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SPATIAL ASSESSMENT OF POPULATION DISTRIBUTION AND NAVIGATION MAP OF ESA-OKE, OBOKUN LOCAL GOVERNMENT AREA, OSUN STATE.

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Abstract
The use of remote sensing data and geographic information system techniques especially with high spatial resolution satellite imagery has great capabilities for mapping and map revision. These techniques have been used at various times and at different stages to study characteristics of earth features, monitoring of natural and physical phenomena, and also to produce street maps and population density maps of different places. In this study, the satellite image of 2022 was used to produce a street map and population density map of Esa-Oke in Osun State. The methodology adopted for the research was data capturing of high-resolution remote sensing images and census data. The data acquired were processed using ArcGIS 10.2. Analyses carried out revealed the total number of roads to be 109 while the total distance of the road network is around 70km. Major roads account to be about 5% while minor road account to be 95%. The population density map revealed the type of distribution that occurs in the study area to be a clustered pattern. From the study, it was recommended, among other things, that government should create more bypasses and open up new roads, especially in the areas that are yet to be built up to ease traffic and avoid environmental hazards in the clustered areas of the town.

Keywords: Esa-Oke,Spatial resolution, Satellite Imagery, and Population density.

Introduction

This studywas focused on the production of a spatial index map for navigation and population distribution within Esa-Oke, Osun State using Remote sensing and GIS method to show the navigation and population density within the study area.

Satellites have played a vital role in the development of many technologies such as world mapping, Global Positioning Systems (GPS), etc. However, their applications are not limited to imaging devices only. To be honest, they are whole a lot more than just imaging devices. Remote Sensing is one of the many innovations that were possible, thanks to these satellites roaming around the earth.

According to Burrough (2016), GIS is a tool for collecting, storing, retrieving at will, transforming, and displaying spatial data from the real world for a particular set of purposes. In short, GIS can be used to add value to spatial data Sharma (2016). This is by allowing data to be organized and viewed effectively, by integrating them with other data, by analysis, and by the creation of new data that can be operated on in turn to create useful information that can help decision-making. The uniqueness of GIS is in its ability to integrate data from a variety of sources. A GIS can thus be described as a form of spatial decision support system.

Street guides are a graphic portrayal of a town or city showing the positions and names of all the streets; major/minor highways and roads, railroads, tracks, and other points of interest, and the general road network. It is a form of map that details roads and transport links. They are produced to show current road information, especially to visitors and researchers Ogunleye et al(2007) Street guides are not only important for aiding navigation within the city but are also useful in planning enumeration areas by demographers and are equally useful to tourists, sales fireman, police, security agents, tax collectors, postal service and also serve as a base for land use classification mapping and town planning.

Migration of people from one region to another cause an increase in population density. Urbanization

is the main cause of change in hydrologic and hydraulic processes, loss of existing drainage capacity, and flooding in urban areas. It increases the total runoff volume and peak discharge of storm runoff events (Dewan and Yamaguchi, 2019). The land use change is influenced by humans trying to meet various needs such as residential, industrial, agricultural, mining, and other infrastructural facilities and is a major concern associated with the economic and sustainable growth of an area. Correct use of every part available without further deterioration (Fawat et al., 2017). Land use and land cover change and its implication on hydrological processes have been prominent research topes in recent times.

Remote sensing is used in the study of population distribution, navigation, and analysis because of its ability to cover large areas in a single image scene (Singh. A, 1984). Over the past years, data from earth-sensing satellites has become indispensable in mapping the earth's features, natural resources management, and environmental change studies (Fischer 2019).

The essence of this is to encourage and monitor development in a way that will not damage the environment for the incoming generation. These policies should include taking an appropriate inventory of the available resources, planning for their present and future use, and classifying the land uses.

Recent advances in sensor technology, as well as mobile systems, are revolutionizing the way by which geospatial information is collected, processed, and utilized. The unprecedented wealth of sensor data and image-based geospatial information produce large volumes of data and result in large imagery-based data repositories. This requires the development of new technologies that will be capable of searching, querying, retrieving, and mining to fully utilize the rich data repositories.

The spatial dimensions of population distribution and navigation need to be sufficiently equipped to take informed decisions on land resources. Therefore, a wide range of scientists and practitioners, including earth systems scientists, land and water manager as well as urban planners seek information on the location, distribution, type, and magnitude of land use and land cover change (Weng 2002, Singh and Kumar 2012). The natural vegetation of the reserves has been destroyed and converted at a rapid rate from excessive logging, conversion to forest plantation and farming

Mapping showing population density provides invaluable information for managing land resources and projecting future trends of land productivity (Al-Bakri et al., 2013).

Population density maps are an important requirement for a range of environmental applications, including land use planning, landscape monitoring, natural resources management, and habitat assessment (Brooks et al., 2000, Chen Wang, 2010). These changes have impacts on the ecological stability of the forest regions and, thus identifying and investigating the status of a resource such as the forest cover which is a crucial part of resources management and monitoring from local or global perspectives (Marcal et al., 2015).

