

Blockchain-Based Land Registration for Trusted Property Records: System Design and Functional Validation in Nigeria

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ARTICLE INFORMATION	ABSTRACT
Article history: Published: October 2026 Keywords: Blockchain Land Registration Property Records Smart Contracts Functional Testing	Land registration depends on reliable records, verifiable ownership histories, accountable administrative decisions, and legally recognized procedures for creating and transferring property rights. Paper-centred processes can make record search slow and expose registries to risks associated with document loss, unauthorized alteration, fragmented information, and competing claims. Blockchain technology offers a possible technical layer for maintaining tamper-evident transaction histories, while smart contracts can encode selected procedural rules. This paper presents the design and reported functional validation of a blockchain-based land registration system developed for the Ebonyi State, Nigeria, context. The project adopts a permissioned Ethereum architecture, Solidity smart contracts, and a hybrid data model that combines on-chain transaction references with off-chain application and land-record data. A Node.js/Express service layer and React interface are described as the application components. The development process follows a Waterfall system-development life cycle, informed by observation, interviews, examination of records, and questionnaires described in the project report. The documented functional tests cover authentication, title issuance, ownership transfer, duplicate-title detection, payment processing, and dispute filing. All six cases are reported as passing; the payment case records a two-minute completion time for a stated ₦8,000,000 transaction. These results provide preliminary evidence of functional workflow coverage, but they do not establish statewide operational effectiveness, statistically significant processing-time improvement, resistance to adversarial attacks, or legal validity of blockchain records as conclusive proof of title. The paper's contribution is a locally contextualized system architecture and an evidence-conscious functional evaluation that identifies both the value and the limits of blockchain-supported land administration. It concludes that blockchain can strengthen auditability only when combined with authoritative source-data validation, accountable registry governance, privacy controls, security testing, institutional adoption, and a clear legal framework.

1. Introduction

Land records are foundational public information assets. They help establish who holds a recognized interest in a parcel, describe the parcel and its boundaries, record transactions and restrictions, and support planning, taxation, investment, and dispute resolution. A land registration system therefore does more than store documents: it connects evidence, administrative authority, legal rules, and the sequence of decisions through which rights are recognized. When those connections are fragmented or difficult to audit, uncertainty can arise for owners, prospective purchasers, lenders, surveyors, lawyers, and public agencies. Digitisation can improve access and retrieval, but a conventional database alone does not automatically provide a shared, independently verifiable history of changes across institutional actors.

The project underlying this paper focuses on the land-registration context of Ebonyi State, Nigeria, with the Abakaliki Land Registry identified as its institutional setting. The project report describes weaknesses associated with paper-based processing, including slow manual searches, exposure of physical records to loss or damage, limited transparency, and the possibility of conflicting or duplicate claims. These are presented here as the problem context reported by the project, rather than as independently measured statewide prevalence estimates. The distinction matters because a technical prototype can demonstrate that selected workflows are implementable without proving that the whole public registry has adopted the system or that fraud has been eliminated in practice. Blockchain is relevant to this problem because it can maintain an append-only, replicated transaction history and make changes more difficult to conceal after records have been accepted by the network. Smart contracts can enforce machine-checkable conditions such as whether a parcel identifier already exists, whether an authorized account has initiated a transfer, or whether a dispute flag blocks a further transaction. Research on blockchain and property, however, cautions that the technology does not itself establish the truth of information entered into the system, resolve conflicts in the underlying legal record, or replace public institutions responsible for recognizing property rights (Graglia & Mellon, 2018; Kaczorowska, 2019; Saari et al., 2022). This paper adopts that more bounded understanding of the technology.

The system described in the project combines a permissioned Ethereum network with Solidity-based smart contracts and a hybrid on-chain/off-chain data architecture. The application layer is described as using Node.js and Express.js, with a React.js user interface

and a PostgreSQL database. The proposed workflows include land registration, title issuance, ownership transfer, title verification, encumbrance recording, payment processing, and dispute filing. The design intends to support authorized access to current records and a durable history of transactions. Because the production source code was not inspected for this manuscript, the implementation description is based on the project report and must be checked against the code before submission.

The purpose of this paper is to present the system as an applied information-systems contribution and to assess what its reported functional tests demonstrate. It does not claim to prove that the system is legally authoritative, ready for statewide deployment, immune to fraud, or more efficient than the existing registry by a statistically established margin. The distinction between a successful software workflow and a validated land-administration intervention is central to a credible research contribution.

The paper makes three contributions. First, it synthesizes the project's architecture into a layered model that separates institutional authorization, application services, smart-contract rules, blockchain transaction history, and off-chain data management. Second, it maps the documented functional test cases to the land-registration functions they exercise, making the evaluation more transparent and reproducible. Third, it identifies technical, legal, data-governance, and deployment conditions that must be addressed before the prototype can be interpreted as an operational public registry. The paper's novelty is therefore an implementation-focused, Nigerian-contextualized design and evidence audit—not a claim that blockchain land registration is globally unprecedented.

