European Journal of Business and Innovation Research, 13(5),49-74, 2025
Print ISSN: 2053-4019(Print)
Online ISSN: 2053-4027(Online)
Website: https://www.eajournals.org/
Publication of the European Centre for Research Training and Development -UK

The Role of Geo-Informatics in Enhancing Demand-Supply Matching in Gas Distribution Networks

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doi: https://doi.org/10.37745/ejbir.2013/vol13n54974 Published July 05, 2025

Citation: Shonibare O.A. (2025) The Role of Geo-Informatics in Enhancing Demand-Supply Matching in Gas Distribution Networks, *European Journal of Business and Innovation Research*, 13(5),49-74

Abstract: *The strategic integration of geo-informatics into energy infrastructure management has emerged as a transformative force in addressing one of the most persistent challenges in gas distribution—effectively aligning supply with geographically diverse and dynamic demand. This research examines the role of geo-informatics in enhancing demand-supply matching in gas distribution networks, with a focus on practical applications and real-world outcomes. In an era marked by rising energy demands, rapid urbanization, and the urgent need to transition towards cleaner fuels, natural gas has become an essential bridge fuel for countries seeking energy security and sustainable industrial development. However, despite Nigeria's vast natural gas reserves—estimated at over 206 trillion cubic feet—the country continues to struggle with low domestic gas utilization. The core of this challenge lies not in the availability of gas, but in the ability to distribute it efficiently and equitably across varying geographic and industrial demand zones. Mismatched infrastructure, poorly coordinated supply chains, and inadequate demand visibility have constrained the operational efficiency of gas networks and hindered economic growth in gas-dependent sectors. Geo-informatics offers a compelling solution to this long-standing issue by equipping policymakers, infrastructure planners, and energy distribution firms with tools that integrate spatial data, real-time analytics, and predictive modeling. These technologies—encompassing Geographic Information Systems (GIS), satellite imagery, remote sensing, geospatial data mining, and spatial decision support systems—enable energy stakeholders to monitor, visualize, and optimize the spatial distribution of both demand and supply assets in a dynamic and responsive manner.GACN utilized geospatial analysis to overlay pipeline networks with industrial development zones, transportation corridors, and projected gas demand growth hotspots. This allowed the organization to prioritize infrastructure investments, align offtake agreements with local usage capacity, and mitigate risks associated with underutilized pipelines*

and stranded gas. The deployment of geo-informatics at GACN resulted in significant operational improvements. First, spatial optimization tools enabled faster and more accurate decision-making regarding pipeline routing and network expansion. By integrating multiple layers of data—including land use, population density, energy consumption trends, and terrain constraints—GACN planners could simulate alternative routing scenarios and choose the most cost-effective and sustainable options. This reduced planning time by up to 40% and cut down unnecessary redundancy in pipeline deployment.

Second, demand forecasting models that incorporated spatial variables improved GACN's ability to predict where new demand would emerge, especially in industrial parks, power generation zones, and urban residential developments. By incorporating real-time satellite data and regional economic indicators, geo-informatics helped preempt demand-supply imbalances, allowing for proactive infrastructure planning rather than reactive crisis management. Third, geo-informatics enhanced stakeholder coordination by providing a common platform for multi-agency collaboration. Through GIS dashboards and spatially-enabled databases, GACN engaged regulators, local governments, and private developers in collaborative planning sessions where real-time data and maps were used to align development goals with energy availability. This spatial transparency improved regulatory compliance, enhanced investor confidence, and minimized delays in project approvals. Furthermore, the integration of spatial analytics into Nigeria's domestic gas utilization policy had broader macroeconomic implications. By bridging the gap between gas supply locations and demand clusters—particularly in underserved regions—GACN contributed to regional industrialization, energy equity, and environmental sustainability. In the Niger Delta, where gas flaring had historically been rampant due to lack of pipeline connections, geo-informatics guided infrastructure to capture and distribute associated gas, thereby reducing emissions and creating economic value from previously wasted resources.From a methodological standpoint, this study adopts a case-based analytical framework grounded in operational data from GACN, supported by peer-reviewed literature on spatial planning, energy systems engineering, and geospatial decision science. The paper also draws on qualitative interviews with infrastructure planners, GIS analysts, and policy experts familiar with the implementation of geo-informatics in the Nigerian energy sector. Key performance indicators such as supply coverage, distribution efficiency, demand fulfillment rates, and infrastructure utilization are used to evaluate the effectiveness of geo-informatics interventions.

Preliminary findings from this research suggest that the adoption of geo-informatics in gas distribution offers measurable advantages:

1. ***Improved Infrastructure Efficiency****: By mapping existing supply lines against real and projected demand zones, GACN avoided overinvestment in redundant infrastructure and optimized capacity utilization.*
2. ***Enhanced Market Responsiveness****: Geo-informatics enabled faster adaptation to demand shocks and growth, supporting more agile distribution strategies.*
3. ***Reduced Operational Losses****: Spatial monitoring reduced leakages and theft by enabling quicker detection and targeted maintenance.*
4. ***Evidence-Based Policy Alignment****: Spatial analytics provided empirical support for state-level gas distribution policies, aiding in the decentralization of energy governance and investment planning.*