According to UN Statistics (2018), natural population increase is supplementary by more than ten thousand inhabitants migrating to cities every week. Esa-Oke is an example of such population growth, most of the population density is concentrated in the city or the town

Exemplarily, we want to focus on Esa-Oke town, the population distribution, and navigation in the study area to highlight the type of distribution that occur in the area and opportunities for sustainable development.

Central population density poses serious threats to the integrity of the ecosystem and biodiversity especially in drought-sensitive landscapes, natural disasters (flooding), and diseases. Based on the above background, this study assessed the drivers of population distribution in the study area to provide a basis for future landscape management and town planning to combat the transformational crisis and ensure ecosystem sustainability.

Statement of Problem

Due to the locational position of Esa-Oke, no updated map shows the population density and navigation map of the study area. Thus, there is a need for a spatial index, street guide, and population distribution map of Esa-Oke to show the population density, and navigation and to provide a basis for future landscape management and town planning to combat the transformational crisis and ensure

ecosystem sustainability.

Aim

The project aimed to produce a spatial index map for navigation and population distribution using remote sensing and GIS method in Esa-Oke, to suggest urban land use management strategies and navigation purposes.

Objectives

The following objectives were carried out:

1. Download satellite imagery of the study area
2. Produce a spatial index map for population distribution and navigation of the study area
3. Analysis and determine where population density is of greater value

Study Area

Esa Oke is in Osun State, located in Obokun Local Government Area of Ijesa North Federal Constituency and Ife/Ijesa Senatorial district of Osun State, Southwest of Nigeria. It shares boundaries with other towns like Oke-Imesi, Imesi-Ile, Ijebu-Ijesa, Esa-Odo, and Efon-Alaaye.

The geographical location of Esa-oke lies between 7045'30"N and 70 46'28" N latitude and longitude 40 53' 50" E and 40 54' 57" E has a land mass area of 3.117kmsq with a projected population of 16,839 in 2020. 51% of the male population and 49% of the female population, Esa Oke people are predominantly farmers, the vegetation allows planting in all seasons due to annual rainfall of eight months in a year. The people of Esa Oke are majorly Christianity by religion. They are Yoruba by tribe and culture. The town is surrounded by hills, which is why it is called Esa Oke.

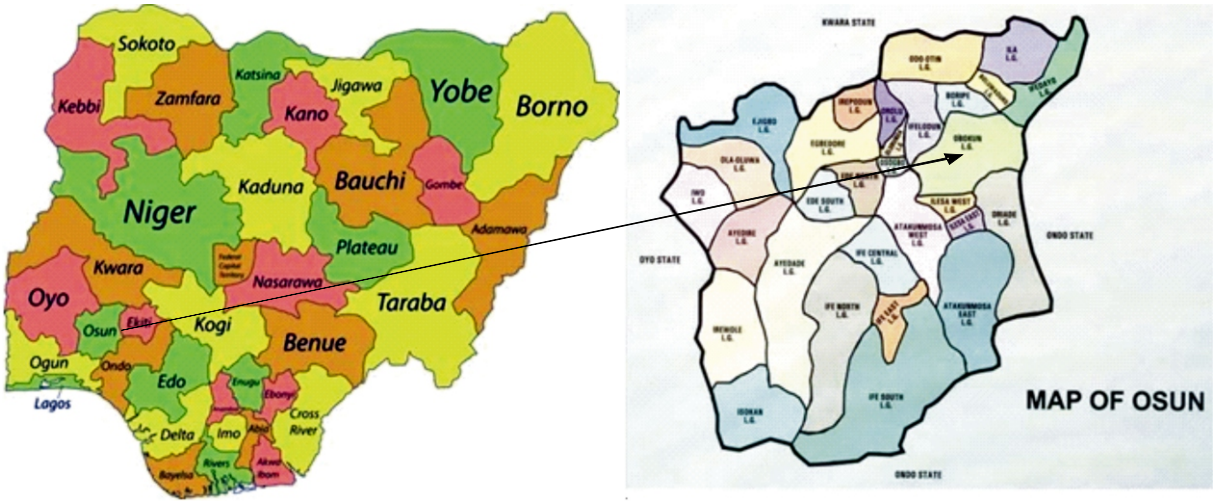


Fig 1: Map of Nigeria **Map of Osun State Showing Obokun LGA**

Research Methods

The satellite dataset used for this study was imagery that was acquired from the USGS Earth Explorer website. Data capturing from high-resolution Remote sensing images. Several techniques can be used to achieve the objectives but the application of Remote Sensing and GIS methods is used to show the population distribution and navigation for the project.

