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Spatial Analysis of Topographical Map Sheet 266 Auchi S.E For Socio-Economic Development

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Abstract

The research is on the spatial analysis of the topographical map sheet 266 Auchi S.E with a focus on its implications for socio-economic development. The existing map last updated several decades ago, no longer accurately represents the current terrain and land use patterns in the area. The high and accelerating rate of change and expansion of urban centres demands a fast technique for updating existing maps. The research demonstrates the application of satellite imagery and the Shuttle Radar Topography Mission (S.R.T.M) in topographical map revision. The S.R.T.M. and Google Earth imagery of 2024 of the study area were used to update the existing topographical map of the study area. AutoCAD Land-dev 2009 was used for geo-referencing and digitizing of the required features while ArcGIS 10.1 was used in processing and analyzing the data. Global Positioning Systems (GPS) and Geographic Information Systems (GIS) techniques were utilized in updating the topographical map to reflect recent changes in the landscape. The revised map reveals significant alterations in land use, infrastructure development, and demographic patterns. The study analyses the socioeconomic implications of these changes, highlighting opportunities for sustainable development, infrastructure planning, and environmental management. The revised map serves as a vital tool for policymakers, urban planners, and stakeholders, enabling informed decision-making and contributing to the socio-economic growth of the region. It is recommended that revisions of all categories of maps should be embarked upon, and for fast revision and production of maps, the use of remotely sensed data should be adopted by relevant mapping agencies.

Keywords: GIS, GPS, Satellite Imagery, S.R.T.M, Socio-Economic Development, and Spatial Analysis

1. Introduction

Topographical maps are essential tools for urban and regional planning, as they provide detailed information on the physical features of an area (Akinwumi, 2012) [3]. The revision of topographical maps is important for effective socio-economic development, as it enables policymakers and planners to make informed decisions on infrastructural development, resource allocation, and environmental management (Olayinka, 2015) [9]. Topographical map sheet 266, Auchi S.E. covers a significant area in Edo State, Nigeria. The area has undergone significant changes in recent years due to urbanization, agricultural development, and infrastructure projects.

Nnam (2005) [7] showed how the use of satellite imagery in conjunction with computer hardware and software (GIS) has significantly increased productivity, precision, accuracy, and quality of map construction, as well as speed. Abbas *et al.* (2000) concluded that revising a map using GIS and remote sensing data is less labour-intensive and more economical than creating a map the old-fashioned way. The township map of Mubi metropolis was updated using remote sensing and the Geographic Information System (GIS) by Yohanna & Nuhu (2011) [12]. They proposed that remotely sensed data offers precise information that can be utilized to create up-to-date maps as well as a repeating, synoptic picture.

Topographic map serves diversified areas of applications. They are general-purpose maps that show an area of interest based on scale, projection and with the proper cartographic generalization (Sewell, 1995) [11]. Height information is shown with the help of contour lines. Entities are represented in terms of points, lines, and polygons with the help of cartographic symbols. Scale, coordinates and legend are the keys for the map readings (Hurst & Paul 2010) [5]. Iyiola, *et al.*, (2019) [6] affirmed that a sustainable land management system serves as a foundation for creating socio economic development, social coherence and effective land planning; that the unavailability of current topographic maps in African countries is an obstacle to the development of an effective land administration system. According to Ejikeme (2012), topographic maps are essential for nearly all public and private sector operations, including general engineering and construction projects, physical and economic planning regulations, environmental management, general planning, and serving as a foundational map for mapping land use and cover.

The revision of the topographical map of sheet 266, Auchi S.E, is imperative for socio-economic development in the area as the research intends to provide up-to-date information on the physical features of the area, including roads, rivers, and vegetation. This information is essential for planning and implementing development projects, such as road construction, housing development, and agricultural programs (Adepoju, 2016) [2]. Furthermore, the revised topographical map will facilitate the identification of areas prone to natural hazards, such as flooding and erosion (Ologunorisa, 2018) [10]. This information is critical for disaster risk reduction and management, as it will enable policymakers to develop effective strategies for mitigating the impacts of natural hazards on communities (Okogbue, 2019) [8].

The research offers a new method of recognizing socio-economic patterns in the inner city. Indeed the processes of manual map revision are time-consuming and the need for up-to-date urban and rural maps is global however, it is more desirable in countries where urban and rural developments are high. The study area is well noted for changes, especially in cultural features and social development. This is why planning, especially urban planning faces serious implementation problems, since most of the information on features is now outdated. The patterns, and lengths of roads have changed; the numbers of social amenities in various settlements, the population and some administrative boundaries have altered, hence the need to update the existing map.

Spatial Analysis of topographical map sheet 266 Auchi S.E, marks a significant milestone in harnessing geospatial data for socio-economic development in Nigeria. The study area covers mostly Auchi town and other towns such as Fugar, Ogbona, Jattu, Irakhor, Iyakpi, Afowa, Fugar, South Ibie, and Ugbekpe. As the country strives to achieve sustainable development goals, accurate and up-to-date topographical information is considered important. The revised topographical map sheet provides platforms into the region's physical landscape facilitating informed decision-making for infrastructural development, urban planning and natural resource management.

