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THE CREATION OF A CADASTRAL INFORMATION SYSTEM (CIS) FOR THE FEDERAL POLYTECHNIC DAMATURU FARMLAND, YOBE STATE, NIGERIA

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ABSTRACT
Persistent challenges in spatial land governance within institutional settings necessitate integrated geospatial solutions. This study details the creation, implementation, and validation of a digital Cadastral Information System (CIS) for the Federal Polytechnic Damaturu (FEDPODAM) farmland to address lingering land administration inefficiencies. Employing an integrated geospatial methodology, it utilized high-resolution satellite imagery and conducted cadastral surveys using Global Positioning System. Spatial data for 115 leasehold parcels were integrated with socio-tenurial attributes within an ArcGIS 10.5 geodatabase. The system facilitates core geospatial functions including spatial query, parcel identification, and automated cartographic output. Primary deliverables include a georeferenced base map, a spatially accurate digital parcel layer, a relational geodatabase, and an interactive query interface. Validation confirmed high spatial fidelity with a Root Mean Square Error (RMSE) of 0.12 meters for parcel coordinates and 98.5% attribute consistency. The implemented CIS successfully transitions land records from an analogue, spatially ambiguous system to a precise, transparent digital framework, effectively resolving boundary conflicts and establishing a foundation for sustainable land-use planning. This model, built on accessible geospatial technology and a clear methodological workflow, presents strong potential as a replicable and practically feasible solution for institutional land administration in similar developing contexts, thereby contributing to spatially informed sustainable development.

Keywords: Cadastral Information System; Geographic Information System; Land Administration; Spatial Governance; Institutional Land Management; FEDPODAM; Nigeria.

INTRODUCTION
Land represents a fundamental spatial resource critical for institutional sustainability and socio-economic development (Williamson et al., 2010). Effective land administration is inherently geographical, requiring precise spatial representation, clear demarcation of rights, and responsive planning mechanisms. Globally, the paradigm has evolved from paper-based cadastres to spatially enabled Land Information Systems (LIS), now recognized as essential geospatial infrastructure for transparent governance (Enemark et al., 2014; FIG, 2014).
In Nigeria, the spatial dimension of land administration remains underdeveloped, characterized by incomplete, non-georeferenced records that perpetuate boundary disputes and hinder sustainable land management (Udoekanem et al., 2014; Nwilo et al., 2020). Institutional land holdings, particularly those belonging to tertiary institutions, exemplify this challenge. These spatially extensive assets are vital for agricultural production, staff welfare, and institutional revenue, yet their management frequently relies on non-spatial, manual record-keeping systems, resulting in tenure ambiguity and inefficient land allocation (Wayumba, 2013; Babalola & Kardam, 2011). The Federal Polytechnic Damaturu (FEDPODAM) farmland serves as a pertinent case study. The institution's management of approximately 80 hectares of allocated land has been hampered by the absence of a coherent geospatial framework. Previous studies in Nigeria have documented CIS development primarily in urban contexts (Orisakwe & Bakari, 2013; Babalola & Kardam, 2011),

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revealing a significant gap in the documented application, operational implementation, and accuracy validation of such systems for peri-urban institutional farmlands, especially within Nigeria's semi-arid north-eastern region.

This study was therefore designed with the explicit objective of creating a fully operational Cadastral Information System (CIS) for the FEDPODAM farmland. It addresses the core research question: How can an integrated geospatial methodology be systematically applied to create, implement, and validate a CIS that effectively resolves the spatial governance challenges inherent in the management of the FEDPODAM farmland? This paper documents the complete geographical workflow from geodetic control establishment to system delivery and validation, providing a replicable spatial model for institutional land governance reform.