The methodology is discussed under the following headings

1. Data Acquisition
2. Data Processing

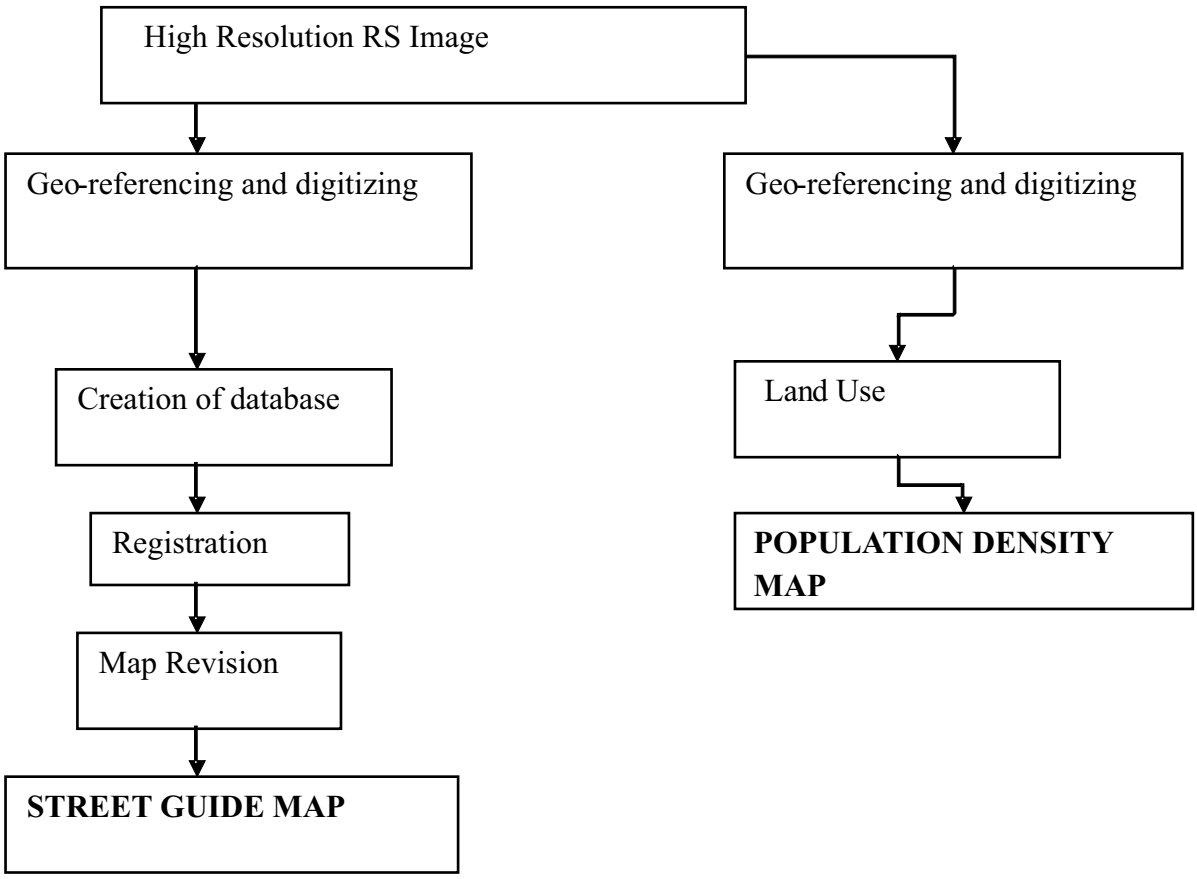


Fig 2: Cartographic Model

Data Acquisition

This is the first step in the execution of the mapping project after the preliminary stage of planning. It is a very important aspect of GIS as the type of data to be obtained and the accuracy of the data determines the output of the whole process. In this work, this was taken into consideration. The data collected consist of three types:

Spatial Data: The spatial data are the high-resolution image, land use data, and building parcel data. Land use data involve the built-up area as a basis for population distribution while Attribute data involves a direct visit to the site to interview people around to get information that is needed for the execution of the project. The data are street names, Number of people residing in the built up.



Fig 3: High-resolution image of the study area: source Google Earth

Data Processing: This is the procedure involved in the acquisition of data required to achieve this project which is:
Boundary Determination: The boundary of the study area was determined using SAS Planet software. The SAS planet was launched and the satellite imagery of the study area was downloaded for two imageries.



Fig 4: Boundary determination using SAS Planet software
Amosaic is produced, this is the merging of two or more images together. After the mosaic process, a couple of images in the same year are merged, a geometric correction is applied and re-projection into a common UTM zone 31. The imagery of the study area was added to the Arc map and the imagery was merged to form one single image.

Geo-referencing is the process of taking a digital image; it could be an air photo, a scanned geological map, or a picture of a topographic map and adding geographic information to the image so that GIS or mapping software can place the image in its appropriate real-world location. These imageries were all brought to the UTM projection systems.

Digitizing is the process of converting geographic data either from a hardcopy or a scanned image into vector data by tracing the features. Digitizing of the study area was done on the Arc map using catalog tools by converting the boundary to shape files.

