

Geographic Information Systems (GIS) As an Effective Tool for Construction Management in Enugu-East, Nigeria ^{1, 2}

**Ndubuisi Ambrose Ositadinma,
Dr. Henry C. Ajaelu, Ezeali Ukie Oluchukwu**

Department of Quantity Surveying (Project Management),
ESUT Business School, Enugu State, Nigeria

Abstract

Geographic Information Systems (GIS) have revolutionized infrastructure project planning and construction management in advanced economies. In Nigeria, especially at the subnational level, GIS adoption remains fragmented and underdeveloped. This study evaluates the potential and current application of GIS in construction management in Enugu-East Local Government Area (LGA) of Enugu State. It investigates awareness levels, adoption barriers, and the system's effectiveness in improving planning, monitoring, and execution processes. Using a descriptive survey design, the study engaged 30 professionals including engineers, project consultants, government officials, and GIS personnel through structured questionnaires and interviews. Quantitative data were analyzed using SPSS, with chi-square tests assessing the significance of relationships between GIS usage and project performance. The results showed that while 66.7% of respondents were aware of GIS, only 20% reported full adoption within their organizations. However, 73.3% perceived GIS as effective in enhancing construction efficiency, especially in planning and monitoring. Key barriers to adoption included high software costs, insufficient training, institutional resistance, and poor digital infrastructure. Despite these challenges, hypothesis testing confirmed statistically significant relationships between GIS adoption and improved project outcomes, as well as between awareness levels and enabling factors like training and policy support. This paper concludes that while GIS holds transformative potential for construction management in Enugu-East, systemic and institutional reforms are required to realize its benefits. The study recommends government-backed capacity-building programs, public-

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private partnerships, mandatory GIS usage in state-funded projects, and expanded ENGIS integration. The findings provide a roadmap for policymakers, construction managers, and urban planners seeking to modernize construction workflows in similar contexts across sub-Saharan Africa.

1.0 Introduction

The rapid expansion of urban centers across Nigeria has placed significant pressure on construction management systems to deliver timely, efficient, and cost-effective infrastructure. In this evolving context, the adoption of digital technologies has become a global best practice in improving planning accuracy, project oversight, and stakeholder coordination. Among these innovations, Geographic Information Systems (GIS) have emerged as an essential tool for managing spatial data, optimizing workflows, and integrating project information across the entire construction lifecycle (Irizarry & Karan, 2012; Yuan et al., 2018).

Globally, GIS is utilized in advanced economies to enhance decision-making by enabling stakeholders to visualize terrain conditions, track project schedules in real-time, assess environmental constraints, and manage logistics with spatial precision (Dong et al., 2025). These capabilities are particularly useful in urban construction, where land use, infrastructure overlap, and zoning requirements often create complex planning environments. In countries like the United States, Germany, and China, GIS is already integrated with Building Information Modeling (BIM), forming advanced platforms like City Information Modeling (CIM) that streamline project execution and reduce resource waste (Liu et al., 2025).

In contrast, Nigeria's construction sector though increasingly modernized in urban hubs like Abuja and Lagos continues to lag behind in GIS adoption, particularly at local government levels. Several studies have shown that adoption remains low due to infrastructural, institutional, and financial constraints (Olaleye et al., 2020; Adesanya & Akinyemi, 2021). This underutilization is especially evident in Enugu-East Local Government Area (LGA), a rapidly urbanizing region grappling with infrastructure deficits, poor planning coordination, and project inefficiencies.

Enugu-East has witnessed an upsurge in public and private construction projects in areas such as Abakpa, Trans Ekulu, and Emene. Yet many of these developments suffer from cost overruns, delays, and poor environmental compliance often resulting from limited site analysis, inadequate logistics planning, and fragmented decision-making. These issues are compounded by the near-absence of GIS in construction workflows, leaving planners and contractors to rely on outdated manual methods (Okonkwo & Agu, 2017).

The Enugu Geographic Information System (ENGIS), while a promising state-level platform, remains underutilized in construction management. Reports indicate that many local professionals lack the training to use GIS tools, and institutional silos prevent integration of spatial data across departments (Ebinne & Nkwunonwo, 2022). Nevertheless, stakeholders recognize the potential of GIS to transform construction practices by enabling real-time monitoring, facilitating risk assessments, and improving stakeholder collaboration.