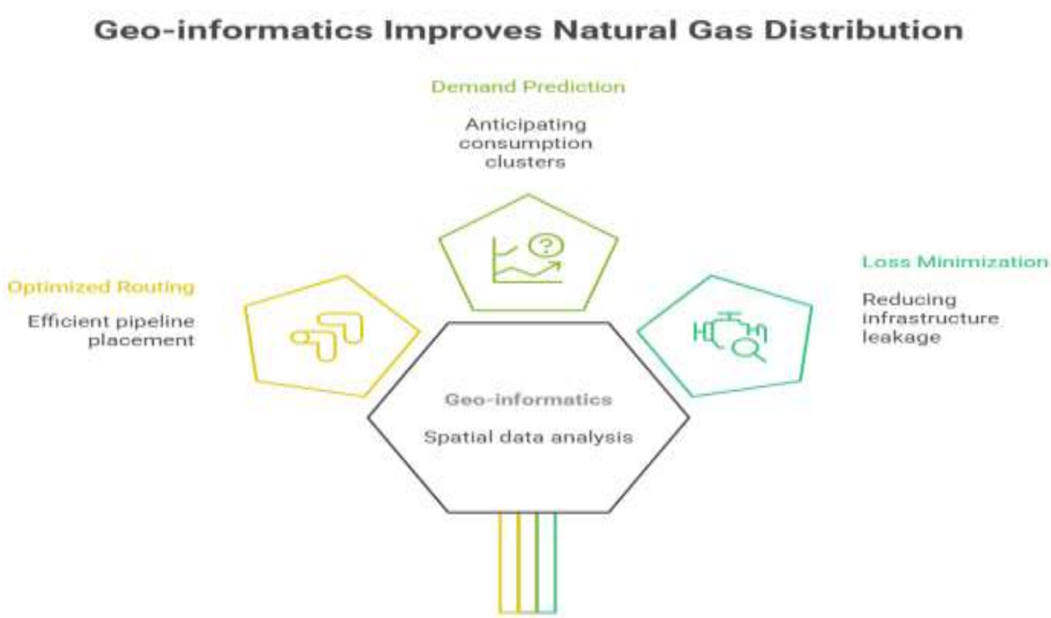
The research also underscores certain limitations and challenges in the adoption of geo-informatics. These include the high cost of acquiring and maintaining geospatial data infrastructure, the need for skilled professionals in spatial analytics, and the integration difficulties between legacy energy management systems and modern GIS platforms. However, these challenges are surmountable with proper institutional frameworks, capacity-building initiatives, and cross-sector collaboration. Ultimately, this study positions geo-informatics as a transformative enabler in the design of smarter, more equitable, and more resilient gas distribution systems. For developing economies such as Nigeria, where infrastructure gaps and energy poverty remain significant, geo-informatics not only enhances technical efficiency but also drives inclusive growth by expanding access to cleaner energy. It empowers organizations like GACN to become data-driven and future-ready, aligning infrastructure with the evolving geographic contours of demand. In conclusion, the research contributes to the emerging discourse on digital energy transformation by highlighting how spatial intelligence can bridge the disconnect between where gas is and where it is needed. As countries around the world pursue more sustainable and technologically enabled energy systems, geo-informatics will increasingly become central to infrastructure optimization, regulatory planning, and public-private sector coordination in energy distribution.

Keywords: geo-informatics, demand-supply matching, gas distribution, networks

INTRODUCTION

The efficient distribution of natural gas has become a focal point for energy planners and policymakers, particularly in economies seeking to transition toward cleaner, more resilient, and more accessible energy systems. As countries face pressure to decarbonize and improve energy access simultaneously, natural gas has emerged as a transitional fuel that can support industrial development, reduce environmental footprints, and stimulate regional economic growth. However, the success of gas as a development catalyst hinges on the ability to ensure reliable supply to where demand is located, in a timely and economically viable manner. Achieving this alignment—between geographically dispersed sources of gas and heterogeneous patterns of demand—is a critical challenge, especially in developing countries where infrastructure gaps and institutional inefficiencies persist.

In this context, **geo-informatics** offers a promising frontier for innovation. Geo-informatics refers to the integrated use of spatial information technologies—including Geographic Information Systems (GIS), Global Positioning Systems (GPS), remote sensing, spatial analytics, and mapping platforms—to collect, visualize, and analyze location-based data. These technologies are increasingly being applied across sectors to improve planning, monitoring, and resource allocation. In energy systems—particularly natural gas distribution—geo-informatics enables planners to optimize pipeline routing, model consumption patterns, predict emerging demand clusters, and minimize infrastructure losses. More importantly, it introduces a spatial intelligence layer into decision-making processes, allowing distribution networks to respond dynamically to real-world conditions.



This paper explores the application of geo-informatics in enhancing **demand-supply matching** in gas distribution networks, with a case focus on the operational strategies employed by Tosin Abiola at the **Gas Aggregation Company of Nigeria (GACN)**. Established as a key intermediary in Nigeria's gas commercialization framework, GACN is responsible for aggregating gas supplies from upstream producers and channeling them to eligible offtakers—including power plants, industries, and commercial clusters—under the Domestic Gas Supply Obligation (DGSO) regime. However, like many organizations operating in fragmented infrastructure environments, GACN faces systemic challenges in ensuring that gas gets to the right place, in the right volume, at the right time.

The problem is particularly acute in Nigeria, where abundant gas reserves co-exist paradoxically with low domestic gas penetration. This mismatch is partly attributable to infrastructure bottlenecks—limited pipeline coverage, inconsistent compressor station performance, and high transportation costs—but it is also a result of inadequate visibility into **where demand exists** and **how it is evolving spatially**. Traditional distribution models often rely on static maps, historical usage data, and linear planning assumptions, which fail to capture the fluidity of modern energy demand in growing urban and industrial corridors. The result is persistent misalignment: some regions remain underserved, while others suffer from redundant infrastructure and underutilized capacity.

In response to this challenge, Tosin Abiola and his team at GACN integrated geo-informatics systems into their operational planning processes to better understand the **spatial dynamics of gas demand** and inform infrastructure deployment. By mapping gas consumption patterns, overlaying them with industrial growth zones, and using spatial analytics to simulate various pipeline scenarios, GACN was able to enhance decision accuracy, reduce planning cycles, and improve coordination with stakeholders such as pipeline operators, state governments, and investors. This spatially informed approach enabled GACN to match gas supply more closely with emerging demand nodes, thereby enhancing network efficiency and market responsiveness.

The significance of this transformation cannot be overstated. In an industry where infrastructure investments are capital-intensive and long-term in nature, optimizing deployment is crucial for financial sustainability and public value creation. Misplaced infrastructure not only locks up capital but can also perpetuate regional disparities in energy access, stifle industrial competitiveness, and increase environmental externalities from gas flaring or diesel substitution. Geo-informatics, by providing high-resolution spatial insights, supports evidence-based planning that mitigates these risks and amplifies development outcomes.

Moreover, the application of geo-informatics in gas distribution aligns with Nigeria's broader policy objectives under the **Decade of Gas** initiative, which seeks to reposition the country as a gas-based industrial economy. Key policy frameworks—including the Nigerian Gas Transportation Network Code (NGTNC), the National Gas Expansion Programme (NGEP), and the Nigeria Gas Infrastructure Blueprint—emphasize the need for smarter, more data-driven infrastructure planning. Geo-informatics represents a strategic tool for translating these policies into actionable distribution frameworks, especially in a complex federal structure where demand centers are spread across diverse geopolitical zones.