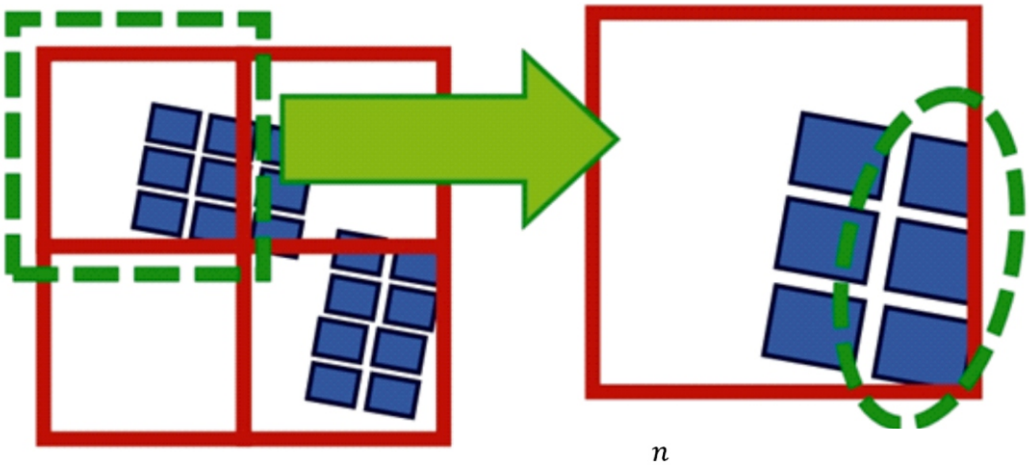
Clipped: This tool allows you to extract a portion of a raster dataset based on a template extent. The clip output includes any pixel that intersects the template extent. The portion of the study area is clipped out from the mosaic image merged.

Raster Population Data: No doubt built-up area represents where population density is of higher value. Raster data creation was conducted as a basis for determining the structure of population distribution. Raster data was developed by 100m*100m area per unit grid.
The initial stage before determining the distribution of the population was estimating the number of people per house building that had been digitized associated with vast proportion throughout the building in the area.

$$ParcelPop_{ab} = \frac{SubPopb * PFLAreaa}{SubPFLAreab}$$

Where:
$ParcelPop_{ab}$= Population in $building_a$, $Esa\text{-}Oke_b$
$SubPop_b$ = Population in $Esa\text{-}Oke_b$
$PFLArea_a$= $buildingarea_a$
$SubPFLArea_b$ =building area in Esa-Oke

By overlapping the building parcel map and grid map the population density in each grid was created. This process was done by the sum of the population within the building in the grid. The population is then converted into density by dividing the amount by the width of one grid.



$$CellPopa = \sum_{b=a}^{n} ParcelPop\ b \times \%P\ In\ Cell$$

$Cell\ Pop_{ab}$= Population in $grid_a$
$ParcelPop_{ab}$ = Population in building $parcel_b$ was cut by $grid_a$
$\%P\ In\ Cell_{ab}$= $Parcel_b$ percentage in $grid_a$

The next step is to change the vector data densities of each grid into raster data to create surface models using the population of the polygon to raster tools in ArcGIS.

$$Population\ Density = \frac{Total\ Population}{Total\ land\ mass}$$

Street Guide Data: The street guide data was gotten from the open street and questionnaire given to the people of Esa-Oke to get the information needed which is then used to create an attribute table and for query purposes.

Equipment (Hardware & Software)

The various equipment employed for the acquisition and processing of data and the subsequent information presentation can be arranged under three categories. These are the hardware, system selection, and software categories.

The hardware equipment is listed below:

Hardware

System Product: HP Laptop computer
Model: HP15 Notebook
Rating: Window 8.1 Enterprise
Processor: Intel(R) Core (TM)2 Duo CPU P8700 @2.53GHZ
Installed Memory (RAM): 4.00 GB
System Type: 64-bit Operating System.

Software

1. ArcGIS 10.2 for producing a plan
2. Notepad for the running of the script
3. Microsoft Excel for editing
4. Microsoft Word 2013 for report writing

Creating Shapefiles (Feature class)

At this point layers (shape files) were created that were used in vectorizing the analog map. All the shape files used were created using a Personal Geo-database. Create a folder in the desired location. Launch the Arc Catalogue from the ArcGIS 10.2. This includes the acquisition of the X, Y coordinates of points. The features on the satellite imagery were digitized. The satellite imagery of high resolution was used for the digitizing to generate X and Y coordinates.

Data Manipulation

Data manipulation is the process whereby the data acquired and recorded from field observation were properly edited and arranged. During this project, the data acquired and recorded from the field observation were properly edited and arranged on Microsoft Excel 2013.

Database Creation

According to (Kuforiji, 1998) which has designed a generic data structure, procuring necessary hardware and software, the overall system model had to be designed to facilitate case of data exchange or networking. The information needs met by a well-designed (spatial) database in GIS include – reliable information storage and retrieval at will, up-to-date and well define functions of updating information as well as the provision of analytical functions which allow spatial query and reality modeling or simulations. After the design phase, the database was created and populated. Below are the processes involved in database creation for the map revision of part of the study area:

1. Creating a database;
2. Adding tables to the database;
3. Updating table and database links;
4. Removing the table from the database;
5. Creating persistent relationships;
6. Building referential integrity;
7. Creating stored procedures; and
8. Viewing and setting database properties.

