Map Revision of Small Scaled Topographic Sheet 303 Abakaliki South-West (SW), Nigeria

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Keywords: Map Revision, Topographic map, sheet 303 Abakaliki Southwest, Land use

SUMMARY

Up-to-date and accurate maps are basic tools for any meaningful planning, systematic development, and effective management of the natural resources of any nation. The importance of the utilization of spatially referenced data such as maps by professionals in the built environment has gained increased public awareness globally in recent times which will require routine revisioning as the need arises. The need for an update and revision of map sheet 303 Abakaliki South West (SW) highlights the need for relevant information from the existing map for ease of planning and future development. In this paper, the existing topographical map of sheet 303 Abakaliki S.W. was revised. This was possible through satellite imageries, the GRID3 Nigeria Infrastructural dataset, as well as evaluation of land use and land cover change between 1966 – 2019, and extraction of heights of the mapped area from the ASTER DEM datasets. To effectively pre-process the acquired satellite datasets and classify land cover features as mapped in the previous edition for the revised edition of map sheet 303 Abakaliki South West, it was necessary to create a current land-use map, adopting the layer concept for each feature in a geographical perspective. Results show a high concentration of human activities in major towns like Amuzu with an expansion rate of 0.99% in land use compared to that of 1966 while Echialike also had an expansion rate of 0.80% as regards the built-up area in the classification result. There was no school as of 1966 but in 2019, a total of 308 Primary schools, 143 Secondary schools, and 7 Tertiary schools were discovered. Based on the study of the map produced, it was discovered that the total number of roads on the revised map was 806 while that on the existing topographical map excluding minor paths was 104 implying that there is an additional 598 roads between 1966 and 2019. Also, the percentage of dual carriage roads, single lanes, and other roads show a considerable increase. Similarly, some areas have increased in elevation as a result of landfill and urbanized construction while there are some areas of decrease in elevation as a result of sand mining and mineral extraction. Furthermore, the result shows a high concentration of human activities in major towns like Amagu, Amuzu, Igbidu, Akahufu, and Echialike as regards the built-up areas in the classification result. From the findings, there were many changes in the topographic information; settlements, road types, and road names in the mapped area for 2019 when compared to what was existing in the 1966 topographic sheet. It is recommended that the use of remotely sensed data should be adopted for mapping purposes, and revision of all categories of maps should be embarked upon as often as possible.

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1. INTRODUCTION

From the earliest civilization, maps have been used to portray information about the earth's surface. Professionals such as Surveyors, Cartographers, Engineers, Navigators, Town planners, Architects, Military personnel, etc used maps to show the spatial distribution of important geographic features. Once produced, in most cases, this graphic image (map) becomes static, therefore, it should be expected that a map may be partly out-of-date by the time of its publication and it may remain in this state for some time (Keates, 1973). There is a constant search for ways of providing the static map with information about changes. Thus, the true aim of map revision is to keep all maps up-to-date with relevant changes as may be witnessed over time. If the accuracy and quality of the map are to be maintained, then the revision information must be compiled (under regulations and specifications) and carefully located. Map revision can be carried out using several techniques and data sources (such as aerial photographs). However, sometimes, this procedure requires the use of sophisticated and expensive equipment.

The advances in the Geographical Information System (GIS) techniques and the decreasing cost of the equipment for data processing of the digital aerial digital elevation model open a wide field of applications where diverse possibilities for the production of topographic information surge through digital procedures. Likewise, air and space-borne technologies such as aerial photography and satellite-based remote sensing have come to the aid of mankind, in the quest to understand and preserve the environment. These advancements have given the map maker new tools for creating and updating maps as well as allowing mapping in detail - the multitude of new environmental phenomena. Therefore, the need for the use of remotely sensed datasets and GIS techniques for updating the map sheet 303 Abakaliki (South West) cannot be overemphasized. Also, it was observed that the last topo map which has Abakaliki metropolis in its coverage was published by Federal survey Nigeria in 1966.

The creation of Ebonyi State in 1996, the adoption of Abakaliki as the State Capital, and the surge in the rate of development since then have been enormous and cannot be ignored. New roads have cropped up and some old roads have been upgraded. These changes must be documented if the maps are to carry accurate information about the earth's surface. Abakaliki city of Ebonyi State, Nigeria, is about 35km east of Enugu and is rapidly undergoing physical development and expansion, with remarkable changes in its land use and urban landscape, especially the road network and settlement. The traditional method of data collection for map-making is laborious and it takes longer time to produce which renders the map obsolete in the real sense by the time the map is published. Revised maps are produced to show the latest information that is currently in existence, especially for visitors and researchers. There is a need therefore to revise the existing maps from data that can portray reality as faithfully as possible so that the rapid nature of changes is shown in the new maps.

This paper revised the existing Topographical map of sheet 303 Abakaliki South West. This was achieved through the evaluation of land use and land cover changes between the two dates under review (1966 – 2019); vectorization of the acquired datasets and creation of a database for spatial analysis and query purposes; and lastly, extraction of heights of the mapped area from Aster DEM dataset using geospatial techniques.

1.1 Study area

The study area lies within Abakaliki, Ezza North, Ezza South, Ikwo, and Onicha Local Government Areas of Ebonyi State which is between Latitude 6°00' to 6°15' North, and Longitude 8°00' to 8°15' East of the equator, and covers an approximate area 780 square kilometers.