2. Materials and Methods

The objective of the research is to revise the 2008 topographical map sheet 266 Auchi S.E, Etsako West Local Government Area of Edo State by producing an up-to-date topographical map of the study area using remote sensing and GIS approach. The revised map serves as a tool for the sustainable socio-economic development of the study area. To achieve the aim the existing topographical map, spatial, non-spatial and height data of the study area are required.

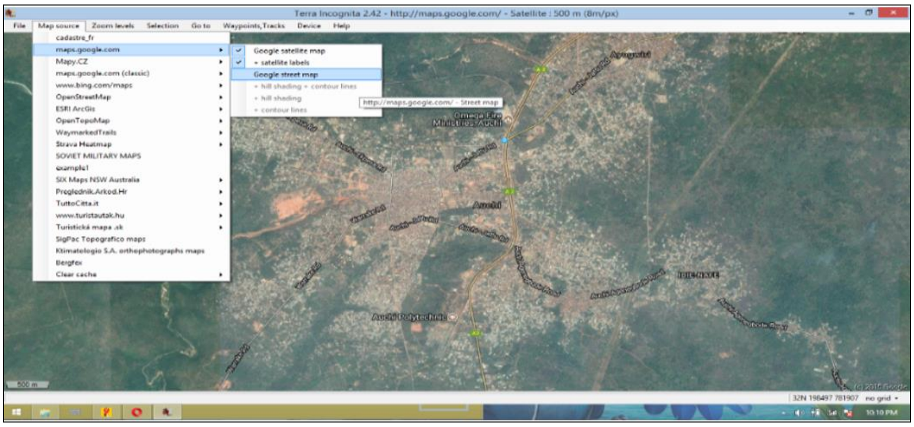
Modern technique and technology in map making and revision was employed in the execution of this research. The methodology involved remote sensing, the use of GPS, and the GIS technique. Relevant software used are Autocad land-Dev 2009, ArcGIS 10.1, Geocal, Terra-Incognita and Earth explorer. The base map was obtained from the Office of the Surveyor General of the Federation (OSGOF), Abuja. The SRTM data that covers the entire project area was downloaded from the internet. The remote sensing method was employed in acquiring the data used for this research.

Primary and secondary data were employed. Coordinates of points and prominent features were obtained using the handheld GPS. Ground truthing was done by updating the digitized map with names and features not captured in the imagery such as names of new features like roads not captured and settlements which were not on the imagery were acquired through socio surveys and updated into the digitized map. Secondary data were obtained from the topographical map of the study area and imagery through scanning and vectorising.

Geo-referencing, digitizing and creation of a geospatial database using shape files and feature extraction were carried out. The Shuttle Radar Topographic Mapping (SRTM) was overlaid on the base map for updating. Field completion and ground truthing using social survey were employed for the final cartographic editing and map production. Roads, river networks, settlements, schools, churches and other necessary features were digitized and contours were generated from the analysis carried out on SRTM.

2.1 Data Acquisition

Terra-incognita 2.43 software was used in downloading the satellite imagery of the study area; this can capture a specific area of the globe from Google Earth. The downloaded imagery was zoomed to the level of 5m, which made the features on the imagery clearer and more visible for easy identification (figure 1). The downloaded image of the selected area of interest was saved.



Source: Author's Field Work, 2024

Fig 1: Google Earth Imagery

2.2 Geo–Referencing

Geo-referencing is a necessary step preceding the digitizing process. The process of geo-referencing relies on the coordination of points on the topographical map (data to be geo-referenced). The topographical map was georeferenced using the geographical coordinates found on the map after converting the coordinate from the geographical coordinate system to (UTM) coordinate using Elshayal Smart GIS software. The converted coordinates used in geo-referencing the topographical map are shown below (Table 1).

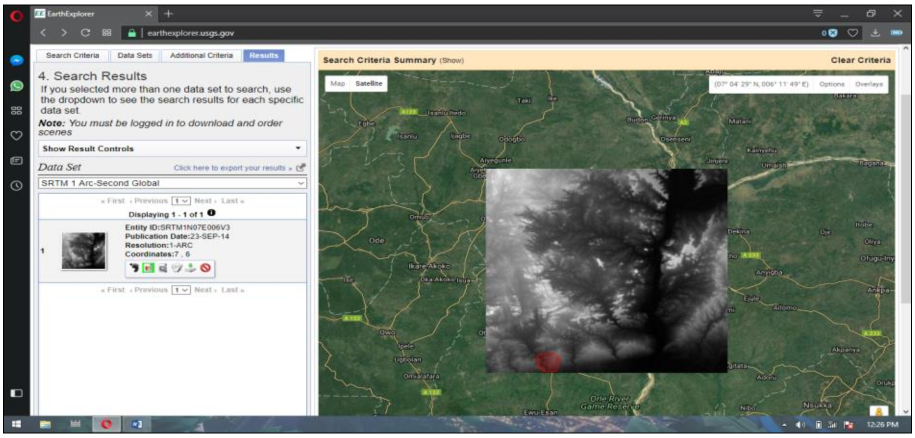
Table 1: Coordinates Used For Geo-referencing

