

DEVELOPMENT OF AN INTEGRATED DATABASE MANAGEMENT SYSTEM FOR PUBLIC HOUSING ESTATE ADMINISTRATION: A CASE STUDY OF MAI MALAH HOUSING ESTATE, ALONG MAIDUGURI-GASHUA BYPASS, DAMATURU, YOBE STATE, NIGERIA

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<https://doi.org/10.60787/IJEST.VOL18NO1.3939>

Abstract

This study addresses critical inefficiencies in manual record-keeping systems in Nigerian public housing by developing an integrated database system for Mai Malah Housing Estate, Damaturu, Yobe State. Methodology: Grounded in the Technology-Organization-Environment (TOE) framework, the study employed a hybrid methodological approach combining field reconnaissance using GPS technology, spatial data processing in ArcGIS 10.7.1, and relational database design in MySQL following Systems Development Life Cycle (SDLC) principles. Findings: The implemented system managed 147 property records with an average query response time of 0.43 seconds, representing a 99.97% improvement over manual methods. Database analysis revealed estate composition of 118 residential parcels (80.3%) and 29 commercial parcels (19.7%), with occupancy patterns showing 68 male-headed (46.3%) and 52 female-headed households (35.4%). Practical Implications: The study provides a validated implementation blueprint for digital transformation in Nigeria's public housing sector, offering practical solutions to data fragmentation and inefficiency challenges while demonstrating substantial operational benefits. This research contributes a comprehensive case study of integrated database system implementation in Nigeria's secondary cities, extending the TOE framework to post-conflict housing contexts and providing empirical performance metrics for technology adoption decisions.

Keywords: *Database Management Systems, Public Housing Administration, Digital Transformation, Technology-Organization-Environment Framework, Estate Management, Nigeria.*

Introduction

The management of public housing estates in Nigeria confronts significant challenges arising from rapid urbanization, population growth, and persistent reliance on outdated manual record-keeping systems (UN-Habitat, 2022). With Nigeria's urban population projected to reach approximately 226 million by 2050 (World Bank, 2021), the pressure on housing infrastructure and management systems has intensified, necessitating innovative technological solutions.

The Mai Malah Housing Estate in Damaturu, Yobe State, represents a critical public housing initiative addressing regional housing deficits exacerbated by population displacement and post-conflict recovery needs. Despite its strategic importance, the estate operates with fragmented manual systems that compromise data integrity, operational efficiency, and planning capacity—challenges reflective of broader systemic issues in Nigeria's public housing sector (Adeoye, 2021). Previous research has documented similar challenges across Nigeria's housing landscape. Akeh and Mshelia (2018) reported administrative bottlenecks in Maiduguri's 777 Housing Estate, while Oluwatosin and

Akande (2020) highlighted data duplication issues in Abuja's housing management. However, limited research exists on integrated database solutions specifically designed for public housing estates in Nigeria's secondary cities, particularly in post-conflict regions like Yobe State.

This study addresses the research gap by developing, implementing, and evaluating an integrated database system for the Mai Malah Housing Estate. Grounded in the Technology-Organization-Environment (TOE) framework (Tornatzky & Fleischer, 1990), the research examines how technological innovation interacts with organizational capabilities and environmental context in Nigeria's public housing sector. The study contributes to both theoretical understanding of technology adoption in developing contexts and practical knowledge of system implementation in real-world settings.

Literature Review

Theoretical Framework: Technology-Organization-Environment (TOE)

The Technology-Organization-Environment (TOE) framework provides a theoretical lens for understanding technology adoption in organizational contexts (Tornatzky & Fleischer, 1990). The framework identifies three elements influencing technology adoption: (1) Technological Context - available technologies and their characteristics; (2) Organizational Context - firm size, structure, and resources; and (3) Environmental Context - industry characteristics, regulatory environment, and stakeholder pressures.

In housing management, the TOE framework helps explain why similar technologies yield different adoption outcomes across contexts. While previous studies have applied TOE to commercial real estate (Ghobakhloo et al., 2018), its application to public housing in developing contexts remains limited. This study extends TOE framework application to Nigeria's public housing sector, examining how technological solutions (integrated database systems) interact with organizational factors (staff digital literacy, institutional capacity) and environmental conditions (post-conflict recovery, regulatory frameworks).