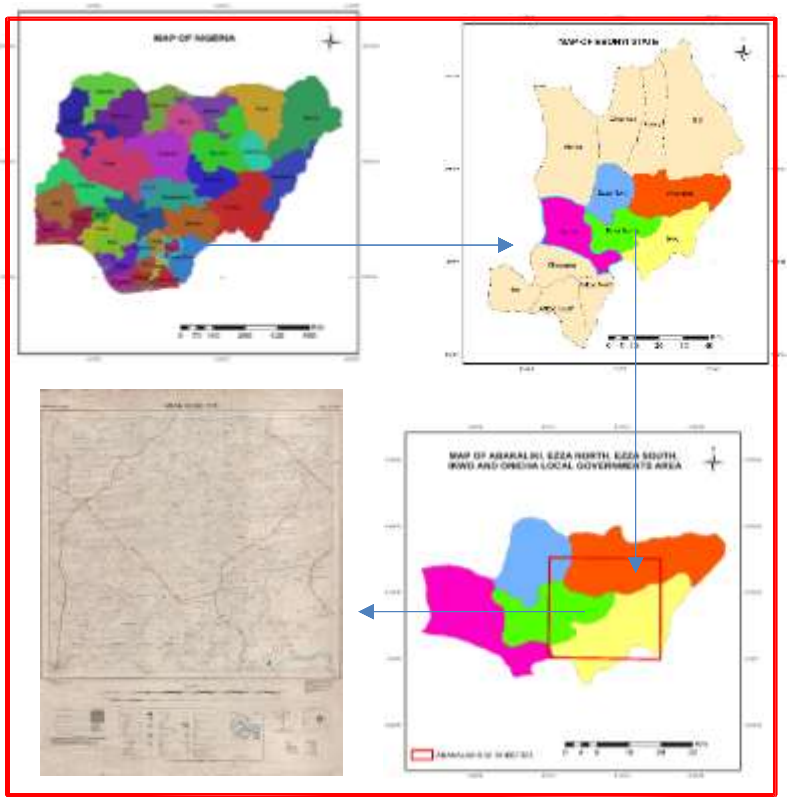


Figure 1: Project area in red (Not drawn to scale)

2. MATERIALS AND METHODS

2.1 Materials

The data utilized consisted of both primary data and secondary data. Other areas considered include existing data that would aid in the execution of the project, determination of the resolution of the imageries used in the project, and the scale in which the data presentation will be done.

2.2 Methods

Planning and preparation are essential before the execution of any research work to get the best result. During this period, a decision on data, equipment type, and all other necessary information required for the proper execution was determined, obtained, and analyzed.

Data searches were for both primary data and secondary data, and the method of acquisition was determined at this stage. Other areas considered include existing data that would aid in the execution of the work, determination of the resolution of the imageries used in the work, and the scale in which the data presentation was done.

At this stage, a random check of the existing major road was done to ascertain the authenticity of the Topographic sheet. This was done by scaling out some intersection roads and the use of Handheld GPS to ascertain the locations.

The revision of the Abakaliki SW topographical map SHEET 303 objectives was achieved using satellite imagery, GRID[3] NIGERIA Infrastructural dataset, and ASTER DEM. The project execution was based on the application of GIS and remote sensing.

GIS techniques were used to extract infrastructural data, vectorize the existing project topographical sheet, digitize the development that was not captured in GRID[3] and apply normal cartographic procedures. The methodology adopted for this project involved three major steps data acquisition, processing, and presentation.