Database Design

The database is the heart of any GIS. The first step in database design is to carry out user requirement studies i.e. ascertain the application and identify the required attributes (Ajibade, 1991). The process of designing such a database is referred to as data modeling. It is the process by which real-world entities and their interrelationships are analyzed and modeled in such a way that maximum benefits

are derived while utilizing a minimum amount of data (Kuforiji, 1998). A spatial database forms the core or heart of any GIS operation in that it allows the system to meet up with the information needs of the people (purpose) for which a GIS project is carried out. The information as well met by a well-designed (Spatial) database in GIS includes – reliable information as well as the provision of analytical functions which allow (spatial) query and reality modeling or simulations. In implementing the database design for the project, two main phases were adopted namely; the design phase and the construction (creation) or implementation phase. The design phase (data modeling) is known to consist of or taken through four stages that are:

1. View of Reality
2. Conceptual Design
3. Logical Design
4. Physical Design

Spatial Analysis

This is the unique capability of GIS that differentiates it from other information systems. The principal objective of spatial data analysis is to transform and combine data from diverse sources into useful information, to improve and understand or to satisfy the requirement of the objective of the decision maker.

This chapter, therefore, deals with spatial analysis, queries, and product generation using ArcGIS 10.2 version software and the analysis and query results show the software's capability of producing specific user information.

The analysis functions of GIS for this project include

1. Population density map
2. Street guide map
3. Cluster of the central service area
4. Queries

A digital database was created for the street guide map of the study area, which facilitated spatial analysis that resulted in the digital map of the study area in 2D. The analyses performed in this project are Population, street guide, and other spatial queries. What differentiates GIS from any other information system is its ability to carry out spatial queries or analyses on the database. Meanwhile, ArcGIS 10.2 version was used for the spatial analysis. The analysis is performed using the ArcGIS 10.2 software where; population density analysis, spatial queries, and street guide

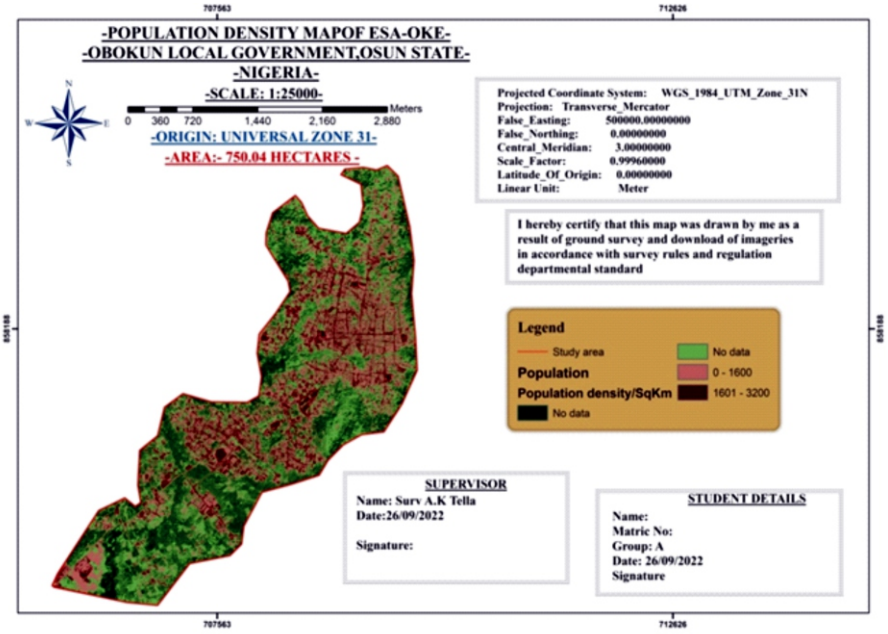


Fig 5: *Population Density Map of the Study area*

Analysis of Result

Population Density Map

The result of the map shows the brown colour has over 1601 - 3200 people per km^2 andis densely populated. The pink colour is between 0 - 1600 people per km^2. The light green and deep green are places that are for vegetation or rock so n data was gotten from it. The brown colour represented the densely populated area where the economic activities of the town are carried out. Most of the infrastructures are concentrated in that portion example the establishment of Osun State College of Technology, Bola Ige Mechatronics Institute. The pink colour represents places that are densely populated after the red colour, they are majorly residential areas. The light green and deep green represent places that are few or no settlements in the area.