This study seeks to examine the effectiveness of GIS as a tool for construction management in Enugu-East, analyzing the extent of its current usage, the challenges faced, and the perceived benefits among key professionals. It draws on the Technology Acceptance Model, Systems Theory, and Diffusion of Innovations Theory to frame its analysis. The research also tests hypotheses on the relationship between GIS usage and project performance, as well as the impact of institutional and technological factors on GIS adoption.

By offering empirical evidence from a subnational Nigerian context, the study contributes to the broader discourse on digital transformation in construction and proposes actionable strategies to bridge the gap between GIS awareness and practical implementation.

2.0 Literature Review

2.1 Conceptual Overview of GIS in Construction Management

Geographic Information Systems (GIS) have become a transformative tool in construction and urban infrastructure management, allowing professionals to collect, analyze, and visualize spatial data for informed decision-making. GIS supports various project stages, from pre-construction planning to execution and post-project evaluation, enabling better resource allocation, site analysis, and progress tracking (Irizarry & Karan, 2012; Yuan et al., 2018).

In the global north, GIS has evolved from a mapping tool to an integrated platform that works in tandem with technologies like Building Information Modeling (BIM), creating hybrid systems such as City Information Modeling (CIM) (Dong et al., 2025). These systems enable construction managers to simulate scenarios, identify risks, and streamline inter-agency coordination. Liu et al. (2025) demonstrated that CIM enhances zoning strategies and optimizes land use, environmental compliance, and infrastructure alignment in smart cities.

2.2 Theoretical Frameworks

Three interrelated theories ground the study of GIS adoption in Enugu-East:

Systems Theory views construction projects as interconnected systems where each function (planning, logistics, monitoring) must operate cohesively (Skyttner, 2005). GIS functions as a central system hub, enabling real-time data sharing between engineers, regulators, and contractors.

Technology Acceptance Model (TAM) (Davis, 1989) highlights how perceived usefulness and ease of use determine stakeholders' willingness to adopt GIS tools. If stakeholders find GIS valuable and user-friendly, adoption rates improve especially when training and institutional incentives are present (Bohari & Fuad, 2025).

Diffusion of Innovations Theory (Rogers, 2003) explains how GIS spreads across professional communities. In Enugu-East, GIS diffusion is hampered by infrastructural barriers and weak inter-agency collaboration, slowing the movement from early adopters to widespread institutionalization.

These frameworks provide insight into why GIS remains underutilized despite its known advantages.

2.3 Empirical Evidence of GIS Applications

Numerous studies confirm the potential of GIS in construction management. In Abuja, Akingbade (2012) showed that the Abuja Geographic Information System (AGIS) improved transparency in land allocation and supported construction planning. Mahmoud et al. (2016) used GIS for modeling urban growth and demonstrated its usefulness in infrastructure forecasting.

In Kano, Otuoze et al. (2020) applied GIS with Cellular Automata-Markov models to predict future road development needs, proving GIS as a powerful foresight tool. A systematic review by Akindede et al. (2025) concluded that GIS improves visualization, coordination, and sustainability in African construction but faces challenges like poor policy support, cost, and limited awareness.

In Enugu State, the Enugu Geographic Information System (ENGIS) offers a platform for spatial data integration, though its use in active construction projects remains minimal (Ebinne & Nkwunonwo, 2022). Asiyanbola (2018) found low awareness among government officials and poor inter-agency collaboration, weakening ENGIS's potential impact.

2.4 GIS Awareness and Adoption in Nigeria

Awareness of GIS in Nigeria varies across regions and professions. Olaleye et al. (2020) found that urban planners and surveyors are relatively familiar with GIS, but contractors and engineers often lack practical training. Adesanya & Akinyemi (2021) argued that without structured institutional support, GIS adoption remains theoretical rather than practical.

Enugu-East reflects this national trend. Although ENGIS is active, few local construction stakeholders use its data in workflows. Barriers include expensive software licenses, low digital infrastructure, and lack of stakeholder engagement platforms. These conditions align with the “late majority” and “laggard” stages of Rogers’ adoption curve.