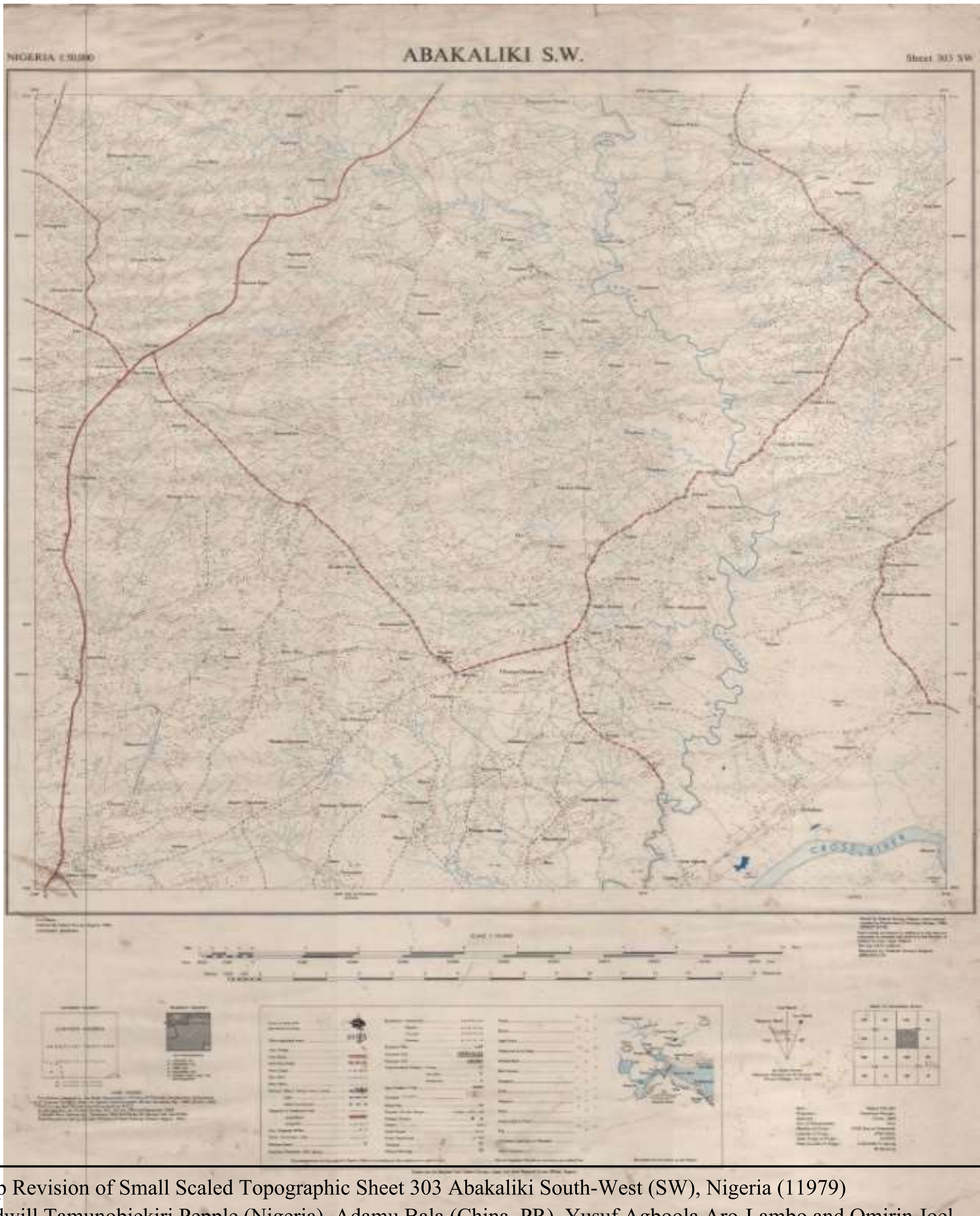


Figure 2: The acquired 1966 map sheet

2.3 Geometric Data Acquisition

The locational data were collected using remotely sensed data. GRID[3] and Satellite imagery were used to obtain the x, and y coordinates of the latest features while the ASTER DEM imagery was used to acquire the x, y, and z coordinates of the contour data. This aspect of data acquisition can be further divided into the following stages: acquisition of the infrastructure dataset from GRID[3], acquisition of the satellite dataset, acquisition of the ASTER DEM imagery, and extraction of the contour data from ASTER DEM.

2.3.1 Acquisition of Infrastructure dataset from GRID[3]

GRID[3] Nigeria was Launched in March 2018, the Geo-Referenced Infrastructure and Demographic Data for Development (GRID[3]) initiative aims to facilitate the production, collection, use, and dissemination of high-resolution population, infrastructure, and other reference data in support of national sectoral development priorities, humanitarian efforts, and the United Nations' Sustainable Development Goals (SDGs). The GRID[3] programme is part of a bigger global initiative that aims to improve access to data for decision-making in all participating countries. The following summarized steps were taken to achieve the results.

2.3.2 Acquisition of Satellite dataset

Before acquiring the satellite dataset, the Area of Interest (AOI) was created by digitizing a polygon shapefile named 'AOI' around the topographic sheet. World Imagery provides one meter or better satellite and aerial imagery in many parts of the world and lower resolution satellite imagery worldwide. The map includes 15m Terra-Color imagery at small and mid-scales (~1:591M down to ~1:72k) and 2.5m SPOT Imagery (~1:288k to ~1:72k) for the world. The map features 0.5m resolution imagery in the continental United States and parts of Western Europe from Maxar. Additional Maxar sub-meter imagery is featured in many parts of the world. In other parts of the world, imagery at different resolutions has been contributed by the GIS User Community. In select communities, very high-resolution imagery (down to 0.03m) is available down to ~1: 280 scale.

2.3.3 Acquisition of Aster DEM

The Shuttle Radar Topography Mission (SRTM) data products result from a collaborative mission by the National Aeronautics and Space Administration (NASA), the National Imagery and Mapping Agency (NIMA), the German space agency (DLR) and the Italian Space Agency (ASI), to generate a near-global digital elevation model (DEM) of the Earth using radar interferometry. The SRTM-1 (1 arc-second) and SRTM-3 (3 arc-second) digital elevation models are being developed from the SRTM C-band radar observations for selected regions to satisfy the needs of NASA-related projects and to speed the evaluation of acquisition and processing and applications algorithms. To load the SRTM-30 data available from the SRTM FTP Site, what is required is to download the *.dem.zip and open it directly into Global Mapper.

Table 1: Shows the coordinate of the mapped area

Point ID	Geographical coordinates to be converted		Result of the Universal Transverse Mercator coordinate	
	Latitude	**Longitude**	**Northing (m)**	**Easting (m)**
Pt1	6º 15'00"	8º 00'00"	690824.721	389453.656
Pt2	6º 15'0"	8º 15'00"	690778.738	417111.412
Pt3	6º 00'00"	8º 15'00"	663140.666	417072.812
Pt4	6º 00'00"	8º 00'00"	663184.837	389402.183

2.4 Adding of DEM dataset for generating relief information

The ArcGIS software was used for extracting relief information such as contour, by clipping out the mapped area from the acquired DEM dataset. Clipping of DEM File to fall within a region of interest (ROI) and Generating Contour from the DEM file in ArcGIS Environment.

