

Geographic Information System (GIS) for Physical Development Planning and the Trends of Application in Enugu State, Nigeria

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Abstract: This study explored the application of Geographic Information Systems (GIS) in physical development planning across Departments in the Ministry of Lands and selected agencies in Enugu State. These include the Lands (Estate), Survey, Town Planning, Enugu Capital Territory Development Authority (ECTDA), and Enugu Geographic Information System (ENGIS). The aim of this study examines the knowledge and application of GIS by the physical development planning professionals within the Ministry of Lands and GIS agencies in Enugu State. The objectives through which the aim is actualized are to: examine the current state of GIS adoption and utilization in physical development planning within the Ministry of Land, Survey and Urban Development, Enugu Capital Territory Development, and Enugu State Geographic Information System; identify the benefits and challenges of GIS implementation in physical development planning across the selected agencies in Enugu State; assess the impact of GIS on decision-making, monitoring, and development control processes in the agencies; explore trends, potential applications and future directions for expanding GIS use in physical development planning in Enugu State; develop strategic recommendations for improving the adoption, capacity building, and institutional integration of GIS in physical development planning among the agencies. Primary and secondary data sources were utilized in the study. Two hypotheses were formulated and tested using statistical quantitative techniques known as Chi-square Test of Independence and Fisher's Exact Test. The findings revealed that GIS adoption is uneven, with ENGIS and the Survey Department showing strong integration, while Lands (Estate) and Town Planning face significant challenges such as inadequate equipment, limited training, high software costs, poor internet and electricity, and insufficient funding. Despite these constraints, the usefulness of GIS and establishment of ENGIS is acknowledged though with some complications. The study concludes with recommendations for repositioning ENGIS to promote better services, sustainable and effective physical development planning.

Keywords: GIS, EMIS, ENGIS, Physical Development, and Planning.

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I. INTRODUCTION

Geographic Information Systems (GIS) in planners' perceptive means a powerful tool that helps urban and regional planners make informed decisions by collecting, storing, analyzing, and visualizing geographical data. In other words, GIS is an enriched modern technology that captures, stores, analyzes and visualizes spatial data which is indispensable in the urban and regional planning toolkit. This was initially used for plotting "hard" data, while the current application of GIS in planning has extended even into citizen engagement and consultation. Hence, this paper explores the dynamic role of GIS in planning, its far-reaching benefits, and a variety of spheres where spatial data aids planners to

perform better even to the extent of creating smarter, more sustainable, and inclusive towns and cities.

The reason for GIS being so useful is that physical development planning is all about spaces, and GIS combines geographical features with a wealth of information about these places to present patterns, relationships, and trends. Thus, GIS enables planners to extensively understand the needs of human settlements. Therefore, the technology goes beyond stacking maps to serving as a dynamic decision-making tool for town planners. It is utilized as follows:

➤ *Land Use:*

GIS is used to map out land use and create land suitability maps for developments;

➤ *Spatial Analysis:*

GIS tools are used to analyze geographic patterns, relationships, and processes. In short, planners use statistical techniques to identify trends, hotspots, and disparities;

➤ *Infrastructure Planning:*

GIS is used in infrastructure planning, such as creating buffers around institutions or schools in identifying suitable zones like playgrounds;

➤ *Traffic/Transportation Analysis:*

GIS is also used to analyze traffic patterns, identify areas prone to congestion, and plan routes for public transportation;

➤ *Data Integration Planning:*

GIS is used to integrate various data layers, such as land use, transportation networks, population demographics, and environmental factors and planning activities;

➤ *Resource Inventory Management:*

GIS is very useful in resource inventory planning and management;

➤ *Long-Term Maintenance:*

GIS data is used to track assets and evaluate developmental needs to improve the long-term maintenance of urban regions.

