# Gully Erosion Study of Owerri South Eastern Nigeria Using Land SAT (ETM) and Aeromagnetic Data

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DOI: 10.56201/ijgem.v10.no7.2024.pg34.

***Abstract***

*Gully erosion is the most obvious form of soil erosion in southeastern Nigeria mainly because of the remarkable impressions the gullies make which are also visible manifestation of the physical loss of land that will have been used for Agriculture and infrastructural development. Gully erosion is a well-defined water worn channel. Gully erosion, the most impressive and striking erosion type, has been recognized as one of the major global environmental problems. Observations have shown clearly that gully erosion is more prevalent in sedimentary terrain than in the basement complex of Nigeria. This erosion activity at various scales has resulted in the loss of lives and properties almost on a yearly basis. This work is about gully erosion study of Owerri using remote sensing and aeromagnetic data. This study is aimed at giving a detailed interpretation of the remote sensing and aeromagnetic data of the study area. This work identifies and studies gully erosion in the study area, Owerri and its environs in Imo State, South Eastern Nigeria which is located between latitude 5.18° – 5.39° N and longitude 6.51°- 7.08° E. Aeromagnetic data (maps) where acquired from Nigerian geological survey Abuja the images was obtained using land sat ETM sensor with band combination 2,3 and 4 with resolution of 30m. The processing of the land sat images and the aeromagnetic data where done using ILWIS 8.0 and 10.0, ILWIS Academia, ARC GIS, ERDAS, Q GIS. These software's have the capacities of carrying various data enhancement techniques such as linear enhancement, statistical analysis, principal component analysis. The interpretation of aeromagnetic survey data is aimed at mapping the subsurface and the subsurface regional structures such as faults, folds, contacts, bodies and vegetation. This paper discusses aeromagnetic technique, in geology and discusses gully erosion, causes of gully erosion, impacts of gully erosion, modes, types and mechanism of gully erosion. It discusses solution to gully erosion in Nigeria. Solutions that have been proffered include public awareness campaign, improved farming techniques, cultural method of gully control, enactment of laws against any activities that favour gully growth, and thorough implementation of suggested solutions.*

***Keywords**: Remote Sensing, Gully Erosion, Aeromagnetic Data, Lineament, TMI, Land Sat.*

## INTRODUCTION

Natural resources development and management are critical concerns for humanity. The benefits derived from using resources and the harmful impacts of their misuse are crucial for natural ecosystems. Degration occurs when natural ecosystems cannot renew themselves due to frequent dusruptions, posing significant threats to human livelihoods and the environment. Mapping and assessing degraded land can be achieved through remote sensing technique, employing statistical methods and human interpretation. Traditional maps categorise land into different use and cover types ( thermathic mapping), while newer methods allow for detailed mapping of land degradation and other land properties as continuous variable, such as tree cover, vegetation, and barren areas ( continuous fields mapping). The presence of gully sites is one of the hazardous features that characterize Imo State and several other eastern states adjoining it (Okereke, Onu, Akaolisa, Ikoro, Ibeneme, Ubechu, and Amadikwa 2012)

## AEROMAGNETIC SURVEY

Aeromagnetic data may be high resolution or low resolution. High resolution aeromagnetic data is a type of data collected at lower altitude and highly reduced flight line spacing. suggested that high resolution aeromagnetic data for petroleum exploration are commonly defined as data collection at a flight line spacing of spacing of 800 meters or less, at flight height of 150 meters or less and 15 meters or less sample spacing along the flight lines and at better than 0.1 nt accuracy. Hence in high magnetism, more data are collected. Such data have more reliable accuracy than low resolution aeromagnetic.

Aeromagnetic survey maps the variation of the geomagnetic field, which occurs due to the changes in percentage of magnetite in the rock. It reflects the variation in the distribution and types of magnetic minerals below the earth surface. Magnetic minerals can be mapped from the surface to great depth in the rock crust depending on their dimension, shape and the magnetic properties of rocks. Sedimentary formations are usually nonmagnetic and consequently have little effect whereas igneous and metamorphic rocks exhibit greater variation and become useful in exploring bedrock geology concealed below cover formation (Reeves 2005).

The anomalies in the magnetic field of the earth may be considered as arising from two principle causes: literal change in the magnetic polarization of the basement rock, and structures of basement surface.

Aeromagnetic data can be used to delineate structural trends by following lineaments in magnetic contours ( Okereke and Ananaba, 2006). Furthermore, they can be used to map new structural successfully, and extending known areas.

## GULLY EROSION

*Gully erosion* is defined as the erosion process whereby runoff water accumulates and often reoccurs in narrow channels and, over short periods, removes the soil from this narrow area to considerable depths ( Poesen *et al.*, 2003

Erosion is one of the surface processes that sculpture the earth's landscape and constitutes one of the global environmental problems. Soil erosion is perhaps the most serious mechanism of land degradation in the tropics. Gully erosion, the most impressive and striking erosion type, has been recognized as one of the major global environmental problems. Many States in Nigeria are currently under threats of this phenomenal process, south-eastern part of the country being the most affected. It has numerous causes; and these causes can be both naturally and artificially-induced, but the underlying geology and the severity of accompany surface processes play a key role. Observations have shown clearly that gully erosion is more prevalent in sedimentary terrain than in the basement complex of Nigeria. This erosion activity at various scales has resulted in the loss of lives and properties almost on a yearly basis. Solutions that have been proffered include public awareness campaign, improved farming techniques, cultural method of gully control, enactment of laws against any activities that favour gully growth, and thorough implementation of suggested solutions.

**Causes of Erosion**

Gully erosion can be caused in a number of ways, having different mechanisms, modes and conditions of formation; some of which are directly related to the underlying geology and the severity of the surface processes operating on the surface geology and soil cover. (Ezechi and Okagbue 1989) summarized the types of gully erosion with respect to their modes and conditions of formation, and common advance mechanism (Table 1). Their study indicated that the nature of the underlying bed (or geology) has a bearing on the initiation and propagation of gullies. Observations have also shown that gully erosion, in Nigeria, is more predominant in the sedimentary terrains and perhaps in the basement/sediment contact areas. This accounts for why its occurrences is more skewed to the south-eastern Nigeria where most of the gullies take the advantage of the loosely consolidated and sometimes friable rocks such as the Ajali Sandstone in Auchi area of Edo State of Nigeria . The causes of gully erosion with respect to the geologic settings as suggested by the earlier studies are numerous. Some of the identified natural causes include tectonism and uplift, climatic factors, geotechnical properties of soil, among others. Anthropogenic causes include farming and uncontrolled grazing practices, deforestation, and mining activities. ( Abdulfatai, Okunlola, Akande, Momoh, Ibrahim 2014).