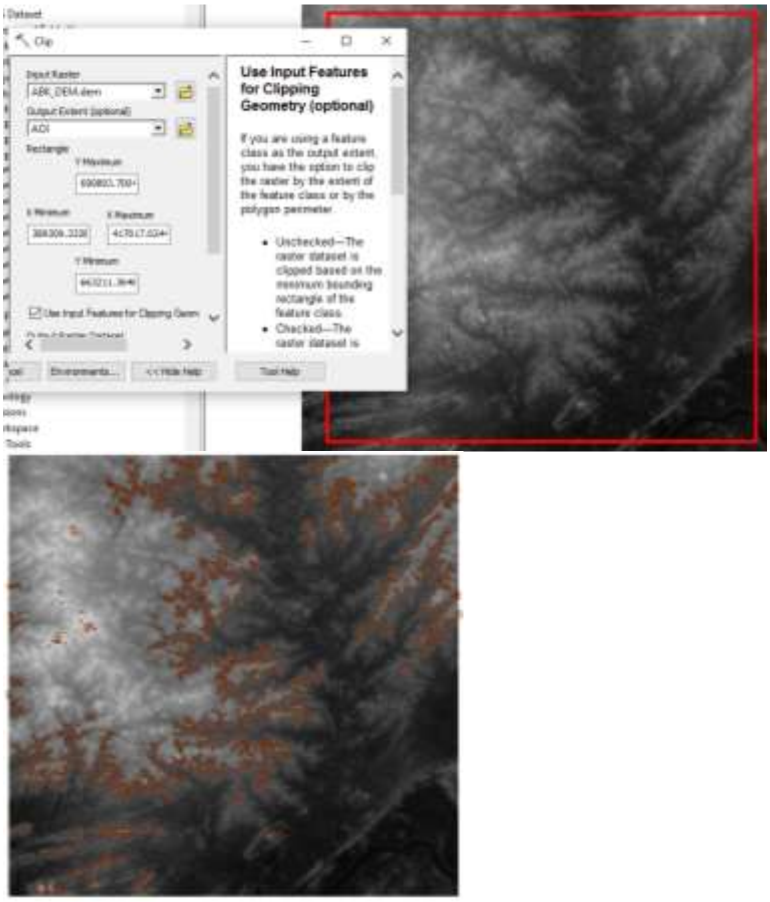


Figure 3: Clipping of DEM File to fall within Area of Interest and generated contour output.

2.5 Database Creation

A database is an organized integrated collection of data stored to be capable of use by relevant applications with data being accessed by different logical parts. In the execution of this project, this was the phase where a database was created. After the table had been populated via the keyboard, some attributes such as area, and perimeter of percale were automatic.

2.6 Data Security

Data security means protecting data, such as a database, from destructive forces, and the unwanted actions of unauthorized users. This is the security measure used for the protection of the database created. Database security is very important since it is vital for data integrity. The strategic measure used included controlling access to the database by use of a password.

2.7 Data Integrity

This ensures that data in the database is accurate and that cases of violation of integrity are detected automatically by the system. Here, care was taken while entering data into the computer system, such that, accurate data was entered and updates can be done accurately without tampering with existing data. Back-ups were provided to cater for any loss of data through system failure.

2.8 Database Maintenance

Having created the database, proper maintenance practice was made to meet its stated objectives. The ability to include more data and remove irrelevant data was possible by way of maintenance. There is every need for the data to be updated regularly because of the physical changes that may occur on the landscape with time. Both security and integrity were also exercised to ensure the maintenance and to meet its stated objectives.

3. RESULTS AND ANALYSIS

3.1 Land use and Expansion

There has been a vast expansion of some major settlements in the initial map (1966). The result shows a high concentration of human activities in major towns like Amuzu with an expansion rate of 0.99% in land use compared to that of 1966 while Echialike also had an expansion rate of 0.80% as regards the built-up area in the classification result. There was no school as of 1966 but in 2019 a total of 308 Primary schools, 143 Secondary schools, and 7 Tertiary schools were discovered. A summary of the settlement expansion and road coverage is presented in Tables 2 and 3 while the graphical portrayal of the expansion rate of settlement for 1966 and 2019 is shown in Figure 5.

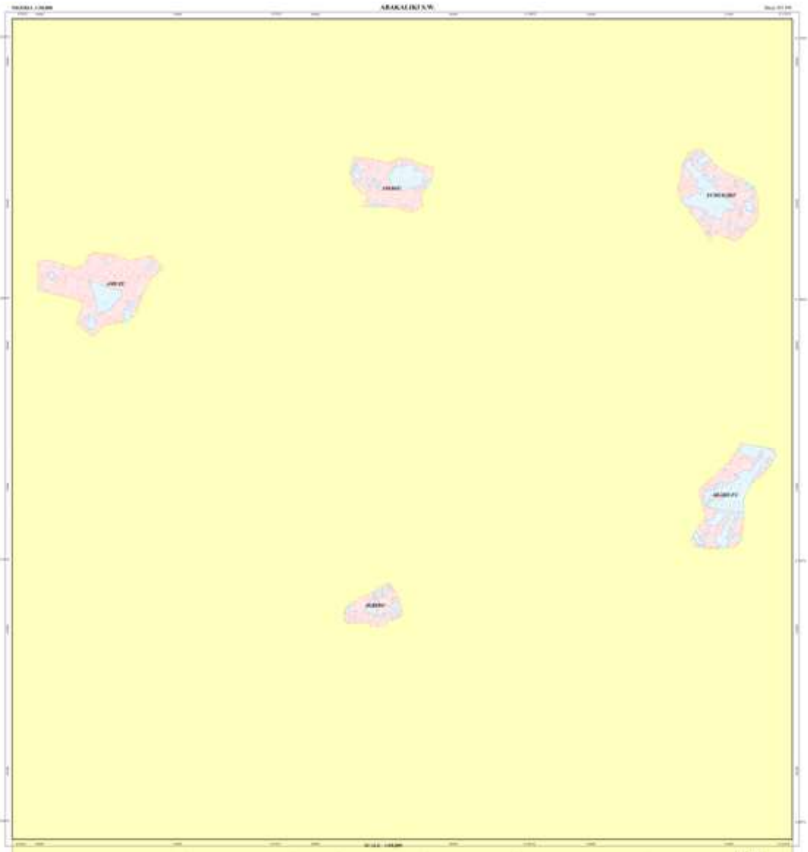


Figure 4: Shows settlement coverage measured in 1966 and 2019

Table 2: Showing expansion of settlement as at 1966

Major settlement extent of expansion as at 1966			
Settlements	**Area (m^2)**	**Perimeter (m)**	**Coverage (%)**
Amagu	1086004.868628	9697.914268	0.14
Amuzu	1081541.302359	10164.10846	0.14
Igbidu	310996.16053	8667.560135	0.04
Akahufu	2782454.808565	24845.931924	0.36
Echialike	1984069.027513	18349.639274	0.26

