Development of an Integrated Land Information Management System (LIMS) for Bayelsa State, Nigeria: A Conceptual Framework for Cadastral Integration and Institutional Implementation

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***Abstract*—Land administration in Bayelsa State, like much of the Niger Delta, remains fragmented across multiple agencies, paper-based registries, and inconsistent spatial reference systems, producing tenure insecurity, registration delays, revenue leakage, and recurrent boundary disputes. This paper presents a conceptual framework for an Integrated Land Information Management System (LIMS) tailored to Bayelsa State's terrain, institutional structure, and land tenure realities. Drawing on the multi-purpose cadastre concept and fit-for-purpose land administration principles, the paper proposes a five-layer system architecture spanning data acquisition, integration and standardization, geospatial database infrastructure, application services, and governance access. It further proposes a five-phase institutional implementation framework addressing policy harmonization, inter-agency coordination, technical deployment, operationalization, and sustainability. The framework gives particular attention to reconciling statutory and customary land records, a persistent challenge in the Niger Delta context, and to building the system on a verifiable geodetic reference (Minna Datum) consistent with national survey standards. The paper concludes that successful LIMS development in Bayelsa State depends less on technology procurement than on institutional coordination, legal backing, and a phased, pilot-driven rollout strategy. The proposed framework offers a replicable model for other Niger Delta states facing similar land administration challenges.**

***Index Terms*—Land Information Management System; Multi-Purpose Cadastre; Bayelsa State; Land Administration; Spatial Data Infrastructure; Niger Delta**

I. INTRODUCTION

Secure and efficient land administration is foundational to economic development, infrastructure planning, and dispute reduction. In Nigeria, land administration is governed primarily by the Land Use Act of 1978, which vests land in state governors in trust for the people, yet implementation has historically suffered from fragmented record-keeping, manual cadastral systems, and weak inter-agency coordination (Igbokwe, 2008; Arungwa & Igbokwe, 2017). Bayelsa State, situated in the riverine core of the Niger Delta, presents particularly acute challenges: a predominantly wetland and creek-dissected terrain that complicates conventional ground surveying, a dense overlay of statutory and customary land claims, and limited institutional capacity for digital land records management compared to more urbanized Nigerian states.

The consequences of fragmented land administration in Bayelsa State are well documented in adjacent literature on the Niger Delta: unresolved boundary disputes, multiple and conflicting allocations of the same parcel, difficulty in attracting formal investment due to weak title security, and constrained internally generated revenue from land-based taxation (Nwilo & Olayinka, 2006; Ogbuene & Nwankwoala, 2015). These problems are not unique to Bayelsa, but the state's hydrological geography, dominated by the Niger Delta's distributary network, intensifies the technical difficulty of establishing and maintaining a reliable cadastral framework.

An Integrated Land Information Management System (LIMS) offers a pathway to address these challenges by consolidating spatial and textual land records into a unified, continuously updated digital infrastructure. Globally, the multi-purpose cadastre concept, which integrates parcel-based legal, fiscal, and land-use information into a single spatial framework, has informed land administration modernization efforts in jurisdictions ranging from Rwanda's land tenure regularization programme to various state-level GIS-based land information systems in Nigeria (Enemark et al., 2014; Nwilo et al., 2020). However, the literature specific to Bayelsa State remains limited, with most Nigerian LIMS scholarship concentrated on Lagos, Kano, and Federal Capital Territory contexts where institutional capacity and funding differ substantially from the Niger Delta states.

This paper addresses that gap by proposing a conceptual LIMS framework specifically adapted to Bayelsa State's institutional and physical context. The paper is organized as follows: Section II reviews relevant literature on land information systems and multi-purpose cadastre development. Section III outlines the conceptual approach. Section IV presents the proposed system architecture. Section V presents the institutional implementation framework. Section VI presents the cadastral data integration workflow. Section VII discusses implementation challenges and strategic considerations, and Section VIII concludes with recommendations.