ID	X	Y	EASTING	NORTHING
1	6° 15' 00''	7°15' 0''	196310.536	802305.921
2	6° 30' 00''	7°15'00''	223936.611	802146.078
3	6° 30' 00''	7°00'00''	223786.804	774483.606
4	6° 15' 00''	7°00'00''	196145.694	774638.049

AutoCAD Land-Dev (2009) software was launched, and the scanned topographical map sheet 266, Auchi S.E on a scale of 1:50000 was converted to UTM data and imported into the Autodesk 2009 software environment using the add data button, and the folder where the map saved was navigated and selected. Then 'add control point' tool was clicked on the toolbar tool - rubber sheet.

1. The first control point was clicked (The interception of the horizontal and vertical line at the upper left corner of the map) – copy and paste the coordinate of the first control point and click enter.
2. The same step was repeated for the other three points. At the end of the last point (4th point), the "Enter Key" was clicked twice, the object was selected, and the enter key was pressed. Enter key" was clicked again.

The Shuttle Radar Topographic Mission (SRTM) was downloaded from the United States Geological Survey (USGS) archive via earth explorer (Figure 2).



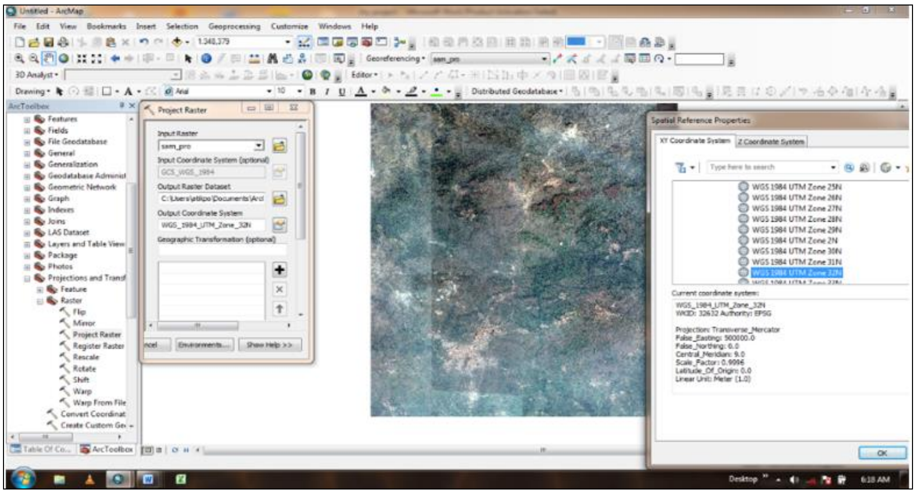
Source: Author's Field Work, 2024

Fig 2: SRTM Imagery

2.3 Data Processing

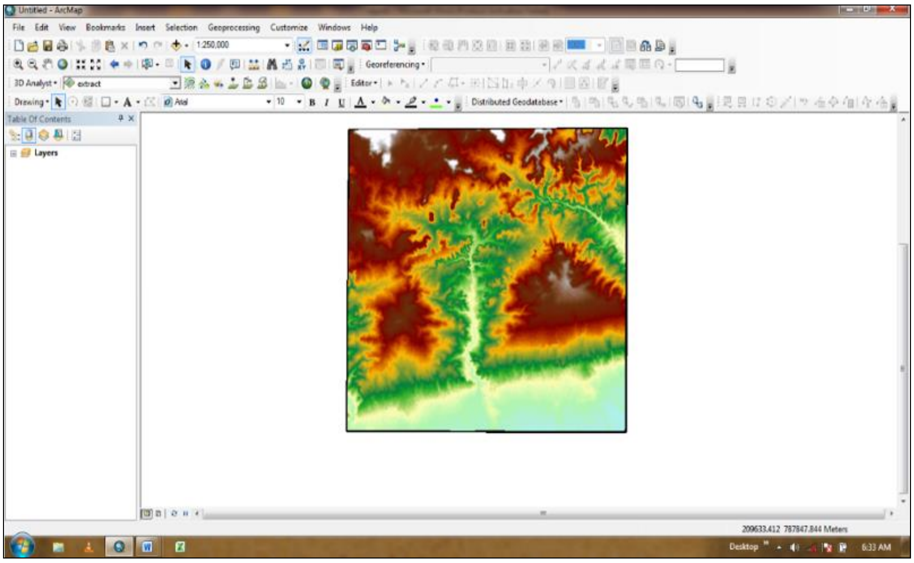
Data about the characteristics of features especially man-made features, and settlements -were acquired through social survey. Layers (shape files) were created before vectorising the base map. All the shape files used were created using a Layer Properties Manager. Some of the layers created were: Major roads, Secondary roads, Minor roads, settlements, Rivers, buildings and pipelines etc. The method employed in vectorising the topographical map was the on-screen digitizing method. To validate these elevation data against their ground survey version, the need to calculate the geometry (x, y) becomes necessary.

