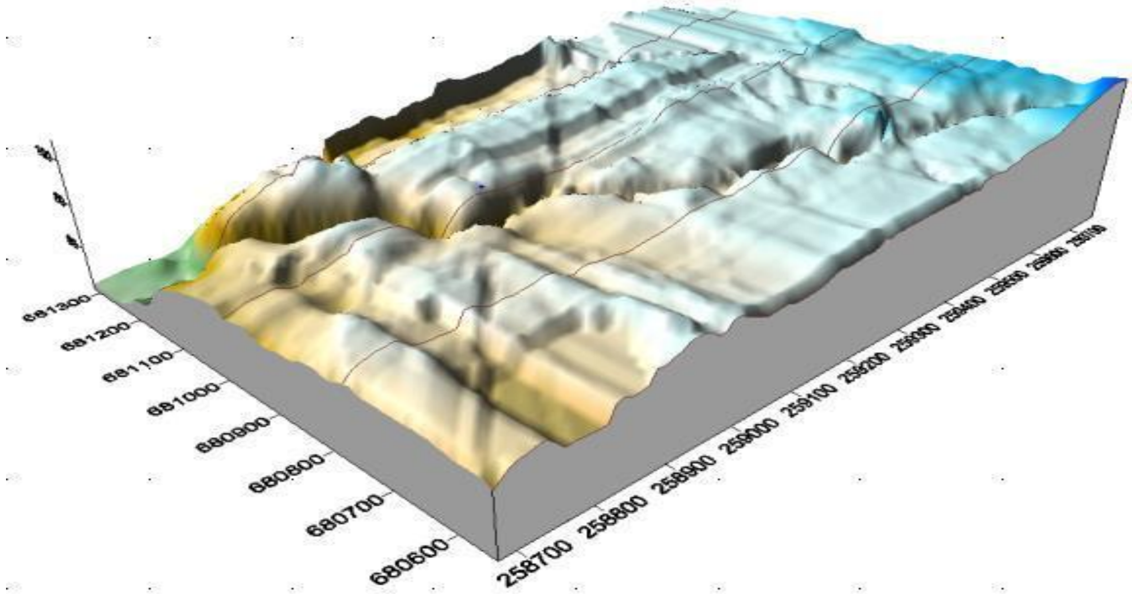

Figure 10**:** 3D-Model of the Nkpor Axis Gully Site (2018)

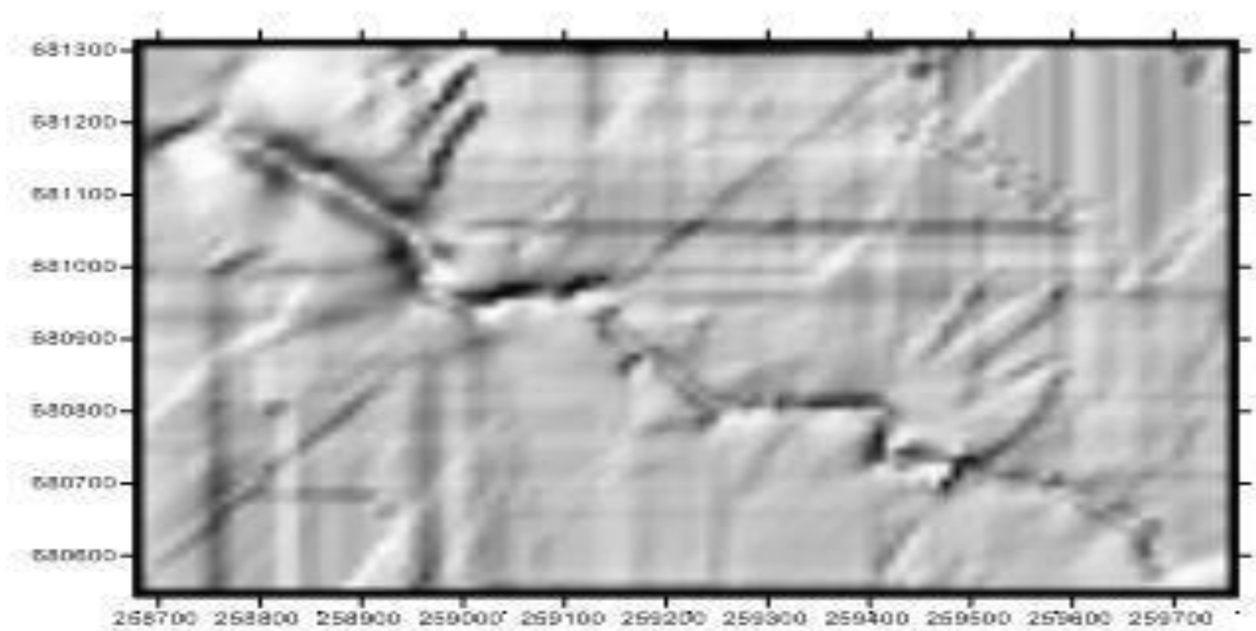

Figure 11: Shaded Relief Map of Nkpor Axis Gully (2018)

1.6 CONCLUSION AND RECOMMENDATION

The study demonstrated the use of GNSS, in the determination of gully dimensions in part of South Eastern geopolitical area of Nigeria. This work provides the spatial framework for baseline studies of the trend and dimensional changes due to gully and geological effects in the study area. The result showed that the extent of the study locations are 6.965 hectares and 22.485 hectares for Nkpor and Obosi respectively. The use of GPS receivers in the provision of spatial information within and around the study area in the form of projected coordinates (i.e. Eastings and Northings) and measuring gully dimensions, has not only proved, accurate, reliable and useful in urban gully studies but opened up a new approach particularly when and where there is urgent need to assess gully growth and development. As a result of digital format in which the data were recorded and stored, the gully channels and the immediate surrounding could be represented in a 3-dimentional view. However, as a result of dynamic nature of gully development, the study recommends the need for continual and systematic real time assessment of changes that take place within the study area.

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