A. Objectives of the Study

- To examine the institutional and technical deficiencies in Bayelsa State's current land administration arrangements.
- To propose a conceptual system architecture for an integrated LIMS suited to the state's terrain and institutional context.
- To develop an institutional implementation framework addressing policy, coordination, and sustainability requirements.
- To identify strategic considerations for reconciling statutory and customary land records within the proposed system.

II. LITERATURE REVIEW

A. Land Information Systems and the Multi-Purpose Cadastre

A Land Information System (LIS) is broadly defined as a tool for legal, administrative, and economic decision-making, comprising a database of land-related information linked spatially to land parcels (FIG, 1995; Williamson et al., 2010). The multi-purpose cadastre extends the traditional fiscal or legal cadastre by integrating multiple data layers, including ownership, value, land use, and infrastructure, around a common parcel identifier (Enemark et al., 2014). This integration reduces duplication of data collection across agencies and supports more coherent land-use planning and revenue administration.

The fit-for-purpose land administration approach, developed by the World Bank and FIG (International Federation of Surveyors) in response to the slow pace and high cost of conventional cadastral surveying in developing countries, advocates for flexible accuracy standards, incremental data improvement, and participatory boundary delineation rather than insisting on survey-grade precision from the outset (Enemark et al., 2014; Zevenbergen et al., 2015). This approach is particularly relevant to Bayelsa State, where the cost and difficulty of conventional geodetic surveying across riverine terrain make a phased, fit-for-purpose strategy more realistic than attempting comprehensive precision cadastral coverage in a single initiative.

B. Land Administration Challenges in the Niger Delta Context

Studies on land administration in the Niger Delta consistently identify several recurring problems: the coexistence of statutory tenure under the Land Use Act with customary and communal land claims, weak documentation of historical land transactions, encroachment and boundary disputes exacerbated by oil and gas infrastructure development, and the physical difficulty of cadastral surveying in wetland and mangrove terrain (Nwilo & Olayinka, 2006; Ogbuene & Nwankwoala, 2015; Arungwa & Igbokwe, 2017). Hydrographic and topographic constraints specific to riverine Niger Delta states such as Bayelsa also complicate the establishment of permanent ground control networks needed to support a reliable

cadastral framework, a challenge documented in related geodetic and hydrographic survey work within the region.

Several Nigerian states have made progress toward digital land information systems, notably Lagos State's Land Information System and Kano State's GIS-based cadastral platform, both of which benefited from comparatively higher institutional capacity, urban land markets generating sustained revenue incentives, and external donor or development partner support (Nwilo et al., 2020). The literature offers comparatively little guidance on how such systems might be adapted for less urbanized, riverine states with dispersed settlement patterns and limited existing digital infrastructure, which is the gap this paper addresses for Bayelsa State.

C. Institutional Frameworks for LIMS Implementation
Beyond technical system design, literature on land administration reform emphasizes that institutional and governance arrangements, rather than technology choice, are typically the binding constraint on successful implementation (Williamson et al., 2010; Zevenbergen et al., 2015). Common failure points identified across African land administration digitization efforts include unclear lead-agency mandates, inadequate legal backing for digital records as evidentiary instruments, insufficient field-level capacity for sustained data maintenance, and the absence of a financially sustainable operating model once initial donor or government capital funding concludes. These institutional considerations directly inform the implementation framework proposed in Section V of this paper.

III. CONCEPTUAL APPROACH AND METHODOLOGY

This paper adopts a conceptual, literature-grounded design methodology rather than an empirical case study. The approach synthesizes principles from the multi-purpose cadastre and fit-for-purpose land administration literature with the specific institutional and physical conditions known to characterize Bayelsa State, drawing on the broader Niger Delta land administration literature and standard Nigerian surveying conventions (Minna Datum geodetic reference, Surveyors Council of Nigeria (SURCON) professional standards, and Land Use Act statutory provisions).