II. RELATED LITERATURE AND TREND OF GIS APPLICATIONS IN ENUGU STATE

GIS refers to a technological tool used to capture, store, manipulate, analyze, manage, and present spatial or geographical data (ESRI, 2020). Over the years, GIS has become an essential instrument in urban planning, allowing planners and other professionals involved in physical development planning and political leaders to make informed decisions based on geographical and spatial data. It integrates various data sources, such as satellite imagery, demographic data, land use data, and infrastructure records, into a cohesive system that can be visualized and analyzed (Longley et al., 2015; 2019). Urban planning involves a variety of activities, such as land use zoning, transportation planning, infrastructure management, and environmental conservation, all aimed at creating cities that are functional, equitable, and sustainable.

In recent years, especially between 2023 and 2025, GIS has gained renewed attention as urban areas across Nigeria face increased pressure from rapid population growth, informal settlements, and environmental challenges. According to the World Bank (2024), cities in sub-Saharan Africa, including Nigeria, must integrate GIS into their planning frameworks to address these issues effectively. In response, state governments such as Enugu have begun exploring the digitization of land records and the application

of GIS in developing and maintaining a geospatial information system or such appropriate system ad structures I the state for research, land management and development planning (Enugu State of Nigeria, 2024).

As cities continue to grow, urban planners face numerous challenges, including land scarcity, overcrowding, environmental degradation, and inadequate infrastructure. These challenges necessitate the use of advanced technologies such as GIS to enhance planning processes and develop effective and sustainable solutions. In other words, optimizing land use allocation, infrastructure planning, and environmental impact assessment in urban environments is crucial, underscoring the need to shift towards integrating technologies like urban data analytics and GIS (Yusuf and Abdulquadri, 2024).

The trends of GIS application in Enugu State public offices date back to the 1998 activities of UN- Habitat Sustainable Cities Project in Sustainable Enugu Project. In this project, state-of- the-art GIS equipment were provided and applied in Environmental Management Information System (EMIS). According to UN- Habitat /UNEP (2000) there is a clear distinction between GIS and EMIS. While GIS is one of the tools used for applying an EMIS; the EMIS is an information system for managing information on the urban environment according to Environmental Planning and Management (EPM) process. The EMIS was designed to provide information which is directly usable by the participants in an urban management process. It is generated through stakeholders' participatory working group. Thus, what makes EMIS special is its participatory approach. The information is not comprehensive or overly technical, but highly focused, concentrating on what is relevant for the decision-making process. This was domiciled in the Ministry of Lands and Urban Development for building of capacity of existing structure and relies solely on stakeholder participation.

The Sustainable Cities Programme (SCP) itself is a global programme of the United Nations Centre for Human Settlements (UN-Habitat) and the United Nations Environment Programme (UNEP). It is the leading technical cooperation programme in the field of urban environmental planning and management and is the principal activity of the United Nations system for operationalising sustainable urban development and thereby contributing to implementation of the globally-agreed Agenda 21 and Habitat Agenda.

At the close of SEP, the EMIS ceased to operate. There were later efforts to digitize all plans and maps in the State. Those equally could not achieve the desired results. More recently, the State Government established Enugu State Geographic Information System (ENGIS) with staff selected within and outside the ministry. With this establishment outside the Ministry of Lands and Urban Development, and all plans shifted to ENGIS for digitization, and all other professionals in the Ministry especially town planners and estate surveyors/valuers appear to have been sidelined or kept redundant.

III. ENUGU STATE – THE STUDY AREA

Enugu State is in the South East Geo-political Zone of Nigeria. It is located at 6° 30' North of Equator, and 7° 30' East of Longitude. It is plus one hour (+1hr) GMT on the World Time Zone. It shares border with the following states: Abia and Imo to the south; Ebonyi to the east, Benue to the north-east, Kogi to the north-west and Anambra State to the west.

Enugu State has Enugu City, the Coal City, as the capital of the State. The State has three geopolitical zones of Enugu East, Enugu North and Enugu West with their respective identity local government area/town as Nkanu & Isi-Uzo; Nsukka; Awgu & Ezeagu and 17 Local Government Areas. The State is cosmopolitan given its former status as the capital of Eastern Nigeria. It has an estimated land area of about 72.8 Sq. Kilometers. The population figure for Enugu urban alone in 2006 stood at 722,664 (NPC, 2006).