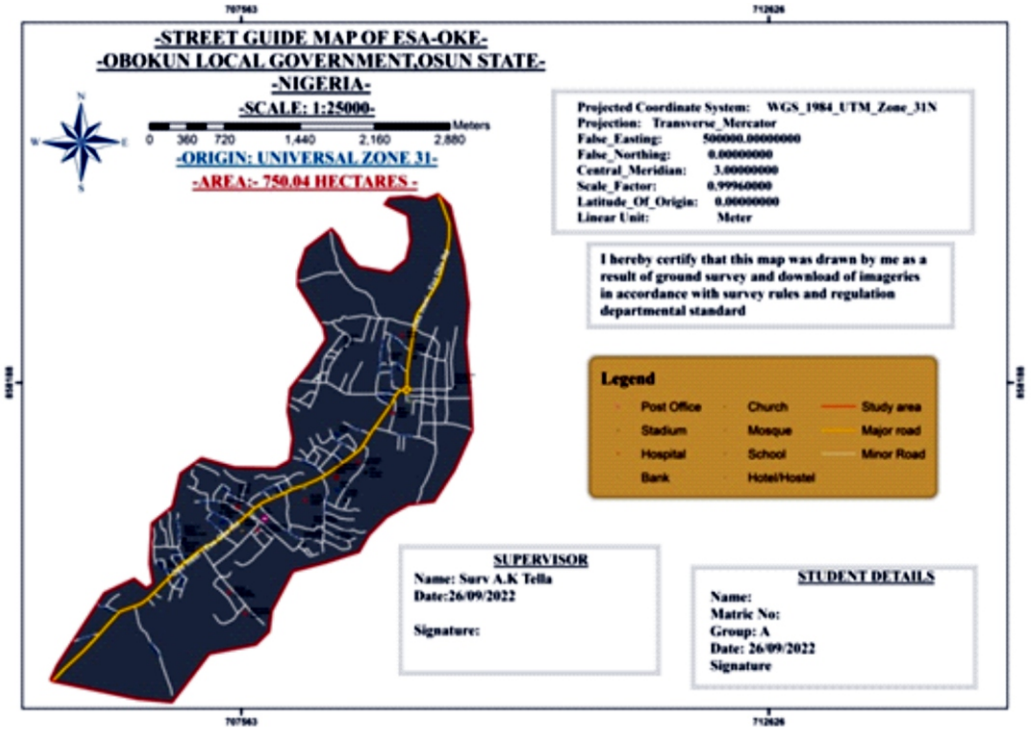


Fig 6: Street Guide Map *of the Study Area*

Street Guide Map

Based on the study area and the result produced, different road types were identified. The minor road accounted for 90% of the total roads while the major road accounted for 10% of the total road. The total distance of the road network in the study area is roughly 70,000m while the total number of roads is 109. The study area has only one roundabout where the town's major market is situated. The only transport link for people residing where there is no road is to go through the major road.