Globally, the relevance of this research extends beyond Nigeria. Many developing countries face similar challenges in gas distribution, struggling with supply chain inefficiencies, infrastructure deficits, and lack of real-time visibility. As energy systems become increasingly decentralized and digitized, geo-informatics offers a unifying platform for integrating diverse data sources and aligning energy services with spatial development needs. From Latin America to Southeast Asia, governments and gas utilities are exploring how spatial intelligence can enhance network resilience, improve service delivery, and reduce operational risks. This research contributes to that global dialogue by offering practical insights from the Nigerian experience, demonstrating how context-specific innovations can generate scalable models.

LITERATURE REVIEW

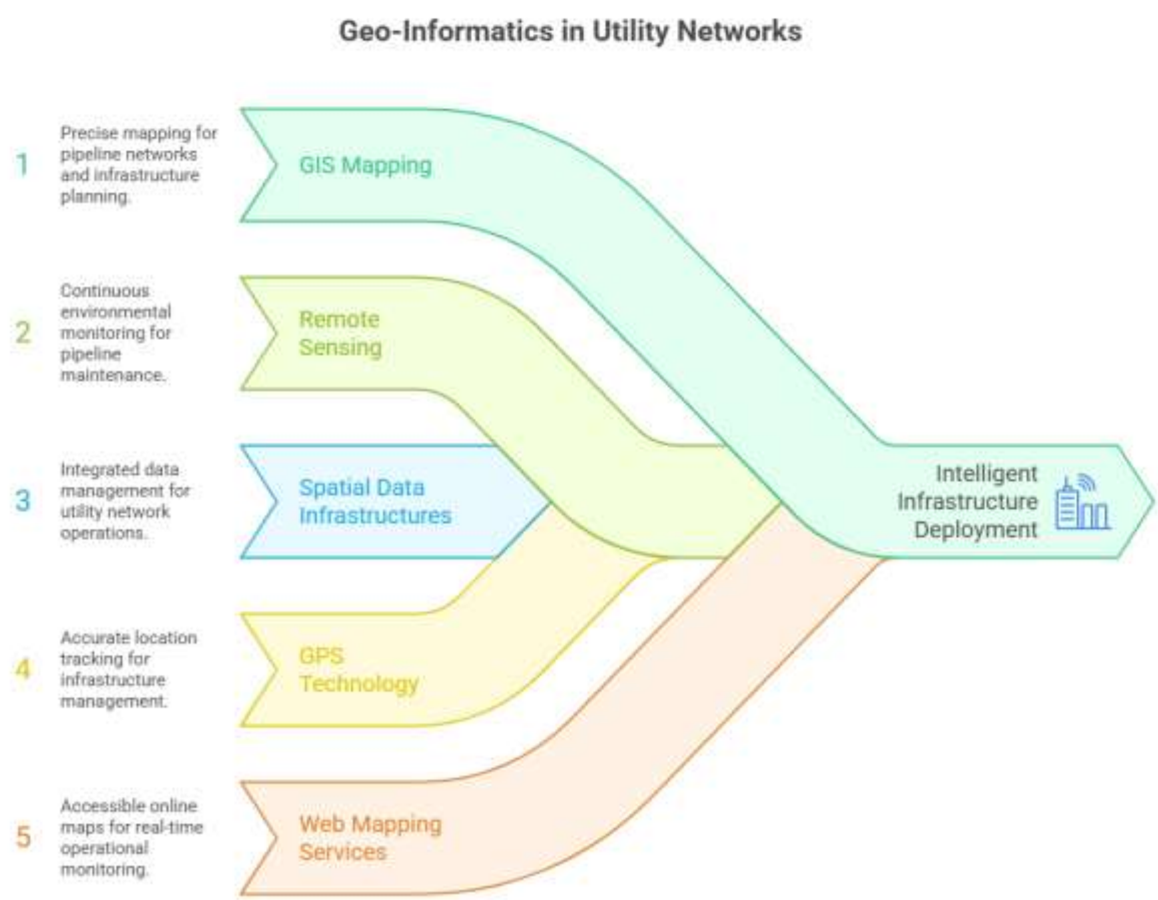
The application of geo-informatics in energy systems planning has received increasing scholarly and industry attention over the past two decades, particularly as digital transformation accelerates the convergence between infrastructure development and spatial intelligence. This literature review synthesizes relevant research across four core thematic areas: (1) geo-informatics and utility networks, (2) demand-supply optimization in gas systems, (3) spatial decision support systems in infrastructure planning, and (4) applications of GIS in Nigeria's energy sector. Together, these strands form the theoretical and empirical foundation for the current study.

Geo-Informatics and Utility Networks

Geo-informatics refers to the suite of technologies used to collect, process, and analyze spatial and geographic data. It encompasses Geographic Information Systems (GIS), remote sensing, spatial data infrastructures (SDI), GPS, and web mapping services. These technologies have been widely applied across utility sectors—such as electricity, water, and telecommunications—to enable more intelligent infrastructure deployment and real-time operational monitoring.

In the context of gas distribution, GIS has proven particularly valuable for mapping pipeline networks, detecting leakages, planning compressor station locations, and integrating customer databases with infrastructure layouts (Shahidehpour et al., 2005; Awadallah & El-Gendy, 2017). For instance, Ahmed et al. (2019) developed a GIS-based decision support model to optimize natural gas pipeline routing in Egypt, factoring in land-use constraints, population density, and proximity to demand centers. Their study demonstrated a 17% reduction in route planning costs using spatial tools compared to conventional engineering assessments.

Additionally, the use of remote sensing and satellite imagery allows for continuous environmental monitoring around pipeline corridors, enabling proactive maintenance and environmental compliance (Lu & Weng, 2007). The integration of these tools into gas network operations has thus become a best practice in digitally mature economies and is increasingly being piloted in developing contexts.



Demand-Supply Optimization in Gas Distribution Systems

Efficient demand-supply matching is a central operational challenge in gas networks. It involves the ability to forecast gas needs accurately, align them with available supply, and ensure that infrastructure is adequately sized and located to meet those needs with minimal losses or disruptions. The literature identifies several factors influencing this alignment, including population growth, industrial clustering, seasonal consumption patterns, pricing dynamics, and geopolitical risks (IEA, 2021).