The system architecture presented in Section IV was developed by adapting standard spatial data infrastructure (SDI) layering, comprising data acquisition, integration, storage, application, and access layers, to the specific data sources and stakeholder structure relevant to Bayelsa State's land administration environment. The institutional framework in Section V follows a phased implementation logic commonly applied in land administration reform programmes, sequencing policy and legal groundwork ahead of technical deployment, and treating monitoring and sustainability as a continuous rather than terminal phase.

As a conceptual framework paper, this work does not present empirical field data, pilot test results, or quantified cost-benefit projections specific to Bayelsa State. It is intended as a planning and reference framework that can guide subsequent empirical pilot studies, feasibility assessments, and stakeholder consultations, which the authors identify as necessary next steps in Section VIII.

IV. PROPOSED LIMS SYSTEM ARCHITECTURE

Fig. 1 presents the proposed five-layer architecture for the Bayelsa State LIMS. The architecture is designed to accommodate heterogeneous data sources, ranging from formal survey plans to customary documentation, while enforcing a common geodetic and database standard at the integration layer.

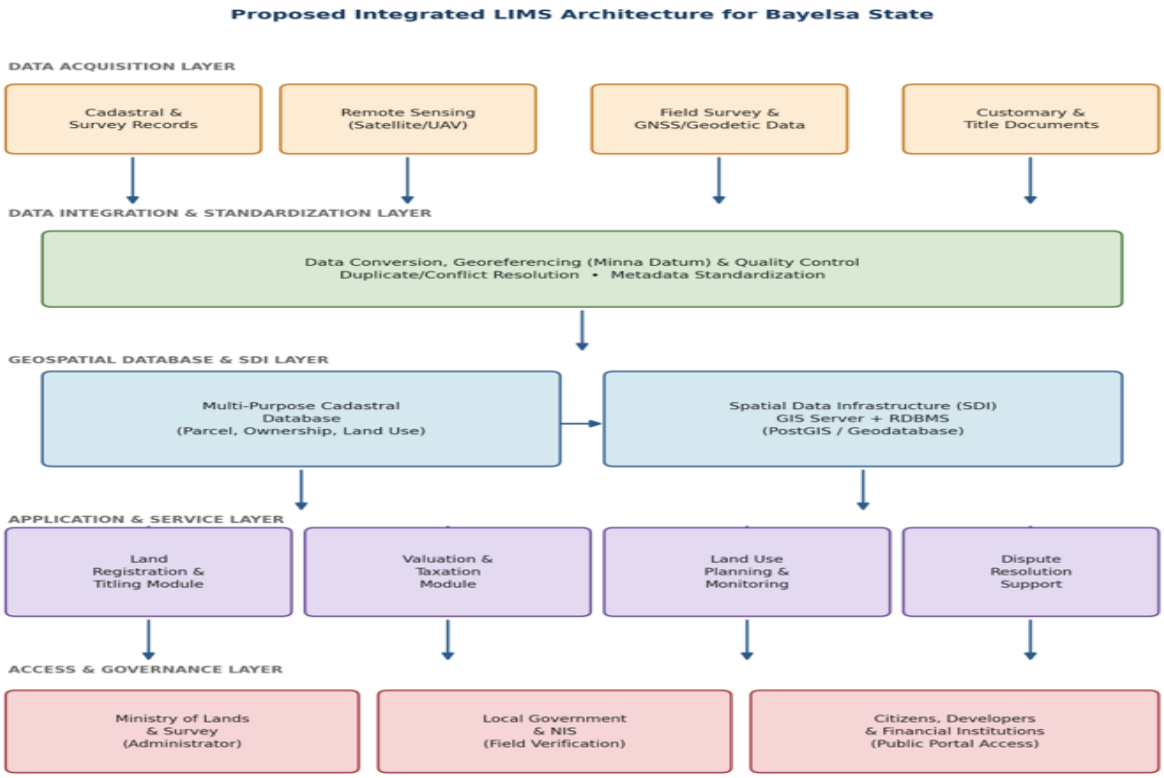

Fig. 1. Proposed Integrated LIMS Architecture for Bayelsa State. Source: Authors' concept (2026).