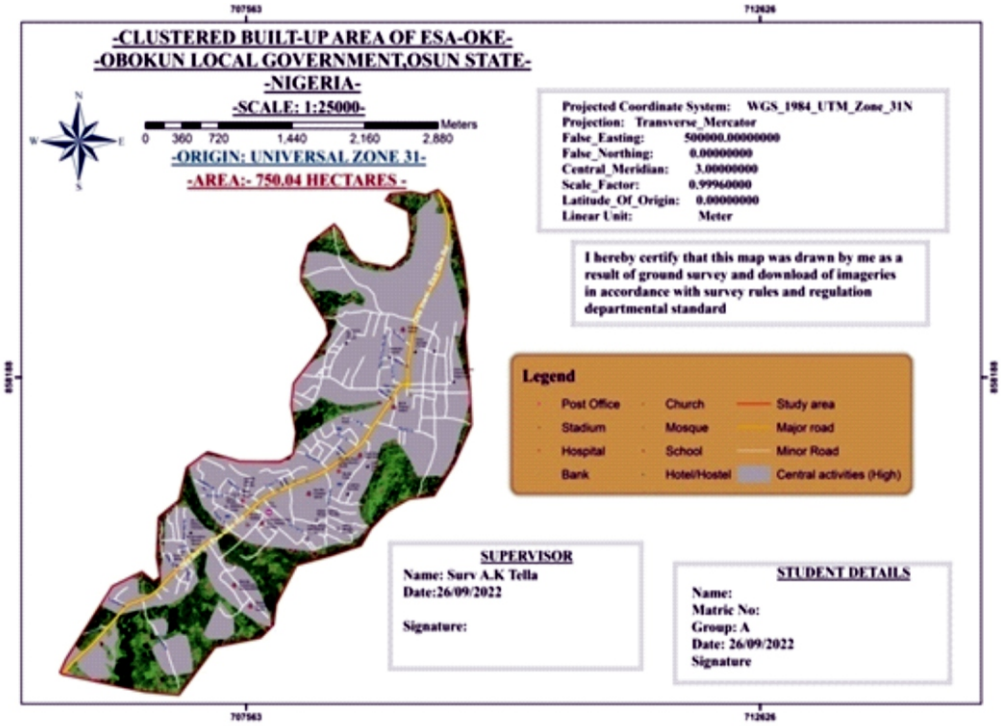


Fig.7 Clusterbuilt-up area of the study area

Analysis type: Query

Process: Query analysis using ArcGIS 10.2

Result: Displayed query analysis of minor roads greater than 500m. Fig 8

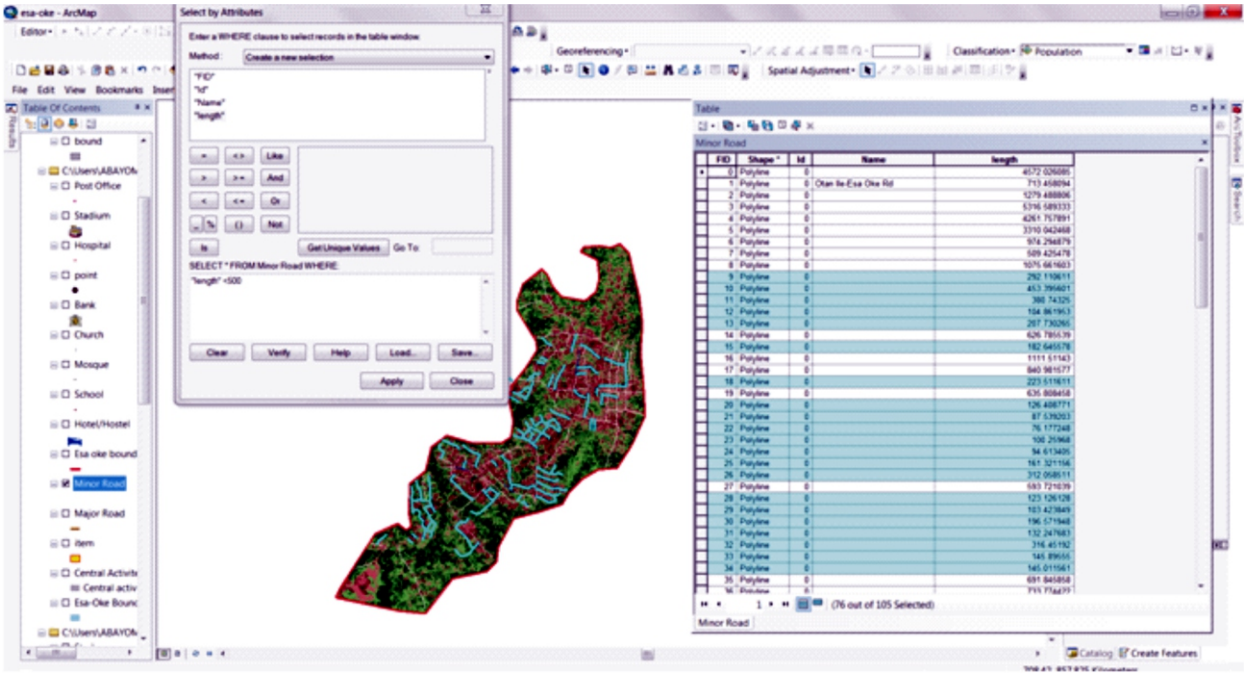


Fig 8: Query Analysis of the Study Area

Road Analysis

The analysis of the result shows that out of 105 minor roads in the study area only 76 of them are less than 500m in length.

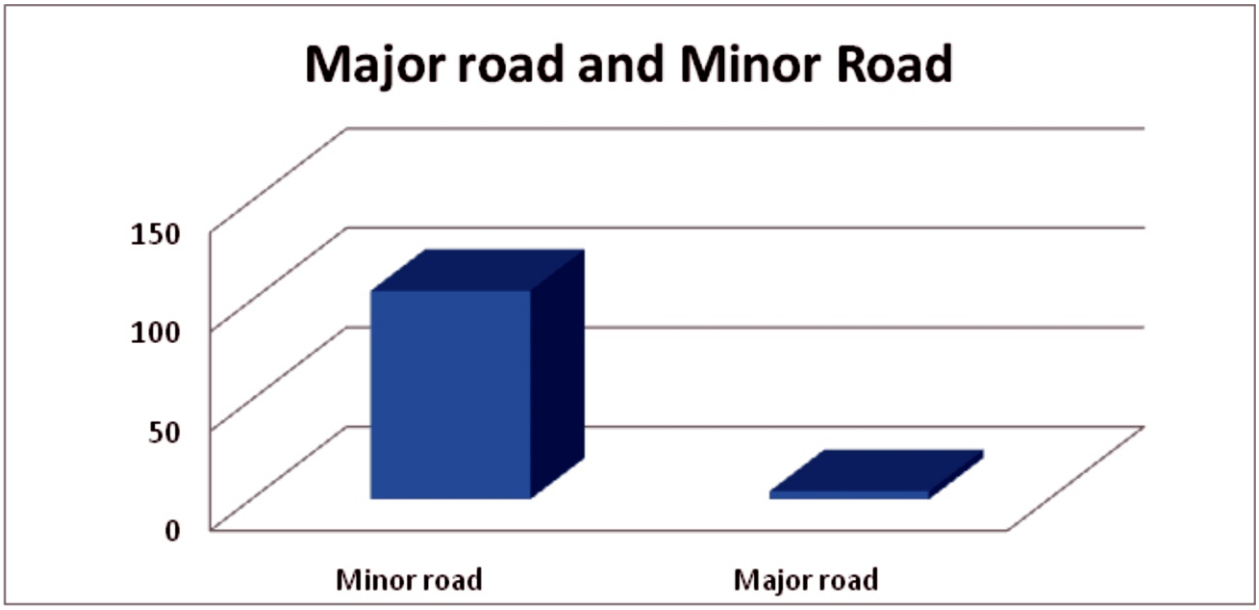


Fig 9: Road Analysis of the Study Area

The analysis of the result shows that there are 105 minor roads and 4 Major roads. The minor road is mostly concentrated in the economic area.

Conclusion

The survey operations carried out provides a framework for future developmental processes in the study area. Furthermore, for the ever-changing trends in technology and the need for spatial information in digital format is a basic necessity. The use of digital equipment and GIS application have become a veritable tool that must be used by all and sundry, high accuracy of spatial information systems must be provided for spatial decision-making. This will in turn aid physical and economic development, hence sustainability of the landscape of the area and the environment at large.