Table 1. Gully types, modes and conditions of formation and common advance mechanism (Ezechi and Okagbue, 1989)

| Gully Type | Modes and Condition of Formation | Common Advance Mechanism |
|---|---|---|
| Base level | Groundwater flow | Slope undermine, sliding and slumping |
| Scarp | Runoff and slope change | Slope undermining, sliding/slumping, toppling |
| Fracture | Runoff and shrinkage fracture | Collapsing, also block failure |
| Incidental | Runoff concentration and vulnerable soil exposure by man | Common sliding/slumping. |

**Impacts of Erosion**

The impacts of gully erosion in Nigeria are enormous and similar to that obtainable elsewhere in the world and they include:

i) Loss of Farmland: A vast area of farmlands has been lost due to the menace of gully erosion while others are at their various stages of destruction leading to drastic decrease in agricultural productivity and ultimately food shortage that can lead to famine. ( Abdulfatai, *et al.*, 2014).

ii) Treat to Vegetation: The gully erosion in Nigeria has resulted in loss of vegetation as its continuous expansion encroaches into areas that are hitherto forest leading to falling of trees and exposure of more surface areas to gully activities. The phenomenon if allowed to continue and remains unchecked may ultimately lead to climatic changes locally or globally.( Abdulfatai, *et al.*, 2014)

iii) Effect on Properties: Several properties whose value cannot be quantified accurately here have been destroyed and others are under treat by this menace especially houses and other properties located on the floodplain. About 10 houses have been lost in a single event of gully erosion in Auchi area of Edo State. Besides, it was reported recently that over 450 buildings are lost in Edo State of Nigeria as a result of erosion (NTA News, Sunday 6$^{th}$ July 2013). On a separate note, Committee on Erosion and Ecological matter recently discovered 15 gully sites in Bida, Niger State of Nigeria (NTA Minna News, Wednesday 17$^{th}$ July 2013). Apart from untimely evacuation from these gully sites, infrastructural facilities such as pipelines, utility cables, roads and houses also suffer from these hazardous events. .( Abdulfatai, *et al.*, 2014)

**MATRIALS AND METHOD**

**THE STUDY AREA**

The Study Area (Imo State, Nigeria) is located in the South eastern section of Nigeria and is one of the 36 States of the Nigerian Federation, with Owerri as its capital and largest city. It lies between latitude 4°45'N and 5°50'N, longitude 6°35'E and 7°30'E. It occupies an area of about 5,329.17 sq. km with a Population of 2,938,708 . The State derives its name from Imo River, which takes its course from the Okigwe/Awka upland. Imo State is located between the lower River Niger and the upper and middle Imo River. The Area experiences the humid, semi-hot equatorial climate. The rainfall is heavy, with an average annual rainfall of 2000-2400 mm and an average number of 152 rainy days particularly during the rainy season (April–October). Rainfall distribution is bimodal, with peaks in July and September and a two weeks break in August. The rainy season begins in March and lasts till October or early November.