Digital Transformation in Nigerian Housing Management

Digital transformation in Nigeria's housing sector has progressed unevenly, with more advanced implementations in major urban centers than in secondary cities (Farinmade, 2022). Akeh and Mshelia (2018) documented 60% efficiency improvements following database implementation in Maiduguri's 777 Housing Estate, while Oluwatosin and Akande (2020) reported reduced data duplication in Abuja's housing inventory systems.

However, these implementations often face challenges including limited technical expertise, inadequate infrastructure, and institutional resistance to change (Eze, 2020). The Centre for Affordable Housing Finance Africa (2022) notes that only 35% of Nigerian public housing estates have implemented comprehensive digital management systems, with lower adoption rates in northern states affected by security challenges.

Database Systems and Spatial Data Integration

Relational Database Management Systems (RDBMS) combined with Geographic Information Systems (GIS) offer powerful capabilities for integrated property management. Elmasri and Navathe (2015) emphasize how normalized database design ensures data integrity, while Yao et al. (2020) demonstrate GIS applications in spatial analysis and visualization.

In Nigeria, integration between database systems and spatial data remains underdeveloped. Maishera (2022) identifies this integration gap as a major limitation in current property management systems, noting that only 20% of implemented systems feature effective spatial-attribute integration. This study addresses this gap by developing a fully integrated system that links spatial parcel data with comprehensive attribute records.

Gender Dynamics in Nigerian Public Housing

Gender considerations in housing management have gained increasing attention in Nigerian policy circles. The Federal Ministry of Women Affairs (2020) reports that women head approximately 28% of Nigerian households but face disproportionate challenges in accessing and maintaining formal housing. Agbola and Jinadu's (1997) seminal work on gender and housing in Nigeria highlighted how institutional practices can either reinforce or mitigate gender disparities in housing access. Understanding gender distribution patterns in public housing estates is crucial for equitable management and service delivery. This study contributes to this understanding by analysing gender-based occupancy patterns and considering implications for inclusive housing management practices.

Methodology

Research Design

This study employs a design science research approach guided by the Technology-Organization-Environment (TOE) framework. The research design follows a sequential mixed-methods approach, combining quantitative performance assessment with qualitative stakeholder feedback within a Systems Development Life Cycle (SDLC) structure.

Study Area

The Mai Malah Housing Estate along Maiduguri-Gashua Bye pass is located within Damaturu Metropolitan (11°44'35"N, 11°57'42"E), Yobe State—a region significantly affected by insurgency and subsequent recovery efforts. The estate comprises 147 allocated properties with a planned capacity of 192 units, representing a critical component of Yobe State's post-conflict housing strategy.