The remainder of the paper is organized as follows. Section 2 reviews land administration, blockchain, smart contracts, and related research. Section 3 describes the development and evaluation approach. Section 4 presents the system architecture and key workflows. Section 5 reports the functional test evidence. Section 6 discusses the implications and limitations. Section 7 concludes with recommendations for further validation and deployment.

2. Literature Review

2.1 Land administration as a socio-technical system

The project situates the proposed system within the administrative context of the Ebonyi State Ministry of Lands, Survey and Urban Development. It identifies manual searching and fragmented records as workflow problems and proposes a unified digital interface with blockchain-backed transaction references. This is an important framing: the relevant outcome is not simply the presence of a blockchain but whether the architecture supports a clearer, traceable, and institutionally controlled registration process. The paper therefore treats blockchain as one component within a broader land-administration system rather than as a replacement for cadastral expertise or statutory authority (Enemark et al., 2014).

2.2 Blockchain properties and their relevance to property records

A blockchain is a replicated ledger in which transactions are grouped into blocks or otherwise ordered according to a protocol and cryptographically linked to prior state (Zhao et al., 2022). Depending on the network design, participants may be open to the public or restricted to authorized organizations. Permissioned networks can provide clearer membership management and predictable governance, but they also require explicit decisions about who operates nodes, who can submit transactions, who can approve changes, and how disputes among participating institutions are resolved. The Hyperledger Fabric design illustrates how permissioned blockchain infrastructure can support enterprise workflows, although the architecture and trust assumptions of Fabric differ from Ethereum (Androulaki et al., 2018).

For land records, the principal benefit is a tamper-evident history of accepted events. If a registered title is transferred, a ledger entry can preserve the transaction's provenance and make unauthorized retrospective rewriting more difficult. A verifier may inspect the relevant transaction reference without relying solely on a mutable application screen. Yet immutability should not be confused with truth. If a forged deed, incorrect parcel identifier, or unauthorized allocation is accepted at the point of registration, the ledger may preserve the erroneous record. The system must therefore combine ledger integrity with verification of documents, authority, survey data, and the legal status of the property.

2.3 Smart contracts and land-registration workflows

Smart contracts are programs executed by a blockchain platform when invoked by a transaction. They can maintain state and enforce deterministic conditions, such as rejecting a duplicate parcel key or allowing a transfer only when the caller is authorized and the title is active. Reviews of blockchain applications identify smart contracts as a way to automate repeatable business rules, while also noting that correctness depends on the quality of the code, the accuracy of inputs, and the adequacy of the surrounding governance (Casino et al., 2019; Onuora et al., 2024a).

2.4 Related blockchain land-registry research

Kaczorowska (2019) examines the potential and limitations of blockchain-based land registration, including the risk that irreversibility and automated transactions may be mistaken for adequate legal control. Graglia and Mellon (2018) similarly argue that blockchain adoption in property registries depends on prerequisites and institutional choices, not only on technical feasibility. Saari et al. (2022), in a systematic review of blockchain's possible role in real estate, identify legal, technical, and implementation barriers and caution that blockchain does not solve the initial problem of bringing reliable land and ownership data into a formal registry. These studies support a cautious, institution-centred approach to system design.

Blockchain research by Onuora et al., provides relevant adjacent work on smart-contract use cases and decentralized networks (Onuora et al., 2024a, 2024b). Their relevance here is conceptual: it helps situate smart contracts and distributed ledgers within a broader body of work on blockchain applications. It is not direct empirical evidence that a land-registration system improves title security. Likewise, work on threat modelling in permissioned blockchain systems from the same research environment provides a useful pointer to the need for explicit adversarial analysis, but an electoral-system threat model cannot be transferred uncritically to land administration (Ana et al., 2025). Perera et al. (2021) developed an incubation-ready prototype for blockchain-based property transactions, demonstrating the technical feasibility of the approach in a controlled environment.

The reviewed literature indicates a recurring gap between technical feasibility and operational proof. A land-registration paper should identify what was implemented, how the system was tested, what the test results establish, and what remains untested. The current project offers a

documented architecture and a small functional test matrix. Its most defensible contribution is a case-specific system design and preliminary functional validation. More extensive claims about security, efficiency, adoption, or impact require additional data and experiments.

2.5 Conceptual framework and research questions

Three research questions guide the analysis:

- (RQ1) How is the proposed blockchain-based land-registration system structured to support title registration, transfer, verification, and dispute-related workflows?
- (RQ2) What functional evidence is reported for the implemented workflows?
- (RQ3) What limitations and assurance requirements must be addressed before the system can support institutionally credible land administration?

These questions are deliberately aligned with the available project documentation rather than with unmeasured social or economic outcomes.