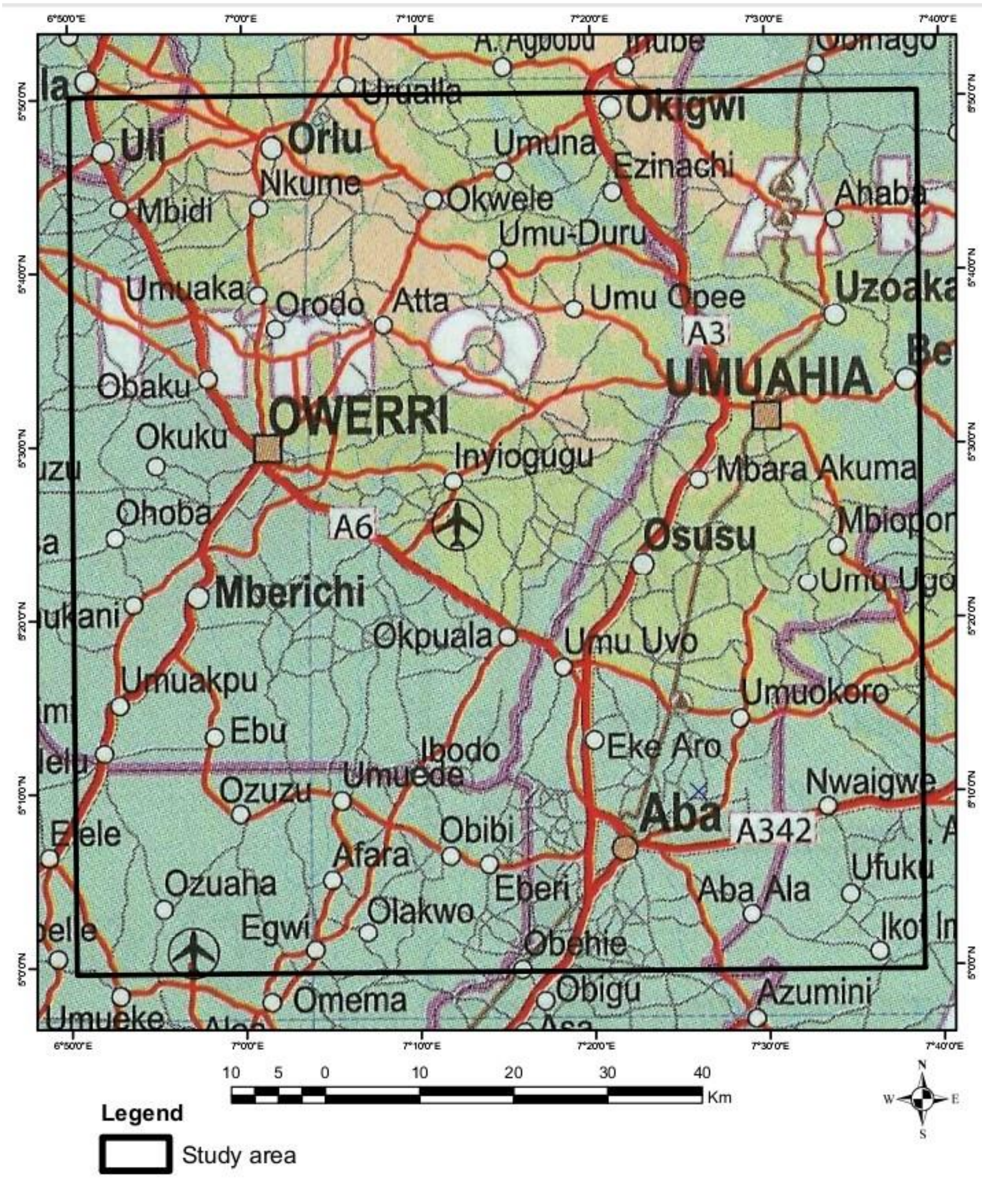


**Fig 1: Location Map of the Study area Owerri above**

## GEOLOGY OF THE STUDY AREA

Geologically, Imo State is underlain by the sedimentary sequences of the Benin Formation (Miocene to recent), and the Bende-Ameki Formation (Eocene). The Benin Formation is made up of friable sands with minor intercalations of clay. The sand units are mostly coarse-grained, pebbly, poorly sorted, and contain lenses of fine grained sands. In some areas like Okigwe, impermeable layers of clay occur near the surface, while in other areas, the soil consists of lateritic material under a superficial layer of fine grained sand. Imo State is characterized by three main landform regions: a highland region of elevation of 340m in the northern sections covering Orlu, Ideato, Okigwe and Ihitte Uboma local government areas. The main stream - Orashi (Ulasi) River, rises near Dikenafai in Imo State, flows northward to Ozubulu in Anambra State and then turns round in a wide loop and heads for the Atlantic Ocean. The second main landform region is midway between the north and the southern section of the State and is of a moderate elevation of between 175m - 240m above msl. They provide elevated, well drained topography with few isolated undulating topography and valleys. The third landform region is the lowland/plains lie South of the high and moderately elevated highlands; the Orashi River plain, south of Oguta, and the inter-basin area between Oguta and Egbema. The main rivers draining the State are Imo, Otamiri, Njaba, Orashi, Nwaorie, Oraminiukwa and a couple of other smaller streams all of which have very few tributaries. These rivers constitute the five sub basins in the ImoAnambra River Basin draining an average area of about 3,777.76km2 of Imo State. Imo River flows through the area underlain by the Imo Shales, other rivers rise within the coastal plain sands. The width and depth of majority of these rivers ranged between 10m to 350m and 0.5m to 2.8m respectively. The Drainage Density is medium texture with a Dd of 0.21, Stream frequency is 0.02 and the drainage intensity is 2.00. Oguta Lake and Lake Abadaba also constitute significant water body in the State.

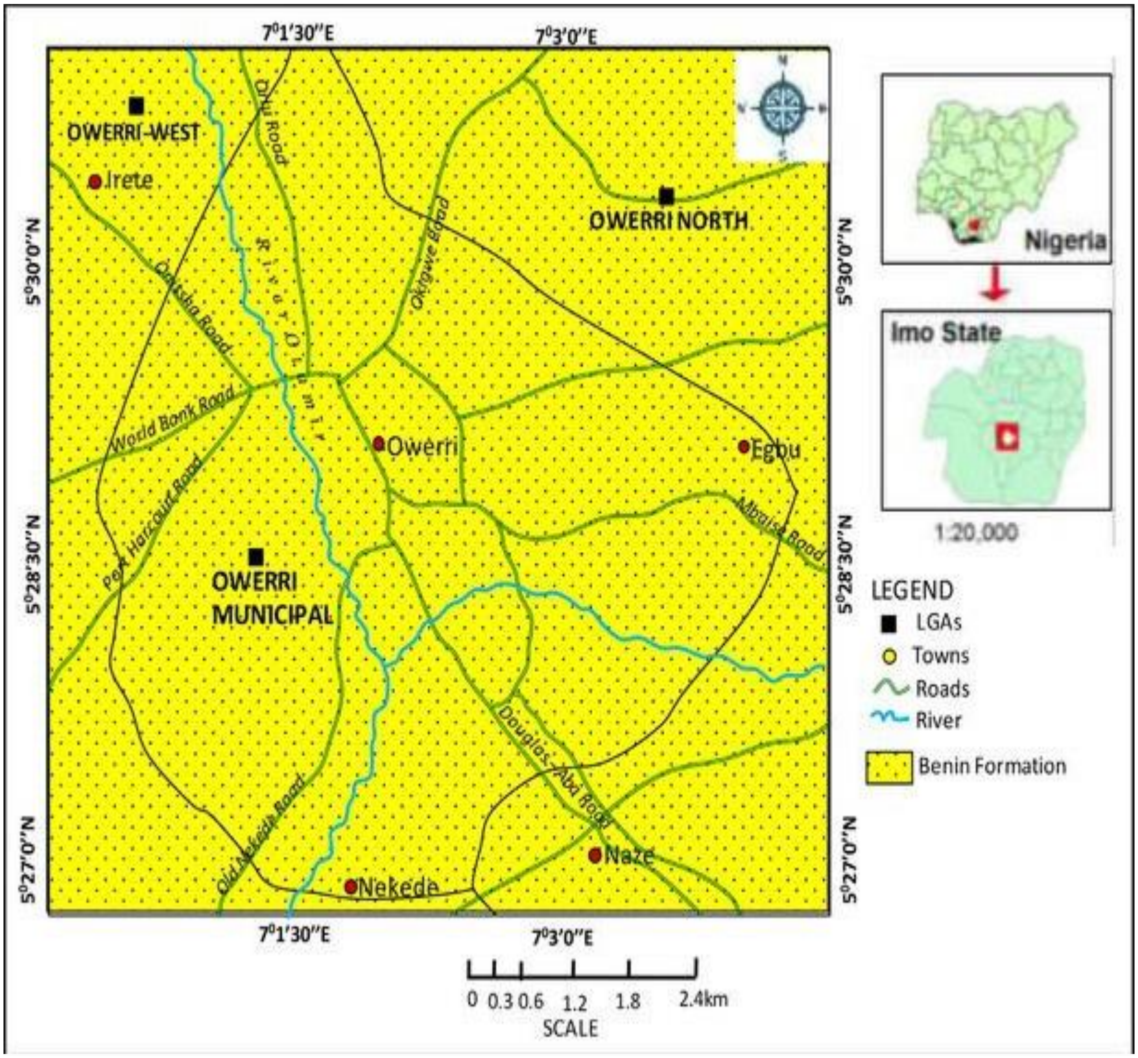


**Fig. 2: Geological map of the study area**

**RECONNAISSANCE SURVEY**

First a reconnaissance survey was carried out in different, selected gully erosion sites within owerri environs. Various stops where made at gully sites. The locations where studied visually and Analised. The positions (latitude, longitude and elevation) of the gully sites measured using a global positioning system (GPS) are listed below:

**AKACHI JUNCTION OWERRI**

LONGITUDE: N 05 28.111secs

LATITUDE: E 007 02.458 secs

Elevation 235ft

**OLD NEKEDE ROAD OWERRI**

LONGITUDE: N 05 27.649Secs

LATITUDE: E 007 01.705Secs

Elevation 209ft

**INLAND ROAD OWERRI**

LONGITUDE: N 05 28.189Secs

LATITUDE: E 007 01.889Secs

Elevation 168ft

**Fig 3: Gully Erosion site at Inland Road Owerri above**


**Fig 4: Gully erosion site at akachi junction owerri**


**Fig 5: Gully erosion site at old nekede road owerri.**

## AEROMAGNETIC DATA SOURCE AND PROCESSING

Aeromagnetic data (maps) where acquired from the Nigerian geological survey Abuja (NGSA)the images was obtained using land sat ETM sensor with band combination 2,3,and 4 with a resolution of 30m. the following color codes where used peach for built up areas, vegetation grey, blue water bodies, black outcrop. The processing of the land sat images and the aeromagnetic data where done using ILWIS,8.0,10.0, ILWIS ACADEMIA, ERDAS, ARC GIS, Q GIS. These software's have the capacities of carrying out various data enhancement techniques such as linear enhancement, statistical analysis, principal component analysis and normalized difference vegetation index. The image enhancement operations were carried out for better visual interpretation, to reduce noise distortion in the image prior to multi-band classification and to detect line features in the satellite image to aid structural interpretation. The images were geo referenced to a universal Mercator (UTM) grid using software to allow compatibility and comparison with data sets.