Since the downloaded SRTM covers more than the area of interest, hence the need to extract the area of interest (Auchi S.E).



Source: Author's Field Work, 2024

Fig 3: Re-projected Satellite Imagery



Source: Author's Field Work, 2024

Fig 4: Extracted SRTM (By Mask) of the Study Area Image

2.3.1 Extraction of Elevation (Z) Values From the SRTM Dem

In extracting the elevation values from the masked SRTM covering the study area as shown in figure 4 above, the boundary extent has to be gridded with a required grid interval, in this case 100m interval was chosen.

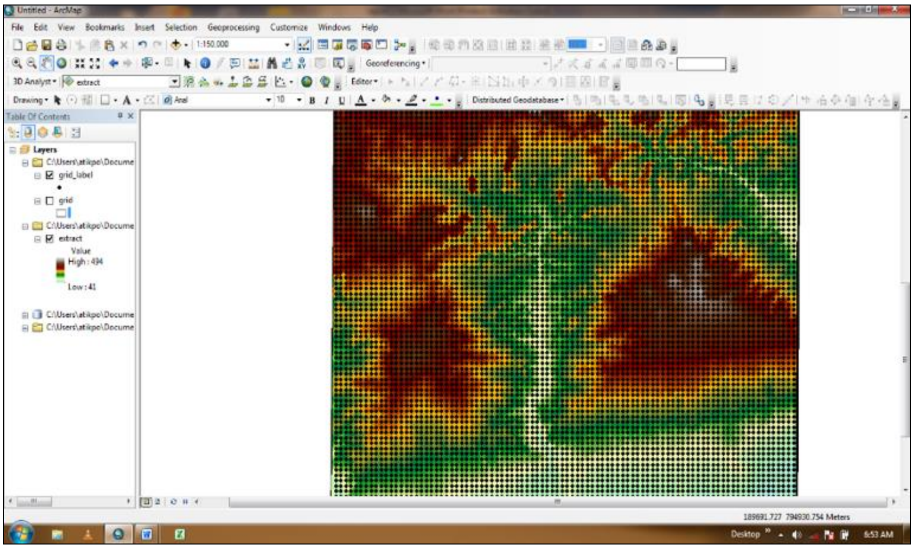


Fig 5: Gridded Map for Extraction of Elevation From the SRTM DEM

2.3.2 Contour Extraction

The SRTM DEM was processed using ArcGIS 10.1 software to generate the contour needed for the study area (figure 6).

2.3.3 Generating of River Network from the SRTM DEM

The river network was generated from the SRTM DEM (figure 7). Arc-map version 10.1 was launched. Stream order was clicked under the hydrology tool - the stream raster was later created, and from the map algebra operation was selected - flow direction layer was selected then OK. Under the hydrology tool stream feature was created - and the stream raster generated from the stream order operation was selected - the stream direction layer was also selected - output folder of the poly line feature to be generated was picked (SRTM folder on the desktop) - OK. The colour of the river was changed to blue by double-clicking on the line under the layer.