Table 3: Showing expansion of settlement as at 2019

	Major settlement extent of expansion as at 2019		
Settlements	Area (m^2)	Perimeter (m)	Coverage (%)
Amagu	4341400.721194	8978.105045	0.57
Amuzu	7583074.471298	13188.408444	0.99
Igbidu	2078044.386122	5933.871442	0.27
Akahufu	5713300.554281	11292.955386	0.75
Echialike	6087833.327937	9940.235933	0.80

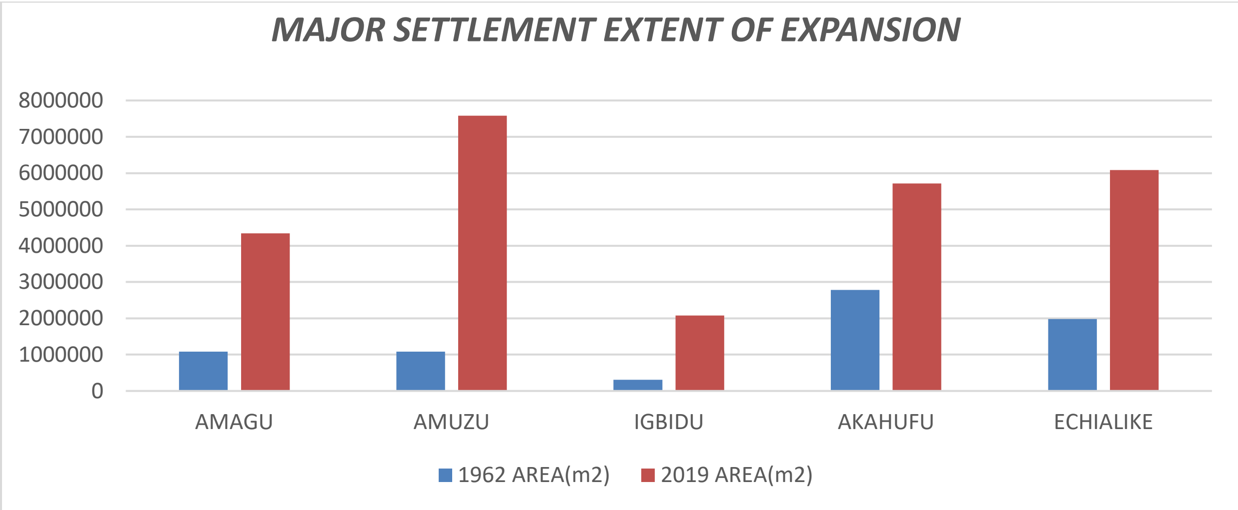


Figure 5: Bar chart showing a comparison of settlements extent as of 1966 and 2019

3.2 Analysis of Road

Based on the study of the map produced, different road classes and types were identified. Amongst the total roads obtained in the project area, the main path category of the road is more prominent within the updated map while a total of 702 roads excluding minor paths were updated within the mapped area. By comparison, it was discovered that the total number of roads on the revised map was 806 while that on the existing topographical map excluding minor paths was 104 implying that there is an additional 598 roads between 1966 and 2019. Also, the percentage of dual carriage roads, single lanes, and other roads show a considerable increase. The summary of the road coverage for both road types and designation (class) is presented in Tables 5 and 6 and Figure 6 while the graphical portrayal of the road coverage for 1966 and 2019 and the comparison between the road coverage types and designation for the two years are shown in Figure 6, 7 and 8 respectively. The revised planimetric map of the project area is given in Figure 9.

Table 4: Roads identified in1966

Roads	Length *(m)*	Coverage %
Main road	33305.4875	16.034
Secondary roads	75526.3019	36.362
Minor roads	98877.1235	47.604
Total	207708.9129	100.000

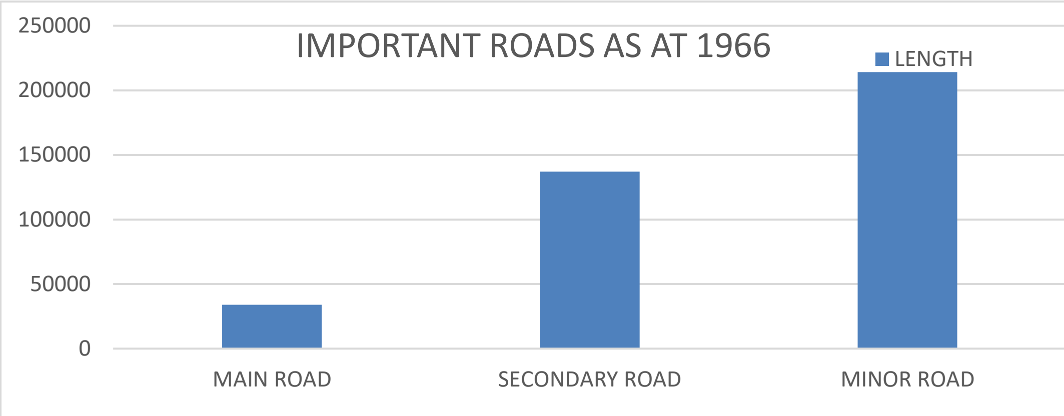


Figure 6-Bar chart showing Total Length Coverage of Road Type in1966
(Source: topographic map sheet 303 ABAKALIKI S. W.)