## AEROMAGNETIC DATA ANLYSIS

Interpretation of aeromagnetic survey data is aimed at mapping the surface and the subsurface regional structures such as fault, folds, lineaments, contacts, bodies and vegetation.

## RESULTS AND DISCUSSION

Aeromagnetic data interpretation and explanation is directed towards qualitative interpretation of both environmental and geological explanation. To explain the causes of the anomalies. An extensive data processing was carried out on land sat which resulted to generation of the following maps: digital elevation model (DEM) map, lineament and lineament density map, normalized difference vegetation index map (NDVI), and the rose diagram.

The map below is the total magnetic intensity map of the study area. The map shows deep seated anomalies comprising of magnetic highs and lows. Some lineaments are observed ranging from 100km to 300km. depicting minor and intermediate lineaments. These could be faults, fracture or folds. Generally such an area shows weak crust.

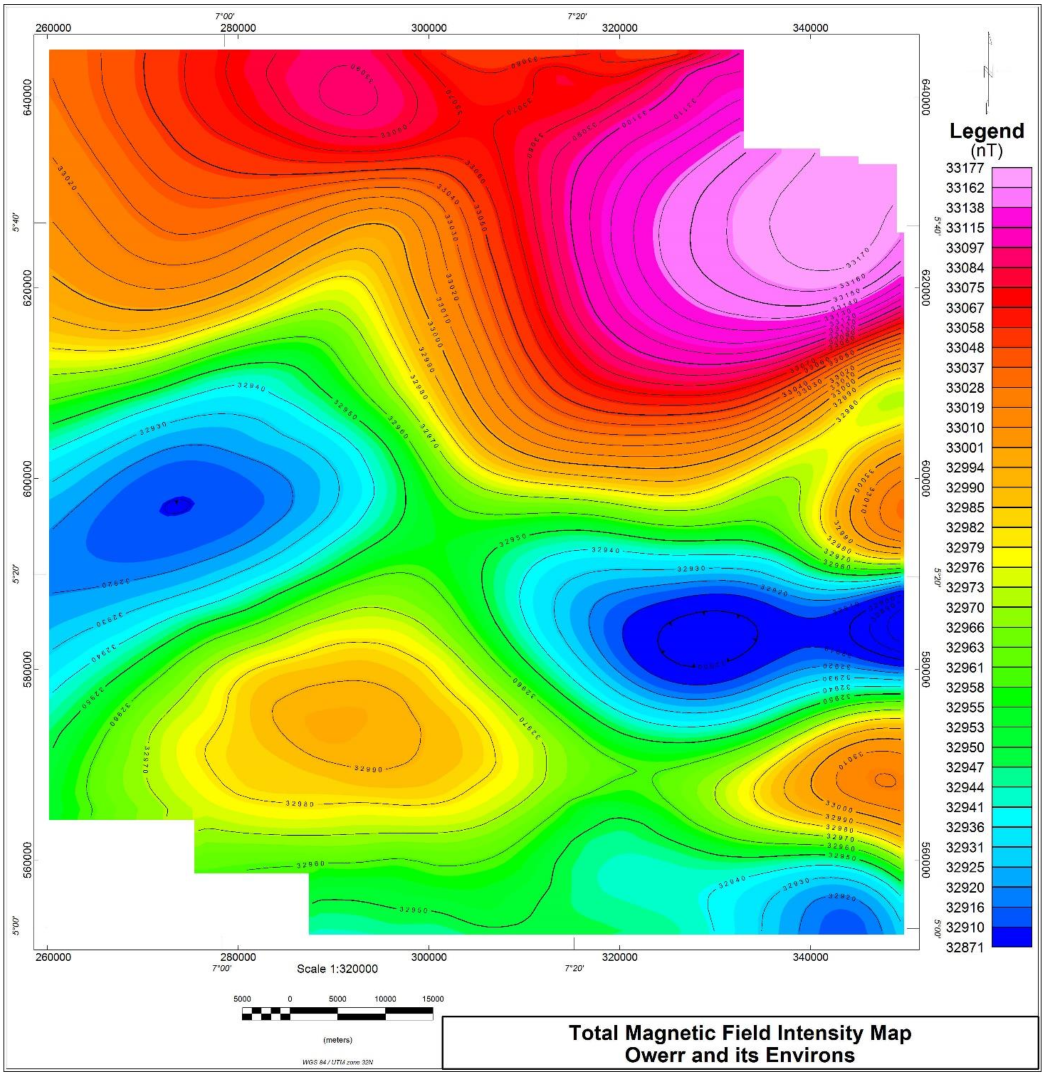


**Fig 6: Total magnetic intensity map above**

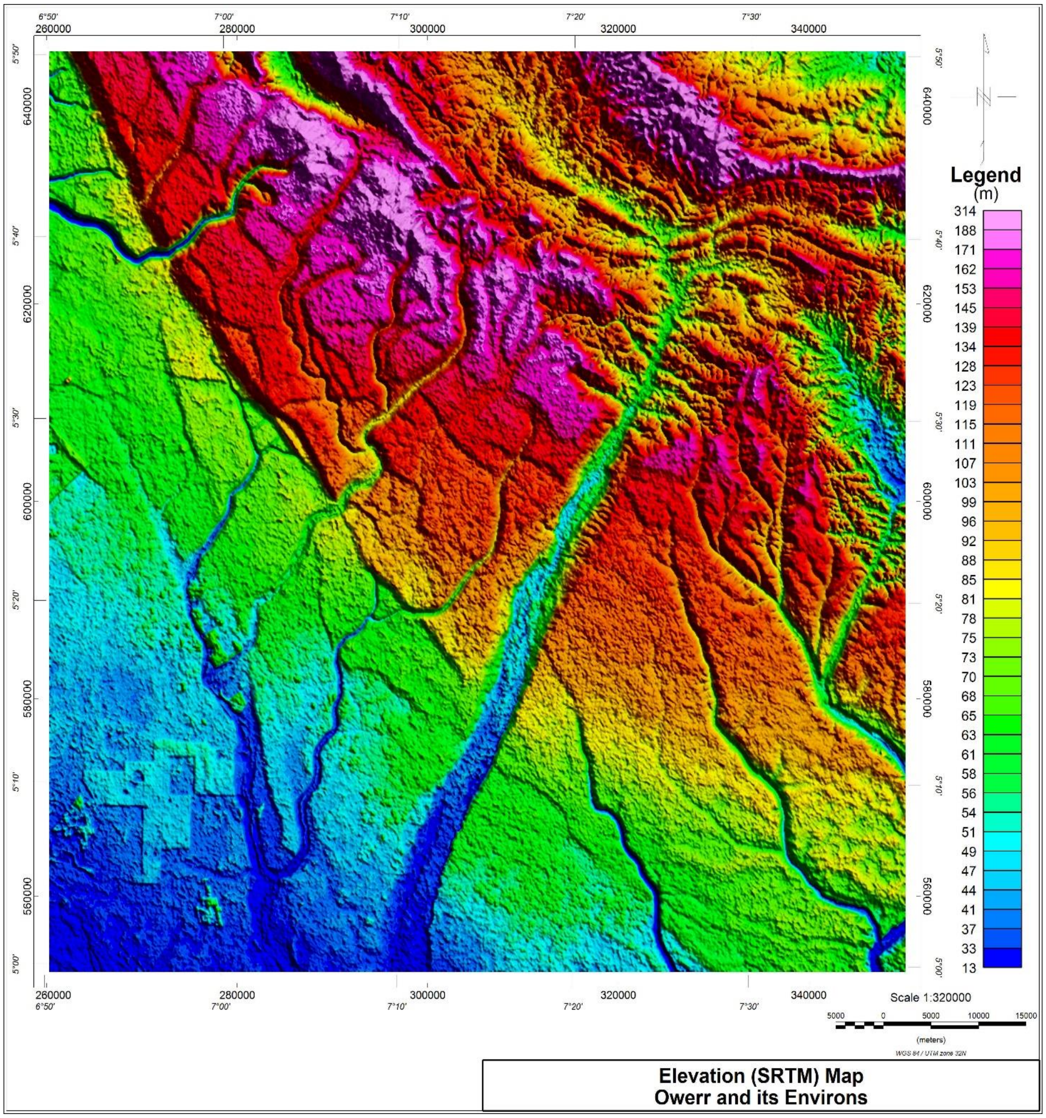


**Fig 7: Elevation map of owerri.**

The elevation map above shows the different heights, and it would possibly shows how water moves from point of high elevation to lower elevation. As rain is falling we have a place of high source where the rain causes gully erosion due to rain moving from high elevation to lower elevation.

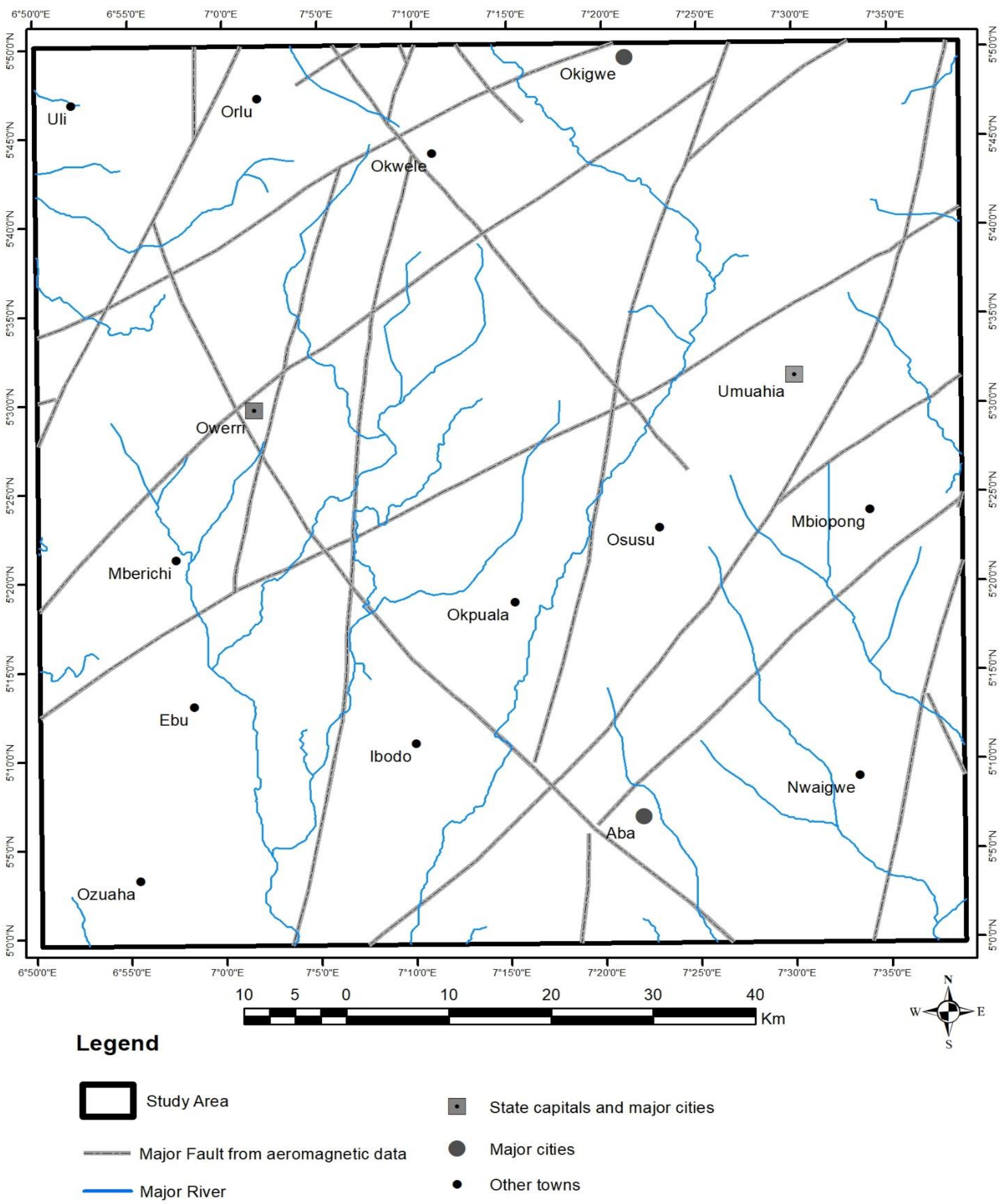


**Fig 8: Map of structures with drainages of owerri**

The structure on the drainage map above shows major faults that occurred round owerri, Drainage here are not tectonically controlled. Because massive infrastructural development has encroached into green areas, thereby resulting in increased storm water generation above the design drainage capacities of the various drains. (Okojie, et al 2017).