STUDY AREA

The FEDPODAM farmland is situated in Damaturu, Yobe State, within north-eastern Nigeria's semi-arid Sudano-Sahelian ecological zone (Fig. 1). Geographically, it extends between latitudes 11°42'N and 11°47'N and longitudes 11°54'E and 12°02'E. The region experiences a unimodal rainfall pattern, making efficient land and water resource management imperative. The 89.3-hectare study area is allocated to polytechnic staff primarily for rain-fed cultivation of staples such Groundnuts, beans, Sorrels and Okra, complemented by small-scale livestock grazing, representing a characteristic mixed land-use system of the region.

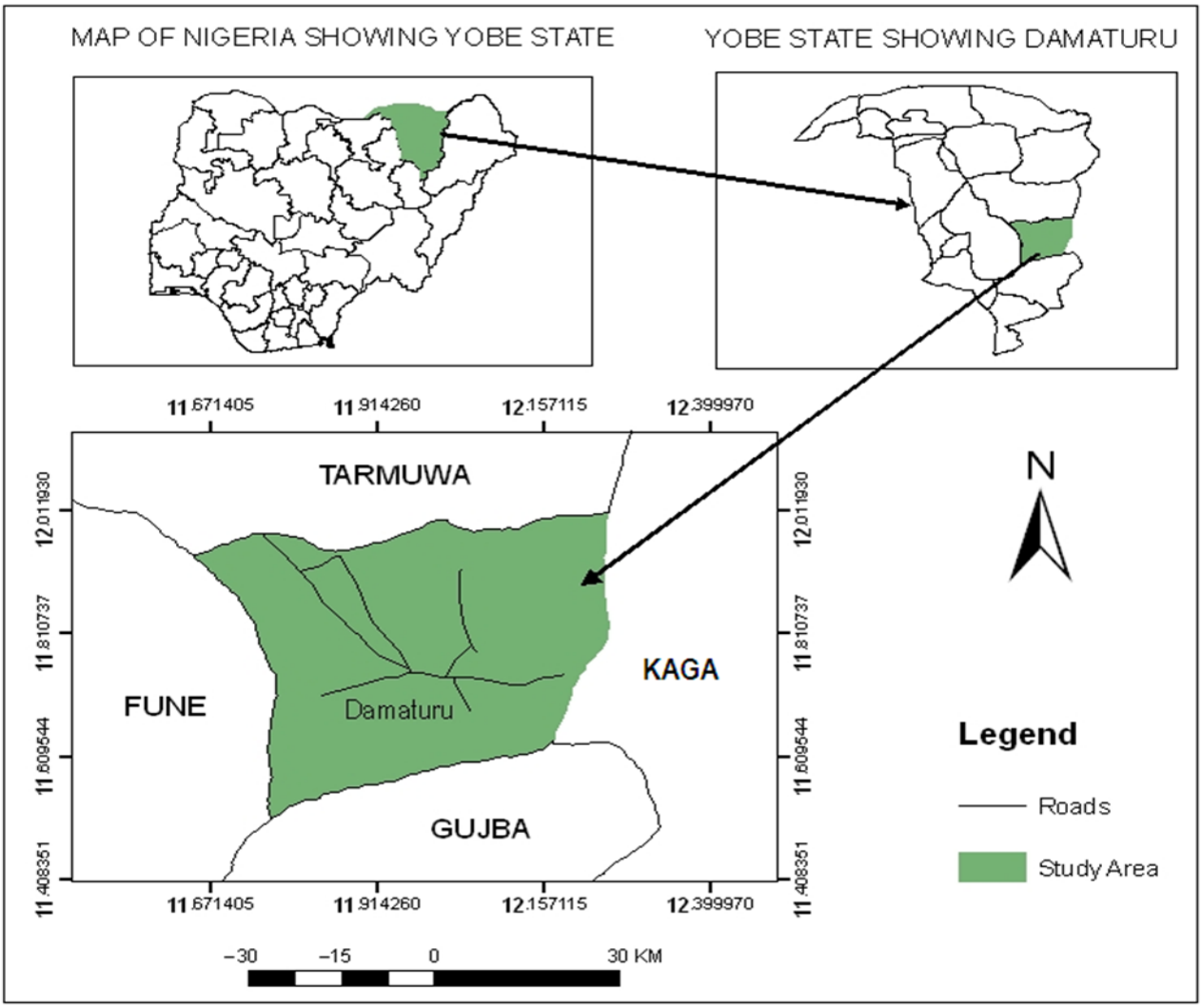

Fig. 1: Map of the Study Area

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METHODOLOGY

Research Design and Data Acquisition

A geospatial design and implementation methodology was employed, following a sequential workflow as indicated in figure 2:

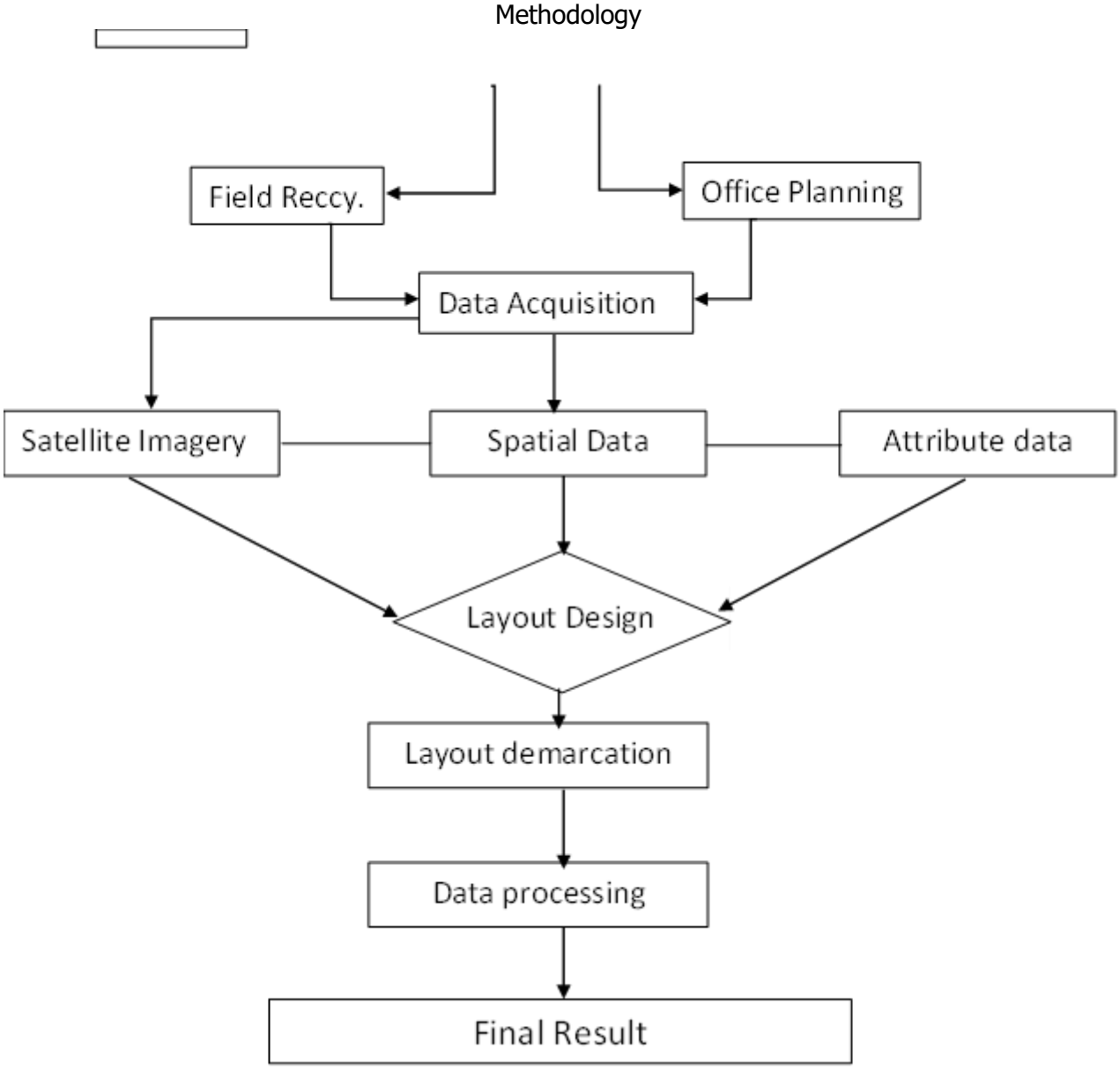

Figure: 2 Workflow Chart

Project commenced with reconnaissance, geodatabase schema design, spatial data acquisition, data processing, system development, and rigorous accuracy validation.

Spatial Data: Remote Sensing data was procured. Primary geospatial data collection utilized GPS receiver for cadastral boundary surveys.

Attribute Data: Socio-tenurial data for all 115 leasehold parcels were collected through structured questionnaires and institutional record audits. Key attributes captured included: Lessee Name, Staff Identification Number, Department, Date of Allocation, Lease Duration, and Land Use/Crop Type.

Field Survey and Data Collection Procedures

Reconnaissance and Planning: An initial site visit facilitated logistics planning and stakeholder engagement with the Farmland Management Committee to define specific system requirements.
Cadastral Boundary Survey: The boundaries of the entire farmland and each internal plot (115 parcels) were obtained.
Socio-Tenurial Data Enumeration: Face-to-face interviews were conducted with leaseholders, and the collected information was meticulously cross-referenced with official institutional records to ensure data integrity and reliability.
CIS Development: Geospatial Data Processing and System Integration
Image Georeferencing and Rectification: The satellite imagery was geometrically corrected and precisely georeferenced within ArcGIS 10.5, using the surveyed control points as Ground Control Points (GCPs).
Spatial-Attribute Integration and System Configuration: Parcel geometry was relationally linked to its corresponding attribute table using a unique Parcel-ID key. The ArcGIS environment was customized to enable essential geospatial functionalities, including thematic mapping and symbology, attribute-based queries (Select by Attribute), location-based queries (Select by Location), and automated cartographic layout generation for official documentation.

Ethical Considerations