3. Methodology

3.1 Research design

This study is a design-and-evaluation paper based on a student software-development project. It combines a descriptive account of the system architecture with a document-based analysis of reported functional tests. It is not a controlled comparison of blockchain and non-blockchain systems, a randomized user study, or a longitudinal assessment of registry performance. This scope is important because the available evidence supports discussion of design decisions and selected software behaviours, but it does not support estimates of population-level effects.

3.2 Requirements elicitation and source material

The project report states that requirements were informed by observation, interviews, examination of existing records, and questionnaires. The participant groups named in the report include landowners, registry officers, surveyors, legal practitioners, and local government land officers. Observation was intended to document the flow of registration and verification activities. Interviews were intended to capture operational experiences and bottlenecks. Record examination was intended to understand the structure and availability of existing title information. Questionnaires were described as gathering stakeholder experiences and perceptions of the existing process and proposed digital solution.

The project also refers to approximately 250 anonymized land-parcel records and simulated transaction scenarios in its scope description. However, the supplied test table does not provide the dataset itself, record-level outcomes, a confusion matrix, or a reproducible protocol showing how many records were used for each test. This paper therefore does not claim that 250 records were processed successfully or use that number as a sample size for performance analysis. The dataset size and its actual use should be confirmed from project artefacts before the manuscript is submitted.

3.3 System Architecture and Technology Stack

The project describes a permissioned Ethereum network using a Proof of Authority consensus configuration, Solidity smart contracts, a Node.js/Express.js backend, a React.js frontend, and a PostgreSQL database. Web3.js is described as the interface between the application service and the blockchain. The architecture is hybrid: blockchain state and transaction references support auditability, while off-chain storage supports application records and document metadata.

3.4 Functional Test Data

The project provides six functional test cases with input, expected output, actual output, and status. They cover user authentication, title issuance, land transfer, duplicate-title/fraud detection, payment processing, and dispute filing. All six are marked “Pass” in the report. The payment test records an ₦8,000,000 transfer completed in two minutes. The title-issuance case reports that a hash was generated and stored on three nodes; the transfer case reports a blockchain-confirmed transaction; and the duplicate-title case reports that a conflict was flagged and escalated. These are presented as project-reported outcomes, not independently reproduced results.

3.5 Analytical Approach

The analysis uses descriptive mapping rather than statistical inference. Each test is mapped to a system function, expected control, reported outcome, and evidence limitation. Claims are classified as

- (a) described design features,
- (b) outcomes reported in the project, or
- (c) future requirements that remain unverified. This classification is intended to prevent the common error of treating planned capabilities as measured outcomes.

These limits do not negate the value of the design work. They define the appropriate strength of the conclusion: the project reports that the selected functional workflows passed its tests, but additional evidence is needed to infer that the platform reduces fraud, accelerates the full registration process, or improves public trust in routine operational use.

4. Findings

4.1 Architectural overview

The system is designed as a layered land-registration application. Users interact through a browser-based interface; the application server authenticates requests, applies application-level validation, and calls the smart-contract layer through a blockchain client. The contract maintains selected parcel and transaction state, while the relational database stores user profiles, application details, document metadata, and search-oriented information. This separation allows the system to combine the blockchain’s ordered transaction history with the query and reporting functions expected from a conventional information system.

Figure 1 presents a system architecture of the project description. It is a paper-level representation, not a deployment diagram generated from source code. The arrows represent logical interactions; the exact APIs, database schema, contract interfaces, and network topology must be verified against the implementation before submission.

Table 1: Logical architecture

Layer	Reported components	Primary responsibility	Assurance question
User and institutional access	React.js interface; owner, registry officer, administrator and other roles	Submit applications, review evidence, search records, initiate transfers and disputes	Are identities and roles verified correctly?
Application services	Node.js and Express.js	Input validation, workflow orchestration, notifications, database operations and blockchain calls	Are API permissions and transaction boundaries enforced?
Smart-contract rules	Solidity contracts on permissioned Ethereum	Register parcel keys, check transfer conditions, record state changes and emit transaction events	Are invariants correct and resistant to unauthorized calls?
Distributed ledger	Permissioned Ethereum network; Proof of Authority stated in project	Replicate accepted transaction state and provide a durable transaction history	Who controls validators and how are governance changes approved?
Off-chain data	PostgreSQL database and document metadata store	Store profiles, application details, supporting-document references and search-oriented data	Are data protected, backed up, synchronized and access-controlled?
Assurance and governance	Audit records, registry review, test procedures and administrative policies	Support accountability, recovery, correction and oversight	Can errors and disputes be handled without obscuring the audit trail?