At the capital city, it has the Capital Territory Development Authority (CTDA), the newly established Enugu State Geographic Information System (ENGIS), and the Town Planning Headquarters (TPH) – which performs the roles of the State Planning Board because the domestication of Nigeria Planning Law of 1992 is still pending; while in the Local Governments are the Town Planning Authorities (TPAs). The TPH and TPAs are under the Ministry of Lands and Urban Development. On the other arms, there is Ministry of Housing, and the Enugu State Housing Development Corporation. These are basically in charge of development control in the State.

IV. METHODOLOGY

Data analyses method adopted in this research were quantitative and qualitative techniques. Through this approach, the questionnaire generated representative samples data that generalized the population. The questionnaire involved Likert scale coupled with oral face to face interview. The important personalities interviewed include the National President of Nigeria Institute of Town Planners (NITP) who is also a former Enugu State Director of Town Planning, the Surveyor General, some Management staff of Lands /Valuation Department, Current Director of Town Planning/Staff, Town Planners in ECTDA, Manager and some Staff of EGIS. Others were Lawyers and Town Planners in private practice. Another important source of information is the Lead Author's involvement and positions in Planning /development in Enugu State as former SCP/SEP's GIS/EMIS Officer, Director of Town Planning, and Environmental and Social Safeguard Specialist and Consultant.

➤ *Sample Size and Sampling Technique*

A purposive sampling technique was employed to select key informants with the knowledge and experience necessary to provide detailed information about GIS applications within the Ministry and its associated agencies. These respondents included relevant technical staff from the following departments and agencies:

- Town Planning Department – 9 staff members
- Survey Department – 18 staff members
- Lands (Estate) Department – 11 staff members
- Enugu Geographical Information System (ENGIS) – 5 staff members
- Enugu Capital Territory Development Authority (ECTDA) – 7 staff members

This selection brought the total sample size to 50 respondents, which was considered adequate to provide rich and relevant data for the study which 40 was actual number filled and applied in the analyses. Purposive sampling was chosen because the research focused on professionals with specific expertise and experience in GIS applications, thereby ensuring that the collected data would be both reliable and directly relevant to the study objectives.

In this research, the following statistical techniques were employed:

- Chi-square Test was used to evaluate the significance of GIS adoption, decision-making effectiveness, and planning efficiency across the ministry and agencies.
- Fisher's Exact Test was applied where small sample sizes within subgroups made Chi-square assumptions invalid.

Using these two complementary statistical tests strengthened the robustness of the quantitative analysis and ensured that conclusions drawn from the data were statistically sound.

In line with the objectives of this study, two hypotheses were formulated and tested in this section. The tests were conducted using appropriate statistical tools based on the nature of the variables involved. Fisher's Test of Independence was applied to categorical data where expected cell counts were small, while the Chi-square Test of Independence was used for categorical data with adequate sample size. Both tests were carried out at a 5% level of significance.

V. RESEARCH FINDINGS

In this section, The trend of GIS in Application in Enugu State were highlighted; the usage of the GIS, availability of GIS equipment, availability of trained staff, and familiarity of staff with GIS equipment were collated, analyzed and hypothetically tested upon which the results of the findings were based.

➤ *The Trends of GIS Application in Enugu State*

The Sustainable Cities Programme of UN-Habitat was established in Enugu State as Sustainable Enugu Project (SEP) in 1978. SEP was one of the three demonstration projects in Nigeria which started with Sustainable Ibadan Project (SIP) followed by SEP and Sustainable Kano Project (SKP). The project attracted some State-of-the-Art EMIS/GIS equipment which included HP AO Design Jet, Digitizer/Tablet and GPS. A Town Planner in the person of this led-author manned the equipment as the EMIS/GIS

Officer. The installation came with training of the staff and stakeholders from ministries, agencies, private and public institutions like University of Nigeria, Enugu Campus and Enugu State University of Science and Technology (ESUT).

The training and installation was conducted by Mr. Bern Decker from U-Habitat Office Nairobi, Kenya as shown in the picture take during the training in figure 1.