This research was conducted under the auspices and formal approval of the Institutional Base Research (IBR) Committee of The Federal Polytechnic, Damaturu, which provides ethical oversight. Informed consent was obtained from all participating leaseholders prior to data collection. Participants were fully briefed on the study's objectives, assured of the confidentiality of their information, and informed that data would be used solely for developing the institutional land management system. No personally identifiable information is disclosed in this manuscript.
Accuracy Assessment and Validation Protocol
The created CIS underwent a multi-faceted validation process against independent measurements and source documents, adhering to international standards (FIG, 1995).
Spatial Accuracy Assessment: Thirty (30) parcel corner points were randomly selected using a stratified sampling method to ensure spatial coverage across the farmland. These points were independently re-surveyed using the DGPS-RTK methodology. The positional accuracy of the CIS was quantified by calculating the Root Mean Square Error (RMSE) between the system coordinates and the validation survey coordinates.
Attribute Accuracy Assessment: A 10% random sample (13 parcels) of the digital attribute records was rigorously audited against the original source documents (signed lease agreements, committee minutes). A consistency rate was calculated to evaluate the thematic accuracy of the database.
System Usability Evaluation: Five (5) members of the Farmland Management Committee, representing potential end-users with varying GIS literacy, participated in a structured usability test. After a 30-minute operational training, they were assessed on performing four core tasks: visualizing the parcel map, identifying parcel details, executing a predefined query, and generating a print-ready map layout, where their success rate was documented.

RESULTS AND DISCUSSION

Outputs and Technical Validation of the Implemented CIS
The creation process successfully yielded four integrated geospatial deliverables: (1) a 1:3200 scale georeferenced orthophoto base map; (2) a topologically correct digital cadastral layer delineating all 115 farm plots (Fig. 3); (3) a fully populated spatial-relational geodatabase linking parcel geometry to comprehensive leaseholder attributes; and (4) a customized interactive ArcGIS interface for querying and map generation.