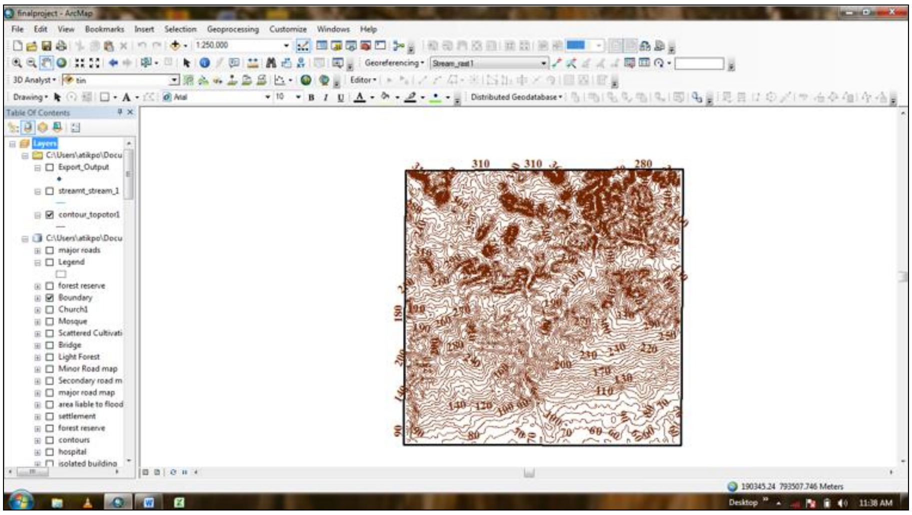


Fig 6: Generated Contour

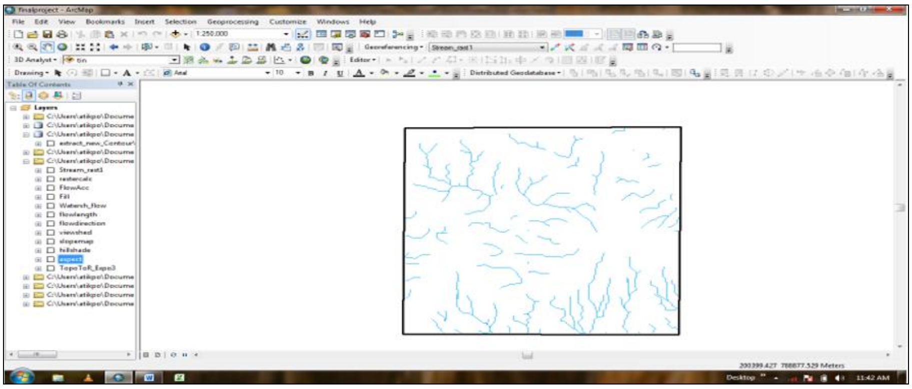


Fig 7: River network generated from SRTM DEM

3. Spatial Analysis of the Topographical Map of the Study Area

ArcGIS software products greatly enhance the optimum use of land, the functional efficiency of a proposed design and its marketability and overall cost-effectiveness of a project. GIS can be used for terrain, land use suitability and visibility analysis. It can also be used to assess environmental impacts to determine the consequences of various regulatory requirements. There is a wide range of functions and capabilities for data analysis in most GIS packages; this is what distinguishes GIS from all other information systems. These capabilities use the spatial and non- spatial data in the spatial database to solve spatial problems which serves as Decision Support System (DSS). This chapter will discuss spatial analysis performed within the study.

3.1 Terrain Analysis

Terrain analysis comprises a collection, analysis, evaluation, and interpretation of geographic information on the natural and manmade features of the terrain, combined with other relevant factors, to predict the effect of the terrain. Terrain analysis was carried out to determine the surface characteristics of the study area. It was carried out in other to graphically portray the relief of the study area. This analysis was performed on the SRTM DEM. Triangulated Irregular Network (TIN), Hillshade, Slope and Contour overlay analysis were therefore carried out.

3.1.1 Triangulation Irregular Network

The Triangulation Irregular Network (TIN) map of the project area (Fig. 4.2.1) provides the elevation model of the project area. It is also the basis for other analysis such as slope, hill-shade etc.