Table 5: Identified road in 2019

Important roads	*Length (m)*	*Coverage %*
Main roads	*33975.83489*	*8.82*
Secondary roads	*137068.700179*	*35.59*
Minor roads	*214080.694126*	*55.59*
Total	*385125.2292*	*100*

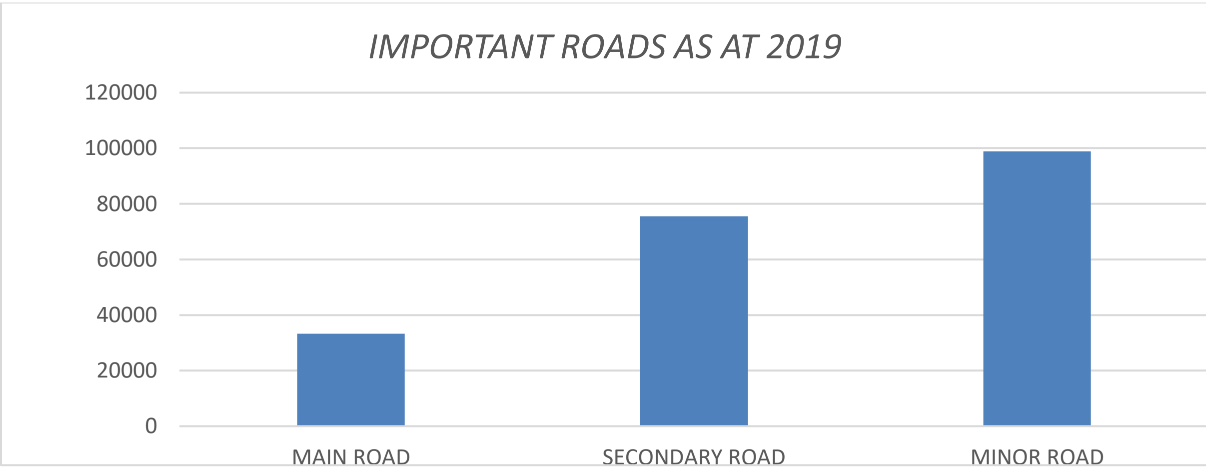


Figure 7: Bar chart Showing Length of Road type in 2019 (Source: GRID[3] NIGERIA.)

Table 6: Comparison of road Length in1966 and 2019

Road Type	*Length (m) (1966)*	*Length (m) (2019)*
Main road	*33305.487518*	*33975.83489*
Secondary Road	*75526.301912*	*137068.700179*
Minor Road	*98877.123471*	*214080.694126*
TOTAL	*207708.9129*	*385125.2292*

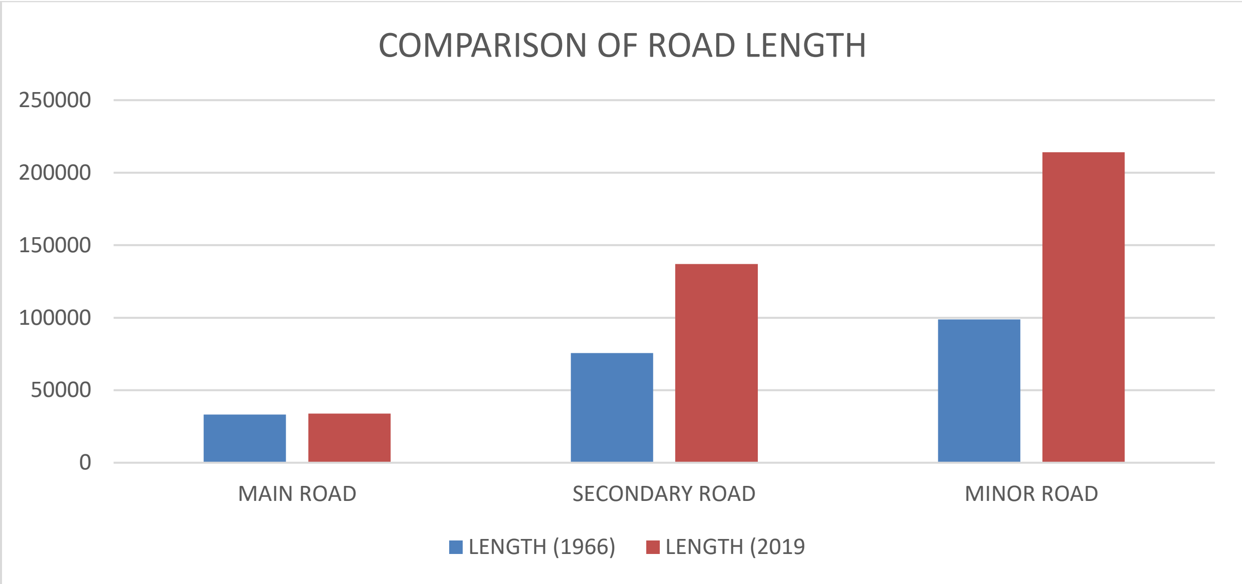
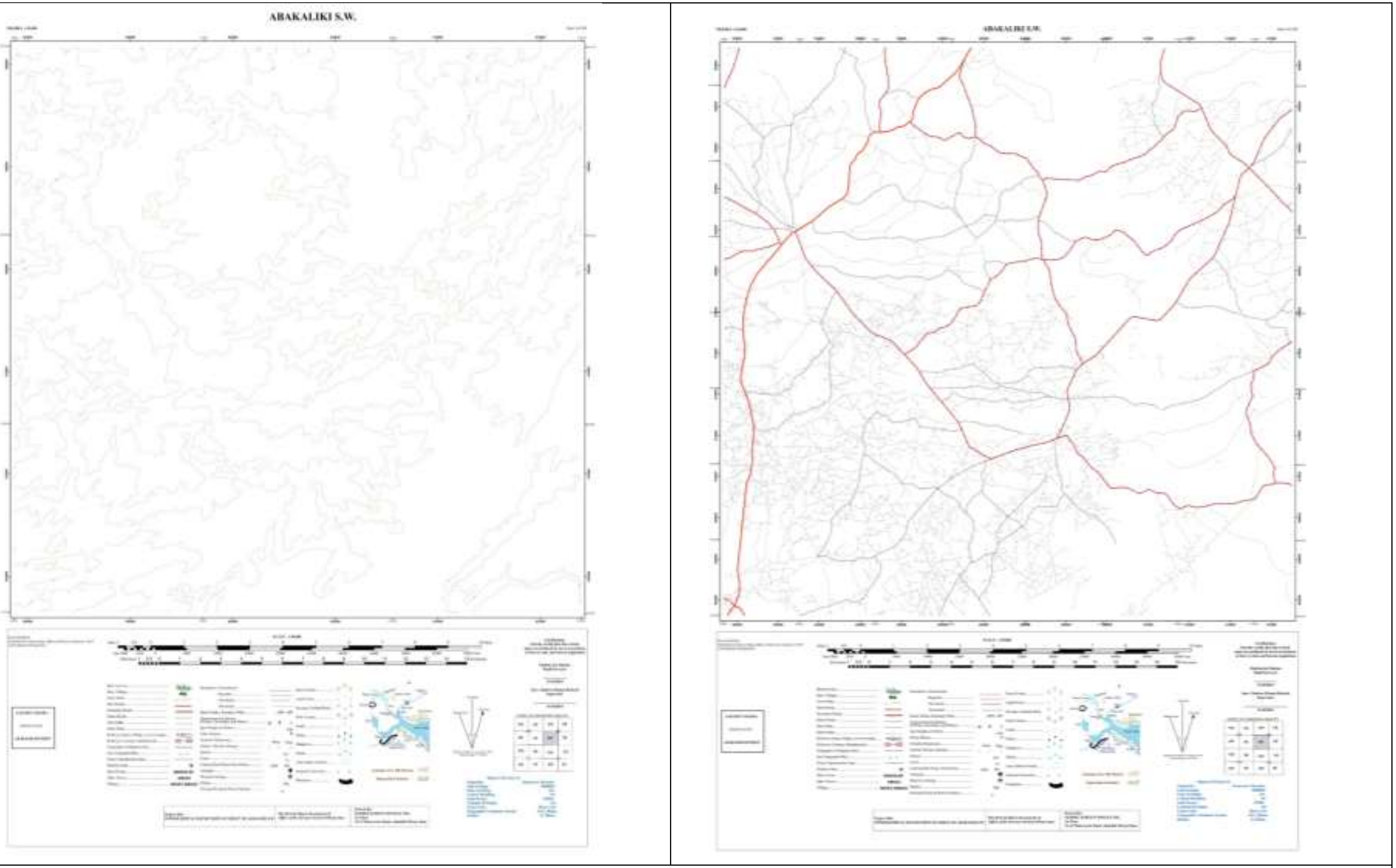