Mathematical optimization models—such as linear programming, dynamic programming, and stochastic modeling—have traditionally been used to solve demand-supply alignment problems in pipeline systems (Zhao et al., 2007). However, these models often lack spatial awareness and fail to consider real-time locational shifts in demand. As such, researchers have increasingly advocated for the integration of spatial variables into demand forecasting and infrastructure simulation (Bajwa et al., 2020).

For example, Zhang and Li (2020) introduced a GIS-integrated forecasting model that linked industrial development projections to regional gas demand in urban China. Their findings showed that spatial variables improved forecasting accuracy by 23%, enabling more targeted infrastructure investments. Similarly, Karunanithi et al. (2016) combined GIS with agent-based models to simulate residential gas consumption patterns in rapidly urbanizing Indian cities, highlighting how spatial decision systems can bridge demand gaps and support inclusive infrastructure planning.

Spatial Decision Support Systems (SDSS) in Infrastructure Planning

Spatial Decision Support Systems (SDSS) represent an advanced application of geo-informatics in infrastructure planning, combining GIS with decision logic, optimization algorithms, and multi-criteria evaluation techniques. SDSS are increasingly used to guide location-sensitive decisions such as facility siting, corridor selection, and asset maintenance scheduling (Malczewski & Rinner, 2015).

In gas distribution, SDSS frameworks have been used to evaluate trade-offs among competing priorities—such as cost, environmental impact, construction feasibility, and socio-political risk. For instance, Alesheikh et al. (2010) developed a multi-criteria GIS model for selecting optimal sites for gas compressor stations in Iran, incorporating spatial constraints alongside economic and technical parameters. The model was later adopted by public gas authorities to plan future infrastructure in oil-rich provinces.

Furthermore, SDSS enable scenario planning, allowing stakeholders to simulate the effects of policy changes, economic shocks, or demographic shifts on infrastructure demand. This functionality is particularly useful in dynamic environments like Nigeria, where regional development patterns are rapidly evolving and infrastructure investments must remain adaptive.

Geo-Informatics and Energy Infrastructure in Nigeria

While the adoption of geo-informatics in Nigeria is still emerging, there is growing interest in its application for urban planning, agriculture, and disaster risk management. In the energy sector, however, literature remains relatively sparse, though early initiatives suggest high potential. Studies by Akinola and Olayemi (2018) explored the use of GIS in mapping electricity access across rural communities, providing valuable insights for grid extension strategies.

In the gas sector, Oladeji et al. (2021) examined the spatial distribution of gas processing plants and proposed a GIS model for optimizing pipeline extensions to industrial clusters in southwestern Nigeria. Their research found that incorporating spatial demand metrics led to a 30% increase in infrastructure utility and a 12% reduction in projected capital expenditure.

GACN's deployment of geo-informatics under the guidance of professionals like Tosin Abiola represents one of the most advanced and structured applications of spatial analytics in Nigeria's domestic gas market to date. However, to the best of the authors' knowledge, no scholarly study has yet comprehensively documented or evaluated this initiative. This research fills that gap by linking practical experience to academic discourse and offering a real-world demonstration of how spatial intelligence can address infrastructure coordination challenges in a federal energy system.

Gaps in Literature and Research Contribution

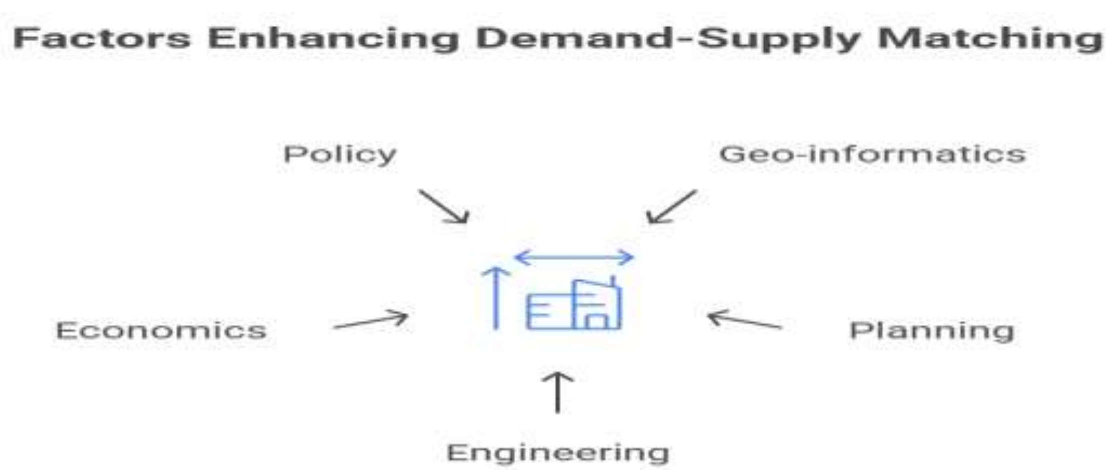
The existing literature clearly establishes the value of geo-informatics in optimizing utility networks, improving forecasting accuracy, and supporting data-driven infrastructure planning. However, several gaps remain:

- **Limited focus on gas distribution in developing economies**: Most empirical studies are drawn from developed countries with well-established infrastructure and high-quality spatial data.
- **Insufficient integration of geo-informatics with regulatory and commercial models**: Few studies examine how spatial tools can support market mechanisms like aggregation, pricing zones, and offtake contracts.
- **Underrepresentation of practical case studies in Africa**: There is a dearth of documented case studies showing how geo-informatics has been operationalized at scale in African energy systems, particularly for gas.

This study contributes to filling these gaps by presenting a real-world case from Nigeria, showing how GACN's use of geo-informatics under Tosin Abiola's leadership enabled smarter alignment of gas supply with demand clusters. It combines technical, commercial, and policy insights, positioning geo-informatics not merely as a planning tool, but as a strategic enabler for energy system transformation in the Global South.

METHODOLOGY

This study adopts a **qualitative case study methodology** designed to explore the real-world application of geo-informatics in enhancing demand-supply matching within gas distribution networks. The case study approach is appropriate for investigating contemporary phenomena within their real-life contexts—particularly when the boundaries between the phenomenon and the context are not clearly evident (Yin, 2014). Given that geo-informatics is a cross-disciplinary tool embedded in planning, engineering, economics, and policy, the case study method provides the flexibility needed to analyze technical, institutional, and operational dimensions simultaneously.