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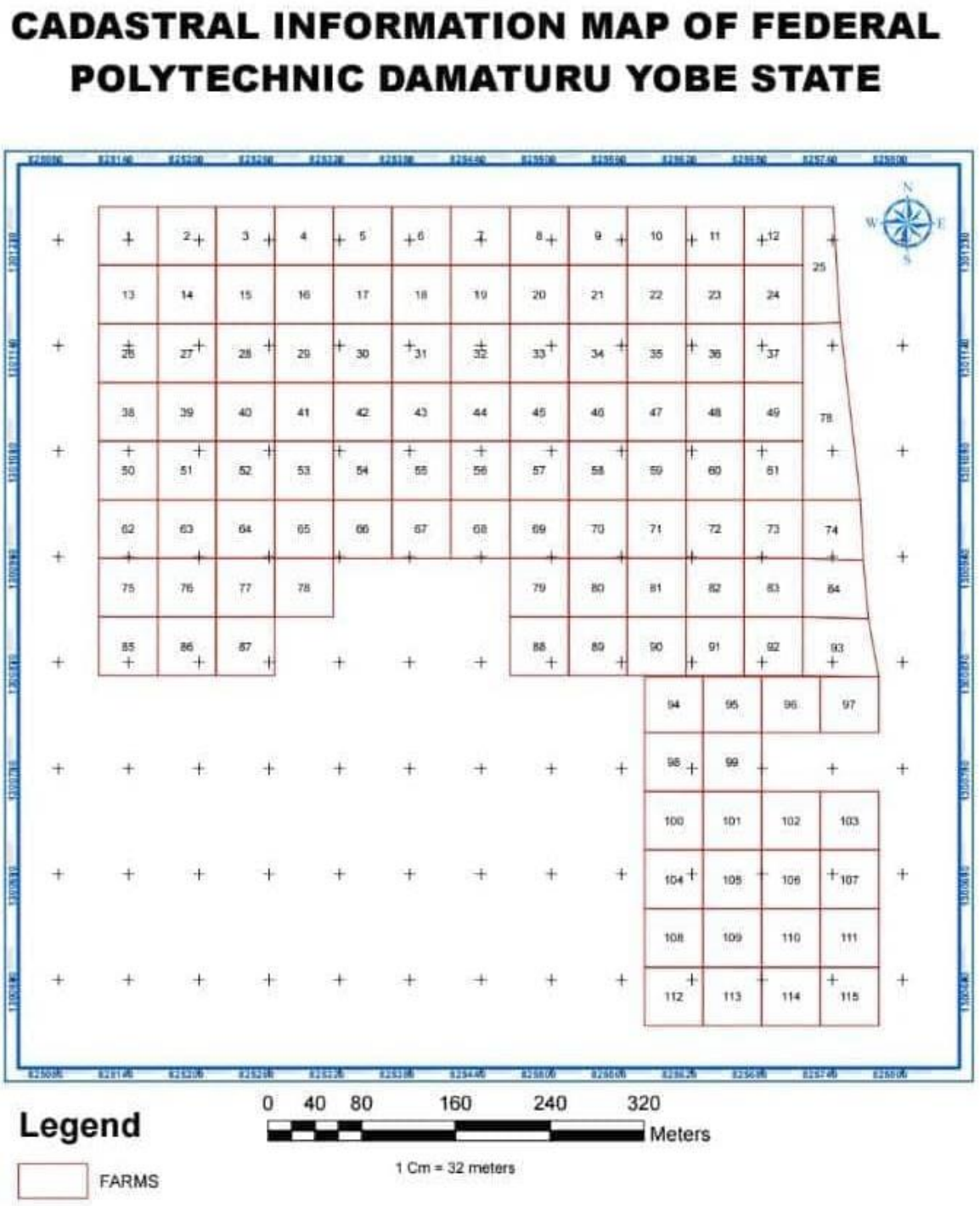

Figure 3: Cadastral Map of FEDPODAM Farmland Showing 115 Parcel Divisions.