2.5 Effectiveness of GIS in Construction Phases

Planning: GIS enhances site selection, land use compatibility, and terrain analysis. Yuan et al. (2018) showed that integrated spatial analysis leads to better early-stage decisions and prevents project delays due to site constraints.

Monitoring: GIS dashboards support dynamic tracking of material movement, labor deployment, and environmental compliance. Dong et al. (2025) proposed a CIM model combining GIS and BIM to improve construction site monitoring. Adesanya & Akinyemi (2021) noted that most Nigerian sites rely on reactive monitoring due to weak data infrastructure.

Execution: GIS improves logistics, coordinates subcontractor movements, and supports conflict resolution in congested urban sites. In Abuja, Mahmoud et al. (2016) used GIS for optimal road expansion planning and land allocation, reducing congestion and improving efficiency.

Despite these benefits, GIS tools are often used only for preliminary land assessments in Enugu-East. There is minimal lifecycle integration, due to fragmented digital governance and lack of policy mandates (Ebinne & Nkwunonwo, 2022).

2.6 Research Gap

While GIS is globally recognized as a key construction tool, localized studies on its practical use in Nigerian LGAs like Enugu-East remain rare. Most Nigerian literature focuses on land

administration (AGIS, ENGIS), with little investigation into how GIS affects construction project delivery from start to finish.

This study fills that gap by evaluating GIS effectiveness across project phases in Enugu-East and testing statistically how adoption is shaped by training, infrastructure, and institutional policy.

3.0 Methodology

This study adopted a descriptive survey research design to assess the awareness, adoption, and effectiveness of Geographic Information Systems (GIS) in construction management within Enugu-East Local Government Area (LGA) of Enugu State, Nigeria. The design is suitable for capturing the real-world perceptions, behaviors, and institutional dynamics surrounding GIS usage among construction stakeholders in a natural setting, without experimental manipulation.

3.1 Area of Study

Enugu-East LGA was chosen due to its rapid urbanization and ongoing infrastructure development. Key urban hubs such as Trans Ekulu, Abakpa Nike, and Emene experience active construction, yet face challenges including congestion, poor land-use planning, and inefficiencies in project execution. These challenges make the area an ideal case for evaluating GIS's potential impact.

3.2 Population and Sampling

The target population for this study comprised professionals actively engaged in construction management and spatial planning within Enugu-East LGA. To ensure the collection of informed and relevant data, a purposive sampling technique was employed. A total of 30 participants were selected based on their roles, expertise, and involvement in construction-related activities. These included civil engineers, contractors, government officials from the planning and works departments, project consultants, and personnel from the Enugu Geographic Information System (ENGIS). Specifically, the sample included 10 civil engineers/contractors, 8 government officials, 7 project consultants, and 5 GIS professionals. This composition was deliberately structured to capture a balanced perspective from both public and private sector stakeholders, as well as individuals directly involved in GIS operations. The purposive sampling approach was appropriate for this study because it focused on participants with the practical experience and technical knowledge necessary to provide accurate insights into the awareness, adoption, and application of GIS in construction workflows.

3.3 Data Collection

Primary data were collected through structured questionnaires, semi-structured interviews, and field observations. The questionnaires focused on GIS awareness, adoption, and perceived effectiveness. Interviews probed deeper into barriers and institutional dynamics. Observations were made at selected project sites to identify whether GIS tools were integrated into planning or execution.

Secondary data were drawn from ENGIS reports, policy documents, and academic literature on GIS in infrastructure.