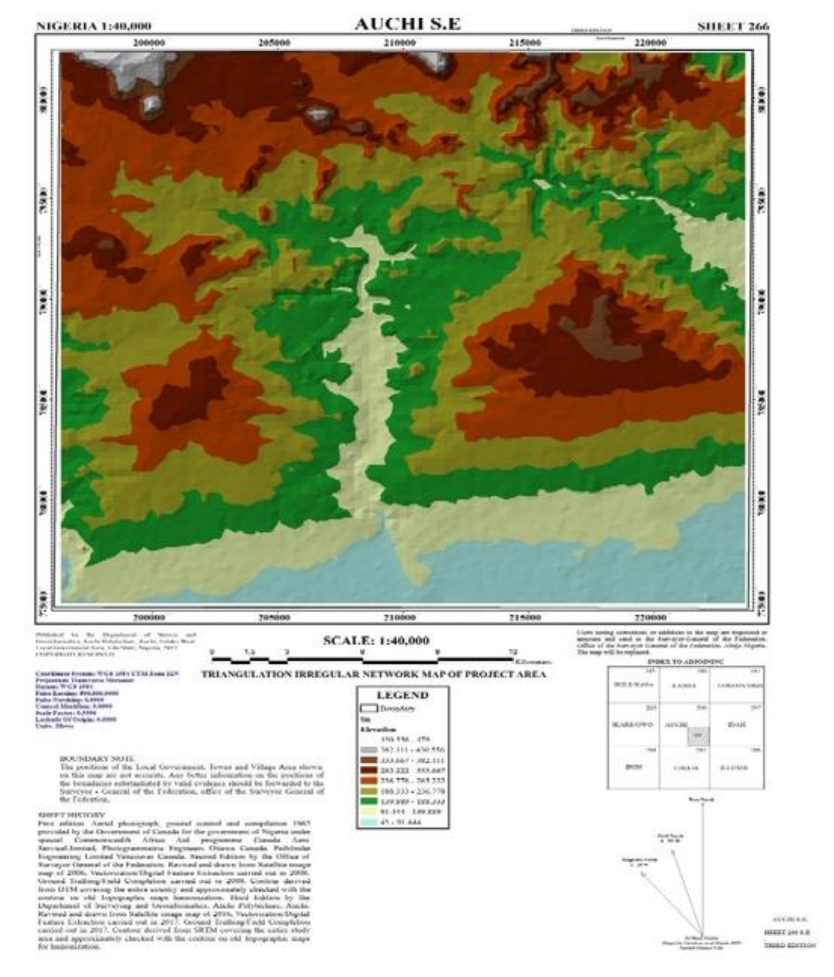


Fig 3.1.1a: TIN Analysis of the Project Area

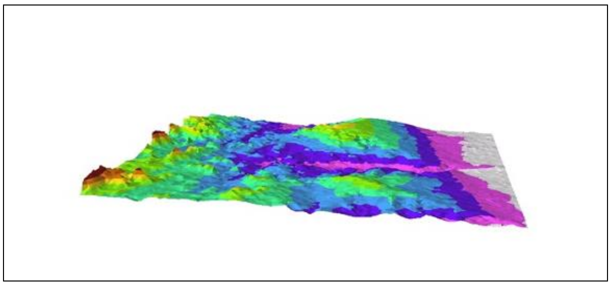


Fig 3.1.1b: TIN Analysis of the Project Area in 3D

3.1.2 Hill-Shade Analysis

Hill-shade maps are often used to better visualize topography, by simulating illumination of a surface. The hill-shade function has normally been used to determine the hypothetical illumination of a surface for either an analysis or a graphical display. For analysis, the hill-shade image can be used to determine the length of time and intensity of the sun in a given location. For a graphical display, hill shade can greatly enhance the relief of a surface (Fig 3.1.2).

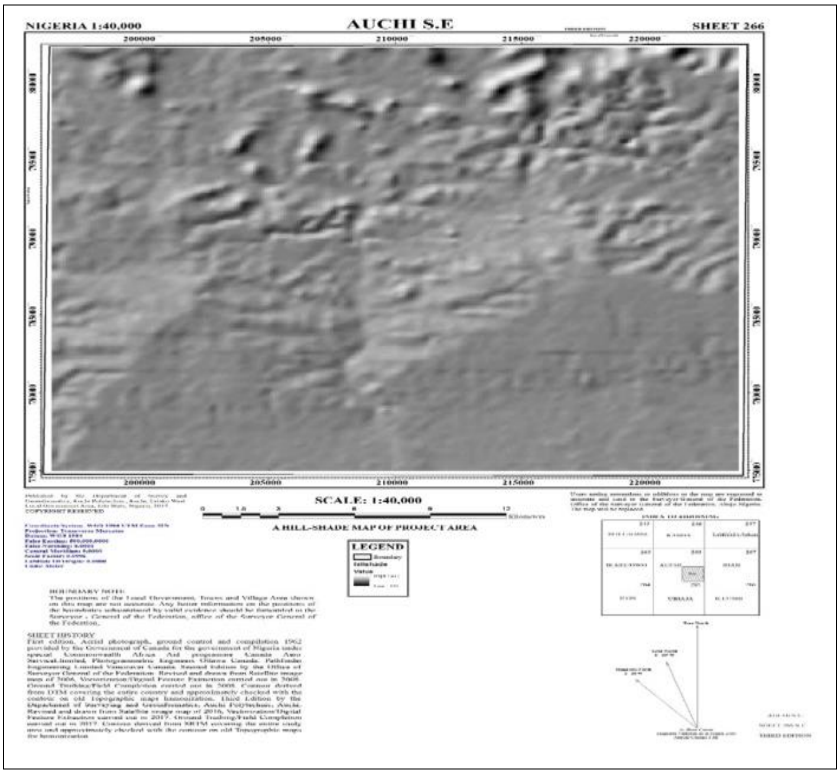


Fig 3.1.2: Hill Shade Analysis of the project Area

3.1.3 Slope Analysis

Slope is defined as the change in elevation (a rise) with a change in a horizontal position (a run). Slope is often reported in degrees (0° is flat, 90° is vertical) or in percentage. Slope describes overland and subsurface flow velocity and run-off rate. It quantifies the maximum rate of change in value from each cell to its neighbours. Slope shows how steep a hill is. It has a direct correlation with water because water moves downhill. It helps in determining which way water is flowing which is a major factor in drainage construction and it could also be used in calculating run off **rate (Fig 3.1.3)**