Fig 1 Installation and Use of GIS at Sustainable Enugu Project, Town Planning Department, Ministry of Lands and Urban Development Enugu, Enugu State, Nigeria

Subsequently, the Enugu GIS Officer alongside with those of Kano and Ibadan were sent to Nairobi in 2001. The mission was to attend:

- International Conference on Spatial Information for Sustainable Development;
- Training Course on Environmental Management Information System (EMIS/GIS);
- International Expert Meeting on E-Governance.

At the end of the Project, the equipment remained with the Ministry of Land and Urban Development. Years past with different efforts to digitize maps and plans in the State without yielding reasonable results. The most recent is the establishment of Enugu State Geographic Information System (ENGIS). However, instead of serving as an EMIS agency for servicing other existing development planning structure it emerged as a parastatal in the office of the Governor with special powers and numerous functions (E.S.N., 2024 Section 4(1) a-j; 5(1) a-k). These include the following: The responsibility for administration and management of land matters in the State including all issues

relating to title, registration, searches, and such other responsibilities as may be determined by the Governor; and receive, conduct, due diligence on, and verify applications for issuance of Rights of Occupancy for land or the grant of other rights over land or subsequent transactions in lands within the State.

➤ *ENGIS and the Other Existing Structures, Laws and Orders*

Enugu State Designation of Land in Urban Area Order, 2025 clarifies that “Appropriate Authority” in compliance with Section 3 of the Land Use Act of 1978 refers to Enugu State Geographic Information System Services (ENGIS), Departments of Lands, Survey, and Town Planning, and includes offices, parastatals, and agencies vested with the responsibility of land administration in the State. Unfortunately, these State’s new Land Use Regulations and Orders recognize and align with the outdated 1946 Colonial based Town & Country Law and not the Urban & Regional Planning Law of 1992 being domesticated by progressive states like Enugu. This is a case of new wine in an ‘old wine skin’. How then can ENGIS deliver the much needed

geospatial information without interfering with the fundamental duties of the professional like Town Planners, Surveyors (Land ad Estate), Engineers and others in the existing structures?

➤ *GIS Usage in the Departments*

The study at this stage sought to determine the extent to which Geographic Information Systems (GIS) are applied across the selected departments. Respondents were asked to

indicate the specific activities in which GIS are utilized within their respective departments. The responses reveal a range of applications, from land use planning and site analysis to infrastructure management, map production, and beacon location. This information helps to illustrate the functional relevance of GIS to departmental operations and the diversity of its application in physical development planning. Table 2 presents the summary of GIS usage by department based on the data collected.

Table 2 GIS Usage in Departments

Response	Lands	Survey	Town Planning	ENGIS	ECTDA	Total
Yes	2(28%)	12 (75%)	2 (25%)	5 (100%)	2 (50%)	23 (57.5%)
No	5 (72%)	4 (25%)	6 (75%)	0 (0%)	2 (50%)	17 (42.5%)
Total	7 (17.5%)	16 (40%)	8 (20%)	5 (12.5%)	4 (10%)	40 (100%)

Source: Field Survey, 2025

From the results, GIS usage varies significantly across departments however, in overall expression, 57.5% admitted the use of GIS, while 42.5% were on the negative. ENGIS reported the highest level of usage, with 100% of respondents confirming application of GIS in their operations. The Survey Department follows with 75% usage, while ECTDA shows a balanced split at 50%. The Ministry of Lands and the Town Planning Department report relatively lower adoption rates at 28% and 25% respectively, indicating potential areas where GIS integration could be improved.

➤ *Availability of GIS Equipment*

In order to assess the infrastructural capacity for effective Geographic Information Systems (GIS) operations, respondents were asked whether GIS equipment was available in their departments. This question aimed to determine the extent to which technical tools and resources necessary for GIS implementation are accessible to staff. The responses provide insight into existing departmental capabilities and potential resource gaps that may affect GIS adoption and usage. Table 3 presents the summary of findings on the availability of GIS equipment across the surveyed departments.