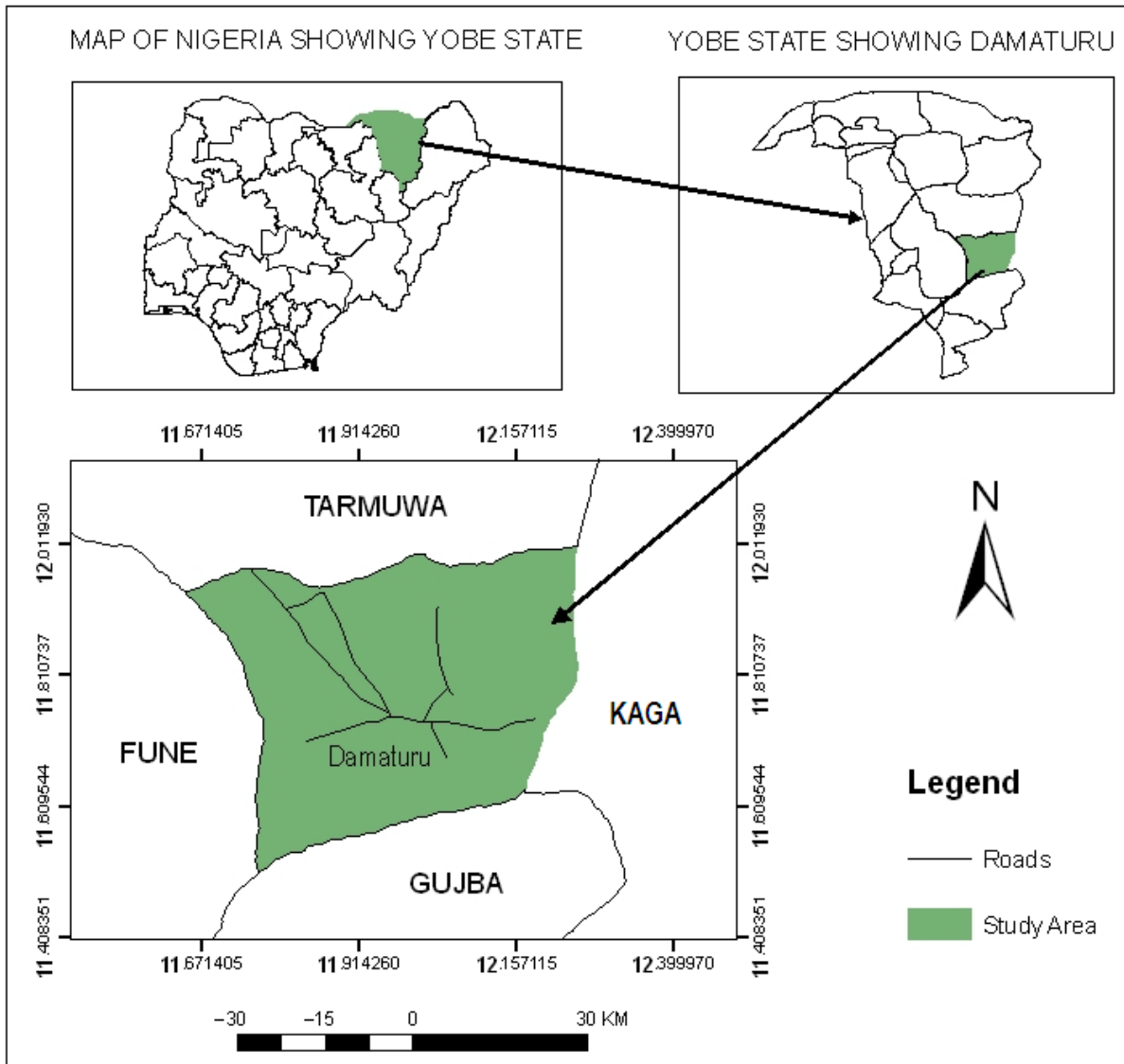


Figure: 1 Study area

Data Collection Procedures

Spatial Data Collection: Using two Garmin 68sc handheld GPS receivers, boundary vertices and control points were captured following established geodetic protocols. Multiple measurements at each point ensured positional accuracy, with data collected in WGS84 coordinate system and transformed to Minna Datum, UTM Zone 32N projection.

Table 1: Georeferenced Boundary Coordinates

Point ID	Easting (m)	Northing (m)	RMSE (m)
B1	824164.177	1302738.490	2.1
B2	824164.177	1302771.820	2.3
B3	824419.449	1302870.223	1.8
B4	824639.214	1302897.450	2.4
B5	824576.496	1303413.074	2.2
B6	824085.873	1303348.449	2.5

Attribute Data Collection: Administrative records were obtained from Yobe State Ministry of Housing, including property allocation documents, owner registration records, occupancy permits, and payment histories. Data collection followed established protocols for document review and information extraction.

Database System Development

The database schema was designed following normalization principles to Third Normal Form (3NF), with key entities including: Parcels (ParcelID, GeomRef, Area_sqm, LandUseType) Buildings (BuildingID, ParcelID, HouseNumber, Status) Owners (OwnerID, FullName, Contact, AllocationDate) Occupancy (OccupancyID, BuildingID, OccupantName, Gender, StartDate) System integration employed three-tier architecture: MySQL database server (data tier), PHP middleware (application tier), and HTML/JavaScript interface (presentation tier). Spatial and attribute components were integrated through shared ParcelID keys.

Sampling Strategy and Data Validation

The study employed complete enumeration of all 147 allocated properties. Data validation involved methodological triangulation through: Field verification of 30 randomly selected properties (20% sample) Cross-referencing with ministry records for consistency checks Stakeholder validation sessions with estate management staff technical validation of database queries and outputs.