Figure 8: Bar chart showing a Comparison of Road Length in 1966 and 2019



Figures 9 (a & **b):** Revised map sheet of 2019

There were changes in the elevation of the mapped area, this was discovered after generating the contour from the downloaded DEM dataset, some areas have increased in elevation as a result of landfill and urbanized construction while there are some areas of decrease in elevation as a result of sand mining and mineral extraction. The elevations of places close to Cross River State have decreased in elevation i.e. the elevation along that area at the time of this revision, the elevation was less than the elevation of the same area in 1966, this could be a result of coastal erosion or subsidence.

3.3 Discussions

Up-to-date and accurate maps are a basic tool for any meaningful planning, systematic development, and effective management of the natural resources of any nation. The topographical base map need of the world, in general, is not being met by the classical photogrammetric mapping method. The use of remote sensing and GIS had been demonstrated in this project as an effective tool for the revision of any1:50000 topographic maps. Up-to-date GOOGLE earth engine dataset 2019 was used to revise the 1966 topographic map of Abakaliki South West of scale 1:50,000. The result shows a high concentration of human activities in major towns like Amagu, Amuzu, Igbidu, Akahufu, and Echialike as regards the built-up areas in the classification result.

Results from the map revision exercise are applicable firstly, for planning the environment i.e. the appropriate location to site a particular project, ranging from bridge construction, rail construction, road construction, Dam construction, etc. Secondly, for monitoring the trends and changes within a particular locality. Thirdly, for mineral and energy exploration and/or exploitation, and lastly, for national defense, navigation, and positioning.

3.4 Problems Encountered

Firstly, one of the challenges encountered in the execution of this project was getting the actual names of the towns, as most towns are being called multiple names. To take care of this situation only names from recognized publishers were adopted. Secondly, security was a challenge as we had to enter into the nooks and cranes of the entire project area to acquire spatial and attribute data, making us exposed to hoodlums, cultists, etc. living within this area, especially at the waterfront. However, this was surmounted by going with security personnel to the project site, though this caused a delay on a few occasions while waiting for the security personnel in accompanying us to the project area.