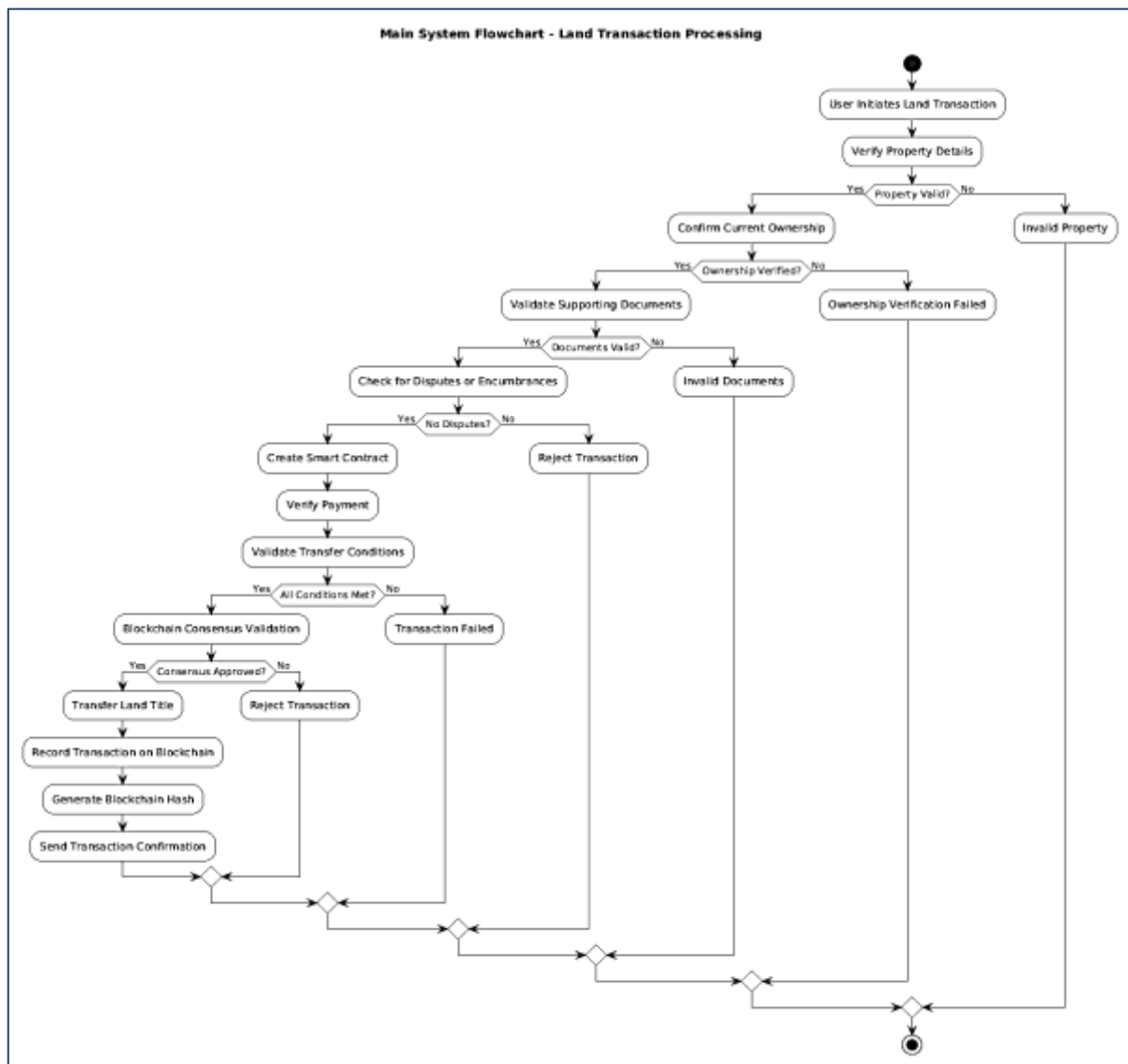


Figure 1: System Flowchart – Land Transaction Processing

4.2 Permissioned network and institutional roles

The project describes a permissioned Ethereum configuration with Proof of Authority consensus. In such a design, participation and validation are restricted to approved nodes rather than being open to any anonymous participant. This is potentially appropriate for a public land

registry where participating institutions must be identifiable and operational responsibilities must be assigned. Permissioning, however, shifts some trust from anonymous consensus toward the organizations that admit participants, operate validator nodes, manage keys, and resolve governance disputes. The system therefore needs a documented membership policy and an audit trail for administrative actions. The report identifies several classes of users, including property owners, registry officers, administrators, and other stakeholders who may verify titles or interact with transactions. Their permissions should be least-privilege: an owner may submit an application or initiate a transfer, while a registry officer may validate supporting evidence and approve an eligible registration. A verifier may read approved public fields but should not modify title state. An administrator may manage accounts and system configuration but should not be able to silently rewrite an established ownership history. Where privileged actions are required, they should be logged and attributable to an authorized identity.

4.3 Hybrid on-chain and off-chain data model

The hybrid model is a central architectural decision. Blockchain storage is best reserved for data that benefit from durable transaction history and shared verification, while personal information and large supporting documents are more appropriately managed off-chain under explicit access and retention rules. A practical design may store a stable parcel identifier, a status field, a reference to the current registered owner, transaction timestamps, and hashes or identifiers linking to approved documents on-chain. Off-chain storage may retain the actual application forms, identity documents, survey plans, contact details, payment receipts, and administrative notes.