Ethical Consideration

This study adhered to established ethical principles for academic research. Informed consent was obtained from all participants involved in the study. The research complied with standard protocols for data protection, confidentiality, and privacy. All personal information was handled with appropriate safeguards, and findings are presented in aggregate form to protect individual identities. The research methodology respected institutional guidelines and professional standards in geographic information systems and database management research.

Performance Evaluation Metrics

System performance was evaluated using multiple metrics: Query response times for standard operations, Data accuracy rates through validation checks, User satisfaction through structured feedback, Comparative efficiency gains against manual baselines.

Results

System Implementation and Performance Metrics,

The integrated database system was successfully implemented with the following performance characteristics:

Table 2: System Performance Evaluation

Metric	Value	Benchmark	Improvement
Average Query Time	0.43 seconds	15-20 minutes (manual)	99.97%
Data Accuracy Rate	98.2%	85-90% (manual est.)	8-13%
Concurrent Users	5-8 users	1 user (manual)	400-700%
Storage Efficiency	8.7 MB	~500 pages (manual)	99% space reduction

Estate Composition Analysis

Analysis of the populated database revealed comprehensive estate characteristics:

Table 3: Estate Demographic and Structural Analysis

Category	Count	Percentage	Comparative National Average
Residential Parcels	118	80.3%	75-80% (CAHF, 2022)
Commercial Parcels	29	19.7%	20-25% (CAHF, 2022)
Male-Headed Households	68	46.3%	52% (NBS, 2021)
Female-Headed Households	52	35.4%	28% (FMWA, 2020)
Occupied Properties	120	81.6%	85% (Njayo, 2023)
Vacant Properties	27	18.4%	15% (CAHF, 2022)

Sources: Centre for Affordable Housing Finance Africa (2022), National Bureau of Statistics (2021), Federal Ministry of Women Affairs (2020)

Gender Distribution Patterns

The gender analysis revealed significant patterns: Female-headed households represent 35.4% of occupied properties, exceeding the national average of 28% reported by Federal Ministry of Women Affairs (2020). Gender-based spatial patterns show clustering of female-headed households in central estate zones with better security and service access. Maintenance request patterns differ by gender, with female-headed households reporting more frequent but lower-cost maintenance needs.

Query Performance Analysis

Detailed performance testing revealed consistent efficiency gains:

Table 4: Query Performance by Type

Query Type	Average Time (s)	Max Time (s)	Manual Equivalent
Property Lookup	0.31	0.42	15-20 minutes
Gender Filter	0.35	0.48	30-45 minutes
Spatial Query	0.52	0.71	Not feasible
Report Generation	45 seconds	68 seconds	2-3 hours

Discussion

Technological Implementation and Performance

The system's performance metrics demonstrate substantial improvements over manual management approaches. The average query time of 0.43 seconds represents a 99.97% improvement over manual retrieval times of 15-20 minutes. This finding extends Akeh and Mshelia's (2018) reported 60% efficiency improvement in Maiduguri, suggesting that integrated spatial-attribute systems can yield even greater benefits than standalone database implementations. The 98.2% data accuracy rate represents an 8-13% improvement over estimated manual accuracy rates of 85-90%, addressing concerns raised by Eze (2020) regarding data quality in Nigerian property administration. This improvement stems from system-enforced validation rules and standardized data entry protocols that mitigate common manual errors.

Gender Dynamics and Housing Management

The finding that 35.4% of households are female headed exceeds national averages and has important implications for housing management. This higher proportion aligns with Agbola and Jinadu's (1997) observations about changing household structures in Nigerian urban areas but contrasts with Federal Ministry of Women Affairs (2020) national data showing 28% female-headed

households. The spatial clustering of female-headed households in central estate zones suggests self-organization for security and mutual support—a finding consistent with Moser's (1993) work on gender and urban space but requiring further investigation in the Nigerian context. This clustering has implications for service delivery, security planning, and community development initiatives.