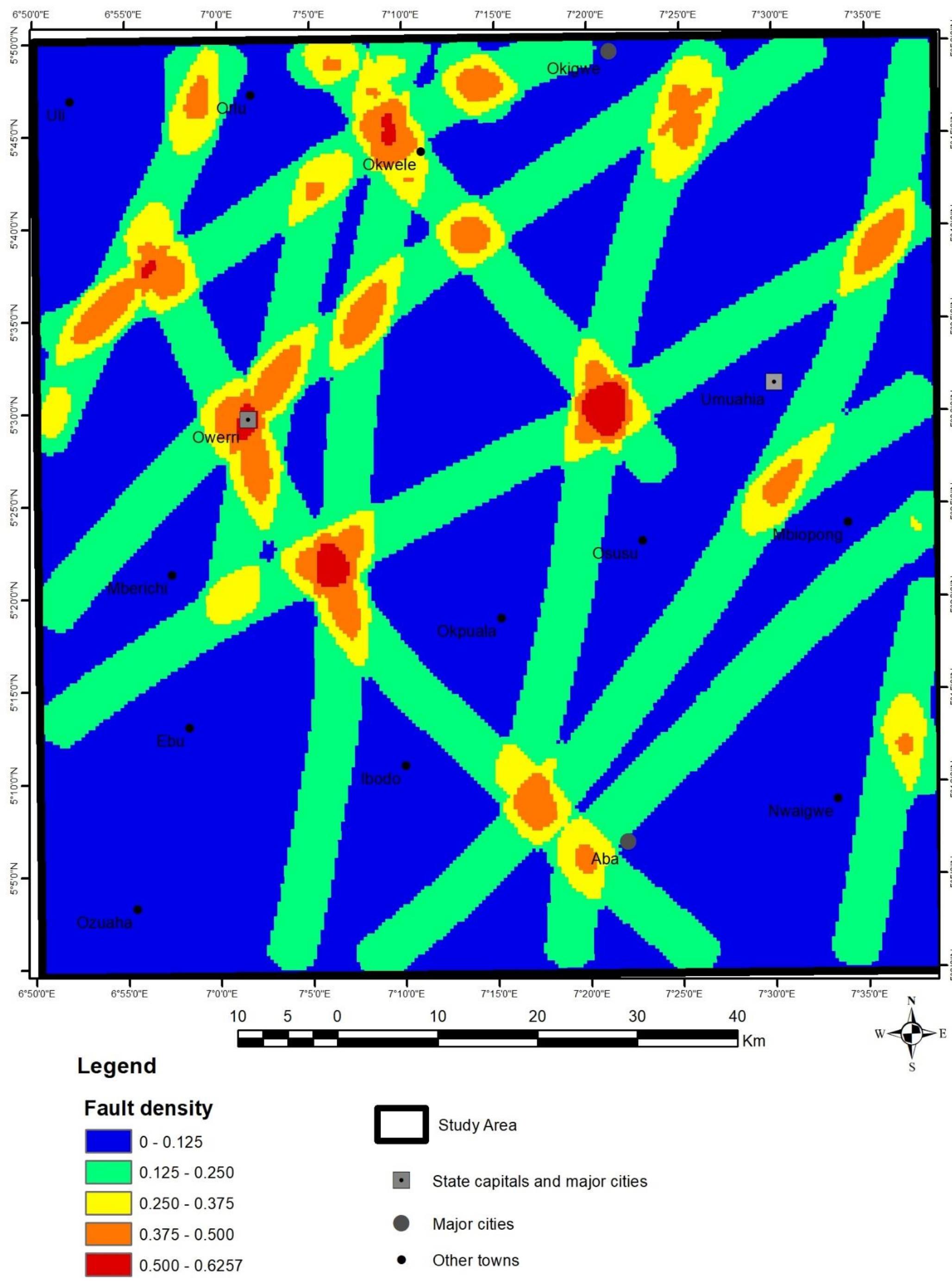


**Fig 9: Aeromagnetic structures density map**

In the aeromagnetic structures density map above, it shows where you have plenty lineaments, Owerri location shows plenty faults. These affects the environments; they lead to erosion. The yellow points shows areas with high concentration of lineaments. It should be observed these points have some lineaments crossing each other and there are prominent source or points where groundwater can be harnessed.