The relational database provides efficient filtering, joins, search, and reporting. It also introduces consistency requirements. If a database update succeeds but a blockchain transaction fails, the application must not display the transaction as finalized. If the blockchain transaction succeeds but the database update fails, the system must be able to reconstruct the local view from the transaction record or place the transaction in a reconciliation queue. The application should use explicit transaction states such as submitted, pending review, submitted to chain, confirmed, rejected, and under dispute. A reliable implementation should not rely on a single success message to represent all these stages.

4.4 Registration and title issuance workflow

The registration workflow begins when an applicant submits parcel information and supporting documents through the interface. Application services validate required fields and store an application record. Registry personnel then review the submitted evidence and determine whether the application satisfies administrative requirements. The project's architecture describes the backend generating a cryptographic hash of verified parcel data and invoking a Solidity contract through Web3.js. The contract checks parcel uniqueness and, where the required conditions are satisfied, records the relevant state and emits a transaction event. A digital title document can then be generated with a QR code or transaction reference for later verification.

The critical boundary is the transition from application submission to authoritative registration. A user-submitted parcel identifier must not be treated as proof of ownership. The registry must establish that the supporting documents and survey references are acceptable and that the official approving the application is authorized. The smart contract can enforce that a parcel key has not already been registered in the ledger, but this is only as reliable as the parcel-identification scheme and the completeness of the existing records. If the same physical parcel is represented under different identifiers, a uniqueness check on the identifier alone will not detect the duplicate.

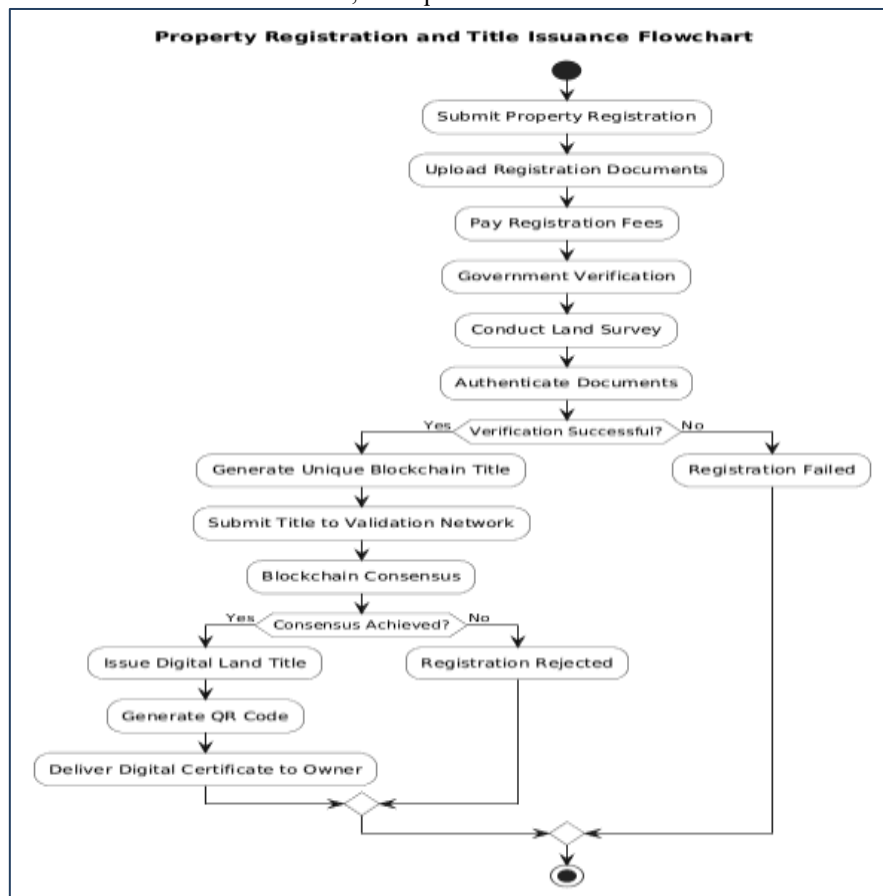


Figure 2: Property Registration and Title Issuance Flowchart

4.5 Ownership transfer and title verification

For a transfer, the registered owner or authorized representative initiates a request identifying the parcel and proposed transferee. The application checks required fields and routes the request for any necessary registry review. The contract should verify that the transaction is initiated by an authorized party, that the parcel is active, and that no unresolved dispute or legal restriction blocks transfer. When the approved transaction is committed, the current owner reference is updated and a transaction event records the change. The application then synchronizes its off-chain representation with the confirmed blockchain state.