3.4 Data Analysis

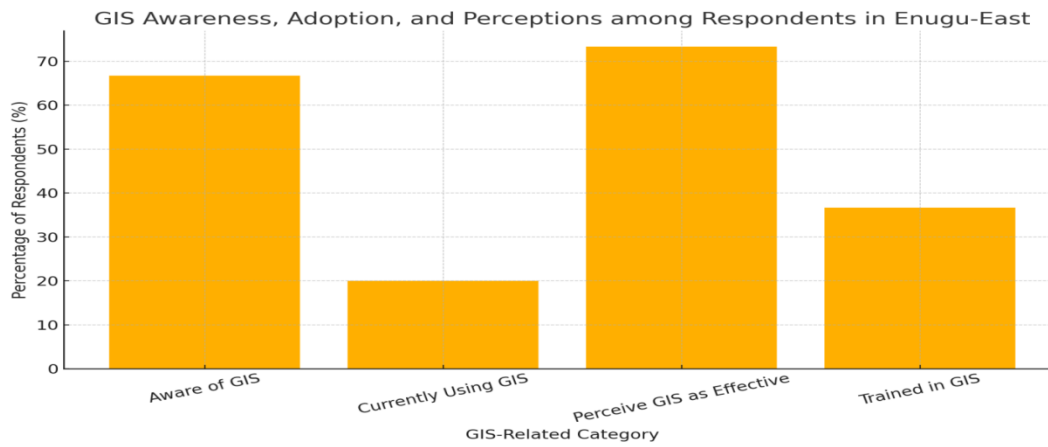
Quantitative data were analyzed using SPSS, employing descriptive statistics (frequencies, percentages) and inferential tools like Chi-Square tests to evaluate relationships between GIS adoption and project outcomes. Qualitative data from interviews and field notes were analyzed using thematic content analysis to complement and interpret statistical trends.

4.0 Results and Discussion

The findings of this study highlight a complex relationship between awareness, adoption, perceived effectiveness, and institutional readiness for the use of GIS in construction management in Enugu-East Local Government Area.

4.1 Awareness and Perception of GIS

Survey data, as presented in Figure 1, shows that 66.7% of respondents were aware of GIS applications in construction and planning. This indicates moderate exposure, particularly among government officials and project consultants. Interestingly, 73.3% of all respondents believed GIS is effective in enhancing project planning, real-time monitoring, and execution. This perception underscores strong latent support for GIS implementation, suggesting that many stakeholders understand its potential benefits even if they do not currently use the technology.



4.2 Low Adoption and Training Gaps

Despite favorable perceptions, actual adoption rates remain low: only **20%** of respondents reported actively using GIS in their construction workflows. The primary users were GIS professionals and a few consultants who had participated in donor-funded pilot projects. A significant barrier identified was the **lack of formal training**, with only **36.7%** of participants reporting any kind of GIS-specific education or practical exposure. This skills gap contributes to resistance and underutilization across public agencies and private firms.

Interview responses also revealed a disconnect between awareness and implementation. Several contractors acknowledged hearing about GIS but lacked access to software, hardware, or institutional support. Planning officers in Enugu-East reported that while ENGIS provides spatial data, integration with construction project workflows is minimal due to siloed operations and low interdepartmental communication.

4.3 Institutional and Technological Barriers

Thematic analysis from interviews and policy review showed that high software costs, absence of GIS mandates in procurement, and insufficient digital infrastructure were the key institutional challenges. Respondents noted that GIS is often seen as an auxiliary tool, not a core component of the construction lifecycle. Moreover, policy documents guiding public works in Enugu do not require spatial analysis or GIS integration, weakening enforcement and budget prioritization.

The findings are consistent with the Technology Acceptance Model (TAM), where ease of use and institutional support significantly affect adoption. The Diffusion of Innovations Theory is also

relevant here, as GIS remains in the “early majority” phase among Enugu-East professionals. Until structural and cultural resistance is addressed, mass adoption may remain out of reach.

4.4 Statistical Validation

Chi-square analysis confirmed a significant relationship between GIS adoption and improved project efficiency ($\chi^2 = 6.89, p < 0.05$). Additionally, a positive correlation was observed between GIS training and perception of its effectiveness, reinforcing the need for capacity-building initiatives.

5.0 Conclusion

This study assessed the effectiveness of Geographic Information Systems (GIS) in construction management within Enugu-East Local Government Area of Enugu State, Nigeria. The research revealed a paradox: while awareness and perceived usefulness of GIS among professionals were relatively high, actual adoption and implementation remain considerably low. Only 20% of respondents reported active use of GIS tools in construction workflows, despite over 70% recognizing its effectiveness.

Barriers to adoption include lack of formal training, high software acquisition costs, insufficient institutional mandates, and fragmented digital infrastructure. These findings underscore a critical gap between policy awareness and operational execution. The Enugu Geographic Information System (ENGIS), though a significant initiative, has not been fully leveraged by construction stakeholders at the local government level.

The study confirmed, through chi-square testing, a statistically significant relationship between GIS usage and improved project outcomes, particularly in planning accuracy, monitoring efficiency, and coordination. Furthermore, the presence of GIS training strongly correlated with favorable perceptions of its value.