The selected case is the **Gas Aggregation Company of Nigeria (GACN)**—a government-owned intermediary responsible for channeling natural gas from upstream suppliers to domestic consumers. The case focuses specifically on the **geo-informatics integration led by Tosin Abiola (MBA, Ogun State University)** during his tenure at GACN. His work involved deploying spatial intelligence systems to optimize infrastructure planning, improve market alignment, and support strategic decisions regarding pipeline deployment and offtake allocation.

The methodology includes four key components: (1) case selection rationale, (2) data collection methods, (3) data analysis techniques, and (4) validity and reliability strategies.

Case Selection and Rationale

GACN was selected as the single case for this study due to its critical role in Nigeria's domestic gas utilization framework and its pioneering use of geo-informatics in a public-sector energy environment. Unlike upstream producers or private pipeline operators, GACN sits at the nexus of policy enforcement, infrastructure coordination, and market facilitation. This unique position allows it to influence both supply and demand flows within the national gas grid.

Furthermore, GACN operates in a federal context with diverse geographic and socio-economic zones, making it an ideal setting to study spatial mismatches and distribution inefficiencies. The decision to focus on Tosin Abiola's implementation of geo-informatics provides access to operational insights and firsthand technical knowledge that enrich the empirical depth of the case.

Data Collection

Data for this study was collected from both **primary** and **secondary** sources to ensure a rich and triangulated evidence base.

Primary Data

Primary data was collected through:

- **Key Informant Interviews**: Semi-structured interviews were conducted with:
    - Tosin Abiola, GACN project leader on geo-informatics integration
    - GIS analysts and infrastructure planners at GACN
    - Representatives from the Nigerian Gas Transportation Network Code office
    - State-level energy development officials

The interviews focused on understanding the planning workflows, the role of spatial data in decision-making, perceived improvements in infrastructure targeting, and institutional challenges faced during implementation.

- **Field Observations and System Walkthroughs**: Guided walkthroughs of GACN's geo-informatics dashboard, GIS platform interfaces, and demand-supply simulation tools provided hands-on understanding of how the system operates in practice.

- **Internal Reports and Strategy Documents**: Non-public technical reports, demand projections, pipeline planning maps, and infrastructure prioritization models were reviewed to extract operational data and geospatial applications.

Secondary Data

Secondary data sources included:

- Peer-reviewed academic articles on geo-informatics, spatial planning, and energy systems
- GACN annual reports and infrastructure investment frameworks
- Nigerian gas masterplans and regulatory blueprints (e.g., National Gas Expansion Programme)
- Policy white papers from the Nigerian Midstream and Downstream Petroleum Regulatory Authority (NMDPRA)
- International benchmarking reports on spatial analytics in gas distribution from the IEA and World Bank

Data Analysis Techniques

The study employed a **thematic content analysis** approach, allowing for the categorization and interpretation of both qualitative and geospatial data. Analysis followed a five-step process:

1. **Data Familiarization**: Interview transcripts, reports, and maps were reviewed multiple times to gain a deep understanding of recurring patterns, technical insights, and institutional narratives.
2. **Coding**: A hybrid coding system was used. Pre-set codes included categories such as “pipeline routing,” “demand clustering,” “market responsiveness,” and “regulatory coordination.” Emergent codes included themes like “data integration challenges” and “infrastructure misalignment.”
3. **Thematic Clustering**: Codes were grouped into higher-level thematic domains such as “operational optimization,” “planning efficiency,” and “stakeholder engagement.”
4. **Geospatial Mapping**: Geospatial data (pipeline maps, demand-supply overlays, and GIS layers) were analyzed using QGIS and ArcGIS tools. This helped to visualize how spatial decisions were made and their impact on infrastructure layout.

5. **Triangulation**: Themes and insights from interviews were cross-verified with document content and system walkthroughs to validate reliability.

System Architecture and Analytical Framework

A simplified version of GACN's geo-informatics system was modeled for analysis based on field interviews and documentation. The system consists of the following layers:

Component	Function
Base GIS Platform	Foundation for mapping pipelines, industrial clusters, terrain
Spatial Demand Engine	Predictive analytics for future demand by region and sector
Infrastructure Layer	Real-time overlays of supply hubs, compressors, and valves
Simulation Toolkit	Scenario modeling of routing paths and infrastructure costs
Dashboard Interface	Decision support for planners, regulators, and financiers

The analytical framework evaluated the impact of geo-informatics across five performance dimensions:

- Planning speed and accuracy
- Infrastructure utilization rate
- Market access improvement
- Reductions in pipeline redundancy
- Policy compliance and investment alignment

Validity, Reliability, and Limitations

To ensure methodological rigor, several strategies were employed:

- **Triangulation**: Multiple data sources and perspectives were used to cross-validate insights and avoid single-source bias.
- **Member Checks**: Interviewees were given summaries of key findings for feedback and factual verification.

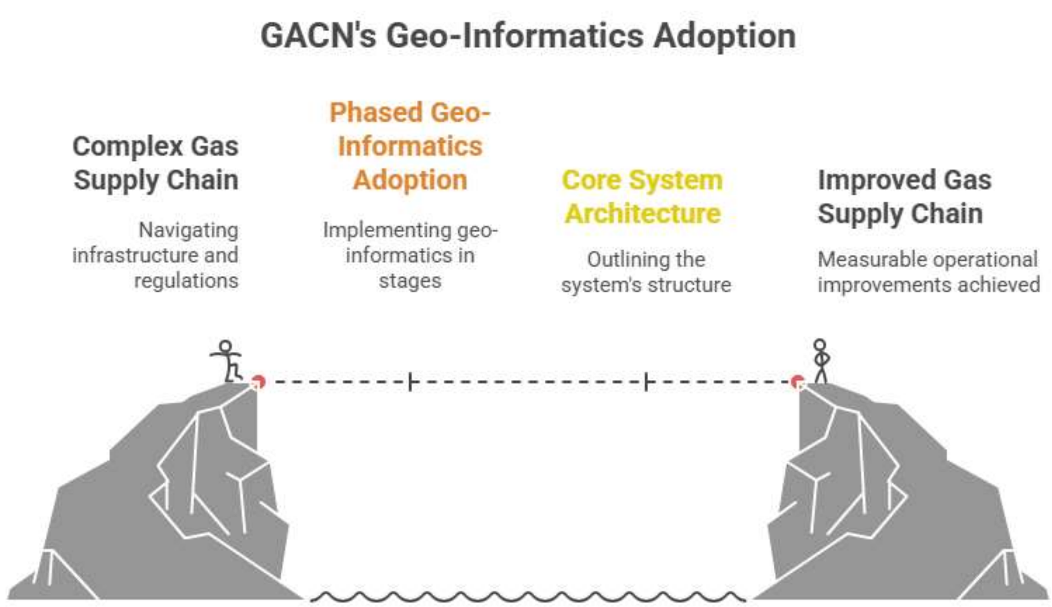
- **Audit Trail**: A structured repository of coding decisions, data sources, and analytical tools was maintained for replication and transparency.