4.6 Encumbrances, payments and disputes

The payment module is described as handling registration charges and other levies, with payment references recorded alongside the relevant workflow. The test matrix reports a payment of ₦8,000,000 completed in two minutes. The report does not explain whether this amount represents an actual financial transfer, a simulated transaction, a sandbox payment, or a test value. For that reason, the manuscript does not interpret the observation as evidence of production financial settlement. A future test protocol should specify the payment provider or sandbox, transaction type, timestamp definitions, failure handling, reconciliation process, and whether the two minutes refers to initiation, confirmation, or end-to-end completion.

4.7 Illustrative uniqueness-check logic

The following Solidity-style snippet is an explanatory illustration of the kind of invariant that a land-registration contract might enforce. It is not copied from the production source code and must not be represented as the code that was implemented or tested. The actual implementation should be reviewed for authorization, parcel identity, dispute handling, upgrade governance, event emission, and access-control correctness.

```
// Illustrative pseudocode only — not production code.
struct ParcelRecord {
    address currentOwner;
    bool registered;
    bool disputed;
}

mapping(bytes32 => ParcelRecord) private parcels;

function registerParcel(bytes32 parcelKey, address initialOwner)
    external onlyAuthorizedRegistrar
{
    require(parcelKey != bytes32(0), "Invalid parcel key");
    require(initialOwner != address(0), "Invalid owner");
    require(!parcels[parcelKey].registered, "Parcel already registered");

    parcels[parcelKey] = ParcelRecord({
        currentOwner: initialOwner,
        registered: true,
        disputed: false
    });

    emit ParcelRegistered(parcelKey, initialOwner);
}
```

5. Functional Evaluation, Results and Discussion

5.1 Reported test outcomes

The source project presents six functional test cases in an “actual versus expected” table. Table 2 reproduces their substance in a more concise research format. Status values are those stated in the project report. No raw execution logs, automated test report, screenshots, transaction receipts, or blockchain explorer records accompanied the materials used to prepare this paper; the table should therefore be understood as a documentary summary of reported results.

Test case	Input or scenario	Expected behaviour	Outcome reported by project	Status
User authentication	Administrator credentials	Successful login and MFA where required	MFA code sent successfully	Pass
Title issuance	Property registration and payment	Title created and blockchain hash generated	Hash generated and reportedly stored on three nodes	Pass
Land transfer	Seller approval and payment	Ownership transferred and prior owner state updated	Transaction confirmed on blockchain	Pass
Duplicate-title/fraud detection	Attempt to register an already-recorded parcel or competing claim	Conflict detected, registration blocked and alert/escalation initiated	System flagged conflict and escalated	Pass
Payment processing	₦8,000,000 stated transaction value	Payment confirmed and linked to blockchain record	Transaction completed in two minutes	Pass
Dispute filing	Submission of competing claim	Dispute recorded and affected property flagged or transactions suspended	Dispute logged and property flagged	Pass

Table 2: Functional outcomes as reported in the project.

5.2 Interpretation by functional objective

Ownership transfer: A confirmed blockchain transaction is evidence that the application reportedly completed the transaction path. A stronger evaluation would demonstrate that the state changed to the intended owner, that the previous owner could no longer authorize another transfer, and that unauthorized or repeated transfers were rejected. The project table records a positive case but does not show these negative cases.

Duplicate-title detection: The reported conflict flag is relevant to a central system objective. However, the test table does not identify whether the duplicate used the same parcel identifier, a different identifier for the same physical land, a modified survey reference, or an overlapping boundary. The test supports a narrow conclusion that the system flagged the scenario tested by the developers. It does not demonstrate universal prevention of multiple allocation or all forms of land fraud.

5.3 What the tests establish

All six documented cases are marked as passing. This provides preliminary functional evidence that the system's main workflows were exercised and that the reported outputs matched the expected outputs for the selected test scenarios. The result is useful for a design-and-implementation paper because it shows that the work extends beyond a conceptual proposal. Nevertheless, the test matrix is small and does not report test coverage, the number of repeated runs, the software versions, the blockchain configuration, or the complete set of input data. The results should be described as a preliminary functional validation rather than comprehensive system validation. The test evidence does not establish that the platform eliminates fraud, guarantees legal ownership, reduces all registration processing times, or improves public trust. Fraud reduction would require a defined threat model and a representative suite of fraudulent and legitimate cases, including false-positive and false-negative analysis. Efficiency claims would require a baseline and repeated measurements of comparable end-to-end workflows. User-trust claims would require an appropriate survey or qualitative evaluation with documented participants and methods. Legal validity would require analysis of the applicable statutes, administrative rules, and institutional acceptance of the electronic records.

5.4 Recommended expanded evaluation protocol

A stronger follow-up evaluation should preserve the existing six cases and expand them into a reproducible test suite. Each test should have a unique identifier, requirement link, preconditions, input data, expected state, actual state, evidence artefact, software version, and pass/fail decision. Tests should be repeated where timing or network behaviour is measured. A test report should distinguish unit tests for smart-contract functions, integration tests for API/database/blockchain interactions, end-to-end tests for user workflows, and security tests for adversarial behaviour.

