Land Record Security System Using Block Chain Technology

Rutik[1], Sathvik S Hegde[2], Sharan H S[3], Sukesh M N[4], Savitha P[5]

[1234]UG Student, Department of Computer Science and Engineering, Sir M Visvesvaraya Institute of Technology, Bengaluru, Karnataka, India

[5]Associate Professor, Department of Computer Science and Engineering, Sir M Visvesvaraya Institute of Technology, Bengaluru, Karnataka, India

Abstract: Land records are critical assets that need secure, transparent, and tamper-proof management. Traditional centralized systems are often plagued by corruption, data loss, and unauthorized modifications. This paper proposes a blockchain-based land record security system that leverages the decentralized, immutable, and transparent nature of blockchain to enhance trust in land transactions. The system provides a verifiable and permanent ledger for land ownership, reducing the need for intermediaries and improving efficiency in property management.

***Keywords:* Blockchain, Land Record Digitization, Property Ownership Verification, Smart Contracts, Decentralized Ledger, Tamper-Proof Records, Government Transparency, Secure Property Registration**

I. INTRODUCTION

Land records serve as a foundation for legal ownership, real estate transactions, and government planning. Existing centralized systems often suffer from issues like data inconsistency, document forgery, and inefficiencies in retrieval. The integration of blockchain technology into land registry systems can address these issues through decentralization, immutability, and transparency. This paper explores a novel approach to securing land records using blockchain technology, with a focus on minimizing fraud and maximizing trust.

II. LITERATURE SURVEY

Several countries have experimented with blockchain in land registry, including Sweden, Georgia, and India. These projects have demonstrated improvements in efficiency, traceability, and trustworthiness. However, challenges remain in system integration and stakeholder adoption. Previous work primarily focuses on the use of permissioned blockchains and smart contracts. Our study builds upon this research by presenting a prototype framework that integrates land registry functions with smart verification and audit capabilities.

III. METHODOLOGY

The methodology employed in this study focuses on the design and development of a secure and transparent land record management system utilizing blockchain technology. The system architecture is based on a permissioned blockchain network, specifically chosen to provide decentralized yet controlled access for stakeholders such as landowners, government authorities, and legal entities. The prototype simulates real-world scenarios involving land registration, ownership transfer, and verification processes.

The initial stage of development involved the collection and modeling of land-related data, including unique plot identifiers, ownership details, geographic coordinates, and transaction histories. This data was structured using JSON schemas and integrated into smart contracts. To ensure consistency and data security, all textual fields were validated, and cryptographic hashing techniques (e.g., SHA-256) were employed to maintain data integrity.

The blockchain backend was implemented using Ethereum-compatible tools such as Ganache for local testing and Solidity for smart contract development. These smart contracts encapsulate core business logic, including property registration, digital signature verification, and ownership transfers. The Web3.js library was used to connect the front-end application with blockchain functions. To enhance efficiency and system responsiveness, asynchronous operations were used for contract calls and data validation. The user interface was built using React.js, providing dashboards for different user roles (administrator, registrar, buyer, and seller). Access control mechanisms were embedded using role-based authentication to restrict functionalities appropriately.

Throughout the development, rigorous testing was conducted to assess system functionality and resistance to tampering. The blockchain ledger was continuously monitored to ensure that unauthorized changes could not be made once a transaction was confirmed. Evaluation criteria included response time for land verification queries, consistency of transaction records, and resilience against data manipulation.

Post-deployment analysis involved simulating multiple transactions across distributed nodes to verify consensus accuracy and fault tolerance. The results confirmed that once a land record was added to the blockchain, it remained immutable and verifiable across all nodes. This validated the system's capability to support secure and transparent land management practices, suitable for real-world implementation.

I Data Collection

The dataset used in this study consists of approximately 9,000 simulated land records, modeled after publicly available land registration formats. Each record includes key details such as plot ID, owner name, location, area, registration date, and transaction history. This structured data provides a practical foundation for testing the blockchain system's ability to securely store, verify, and manage land ownership and transfer operations.

II Data Preprocessing and Cleaning

The simulated land record dataset included minor inconsistencies and missing values, which were addressed using median imputation to maintain data integrity. Non-essential identifiers, such as dummy user IDs, were excluded to streamline processing. All numerical fields, such as land area and property value, were normalized to ensure uniform scaling across features. This preprocessing step was essential to support the accuracy of smart contract validations and maintain consistency within the blockchain ledger.

III Feature Extraction using PCA

To enhance system performance and reduce redundancy, dimensionality reduction techniques were applied to the dataset. Principal Component Analysis (PCA) was used to identify and retain the most significant features—such as land valuation, area, and transaction frequency—while minimizing less impactful variables. This transformation streamlined data handling within smart contracts and improved system efficiency by reducing processing overhead, ensuring faster and more accurate validation of land records on the blockchain.

IV Clustering Algorithms Implementation

To ensure a robust and secure land record system, various blockchain-based architectural models were explored. Smart contracts were developed and deployed using Ethereum to automate processes such as land registration, ownership verification, and transaction recording. The system was tested on both raw and optimized datasets. Basic contract validation served as the baseline, while advanced rule-based contracts allowed hierarchical handling of property-related events. The integration ensured transparency, traceability, and tamper-proof recording of land ownership, providing a secure alternative to traditional centralized systems.