A. Data Acquisition Layer

The acquisition layer draws from four principal sources: existing cadastral and survey records held by the Ministry of Lands and Survey and private licensed surveyors; remote sensing data, including satellite imagery and increasingly accessible UAV (drone) orthophotography, which is particularly valuable for mapping inaccessible creek and mangrove terrain; field-based GNSS and geodetic survey data collected for new parcel registration or boundary verification; and customary and traditional title documentation held by communities and traditional authorities, which remains the de facto basis of land tenure for a substantial share of land in Bayelsa State despite lacking formal statutory registration.

B. Data Integration and Standardization Layer

This layer performs the critical function of reconciling heterogeneous source data into a common format. All spatial data must be georeferenced to the Minna Datum, consistent with Nigerian national geodetic standards, to ensure interoperability with national survey and cadastral infrastructure. Quality control procedures at this stage include detecting duplicate parcel claims, flagging unresolved boundary overlaps for field verification, and standardizing metadata (date of survey, surveying method, data source, and confidence level) to support downstream auditability.

C. Geospatial Database and Spatial Data Infrastructure (SDI) Layer

The core of the system comprises a multi-purpose cadastral database, holding parcel geometry, ownership, and land-use attributes, coupled with an underlying spatial data infrastructure built on a GIS server and spatial-capable relational database (such as PostGIS-extended PostgreSQL or an equivalent enterprise geodatabase). This layer is designed to support concurrent access by multiple agencies while maintaining a single authoritative parcel record, avoiding the duplicated and conflicting registries that currently characterize land administration in the state.

D. Application and Service Layer

Four core application modules are proposed: a land registration and titling module supporting the formal

registration workflow; a valuation and taxation module linking parcel records to land-based revenue assessment; a land-use planning and monitoring module supporting state and local government planning functions; and a dispute resolution support module providing spatial evidence (historical imagery, overlapping claims, survey history) to support adjudication of the boundary and ownership disputes common in the state.

E. Access and Governance Layer

Access is structured around three stakeholder tiers: the Ministry of Lands and Survey as system administrator and data custodian; local government areas and professional bodies such as the Nigerian Institution of Surveyors (NIS) and its Bayelsa State branch performing field verification and data quality assurance; and a public-facing access tier serving citizens, property developers, and financial institutions requiring parcel verification for transactions, lending, and due diligence.

V. INSTITUTIONAL IMPLEMENTATION FRAMEWORK

Consistent with the land administration literature's emphasis on institutional rather than purely technical constraints (Williamson et al., 2010), Fig. 2 presents a five-phase implementation framework sequencing policy groundwork ahead of technical deployment, with an explicit feedback loop returning monitoring outcomes to policy review.