Table 3: Proposed follow-up evaluation plan. These are recommendations, not results of the current project.

Evaluation dimension	Minimum additional evidence	Example metric
Functional correctness	Positive and negative cases for each workflow; automated test output	Pass rate by requirement; unresolved defects
Duplicate detection	Same parcel key, alternate identifier, conflicting survey reference and overlapping parcel scenarios	True-positive, false-positive and false-negative counts
Performance	Defined start/end timestamps, repeated runs, specified hardware and network conditions	Median and 95th-percentile latency; throughput
Security	Threat model, access-control tests, static analysis, dependency review and contract tests	Vulnerability severity and remediation status
Data integrity	Hash generation/retrieval tests, database-chain reconciliation, backup/restore test	Mismatch detection rate; recovery success
Usability and adoption	Documented participant sample, instrument and ethical procedures	Task completion, error rate, perceived usability
Operational readiness	Node governance, incident response, key recovery, privacy and legal review	Control coverage and unresolved deployment risks

5.5 Discussion

The system's most defensible value proposition is the creation of a traceable transaction history around selected land-registration workflows. When records are entered by authorized actors and state changes are accepted by a permissioned network, the ledger can make subsequent alterations more detectable and provide a common reference for transaction history. This can improve the auditability of the digital record. The system does not, by itself, guarantee that every underlying claim is accurate, that all interested parties were identified, or that the state has legally recognized the recorded transaction.

The distinction between record integrity and title validity should remain explicit throughout the paper. Record integrity asks whether the stored record has changed in an unauthorized way. Title validity asks whether the claimant has a legally recognized interest supported by the required evidence and procedures. A blockchain can assist with the former and can help document the latter's administrative process, but it cannot replace authoritative adjudication. The same distinction applies to duplicate detection: a contract can reject duplicate identifiers, but it cannot detect every instance of the same physical parcel being described inconsistently without reliable cadastral data and rules for resolving overlaps.

The hybrid architecture is therefore more realistic than a claim that all land administration should be moved onto a blockchain. A relational database remains useful for operational data, user profiles, search and reporting. The blockchain can provide a durable record of selected events and state transitions. A document service can hold supporting evidence subject to access control. Registry officials remain responsible for reviewing the evidence and authorizing decisions. This division of responsibilities is consistent with the literature's emphasis on institutional readiness and the off-chain conditions needed for land-record modernization (Graglia & Mellon, 2018; World Bank, 2018; Saari et al., 2022).

5.6 Contribution to applied computer science

The paper contributes an implementation-oriented description of a permissioned blockchain land-registration system in a Nigerian state-level context. It maps a set of practical workflows to a layered architecture and documents the test cases reported by the project. The contribution is not a new consensus algorithm or a novel cryptographic primitive. Instead, it is the integration of blockchain-backed transaction recording with application-level workflows for registration, transfers, verification, payments, and disputes in a defined administrative use case.

The user's related publications on blockchain smart contracts and decentralized networks provide a relevant local research context for the technical discussion (Onuora et al., 2024a, 2024b). The prior work on threat modelling in permissioned blockchain applications also points to a natural next step: define the system's adversaries, assets, trust boundaries, and failure modes before making strong security claims (Ana et al., 2025). These related works should be included only after the authors verify their bibliographic metadata and ensure that the final journal's self-citation policy is followed. Their use here is conceptual and does not substitute for land-registration-specific literature.

5.7 Legal and governance considerations

Land administration is governed by law and institutional procedure. The project report references the Land Use Act, Cap. L5, Laws of the Federation of Nigeria 2004 (originally enacted in 1978), as part of the Nigerian legal context and recommends complementary legislative recognition for blockchain-recorded titles. That recommendation signals an important unresolved issue: an electronic record's technical existence does not automatically make it a legally conclusive title instrument.

The legal barrier is substantial. Under the Land Use Act, valid transfers of interests in land must be evidenced by registered instruments—Certificates of Occupancy or Deeds of Assignment—and require the Governor's consent. Current Nigerian law does not recognise digital tokens, blockchain records, or smart-contract transactions as instruments capable of transferring proprietary interests in land. A blockchain-recorded transfer, however technically sound, would not by itself alter the legal title. For the system to function as an authoritative registry, legislative amendment would be required to recognise electronic records and digital signatures as legally effective instruments, and to define how blockchain records interact with the existing registration system. Until such amendment occurs, a blockchain system can at most serve as a supplementary audit layer alongside the legally recognised paper or electronic registry, not as a replacement for it. The legal status of digital signatures, official approvals, electronic evidence, corrections, and records of competing interests should be examined with appropriate legal expertise before operational deployment. Institutional change management is equally important. Registry personnel need training, documented procedures, clear accountability, and support for users who lack reliable internet access or digital literacy. A pilot should operate alongside the legally authoritative process until the relevant authority has approved the transition and reconciliation procedures. Without these arrangements, a blockchain system risks creating a second, conflicting record system rather than improving the existing one.