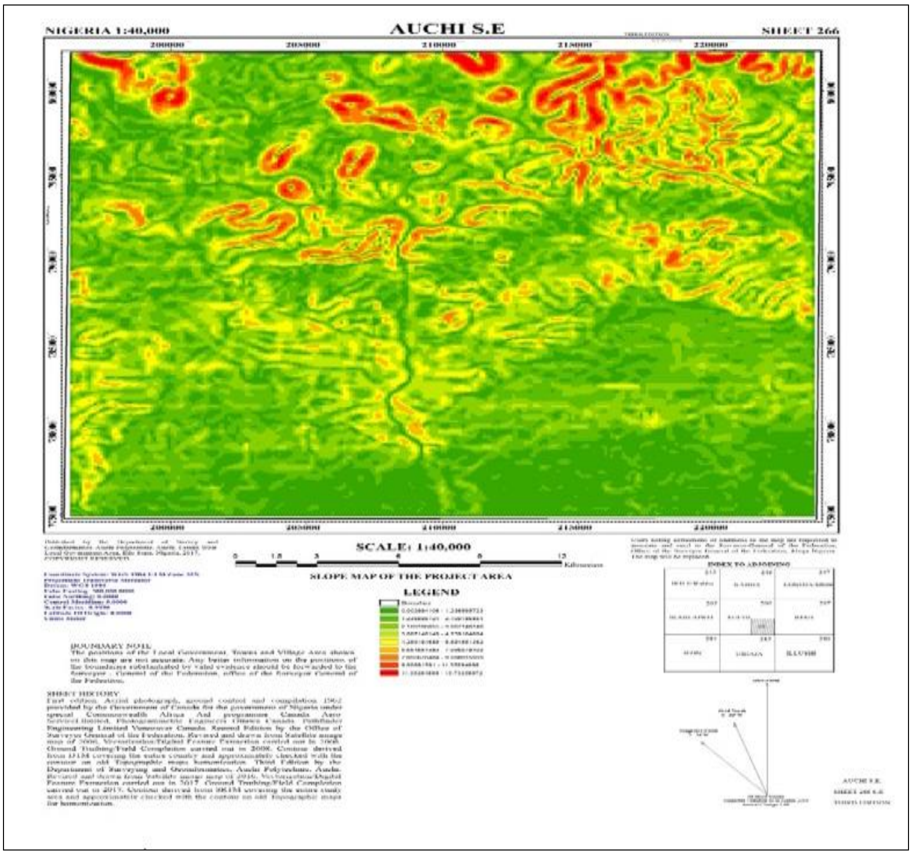


Fig 3.1.3: Slope map of the Project Area

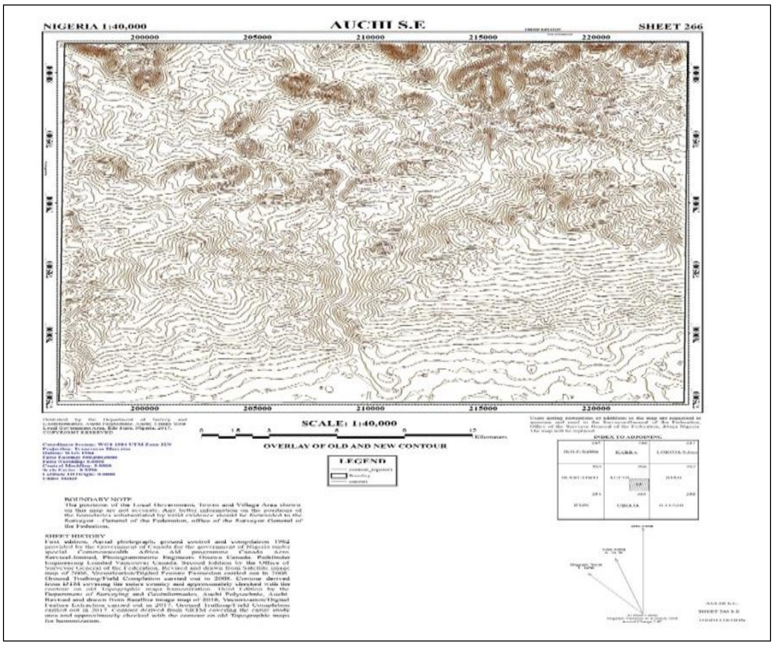


Fig 3.1.4: Contour Overlay Analysis of the Project Area

3.1.4 Contour Overlay Analysis

This analysis was carried out to carefully examine the change that has occurred so far on the terrain within the area under study (Fig 3.1.4)

3.1.5 Land Use and Road Expansion Analysis

There has been a vast expansion of some major settlements in the revised map. The result shows a high concentration of human activities in major towns like Auchi and Fugar (Table 3.1.5, Fig. 3.1.5).

Table 3.1.5: Land use Analysis of the project Area

S. No	Town	Old Map Area (Ha.)	Revised Map Area (Ha.)
1	Auchi	2392.843	4856.805
2	Afeshio Uzaire	232.950	Undefined
3	Fugar	198.312	687.163
4	Ubiana	183.382	751.556
5	Ugbekpe	137.787	685.613
6	Ikabigbo Uzaire	129.288	219.067

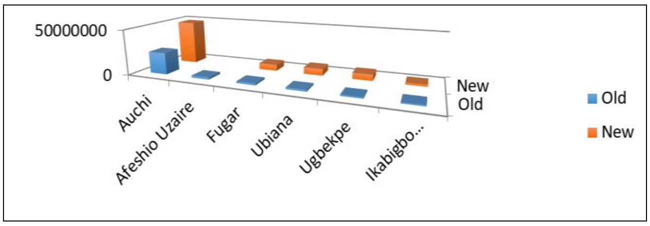


Fig 3.1.5: Bar chart of some town's expansion

3.1.6 Road Expansion Analysis

Based on the study and the map produced, different road classes and types were identified. Amongst the total roads obtained in the study area, the 'main-path' category of road is more prominent within the updated map. From the study, it was discovered that in 2008 there were only one major road, secondary roads twenty-six (26) and minor roads two hundred and fifteen (215). Comparing it with the revised map, it was discovered that the number of roads has increased with the secondary road to eighty-five (85) and minor roads increased to six hundred and eighty-four (684).