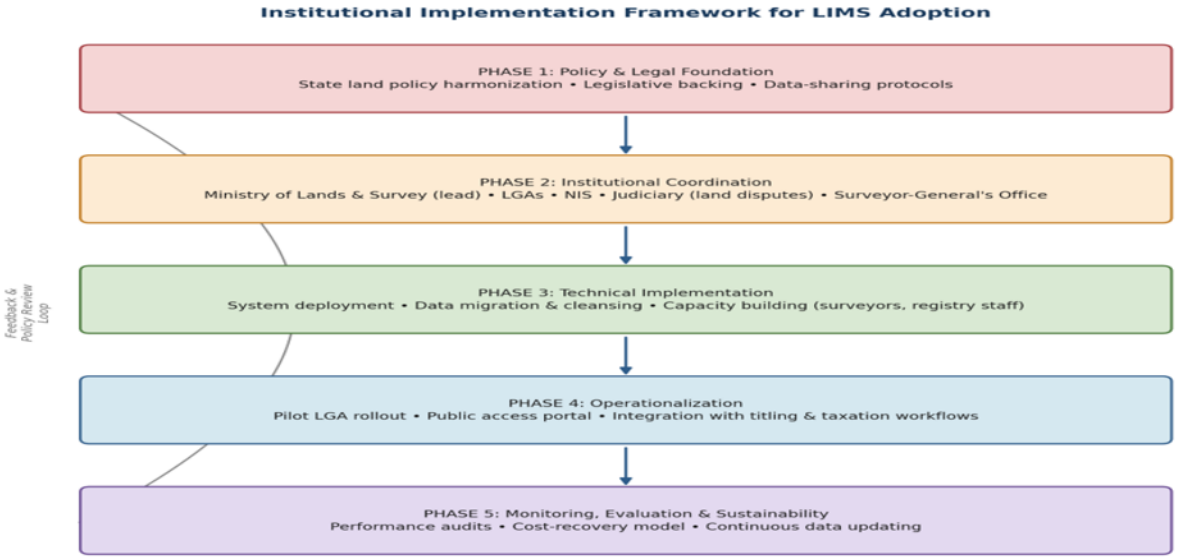

Fig. 2. Institutional Implementation Framework for LIMS Adoption in Bayelsa State. Source: Authors' concept (2026).

A. Phase 1: Policy and Legal Foundation

Implementation should begin with harmonizing existing state land policy instruments, securing legislative or executive backing recognizing digital land records as legally admissible evidence of title, and establishing formal data-sharing protocols between the Ministry of Lands and Survey, local government registries, and the judiciary. Without this foundation, subsequent technical investment risks producing a system whose outputs lack legal standing.

B. Phase 2: Institutional Coordination

A lead agency, most logically the Ministry of Lands and Survey, must be formally designated with the authority to coordinate inputs from local government areas, the Surveyor-General's office, the Nigerian Institution of Surveyors (NIS) and affiliated professional bodies, and the judiciary in its land dispute adjudication role. Memoranda of understanding clarifying data ownership, update responsibility, and access rights among these bodies should be established at this stage.

C. Phase 3: Technical Implementation

This phase comprises system deployment, migration and cleansing of existing paper-based and digital records into the new database structure, and capacity building for registry staff and surveyors who will operate and maintain the system. Given documented capacity constraints in similar Nigerian state contexts, this phase should include structured training partnerships with academic institutions such as the Department of Surveying and Geomatics at Rivers State University and the Department of Quantity Surveying at Niger Delta University, alongside professional bodies such as the Nigerian Institution of Surveyors (NIS).

D. Phase 4: Operationalization

Rather than a state-wide simultaneous launch, a pilot rollout in one or two local government areas is recommended to allow workflow refinement before broader deployment. This phase includes activating the public access portal and integrating the LIMS with existing titling and taxation administrative workflows so that the system becomes operationally necessary rather than a parallel, optional record.

E. Phase 5: Monitoring, Evaluation, and Sustainability

Long-term sustainability requires periodic performance audits, a defined cost-recovery model (such as registration and search fees) reducing dependence on annual budget allocation, and continuous data updating procedures to prevent the system from becoming outdated, a common failure mode in donor-funded land administration projects once initial funding concludes. The feedback loop in Fig. 2 reflects the need for monitoring findings to inform periodic policy and legal review.

VI. CADASTRAL DATA INTEGRATION WORKFLOW

A central technical challenge in the proposed system is reconciling statutory survey records with customary land documentation, which frequently lack precise coordinate geometry. Fig. 3 illustrates the proposed workflow for resolving this challenge at the point of data integration, prior to a parcel record being committed to the authoritative database.