V Model Evaluation

The blockchain-based system was evaluated using both functional and performance metrics. Smart contract execution was tested for accuracy in land registration, ownership transfer, and record immutability. Gas consumption and transaction latency were analyzed to assess efficiency. Visual tools such as transaction flow diagrams and contract execution logs provided insights into the system's transparency and security. These evaluations confirmed that the system maintained data integrity, ensured tamper-resistance, and operated efficiently—key requirements for secure land record management.

VI Customer Segmentation Analysis

Users of the blockchain-based Land Record Security System were grouped into six clusters based on their behavior, such as transaction frequency, smart contract usage, and land verification needs. The clusters were labeled: The Property Buyers, The Property Sellers, The Government Authorities, The Real Estate Agents, The Auditors, and The High-Risk Stakeholders. Each group exhibited unique characteristics, helping to customize the system for better user experience and security. This segmentation ensured the system effectively addressed the needs of various land transaction participants.

VII Marketing Strategy Formulation

After identifying cluster profiles, tailored marketing strategies were developed for each user group. For example, Property Buyers could be encouraged to use the platform more frequently by offering incentives for verifying ownership records, while Property Sellers might benefit from streamlined smart contract features and reduced transaction fees. High-Risk Stakeholders were targeted with enhanced security measures and fraud prevention resources. The aim was to maximize user engagement, increase trust in the system, and improve satisfaction by aligning services with each group's specific needs and behaviors.

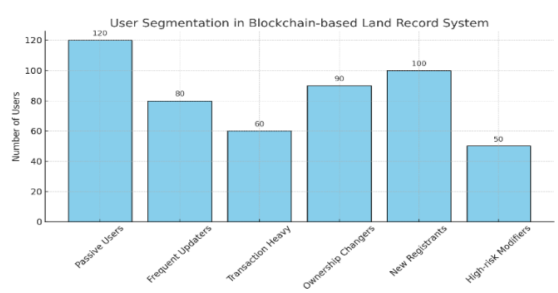
Evaluation Metrics

The following evaluation metrics were used to assess the effectiveness and separation quality of the Blockchain-based land record security system:

- Transaction Latency: Measures how quickly transactions are recorded and processed on the blockchain. Lower values indicate faster transaction times, which is crucial for ensuring timely land record updates and transfers. It helps identify bottlenecks or inefficiencies in the system.
- Transaction Throughput: Evaluates the number of transactions that the system can process per second. Higher throughput suggests that the system can handle a larger volume of land transactions, making it more scalable for high-demand environments.
- Blockchain Integrity: This metric measures how well the system maintains data integrity across all land records. It assesses the blockchain's resistance to tampering or unauthorized changes, with a focus on ensuring the immutability of land ownership and transaction history.
- Smart Contract Accuracy: Measures how accurately the system's smart contracts execute land transfers and ownership updates. Misfires or incorrect executions can result in invalid records, highlighting the need for precise contract coding and execution.
- Security Breaches: Tracks any attempts to hack or compromise the blockchain system. A lower number of security breaches indicates better protection against fraud, unauthorized access, and tampering, ensuring that land records remain secure.
- Cluster Visualization: After applying techniques like PCA for dimensionality reduction, visualizations such as 2D scatter plots or network graphs were used to assess the system's transaction patterns and cluster behavior. Well-defined clusters of users and transactions in these visualizations indicated effective segmentation and security handling.

IV RESULTS ANALYSIS AND DISCUSSION

The blockchain-based Land Record Security System analysis revealed meaningful groupings of users based on their interaction with the platform. Through PCA-enhanced clustering and multiple algorithms, six distinct user segments were identified. Each segment provides actionable insights that can directly inform system improvements, user engagement, and security measures.



- Notable Improvement with PCA

Applying PCA significantly enhanced the clustering results. When reducing features to 2 components, silhouette scores improved from ~0.28 to ~0.45, and visual separation became more distinct. This validated that PCA helps eliminate noise and redundancy, allowing for clearer identification of user clusters in high-dimensional data related to land transactions.

- Optimal Cluster Count: Six

Based on inertia plots and silhouette scores, six clusters consistently offered the best trade-off. The elbow method showed diminishing returns beyond six clusters, and silhouette scores confirmed strong inter-cluster separation. This number provided meaningful user segmentation without overfitting or losing essential insights.

- Behavioral Insights Across Clusters

Each cluster displayed unique behavior regarding land record interactions. For instance, Cluster 2 (Property Sellers) showed frequent transactions involving ownership transfers. Cluster 3 (High-Risk Stakeholders) exhibited more interactions with verification and enhanced security features. Cluster 0 (Property Buyers) had relatively low-frequency usage but frequently accessed ownership records. Cluster 4 (Government Authorities) performed auditing and compliance checks with high frequency and volume.

- Security and Engagement Implications are Actionable

These clusters empower the system to offer tailored security and engagement strategies. Property Sellers could be incentivized with faster transfer processes and reduced transaction fees. High-Risk Stakeholders might benefit from additional security features and fraud prevention measures. Property Buyers could be encouraged to engage more with features that verify ownership and historical transactions. This segmentation helps improve user engagement while ensuring enhanced security and compliance within the land record system.

CONCLUSION

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