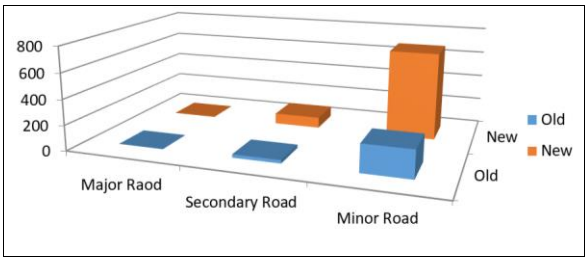


Fig 4.3.1: Bar chart of road expansion

4. Information Content

The measurement of the information content was made using the measure tool on ArcMap, the road was calculated in kilometres (km) and areas in hectares (Ha). The quantitative evaluation of old and updated features was presented (Table 4.0)

Table 4: Length and area of features from the old topographical map and updated topographical map

Features Studied	Old Topo Map		Updated Topo Map		Difference
	Length (km)	Area(Ha)	Length (km)	Area (Ha)	
Roads (Minor)	2.161		2.364		0.203Km (increment)
Auchi Town		2392.843		4856.805	2,463.962 Ha (increment)
Fugar Town		198.312		687.163	488.851 Ha (increment)
Aviele		183.382		751.556	568.174 Ha (increment)

The increase of roads (minor) in the updated map is due to the massive developments that have taken place in the past nine (9) years. For instance, Hamza Street which was two thousand one hundred and sixty-one (2,161) meters has increased to two thousand three hundred and sixty-four (2,364) meters. There are also other minor roads which have also increased due to developments. The built-up areas had equally increased causing the merging of some towns (e.g.

Auchi and Jattu). This is due to urban migration that has taken place over the years- a common trend observed in most Nigerian cities.

5. Summary

The products generated for this project are:-

1. The Triangulation Irregular Network (TIN) of the Study Area
2. Slope map of the study area
3. Hill Shade map of the study area

1. The TIN of the study area will help in planning and resource management, earth science, engineering works, visualization of a 3-dimensional surface, volume calculation etc.
2. Slope map of the study area will help in determining a quality drainage system, laying water pipelines and calculating topographic changes in the landscape.
3. Updated topographical map of the study area can be used in planning drainage, roads, development of water projects and it is also helpful in determining the difference in terrain elevation.

The revision of topographical map sheet 266, Auchi S.E is necessary for sustainable socioeconomic development of the region. It will provide a reliable foundation for planning, decision-making, and research, leading to improved quality of life, economic growth, and environmental sustainability. The revised topographical map will provide up-to-date data on the terrain, land use, and resources that enhance urban planning, infrastructural development, natural resource management and conservation thereby resulting in improved economic opportunities and investment.

6. Summary

This research was carried out in other to produce a revised or updated topographical map Sheet 266, Auchi S.E for socioeconomic development of the study area. The methodology adopted is a demonstration of simplicity, accuracy, versatility, and convenience associated with digital mapping. It is well appreciated since the results of feature extraction showed that there was no difficulty in detecting and identifying area features such as towns, smaller villages and isolated buildings. The research reflects changes in infrastructure, land use, and demographic patterns to support urban and rural planning initiatives, ensuring efficient allocation of resources and providing valuable insights for investors, policymakers, and stakeholders to drive economic growth and improve living standards.

7. Conclusion

The use of remote sensing and GIS has been demonstrated in this study as an effective tool for spatial analysis of topographical map sheet 266 Auchi S.E for socio-economic development. The result shows an increase in human activities and expansion of settlements. Further analysis showed that a lot of changes had happened from 2010 to 2024. The relevance of topographic maps in nation-building and sustainable socioeconomic development cannot be over-emphasized.

8. Recommendations

Based on the results and analysis obtained, the following recommendations are made:

1. Government should expedite action on archiving satellite imagery of the whole country to provide satellite image data of higher resolution, which can facilitate map revision exercises in the country.
2. Use of 2008, 1:50000 topographic map series should be discouraged by map users, rather the revised topographic map series of the study area.
3. This study has highlighted the importance and uses of topographic maps in the area of sustainable socioeconomic development.
4. Government should ensure that geodetic controls are provided for mapping purposes.

Finally, the Federal Government of Nigeria should appreciate the role of surveying and mapping products in the physical, socio-economic and political development of this country. Thus, adequate funding by the government will ensure continuous revision of all maps (including the 1:50,000 topographic series), which will guarantee the use of adequate, relevant and up-to-date data and information for proper planning as well as effective environmental management and sustainable development in Nigeria.

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