Rigorous validation confirmed the system's high degree of spatial and thematic reliability. The spatial accuracy assessment produced a Root Mean Square Error (RMSE) of 0.12 meters, with a maximum observed error of 0.18 meters, complying with international standards for large-scale cadastral mapping. Thematic accuracy was 98.5%, based on a 10% audit of digital records against source documents. End-user testing demonstrated a 90% success rate in performing core administrative tasks after minimal training, indicating the system's practical utility.

Descriptive Spatial Analysis

Analysis of the geodatabase provided key spatial metrics for informed management. The average plot size was 0.41 hectares, with a range from 0.35 to 0.50 hectares, reflecting varied allocation criteria. Groundnut and bean cultivation constituted the dominant land use (65% of leased plots), followed by pasture (20%) and other crops (15%).

Implications for Land Governance and SDGs

The achieved spatial accuracy (RMSE=0.12m) provides an objective, coordinate-based framework that definitively resolves the spatial ambiguity underlying historical boundary conflicts, reinforcing the role of precision surveying in enhancing tenure security (Wayumba, 2013; Babalola & Kardam, 2011). By moving beyond a prototype to an operational system integrated into the institution's workflow, this project bridges a documented implementation gap (Orisakwe & Bakari, 2013).

The CIS transforms land administration by replacing subjective descriptions with authoritative digital maps, thereby securing tenure, and reducing conflicts. It dramatically increases administrative efficiency, enabling complex queries in seconds rather than days, and creates a reliable digital audit trail for enhanced accountability. Furthermore, the system enables proactive, evidence-based spatial planning, supporting decisions on crop rotation, infrastructure, and land reallocation. By establishing a single, transparent geospatial record, it also reduces opportunities for fraudulent allocations.

This work provides a concrete contribution to the Sustainable Development Goals (SDGs). The CIS constitutes resilient and innovative spatial infrastructure, supporting SDG 9 (Industry, Innovation and Infrastructure). By securing tenure and providing a foundation for sustainable land-use planning within the institutional community, it also advances SDG 11 (Sustainable Cities and Communities).

Limitations, Replicability, and Future Directions

The primary limitation is the current desktop-GIS architecture, which restricts access to specific workstations and requires foundational GIS literacy. This presents a direct opportunity for targeted geospatial capacity development within the institution.

The implemented CIS demonstrates strong potential as a replicable and cost-effective model. Its methodology utilizes widely available mid-tier geospatial technology (DGPS, desktop GIS) and follows standardized procedures, making it adaptable to other institutional farmlands. Project execution was contained within a standard institutional research grant, affirming its financial feasibility for comparable settings.

Future work should focus on: (1) migrating the system to a secure web-GIS or mobile platform for broader access; (2) integrating supplementary data layers (e.g., soil, slope) and functional modules (e.g., lease tracking) to evolve into a comprehensive Land Resource Management System (LRMS); and (3) conducting longitudinal studies to quantify the system's long-term impact on productivity, revenue efficiency, and dispute resolution.

CONCLUSION

This research has conclusively detailed the successful creation of a precise, integrated Cadastral Information System for the Federal Polytechnic Damaturu farmland. The project has effectively replaced an opaque, analogue, and conflict-prone manual land record system with a transparent, efficient, and scientifically grounded digital geospatial framework. The implemented CIS secures tenure, empowers administrators with actionable spatial intelligence, and establishes a robust foundation for sustainable land-use planning and decision-making. Beyond addressing an immediate institutional challenge, this work provides a validated, scalable, and cost-effective geospatial model for land administration reform applicable to tertiary institutions and similar public-sector entities across Nigeria and analogous developing regions. It stands as a testament to the transformative potential of applied geospatial science in bridging academic expertise, technological innovation, and tangible institutional development, while making measurable contributions to both local governance objectives and the spatial dimensions of global sustainability goals.

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