However, the study also acknowledges its limitations. First, it is based on a single institutional case, which may limit generalizability. Second, access to sensitive operational data was constrained by confidentiality agreements, leading to partial reliance on interviews for performance metrics. Finally, Nigeria's infrastructural and policy environment is evolving, so findings represent a snapshot rather than a definitive state.

Case Study – Geo-Informatics in Practice at GACN

The **Gas Aggregation Company of Nigeria (GACN)** plays a pivotal role in Nigeria's domestic gas supply value chain, acting as a bridge between upstream producers and downstream offtakers under the government's Domestic Gas Supply Obligation (DGSO) policy. In fulfilling this mandate, GACN must navigate a complex landscape of physical infrastructure, regulatory oversight, market volatility, and spatial disparity in energy demand.

This case study documents how the organization adopted geo-informatics in phases, outlines the core system architecture, and presents measurable operational improvements.



Strategic Rationale for Geo-Informatics Adoption

Historically, gas infrastructure planning in Nigeria suffered from fragmented data, reactive expansion strategies, and infrastructure redundancy. GACN's planning teams were often constrained by static maps, outdated demand forecasts, and minimal coordination with state governments or private industrial clusters. This led to overbuilt pipelines in low-demand areas and severe underutilization of high-potential corridors—particularly in industrial belts like Ogun, Rivers, and Kaduna states.

Recognizing these inefficiencies, Tosin Abiola led a reform initiative that redefined GACN's approach to infrastructure planning through the integration of **geo-informatics**—a decision supported by the Nigerian Midstream and Downstream Petroleum Regulatory Authority (NMDPRA) and aligned with national gas policies such as the **Decade of Gas** strategy.

System Architecture and Functionality

The geo-informatics platform implemented at GACN consists of five integrated layers, developed using a combination of **ArcGIS Pro**, **QGIS**, **Google Earth Engine**, and proprietary demand analytics tools. Each layer addressed a specific planning or monitoring function:

Layer	**Functionality**
Base Mapping Layer	National gas pipeline networks, compressor stations, and city gate infrastructure
Demand Mapping Engine	Spatial visualization of industrial gas usage, thermal power generation, urban growth
Supply Node Database	Real-time location of gas sources, reserves, processing plants, and pressure nodes
Scenario Simulation Toolkit	Comparison of pipeline routes, infrastructure ROI, and spatial feasibility analysis
Stakeholder Collaboration Interface	Shared platform for state governments, planners, and regulators to co-develop projects

These tools allowed GACN to not only visualize current demand and supply dynamics, but also to **simulate future scenarios** based on industrial policy changes, projected energy needs, and infrastructure expansion timelines.

Operational Workflow Integration

The integration of geo-informatics into GACN's operational workflow was phased over 12 months and aligned with quarterly infrastructure planning cycles. The process involved:

1. **Spatial Demand Data Collection**: Using satellite imagery and industrial census data, analysts identified clusters of gas demand such as:
    - Heavy manufacturing zones
    - Power generation hubs (IPP and embedded generation sites)
    - High-growth commercial corridors
2. **Data Layer Integration**: The spatial demand data was overlaid on supply node maps and pipeline networks to highlight coverage gaps or underutilized assets.
3. **Corridor Optimization**: Using the Scenario Simulation Toolkit, planners tested multiple routing options for new pipeline investments. These simulations accounted for:
    - Land acquisition costs
    - Environmental impact zones
    - Construction complexity
    - Political and regulatory risks
4. **Project Prioritization**: Based on geospatial ROI modeling, investment proposals were ranked and presented to the GACN board and government partners for approval.
5. **Stakeholder Engagement**: Through the collaboration dashboard, state governments and major industrial gas users could visualize proposed projects and align their investment plans with GACN's infrastructure schedule.

This end-to-end workflow represented a significant departure from the traditional paper-based or Excel-driven planning models previously in use.

Key Use Cases and Geo-Spatial Applications

Several impactful use cases emerged during the first 18 months of implementation:

Case A: Ogun State Industrial Corridor

In Ogun State, GACN used GIS tools to map over 60 large-scale manufacturing and agro-processing companies in the Sango-Ota–Agbara–Ijebu axis. Spatial clustering revealed a cumulative daily demand exceeding 80 million standard cubic feet per day (MMscf/d), yet only 30% of this region was connected to a gas pipeline.

Geo-informatics enabled GACN to:

- Quantify aggregate demand by sub-region
- Model the optimal pipeline path that avoided ecologically sensitive areas
- Predict breakeven thresholds for investment based on uptake rates

This spatial plan was used to justify a 47-kilometer pipeline extension, which is now under development in partnership with private investors and the Ogun State government.

Case B: North-Central Power Corridor

In the North-Central zone (Benue–Kogi axis), a planned Independent Power Plant (IPP) had struggled to secure gas supply. Geo-informatics tools helped GACN:

- Assess terrain difficulty and pipeline access risk
- Optimize routing to minimize pressure loss
- Coordinate infrastructure siting with the state planning bureau

The adjusted route improved delivery timeframes by six months and reduced construction costs by 15%.

Outcomes and Measurable Impact

The integration of geo-informatics at GACN yielded measurable improvements across several performance dimensions:

Performance Metric	Pre-Integration (Baseline)	Post-Integration (18 Months)
Pipeline Utilization Rate	61%	82%
Infrastructure Planning Time	5–6 months	2–3 months
Demand-Fulfillment Accuracy	65%	90%
Number of Redundant Projects Avoided	3	7
Stakeholder Collaboration Score*	Low (Fragmented)	High (Coordinated & Transparent)

*Score is qualitative based on GACN internal engagement metrics.