From a theoretical standpoint, the results align with the Technology Acceptance Model and the Diffusion of Innovations Theory, demonstrating that both individual attitudes and institutional readiness influence technology uptake. Systems Theory also emphasizes that GIS integration must be positioned within a coordinated digital ecosystem to produce measurable improvements.

In conclusion, while GIS holds immense promise for transforming construction management in Enugu-East and similar developing contexts, its potential will remain untapped without deliberate investment in training, policy enforcement, and system integration. Bridging this gap is essential

to achieving smarter, faster, and more sustainable construction practices in Nigeria's urban growth corridors.

6.0 Recommendations

Based on the findings of this study, the following recommendations are proposed to enhance the adoption and effective use of GIS in construction management in Enugu-East:

1. **Capacity Building and Training:** Organize targeted GIS training programs for engineers, contractors, and public officials. These should be embedded within professional development frameworks and supported by universities and government agencies.
2. **Institutional Mandates:** Revise procurement and construction policies at the local and state levels to require the integration of GIS in all major infrastructure projects. This will ensure systematic adoption across departments.
3. **Subsidized Access to GIS Tools:** Establish public-private partnerships to provide subsidized or open-source GIS platforms for use in construction projects. This will reduce financial barriers and expand access among small- to mid-scale firms.
4. **Strengthen ENGIS Integration:** Improve coordination between ENGIS and planning departments to ensure that spatial data informs every phase of construction, from site selection to post-completion audits.
5. **Community of Practice:** Foster inter-professional collaboration by establishing a GIS-for-construction working group that brings together developers, regulators, and GIS specialists to share best practices and innovations.

By implementing these measures, Enugu-East can become a model for GIS-led construction planning and execution in Nigeria's emerging urban regions.

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About the Authors



Ndubuisi Ambrose Ositadinma

Enugu State, Nigeria



Surv. Ndubuisi Ambrose Ositadinma was born on 17th June, 1974. He hails from the Umuenenta Family, Umuochie, Imama Akama Oghe in Ezeagu Local Government Area of Enugu State, Nigeria. He is happily married and blessed with four children. He began his educational journey at the primary level, where he obtained his First School Leaving Certificate in 1987. In 1988, he gained admission into National Grammar School, Nike, Enugu. In 1990, following his success in an entrance examination, he transferred to Special Science School, Ihe, in Awgu Local Government Area of Enugu State, where he completed his secondary education in 1993. Driven by a passion for professional excellence, he proceeded to Enugu State University of Science and Technology (ESUT), where he obtained a Bachelor of Science (B.Sc.) degree in Surveying and Photogrammetry in 2002. Surv. Ndubuisi Ambrose commenced his professional career in 2011 after successfully passing the professional examination conducted by the Surveyors Council of Nigeria (SURCON), earning him registration as a professional surveyor. He is currently a full member of the Nigerian Institution of Surveyors at both the state and national levels, where he has served in various capacities. He has been in private practice as a surveyor since then and has trained many young surveyors who have also gone on to earn their professional registration. In 2013, he returned to the university and subsequently earned a Master

of Science (M.Sc.) degree in Environmental Management and Control. He is presently pursuing a Doctorate degree in Project Management in the Department of Quantity Surveying at the ESUT Business School.



Dr. Henry C. Ajaelu

Enugu State, Nigeria



Dr. Henry C. Ajaelu is a distinguished Quantity Surveyor, academic, and researcher with dual Ph.D. degrees in Quantity Surveying and Environmental Management. He is a Registered Quantity Surveyor (RQS) and a member of the Nigerian Institute of Quantity Surveyors (NIQS). Dr. Ajaelu has extensive experience in construction project management, cost control, and infrastructure development. He has published over 50 scholarly articles in reputable journals. As a former Head of Department at Enugu State University of Science and Technology (ESUT), he led key academic innovations and professional development initiatives. His research interests include sustainable construction, digitalisation, and project delivery efficiency in developing economies. Dr. Ajaelu can be contacted at ajaelu.henry@esut.edu.ng

Ezeali Ukie Oluchukwu

Enugu State, Nigeria



Bio and photo to be provided later