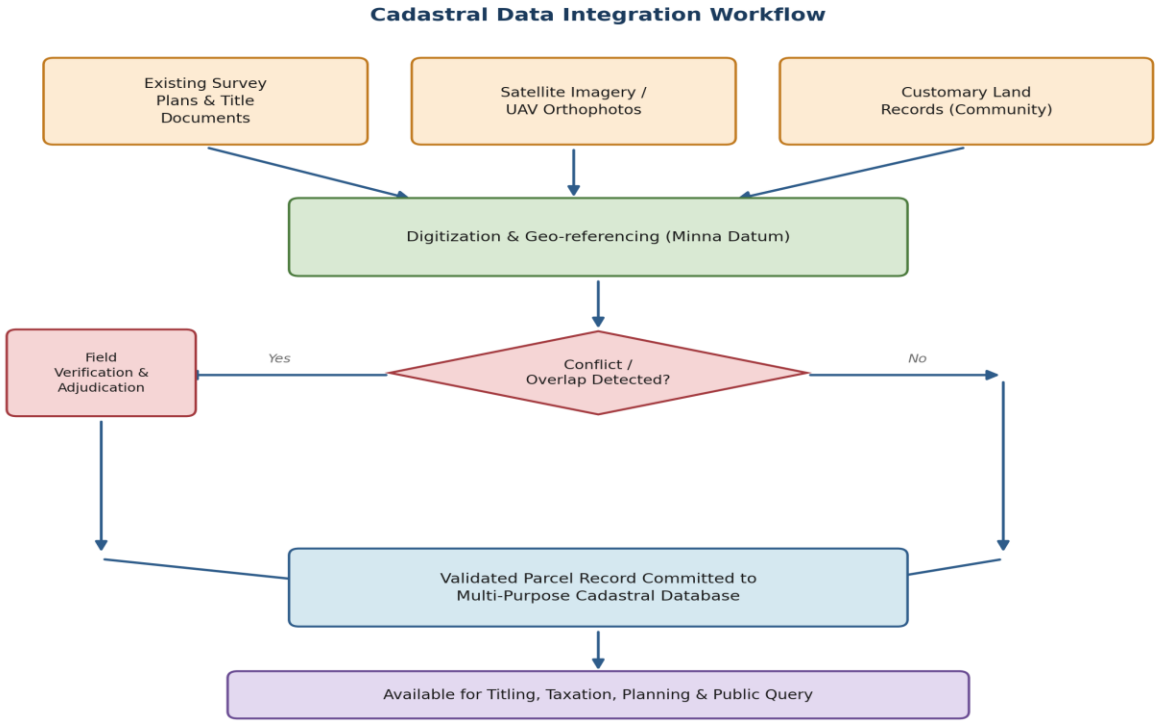

Fig. 3. Cadastral Data Integration Workflow for Reconciling Statutory and Customary Land Records. Source: Authors' concept (2026).

All incoming data, whether from formal survey plans, satellite or UAV imagery, or customary records, passes through digitization and georeferencing to the Minna Datum before integration. Where overlapping or conflicting claims are detected, the workflow routes the parcel to field verification and adjudication, consistent with the fit-for-purpose principle of participatory boundary resolution rather than imposing precision survey requirements that communities may be unable to satisfy in the short term (Zevenbergen et al., 2015). Only validated, non-conflicting parcel records are committed to the authoritative database, after which they become available to the titling, taxation, planning, and public query functions described in Section IV-D.

VII. DISCUSSION: IMPLEMENTATION CHALLENGES AND STRATEGIC CONSIDERATIONS

A. Terrain and Data Acquisition Constraints

Bayelsa State's riverine and mangrove-dominated terrain limits the practicality of conventional ground-based cadastral surveying across large areas, making UAV and satellite-based data acquisition not merely a convenience but, in many cases, a practical necessity. This implies a system design more reliant on remote sensing inputs than would be typical in upland Nigerian states, and a correspondingly greater emphasis on field verification protocols to validate remotely sensed parcel boundaries against ground conditions.

B. Reconciling Statutory and Customary Tenure

The proposed conflict-detection step in the integration workflow (Section VI) is the system's primary mechanism for managing the statutory-customary tenure overlap that characterizes much of the Niger Delta. However, a technical workflow alone cannot resolve what is fundamentally also a legal and social question; the institutional framework's Phase 1 (policy and legal foundation) must establish clear rules for how customary claims lacking documentary evidence are to be treated within the formal system, a matter requiring broader stakeholder and traditional authority consultation beyond the scope of this conceptual paper.