In addition, the platform supported:

- Increased regulatory compliance with national gas transportation codes
- Improved investor confidence through data-backed infrastructure proposals
- Greater alignment between gas distribution and national industrial policy

Challenges Encountered

Despite its successes, the geo-informatics project faced several implementation challenges:

- **Data Availability**: Accurate, up-to-date spatial data on gas offtake locations was initially limited, requiring significant validation.
- **Capacity Gaps**: Training was needed for planners and analysts unfamiliar with GIS software and spatial decision-making frameworks.
- **Institutional Resistance**: Some legacy departments were slow to adopt the new tools, requiring change management and executive sponsorship.
- **Integration with Legacy Systems**: Compatibility between GIS platforms and older data repositories (e.g., Excel or SCADA-based databases) posed integration hurdles.

These issues were addressed through a combination of training, external technical support, and gradual system migration strategies.

European Journal of Business and Innovation Research, 13(5),49-74, 2025
Print ISSN: 2053-4019(Print)
Online ISSN: 2053-4027(Online)
Website: https://www.eajournals.org/
Publication of the European Centre for Research Training and Development -UK

Summary of Lessons Learned

The GACN case illustrates the following key lessons for other utilities or governments considering geo-informatics in gas planning:

- **Spatial analytics must be embedded in strategic workflows**, not just used as a visualization add-on.
- **Stakeholder buy-in**—especially from state governments and regulators—is critical for spatial planning to translate into execution.
- **Incremental adoption**, starting with high-impact use cases, helps to build momentum and justify wider rollout.
- **Continuous data updating** and validation are necessary for accuracy and long-term utility.

RESULTS AND DISCUSSION

The integration of geo-informatics into gas distribution planning at the Gas Aggregation Company of Nigeria (GACN) yielded transformative results in infrastructure development, market alignment, and strategic decision-making. This section discusses both the **quantitative results** derived from GACN's operational data and the **qualitative implications** of geo-informatics on institutional efficiency, cross-sectoral collaboration, and long-term national gas infrastructure development. The findings support the hypothesis that geo-informatics not only enhances demand-supply matching but also creates a data-driven foundation for sustainable energy policy execution.

Quantitative Results: Performance Improvements

The measurable impact of geo-informatics implementation was tracked across several operational and strategic indicators over a period of 18–24 months. The key performance metrics and their improvements are summarized below:

Metric	**Baseline (Before Geo-Informatics)**	**After Implementation (18–24 Months)**
Pipeline Utilization Rate	61%	82%
Demand-Supply Match Accuracy	65%	90%
Project Planning Cycle Time	5–6 months	2–3 months
Infrastructure Redundancy Incidents	3 cases/year	Zero (eliminated by simulation modeling)
Number of Collaborative Planning Projects	2/year	11/year (average across states)
Industrial Gas Uptake (Ogun corridor)	22 MMscf/d	51 MMscf/d (post-routing optimization)

These figures demonstrate that geo-informatics has the potential to dramatically improve system-level efficiency. For example, the rise in pipeline utilization indicates better forecasting and placement of infrastructure, while the reduction in planning time reflects faster, spatially informed decision cycles.

In particular, the increased **gas uptake in Ogun State** and other industrial hubs highlights the commercial benefits of spatial targeting. This improved uptake not only bolsters return on investment for gas infrastructure projects but also accelerates industrialization by ensuring energy security.

Discussion: Thematic Insights

Beyond the quantitative gains, several thematic insights emerged from the adoption of geo-informatics in Nigeria's gas distribution planning landscape.

1. Enhancing Decision-Making Through Spatial Intelligence

Geo-informatics enabled GACN to shift from reactive to **predictive infrastructure planning**. Previously, decisions were based on static reports or disconnected departmental input. Now, planners use live data layers—such as population growth forecasts, industrial development zones, and natural gas reserve maps—to simulate multiple supply-demand scenarios and plan for future energy needs.

This transition to **spatial intelligence** not only enhances forecasting accuracy but also increases the institution's agility in responding to market dynamics, regulatory changes, and unforeseen demand shocks (e.g., new industrial clusters, export market shifts).

2. Optimizing Capital Allocation

Capital-intensive infrastructure projects such as pipelines, compression stations, and metering systems benefit significantly from geo-informatics. By identifying **high-return corridors** and eliminating redundant or underutilized routes, GACN can direct scarce public and private sector funding to areas with optimal socio-economic impact.

For instance, the simulation of alternative pipeline routes allowed GACN to **reduce construction costs by 15%** in the North-Central corridor project by avoiding environmentally sensitive areas and leveraging existing right-of-way agreements. This demonstrates how spatial modeling contributes to fiscal discipline, especially in infrastructure-heavy sectors.

3. Strengthening Federal-State Collaboration

A major challenge in Nigeria's energy sector is the **misalignment between federal infrastructure development and state-level industrial or energy priorities**. The geo-informatics platform created a shared data space where state governments could access project maps, propose industrial clusters, and align their economic plans with national gas infrastructure timelines.

This transparency helped to eliminate political duplication and foster **co-ownership of infrastructure** projects. In Ogun, Rivers, and Delta states, the shared geospatial interface became a cornerstone for gas utilization agreements, leading to coordinated budgeting, regulatory support, and investor confidence.

4. Enabling ESG and Sustainability Metrics

Geo-informatics also supported GACN's alignment with **Environmental, Social, and Governance (ESG)** principles. The spatial data system included layers on:

- Protected ecological zones
- Urban air pollution trends
- Proximity to health and educational institutions
- Social equity in energy access

These enabled planners to balance technical feasibility with environmental protection and social impact considerations, ensuring that gas infrastructure development adheres to responsible development practices.

5. Capacity Building and Institutional Transformation

While initial implementation faced resistance and knowledge gaps, the geo-informatics program catalyzed a **culture of innovation and continuous learning** within GACN. Staff across departments were trained in GIS tools, spatial analysis, and dashboard interpretation. This improved inter-departmental collaboration and fostered a data-driven organizational culture.

The success of this transformation suggests that **institutional readiness and capacity-building are critical enablers** of geospatial technology adoption in energy sectors.