5.8 Privacy, security and data governance

Property records may contain personal identifiers, addresses, signatures, financial information, family relationships, and evidence associated with disputes. A responsible design should collect only data necessary for the process, restrict access by role, encrypt sensitive information in transit and at rest, maintain auditable access logs, and define retention and disclosure rules. Because blockchain records are difficult to delete, sensitive personal data should generally remain off-chain unless a specific legal and technical assessment justifies otherwise. A cryptographic hash may still be sensitive if it enables linkage to a known document or person.

The project report lists several intended security controls, including MFA, role-based access, cryptographic signing, encrypted communication, database protections, and audit logs. These controls should be retained as design objectives only where they are actually implemented and verified. The paper does not claim that the system is compliant with a particular data-protection law or that all listed controls have passed a security audit. Before publication, the authors should inspect the code and deployment configuration and report the controls that exist, the tests performed, and the limitations that remain.

5.9 Limitations of the current evidence and Practical recommendations

The first limitation is the lack of reported quantitative field evidence. Although the project describes questionnaires, interviews, observation, and record examination, the material available for this paper does not establish sample size, response rate, instrument design, or numerical analysis. The paper consequently does not make quantitative claims about user acceptance, time savings, fraud prevalence, or stakeholder trust. Similarly, the stated approximate dataset of 250 parcel records cannot be treated as a verified evaluation sample without a clear description of how those records were selected and used.

The next limitation is legal and institutional. The paper does not provide a legal opinion on the status of blockchain-recorded titles or evidence that the relevant public authorities have adopted the system as an authoritative registry. It should therefore be read as a system-design and functional-validation study, not as a claim of statutory implementation or replacement of the existing registry.

For recommendation: First, freeze a reproducible evaluation version of the system separate from production. This need not alter the production environment: a tagged commit, local test network, staging deployment, or copied test fixture can be used to run the test suite without changing live data. The paper should identify the tested version and provide a short description of the environment.

Second, add a test-to-requirement traceability matrix. Every critical requirement should link to a test case and evidence artefact. For example, duplicate registration should be tested for an identical key and for semantically equivalent parcel records with different identifiers. Transfer authorization should be tested with valid and invalid callers. Dispute handling should be tested for both blocking and authorized resolution.

Third, conduct a security review before making stronger claims about trusted records. A threat model should identify assets such as title state, user identity, documents, and validator keys; adversaries such as unauthorized users, compromised officials, malicious applicants, and compromised service accounts; and mitigations such as least-privilege roles, multi-party approval, audit trails, and key recovery. The review should report findings and remediation rather than simply list security controls.

Fourth, design a pilot with registry approval, a defined set of records, trained users, clear privacy protections, and a rollback or parallel-operation procedure. Measure processing time from a clearly defined start event to a clearly defined completion event. Record manual and digital workflow observations under comparable conditions and report median and percentile statistics rather than isolated best-case values. Finally, treat legal and institutional adoption as a parallel workstream. Engage registry leadership, surveyors, legal practitioners, data-protection specialists, and representatives of landowners. The deployment should define how electronic records relate to official instruments, how conflicts are adjudicated, and who is responsible when the ledger and source documents disagree. Technology should support public authority and accountability rather than obscure responsibility behind automation.

6. Conclusion

This paper has presented the design and reported functional validation of a blockchain-based land-registration system for the Ebonyi State, Nigeria, context. The project describes a permissioned Ethereum network, Solidity smart contracts, a Node.js/Express application layer, a React interface, and a PostgreSQL-backed hybrid data model. Its principal workflows include title registration, ownership transfer, title verification, payment processing, and dispute filing. The architecture is intended to provide a traceable transaction history while preserving the application and document-management capabilities of a conventional information system. The project documents six functional tests, all marked as passing: authentication, title issuance, ownership transfer, duplicate-title detection, payment processing, and dispute filing. These outcomes provide preliminary evidence that the selected workflows were exercised successfully in the project environment. The reported two-minute payment case and three-node title hash record are useful details, but supporting logs and a reproducible protocol are needed before they can support broader performance or resilience claims. The main conclusion is that blockchain can contribute to the auditability of land records when integrated with authoritative data validation, role-based access, sound contract logic, secure off-chain storage, and accountable registry governance. It cannot by itself guarantee that submitted land claims are true, resolve competing legal interests, or confer statutory validity on an electronic record. The current evidence supports a design-and-functional-validation contribution, not a claim that the system has eliminated fraud or demonstrated statewide operational impact.

Future work should verify the architecture against the source code, expand functional and adversarial testing, report reproducible performance measurements, document the questionnaire and record dataset, and establish a legally and institutionally approved pilot. A successful deployment will depend as much on data quality, governance, privacy, legal recognition, training, and change management as on the blockchain itself.

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