C. Financing and Sustainability

Experience from comparable Nigerian state LIMS initiatives suggests that initial capital investment, whether state-funded or donor-supported, is more readily secured than the recurrent funding needed for data maintenance, system administration, and staff retention. The cost-recovery emphasis in Phase 5 of the institutional framework is intended to address this risk, but its feasibility depends on land transaction volumes sufficient to generate meaningful fee revenue, a question that would benefit from empirical study in subsequent research.

D. Limitations of the Conceptual Framework

As a conceptual paper, this framework has not been empirically tested against primary data from Bayelsa State, and the architecture and implementation phases proposed here should be treated as a planning reference rather than a validated blueprint. Pilot implementation, stakeholder consultation with the Bayelsa State Ministry of Lands and Survey, and empirical cost and capacity assessment are necessary before full-scale deployment, as discussed in Section VII-C above and the recommendations in Section VIII.

VIII. CONCLUSION AND RECOMMENDATIONS

This paper has proposed a conceptual framework for an Integrated Land Information Management System for Bayelsa State, comprising a five-layer technical architecture and a five-phase institutional implementation pathway. The framework's central argument is that the binding constraint on successful LIMS development in Bayelsa State is institutional coordination and legal backing rather than technology procurement, and that a phased, pilot-driven rollout grounded in fit-for-purpose land administration principles offers a more realistic pathway than an attempted comprehensive, simultaneous state-wide deployment.

The paper recommends that the Bayelsa State Ministry of Lands and Survey, in collaboration with relevant professional bodies and academic institutions, commission a feasibility study and stakeholder consultation process building on the framework presented here, with a pilot implementation in one local government area as the recommended first practical step. Future research should pursue empirical validation of the proposed architecture through pilot

deployment, quantified cost-benefit analysis specific to Bayelsa State's land market, and detailed legal analysis of the evidentiary status of digital land records under Nigerian law.

REFERENCES

[1] C. Arungwa and E. C. Igbokwe, "Land tenure and cadastral systems in Nigeria: Challenges and prospects for the Niger Delta region," Journal of Environmental Sciences and Resources Management, vol. 9, no. 2, pp. 45–58, 2017.

[2] S. Enemark, K. C. Bell, C. Lemmen, and R. McLaren, Fit-for-Purpose Land Administration. International Federation of Surveyors (FIG) and World Bank, FIG Publication No. 60, 2014.

[3] International Federation of Surveyors (FIG), Statement on the Cadastre, FIG Publication No. 11, 1995.

[4] E. C. Igbokwe, "Land administration reform and the cadastral system in Nigeria," Nigerian Journal of Surveying and Geoinformatics, vol. 4, no. 1, pp. 22–34, 2008.

[5] P. C. Nwilo and D. N. Olayinka, "Land administration and the challenges of land tenure in the Niger Delta region of Nigeria," Journal of the Nigerian Institution of Surveyors, vol. 12, no. 3, pp. 12–21, 2006.

[6] P. C. Nwilo, A. T. Olajide, and C. J. Okolie, "Geospatial approaches to land information system development in Nigerian states: A comparative review," Journal of Geoinformatics and Land Administration, vol. 6, no. 1, pp. 33–47, 2020.

[7] E. B. Ogbuene and H. O. Nwankwoala, "Geo-environmental challenges of land use and land tenure in the Niger Delta wetlands," International Journal of Environment and Geoinformatics, vol. 2, no. 2, pp. 89–101, 2015.

[8] Williamson, S. Enemark, J. Wallace, and A. Rajabifard, Land Administration for Sustainable Development. Redlands, CA, USA: ESRI Press, 2010.

[9] J. Zevenbergen, C. Augustinus, D. Antonio, and R. Bennett, "Pro-poor land administration: Principles for recording the land rights of the underrepresented," Land Use Policy, vol. 31, pp. 595–604, 2015.