In the context of environmental planning or assisted navigation, the availability of recent maps is crucial. The process of updating maps has been time-consuming, error-prone, and expensive, requiring traditionally long hours of manual change detection and correction. Cost reduction has been recently achieved from the delocalization of manual work towards developing countries. But gain in time, cost, and error is currently expected from automated techniques-based map updating. The map was produced quickly and cost-effectively underscores the advantages of digital mapping over the traditional methods currently being employed in the state

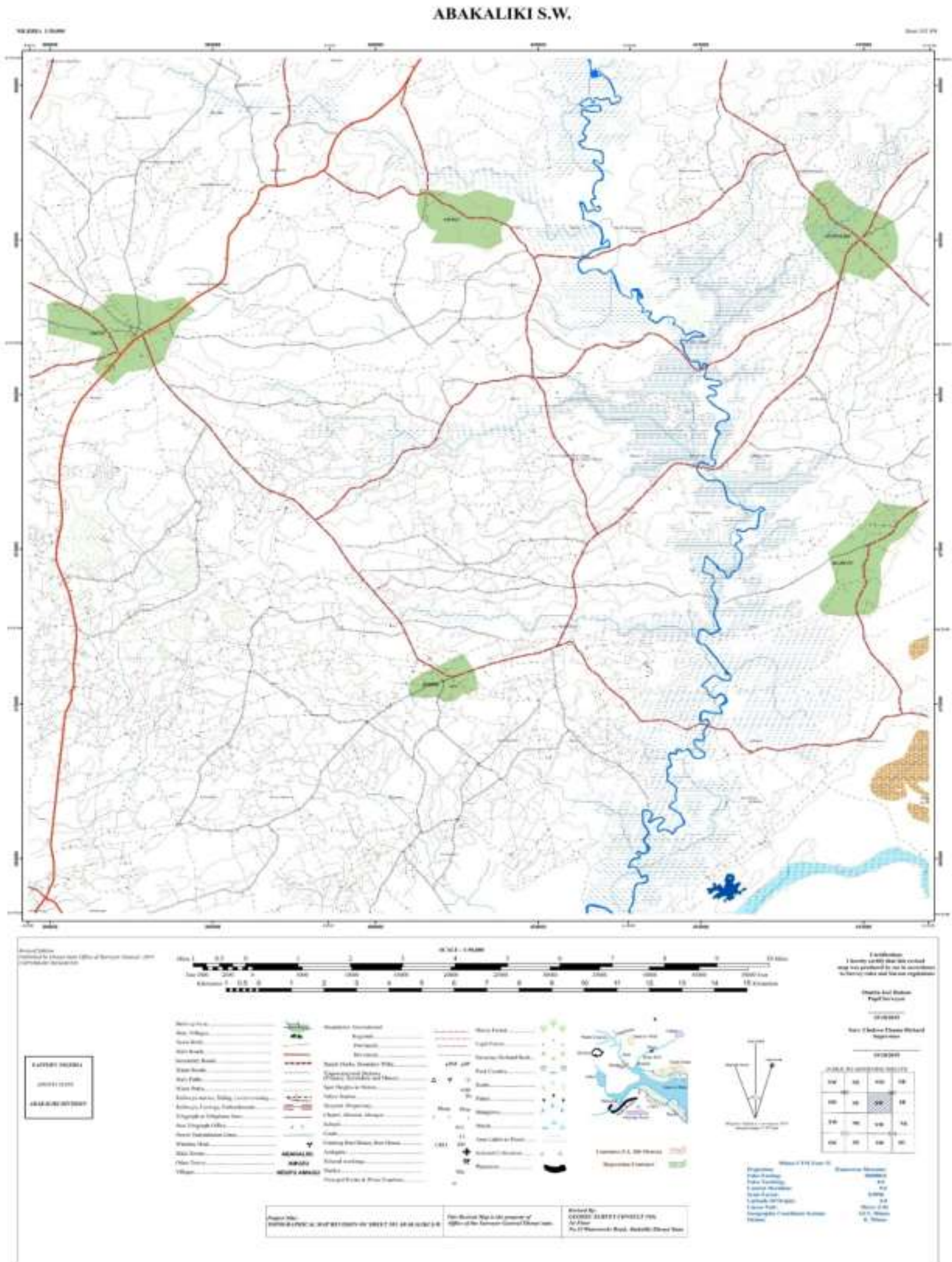


Figure 7: Revised Topographical Map of the Project

4. CONCLUSION

From the findings, there were many changes in the topographic information; settlements, road types, and road names in the mapped area for 2019 when compared to what was existing in the 1966 topographic sheet. It was worthwhile to state from this project, that map updating using remotely sensed data like the ones used in executing this project i.e. satellite dataset and ASTER-DEM and GIS technique is very important and less tasking compared to the traditional manual map making. It is also cost-effective and time-saving because of the size of the project area. From this project, therefore, it can be concluded that: firstly, further analysis showed that a lot of changes had happened from 1966 to 2019. Secondly, Remote sensing and GIS techniques provide a reliable base for updating maps especially when high-quality or high-resolution satellite imageries are used. Thirdly, updating maps is easier and less costly than using remotely sensed data in a GIS environment because it only entails updating the digital mapping system database. Lastly, an integrated approach should be employed in any map production because it provides versatility in acquiring data from various sources and thus provides support and alternatives for data quality, processing, and presentation.

It is recommended that the use of remotely sensed data should be adopted for mapping purposes. Additionally, the revision of all categories of maps should be embarked upon as often as possible. Furthermore, the use of the 1966 1:50000 topographic map series should be discouraged by map users rather revision of 1: 50,000 topographic map coverage of the country should be carried out without further delay.

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BIOGRAPHICAL NOTES

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Surv. Yusuf Aro-Lambo

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Surv. Omirin Joel IBUKUN

Surv. Omirin Joel IBUKUN is a GIS Specialist with Ebonyi State Nigeria Erosion Watershed & Management Project (World-Bank Assisted) from 2016 till the end of the project (2021). A Registered Surveyor with the Surveyors Council of Nigeria (SURCON) in February 2023 with registration number 5030 and a member of Geoinformatics Society of Nigeria (GEOSON) since 2017. He is currently the Director of Jayel Geospatial Limited.

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