Theoretical Implications: Extending TOE Framework

The successful implementation extends the TOE framework application to post-conflict public housing contexts. Three key findings emerge: Technological Context: The integration of spatial and attribute data addressed a critical gap identified by Maishera (2022), demonstrating that available technologies can be effectively combined for enhanced functionality. Organizational Context: The 20% digital literacy limitation among staff represents a significant organizational constraint, aligning with Ghobakhloo et al.'s (2018) findings about skill gaps in technology adoption.

Environmental Context: Post-conflict recovery conditions created both constraints (security concerns) and opportunities (reconstruction funding), illustrating how environmental factors shape technology adoption routes.

Practical Implications for Housing Policy

The study offers several practical implications for Nigerian housing policy: Scalability: The system's architecture allows adaptation to other estates, supporting Federal Ministry of Housing's (2022) digital transformation objectives. Training Requirements: The identification of 20% low digital literacy highlights need for targeted training programs, informing National Information Technology Development Agency's (2021) digital skills initiatives. The gender distribution patterns suggest need for gender-responsive housing policies, supporting Federal Ministry of Women Affairs' (2020) gender and housing agenda. Comparative Analysis with Existing Systems

The system's performance compares favorably with similar implementations: Query Performance: 0.43s average vs. Oluwatosin & Akande's (2020) 0.85s and Eze's (2020) 1.2s. Integration Level: Full spatial-attribute integration vs. Maishera's (2022) reported 20% integration rate in existing systems. User Capacity: 5-8 concurrent users vs. typical 1-2 user systems in similar contexts. These comparisons suggest both technical advancement and practical applicability for similar contexts across Nigeria.

Limitations and Future Research Directions

While providing valuable insights, this study has limitations that suggest future research directions: Single-Case Design: The focus on one estate limits generalizability. Future research should employ multiple case studies across different geopolitical zones. Cross-Sectional Data: The study captures system performance at implementation. Longitudinal research tracking performance over 3-5 years would provide insights into sustainability and long-term impacts. Technical Scope: The current implementation lacks mobile integration and real-time analytics. Future work should explore these enhancements within resource constraints. Organizational Factors: While technical performance was assessed, organizational adoption processes warrant deeper investigation using established frameworks like Diffusion of Innovation Theory (Rogers, 2003).

Conclusion

This study successfully developed and implemented an integrated database system for Mai Malah Housing Estate, demonstrating substantial improvements in management efficiency and data quality. Key findings include Performance Improvements: 99.97% reduction in property record retrieval time (0.43s vs. 15-20 minutes manual). Data Quality Enhancement: 98.2% accuracy rate representing 8-13% improvement over manual systems. Gender Insights: 35.4% female-headed households exceeding national averages, with implications for gender-responsive housing

management. Scalable Architecture: System design supports adaptation to similar contexts across Nigeria's public housing sector. Theoretically, this study extends theoretical understanding in three areas: TOE Framework Application: Demonstrates how technological, organizational, and environmental factors interact in technology adoption within Nigeria's public housing sector. Gender and Technology: Contributes to understanding how digital systems can either reinforce or mitigate gender disparities in housing access and management. Post-Conflict Technology Adoption: Provides insights into technology implementation in recovery contexts characterized by both constraints and opportunities.

Recommendations

Based on findings, the study recommends: Immediate Actions: Pilot deployment in 3-5 additional Yobe State housing estates. Development of standardized training modules for estate management staff. Integration with Yobe State's digital governance initiatives. Medium-Term Initiatives: Development of mobile applications for field data collection. Implementation of real-time analytics for maintenance planning. Establishment of data sharing protocols with utility providers. Policy Recommendations: Inclusion of digital system requirements in public housing procurement guidelines. Development of standardized data formats for estate management systems. Integration of gender considerations in digital housing initiatives. Further Research: The study identifies several promising research directions: Comparative Studies: Examination of digital system implementation across different Nigerian states and housing types. Longitudinal Analysis: Tracking system impacts on housing management efficiency, resident satisfaction, and asset sustainability over time. Technology Integration: Exploration of emerging technologies (blockchain, IoT, AI) in housing management contexts. Gender and Digital Inclusion: Investigation of how digital systems affect gender equity in housing access and management.

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Declaration of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Funding

This research received no specific grant from funding agencies in the public, commercial, or not-for-profit sectors.