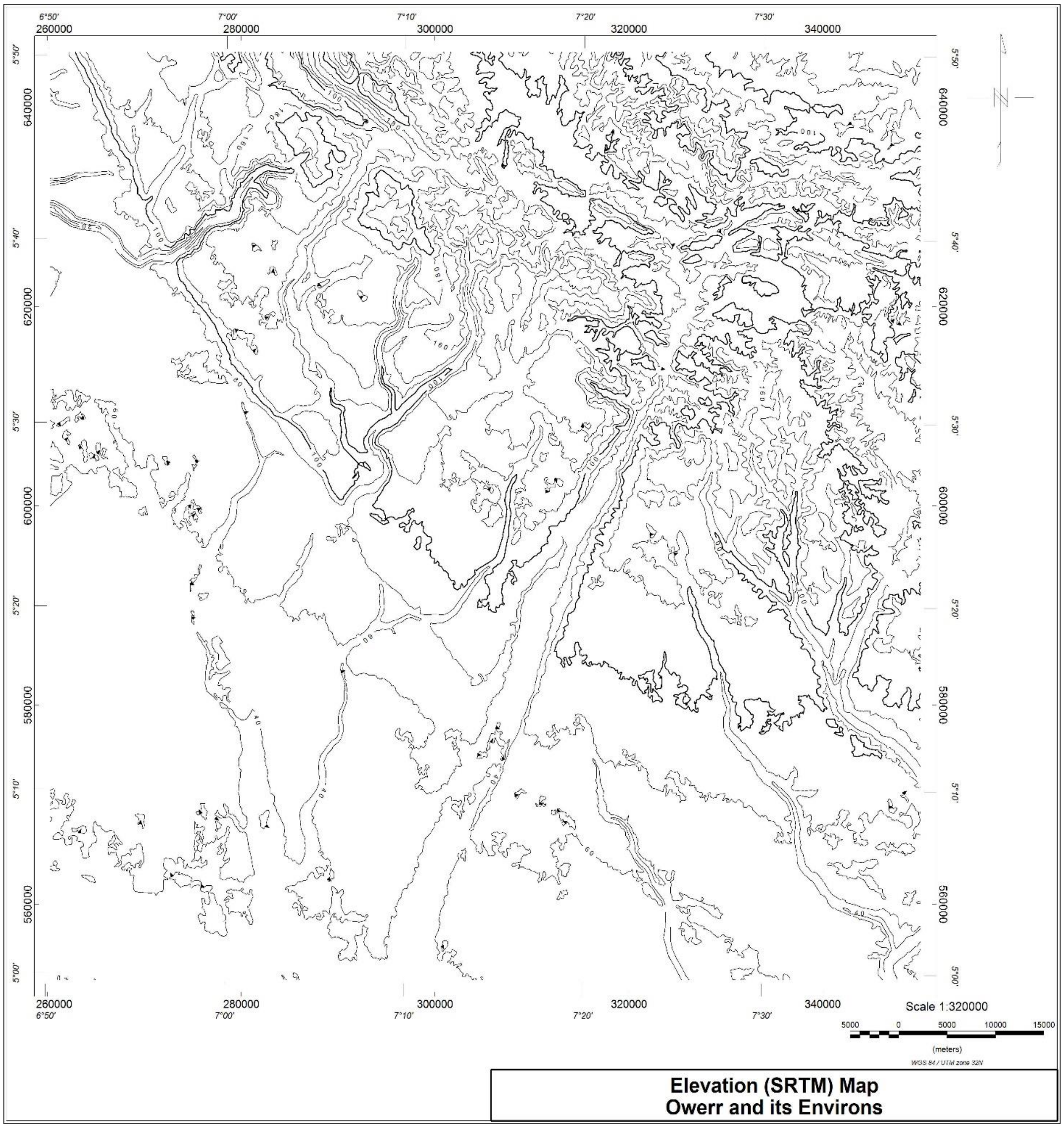


**Fig 10: Elevation contour 20m above**

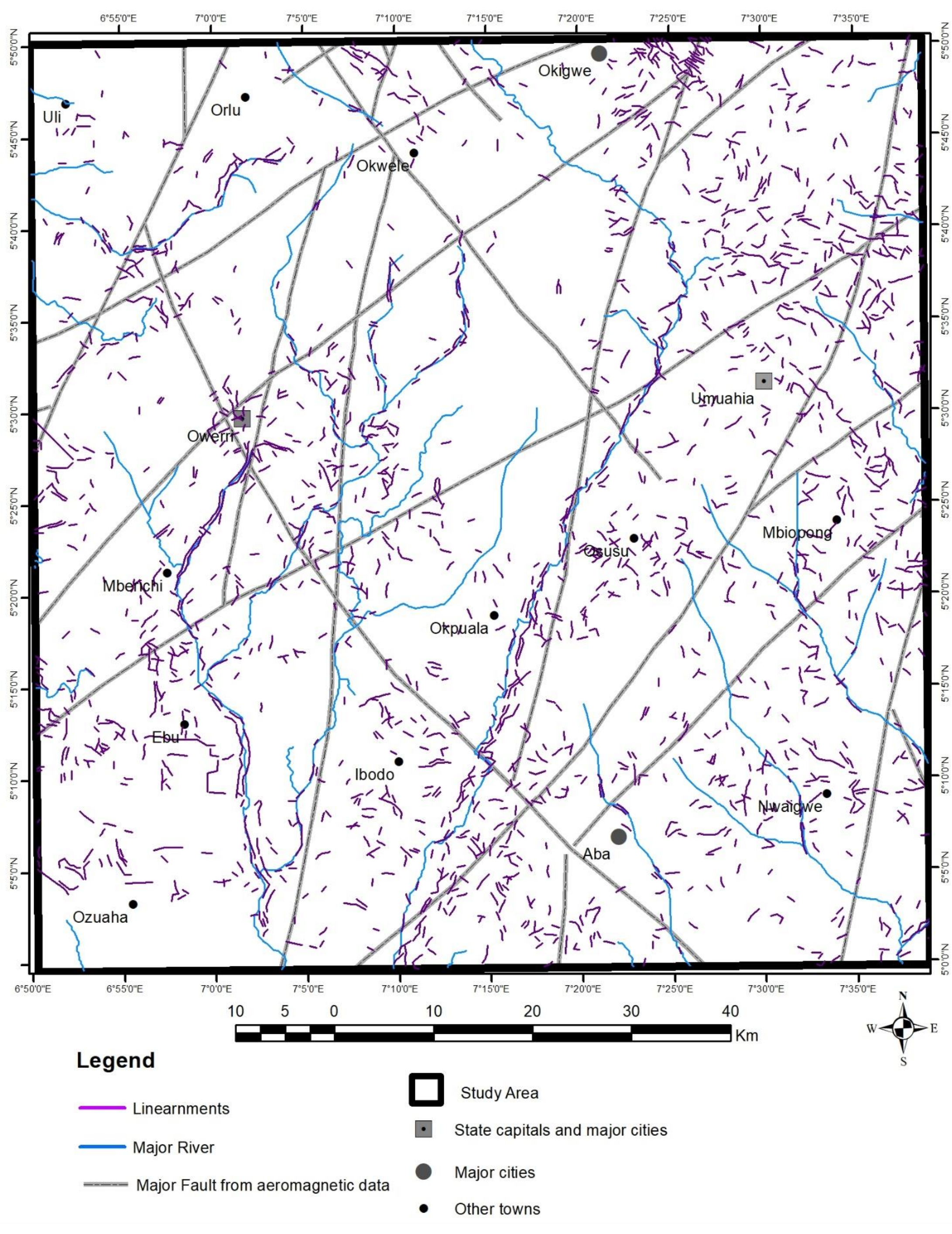


**Fig 11: lineament with drainages,** the above map shows clusters of underground structures in Owerri.

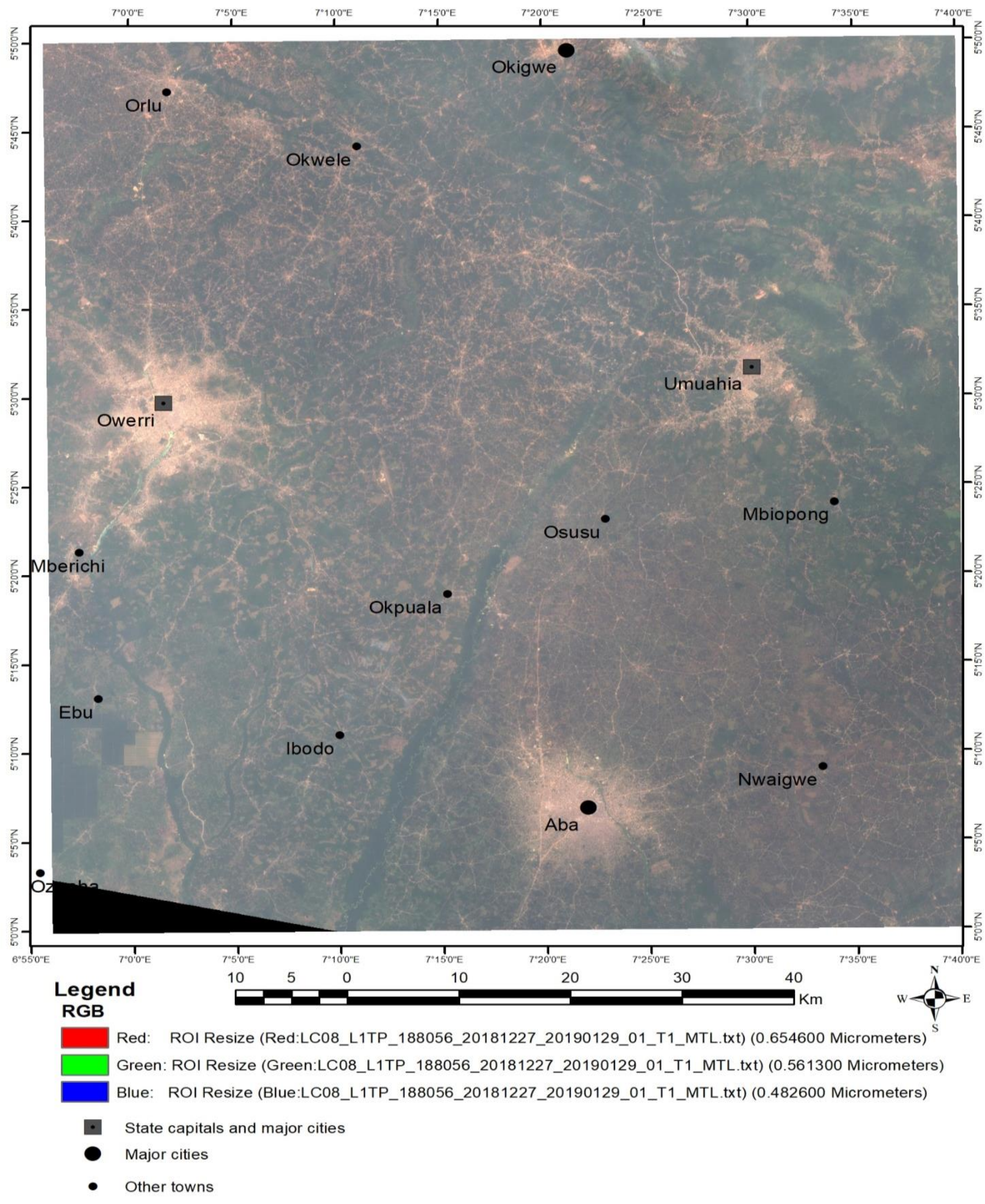


**Fig 13: land sat map**

The above map shows built up areas in peach color, vegetation in grey, river in blue, black shows out crop.

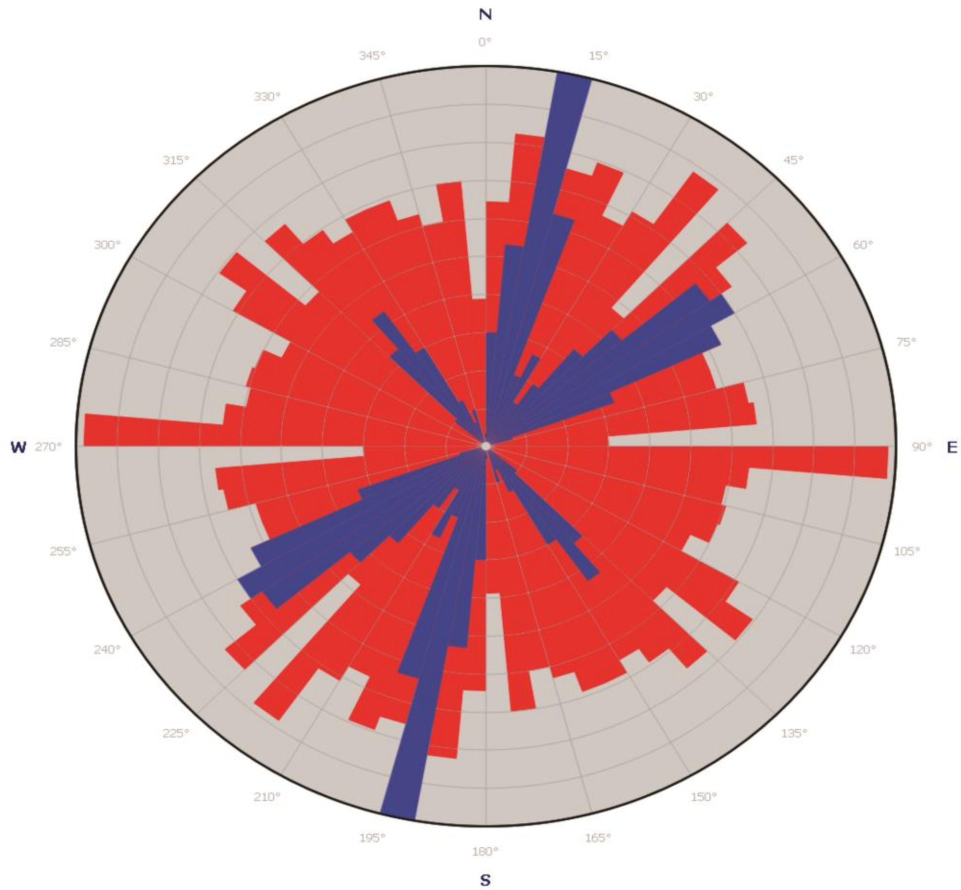


**Fig 14: combined lineament rose diagram above.**

The above map shows dominant lineament trends, NE, SW, and NNE, SSW. And NW, SE.

Major dominance of the lineament trends is NNE, and SSW.

Combined rose diagram above aeromagnetic is indicated with (red) and landsat in (blue)

## PROPOSED SOLUTIONS TO GULLY EROSION

Control measures to stem gully erosion that are incipient are most effective when erosion is still at an early stage (Obidimma and Olorunfemi, 2011). Organic carbon, chemical properties, textural characteristics and moisture content of the soil have been suggested as the most useful factors to be considered in a detailed survey and control of gully (Osadebe and Enuvie, 2008). Thus, these factors and others should be carefully examined in the erosion-prone regions of the country in a bid to better design preventive measures. Other measures that could be used to curb the menace of gully erosion are suggested as follows:

i) Poor farming techniques were found to be a contributing factor to the growth of gully erosion. Improved farming practices that reduce the gully erosion processes to the barest minimum therefore should be encouraged.

ii) Refuse dump along the river courses impede the flow of water leading to flooding especially during heavy rainfall. Therefore, dumping of refuse on the river channels and floodplains should be prohibited. Government at all levels should enact and enforce laws to deter such activities.

iii) Cultural method (also called vegetative techniques by Simpson, 2010) of erosion control has been found to be a cheap and effective method. Cultivation along contours. Treesand crop planting. Sand bagging/ speed breakers. Control of animal grazing. Back filling. Construction of channels. Planting of plantain and banana on the floodplains have also been found to be effective in controlling erosion. Grasses species such as *Eulaliopsiss binata* (Babiyo), *Neyraudia reynaudiana* (Dhonde), *Cymbopogon microtheca* (Khar), *Saccharum pontaneum* (Kans) have been suggested by Ojha and Shrestha (Ojha and Shrestha, 2007) as suitable especially for slope stability.

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