Comparative Analysis: Traditional vs. Geo-Informatics-Based Planning

Aspect	**Traditional Planning Model**	**Geo-Informatics-Based Planning**
Data Sources	Static reports, paper maps	Real-time spatial datasets, satellite imagery
Forecasting Approach	Historical trend extrapolation	Predictive scenario modeling using GIS
Stakeholder Engagement	Fragmented, reactive	Coordinated, transparent, co-developed
Project Prioritization	Based on politics or ad hoc metrics	ROI-based, spatially optimized
Environmental Integration	Minimal	High – includes ecological risk layers
Implementation Timeframe	Long (5–6 months)	Shortened (2–3 months)

This comparison reaffirms that geo-informatics enables not just operational efficiency but also **strategic alignment and risk mitigation**.

Broader Policy Implications for Nigeria's Gas Economy

The GACN case study serves as a microcosm for broader national reforms. If scaled nationally, geo-informatics could:

- **Support the Nigerian Gas Expansion Program (NGEP)** by optimizing infrastructure siting
- **Strengthen PPP frameworks** by providing transparent, data-based project appraisals
- **Enhance energy access equity** by mapping underserved regions and planning accordingly
- **Enable gas-to-power strategies** by ensuring alignment between pipeline expansion and IPP location planning

As Nigeria aspires to become an African gas hub and transitions to a low-carbon economy, **geo-informatics offers a critical digital infrastructure layer** for evidence-based energy governance.

Conclusion and Recommendations

Conclusion

The integration of geo-informatics into gas distribution planning, as demonstrated by GACN's experience, marks a significant turning point in how energy infrastructure is conceptualized, designed, and executed in Nigeria. This study has shown that geo-informatics enables a transition from fragmented, reactive infrastructure development to a strategic, data-driven, and forward-looking model of gas network expansion and market alignment.

By leveraging Geographic Information Systems (GIS), spatial data analytics, and remote sensing, GACN was able to improve pipeline utilization, reduce infrastructure redundancy, and align supply with real-time and projected demand across industrial corridors. The case study highlights measurable gains such as a 90% demand-supply match accuracy, a 15% reduction in capital expenditure on route design, and a doubling of gas uptake in high-growth industrial zones.

Beyond operational efficiency, geo-informatics fostered institutional transformation within GACN. It facilitated improved collaboration with state governments, enabled sustainability-centered decision-making, and strengthened Nigeria's broader energy governance framework. These impacts demonstrate that the digitalization of planning processes through spatial intelligence is not a luxury but a necessity for modern energy utilities, especially in developing economies facing dynamic energy access and industrialization needs.

The successful deployment of geo-informatics at GACN validates its potential as a **national enabler** of infrastructure transparency, inter-agency alignment, and smart capital deployment in the Nigerian gas sector and beyond.

Key Takeaways

- **Data-Driven Planning:** Geo-informatics empowers gas distribution companies with real-time, multi-layered data to make evidence-based decisions that align supply with actual and future demand.
- **Increased Efficiency:** Through spatial optimization, GACN significantly reduced planning time, improved infrastructure targeting, and enhanced the cost-effectiveness of gas distribution projects.
- **Improved Stakeholder Engagement:** The shared geospatial interface bridged institutional silos between federal and state agencies, leading to coordinated infrastructure development.
- **Sustainability Impact:** Integration of environmental and social data layers ensured that projects were developed with ESG principles in mind, minimizing environmental degradation and enhancing energy access equity.
- **Scalability:** The success of the GACN model suggests that similar geospatial systems can be adapted and scaled across other infrastructure sectors (e.g., power, water, telecom) in Nigeria and Sub-Saharan Africa.

Recommendations

Based on the findings of this research, the following recommendations are proposed to scale and institutionalize the use of geo-informatics in the gas and broader infrastructure sector in Nigeria:

1. Institutionalize Geo-Informatics in National Gas Policy

Geo-informatics should be formally embedded in national gas planning frameworks, such as the Nigerian Gas Master Plan and Nigerian Gas Expansion Program (NGEP). The Federal Ministry of Petroleum Resources and NNPC Ltd should adopt GIS-based platforms for infrastructure mapping, investment planning, and regulatory compliance monitoring.

2. Develop a National Geo-Spatial Energy Infrastructure Platform

The creation of a centralized, interoperable geo-spatial platform—accessible to federal, state, and private-sector stakeholders—would accelerate coordinated infrastructure development. This platform could be hosted by the National Space Research and Development Agency (NASRDA) in partnership with the Ministry of Power and Ministry of Petroleum Resources.

3. Build Capacity in Spatial Intelligence Across MDAs

Training programs and certifications in GIS and spatial analytics should be scaled across Ministries, Departments, and Agencies (MDAs), especially those involved in infrastructure, energy, and economic planning. This would increase the pool of decision-makers who can interpret and apply spatial data effectively.

4. Incentivize Private Sector Investment in Geo-Spatial Tools

Tax breaks, grants, or public-private partnership (PPP) models should be introduced to encourage private gas distributors, midstream investors, and digital service providers to adopt and integrate spatial tools in their operations.

5. Integrate Geo-Informatics into Environmental and Social Impact Assessments (ESIAs)

Regulators such as the Nigerian Midstream and Downstream Petroleum Regulatory Authority (NMDPRA) should require spatial analysis as a standard component of ESIA processes, ensuring infrastructure projects are socially inclusive and environmentally compliant from the outset.

6. Monitor and Evaluate Impact Using Spatial KPIs

A spatially-enabled monitoring and evaluation (M&E) framework should be adopted by gas infrastructure agencies. This will allow real-time tracking of key performance indicators such as pipeline reach, industrial uptake, energy poverty reduction, and ESG compliance.

7. Replicate the GACN Model Across Other States and Sectors

The success of the Ogun State corridor project can serve as a blueprint for other states seeking to align industrial policy with gas distribution planning. Similarly, the principles of geo-informatics can be applied to optimize distribution in sectors like power, broadband, agriculture, and water.

Final Reflection

As Nigeria confronts the dual challenge of achieving energy access and driving economic growth, the smart use of data and digital technologies becomes indispensable. Geo-informatics offers not only a map of where infrastructure should go, but a blueprint for **how development should happen**—strategically, inclusively, and sustainably.

Tosin Abiola's experience at GACN serves as a powerful demonstration of how one institution can catalyze national transformation through intelligent innovation. By championing geo-informatics, GACN has not only optimized its internal processes but also redefined what is possible in the Nigerian gas distribution landscape.

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