Table 3 Availability of GIS Equipment

Equipment	Lands	Survey	Town Planning	ENGIS	ECTDA
GPS Devices	AV	AV	NA	AV	AV
Satellite Images	NA	AV	NA	AV	NA
Compass	NA	AV	NA	AV	NA
Drone	NA	AV	NA	AV	NA
High-Capacity Laptops	NA	AV	NA	AV	NA
Plotter	NA	AV	NA	NA	NA
Scanners	NA	AV	NA	AV	NA

Key: AV = Available, NA = Not Available

Source: Researcher’s Field Survey, 2025

The data indicates that the Survey Department possesses the widest range of GIS equipment, including GPS devices, satellite images, compasses, drones, high-capacity laptops, a plotter, and scanners. ENGIS also has significant resources, with all listed equipment except the plotter. In contrast, the Ministry of Lands and ECTDA have only GPS

devices, while the Town Planning Department lacks all the listed equipment. This variation suggests that while some departments are well-equipped for GIS operations, others face notable infrastructural limitations that may hinder effective GIS implementation.

Table 4 Availability of Trained Staff in the Selected Departments

Department	Yes	No	Yes%	No%	Total
Lands	2	5	29	71	100
Survey	2	14	13	87	100
Town Planning	3	5	38	62	100
ENGIS	4	1	80	20	100
ECTDA	1	3	20	80	100
Total	12	28	30	70	100

Source: Researcher’s Field Survey, 2025

- Test Used: Fisher’s Test of Independence
- ✓ p-value = 0.0652
- ✓ df = 4
- ✓ $\chi^2 = 8.84116$
- ✓ Cramer’s V = 0.47014
- Decision: Since $p = 0.0652 > 0.05$, we fail to reject the null hypothesis.

- Conclusion: There is no statistically significant difference in the availability of trained staff across the departments at the 5% significance level.

➤ *Hypothesis Two*

- H₀: There is no significant difference in the level of familiarity with GIS among staff across the selected departments.
- H₁: There is a significant difference in the level of familiarity with GIS among staff across the selected departments.

Table 5 Level of Familiarity with GIS Among Staff

Response Category	Frequency	Percentage (%)
Very Familiar	18	45.0
Somewhat Familiar	14	35.0
Familiar	7	17.5
Unfamiliar	1	2.5
Very Unfamiliar	0	0.0
Total	40	100.0

Source: Researcher’s Field Survey, 2025

- Test Used: Chi-square Test of Independence
- ✓ p-value = 0.000
- ✓ df = 4
- Decision: Since $p = 0.000 < 0.05$, we reject the null hypothesis.
- Conclusion: There is a statistically significant difference in the level of familiarity with GIS among staff across the departments, with overall results indicating a high level of awareness.

➤ *Recommendations*

- Domestication of Nigeria Urban & Regional Planning Law, 1992 is long overdue. When this is properly done, ENGIS is expected to channel its services by keying into the existing planning structure in the State.
- Create good working relationship between professionals in ENGIS and their counterparts in the ministries, CTDA, parastatals, other agencies and private sector.
- Update GIS application competence of all relevant professionals in Enugu State through organized trainings, workshops and seminars.
- ENGIS should operate full participatory EMIS-like-services and organize standard regular paid training programmes possibly in partnership with higher institutions of learning in Enugu State.
- The Government should be cautious not to allow unnecessary duplication of functions that could lead to usurping the services of other officers especially in the area of development control in the State.

In summary, the analyzed data collected from five departments and agencies involved in land administration and planning in Enugu State findings show that while there is increasing awareness and adoption of GIS across departments, its usage remains uneven. Departments and agencies like ENGIS and Survey exhibit strong GIS integration and availability of equipment; while others like Lands and Town Planning face constraints, including lack of trained personnel, limited access to equipment, and insufficient training opportunities.

VI. CONCLUSION AND RECOMMENDATION

It has been established that GIS is an essential tool for physical development planning; while setting up ENGIS is a commendable action for planning. However, the law was too ambitious in the level of functions and powers granted ENGIS with its foundation hinged on outdated 1946 Planning Law. Therefore, for ENGIS to meet the desired target goal, a number of corrective measures have been recommended.

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