Many factors were identified as being responsible for a centralized population in the economic activities area. Some of these include the establishment of Osun State College of Technology, Bola Ige Mechatronics Institute, and Adonis College of Nursing.

Recommendation

Proper naming of the streets should be encouraged by erecting a signpost for proper identification, Social amenities such as good water, and electricity supply should be evenly distributed in the town to avoid congestion in a particular area. Government should create more bypasses and open up new roads.

References

Abiodun, J.O (2003). The Impact of the Railway on the Growth Pattern of the Nigeria Town. The Case Study of Osogbo. An Unpublished Conference Paper, Environmental Resource Management in Nigeria, Department of Geography, University of Ife, Ile-Ife, 9-14 July.

Adaramo, A.J, (2018). Urbanization and Transportation in Nigeria*:* Urbanization, Resources Exploitation, and Environmental Stability, Association of Nigeria Geographer book of proceedings of the 4th annual conference held in the department of Geography, University of Abuja, 15th – 19th October 2017, Kaduna Joyce publishers.

Adegboyga, S.A (2008). Urban Sprawl Measurement in Egbeda Local Government Area, Ibadan Nigeria, Unpublished MSc Thesis, Department of Geography, OAU, Ile-Ife.

Agular et al., (2017). *Using Remote Sensing and GIS to Detect and Monitor Land Use and*

LandCover Change in Dhaka Metropolitan of Bangladesh during 1960-2005. Environ Monitor Assess 150(1-4): 237 – 249.

Allen J, Luke (2013). *Modeling and prediction of future urban growth in the Charleston region of South Carolina:* a GIS base integrated approach. Conserv. Ecol 8(2)

Brooks et al., Chen Wang (2010). *Monitoring Urban Landscape Dynamics over Delhi (India)* Using Remote Sensing Inputs, 1998-2011, 2013.

Burgess, E.W. (1925): The Growth of the City: An Introduction to a Research Project in Park, R.E., Burgress, E.W and Mckenzie, R.D (Eds), The City, The Chicago University Press, Chicago, Il, pp 44-62.

Burrough A., & McDonnell (2008): *Principles of Geographical Information Systems.* Oxford University Press, Oxford.

Colby, C. C. (2003): *Centrifugal and Centripetal Forces in Urban Geography,* In Association of American Geographers, *Vol 23 No. 1, pp. 1-10.*

Gadal, S. (2009): *Remote Sensing Monitoring of Rural Urbanization in Jaipur Region In Proceeding of the 4th International Conference Rural Development 2009.The TransitionsTowards Sustainably.* Kaunas, Lithuania, pp 15-17.

Goetz A. (2013): Suburban Sprawl or Urban Centers: Tensions and Contradictions of Smart Growth Approaches in Denver, Colorado. Urban Stud 50(11):2178-2195.

Grimm, N. B. (2000): Integrate approaches to long-term studies of urban ecological systems. Bio-Science 50:571-584.

Herold, M., Goldstein, N. C., & Clarke, K. C. (2013): The Spatiotemporal Form of Urban Growth: Measurement, Analysis, and Modeling. Remote Sensing Environ 86:286-302.

Kumar, J. Garg, K., & Deepak (2008): *Monitoring and Modeling of Urban Sprawl using Remote Sensing and GIS Techniques. Int Journal on Appl Earth Obs Geo-information 10(2008): 26-43.*

Liu, X., Lathrop, R. G. (2002): *Urban Change Detection Based on An Artificial Neural Network. Int Journal on Remote Sensing 23(12).*

Mabogunje, A.L (2008). *Urbanization in Nigeria,* London University Press, London.

Marcal et al., (2015): Monitoring Land Cover Changes: A Comparison of Change Detection Techniques. *International Journal of Remote Sensing.* 199; 20:139-152.

Mesev, V. U. (2007): *Integration of GIS and Remote Sensing.* John Wiley & Sons, New York.

Sudhira H. S. *et al* (2003). *Urban Growth Analysis Using Spatial and Temporal Data. Journal of the Indian Society of Remote Sensing 31(4):299-311.*

Oladimeji, J. K. (2018): Climate Change and Rapid Urban Expansion in Africa Threaten Children's Lives. Unearth News.

Oyeniyi, A. D. (2000): *Application of GIS in Urban and Regional Planning,Journal of Nigerian Inst. Of Town Planners, Vol XIII, p. 45.*

Oyinloye, R. O. (2013): *Generation of Environmental Sensitivity Index (ESI) Map of Impacts of Urbanization in Ibadan, Nigeria, using Satellite Multi-Temporal Imageries.* Institution of Ecology and Environmental Studies, Obafemi Awolowo University (OAU) Ile-Ife, Nigeria.

Singh, A. K. (2021): *Modeling Land Use Land Cover Changes using Cellular Automata in a Geo-spatial environment.* International Institute of Geo-information Science and Earth Observation Enchede. The Netherlands.

Yuan F., Sawaya, K. E., Loeffelholz, B. & Bauer, M. E. (2015): Land Cover Classification and Change Analysis of the Twin Cities (Minnesota) Metropolitan Area by Multitemporal Landsat remote sensing. Remote Sensing. Envi 98:317-328.