Land Secure Using Blockchain

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doi.org/10.64643/IJIRTV12I12-206848-459

***Abstract*—In an era where data integrity and transparency are paramount, the integration of blockchain technology into land record management offers a transformative solution to combat fraud, improve traceability, and ensure secure data access. This paper presents a robust and tamper-proof Land Record Security System underpinned by decentralized blockchain architecture. The decentralized structure of blockchain helps maintain secure and transparent land records while reducing manual verification efforts and administrative delays. The proposed framework uses Ethereum smart contracts to handle processes such as land registration, ownership validation, property transfer, and dispute handling in an automated manner. A web-based interface with role-based access control (RBAC) allows citizens, government officers, and legal authorities to securely interact with land records. Testing showed that transactions were processed within a few seconds while maintaining accurate smart contract execution and strong protection against unauthorized record modification, double-ownership claims, and unauthorized access. The system represents a citizen-centric, scalable, and secure solution for modernizing land governance.**

***Index Terms*—Blockchain, Smart Contracts, Land Record Management, Ethereum, Decentralized System, Solidity, RoleBased Access Control, Cryptographic Hashing, Immutable Ledger.**

I. INTRODUCTION

The rapid digitization of government services and the growing need for secure, transparent, and tamper-proof land ownership records have made the modernization of land record management systems increasingly critical. Traditional land registry systems, whether paper- based or reliant on centralized digital databases, suffer from significant vulnerabilities including data manipulation, unauthorized access, lack of transparency, and susceptibility to fraud and corruption. These inefficiencies result in legal disputes, delays in property transactions, and erosion of public trust in government services.

Blockchain provides an effective approach for improving the security and reliability of land management systems. By leveraging its decentralized, immutable, and cryptographically secured architecture, blockchain ensures that once a record is created, it cannot be altered or deleted without consensus from the network. This approach helps prevent unauthorized modifications that are commonly found in traditional record systems. Furthermore, smart contracts automate critical administrative workflows such as property registration, title verification, ownership transfer, it cannot be altered or deleted without consensus from the network.

This eliminates the primary risk of unauthorized tampering that plagues conventional systems by leveraging its decentralized, immutable, and cryptographically secured architecture, blockchain ensures that once a record is created dispute resolution, removing dependence on manual processes and reducing the scope for human error or corruption.

This paper presents a Land Record Security System that integrates blockchain technology to securely store, manage, and verify land ownership data. The proposed system employs a permissioned blockchain framework, enabling only authorized entities to participate and perform transactions. Every update is securely connected with previous transactions, creating a reliable history that can be verified whenever required.

A role-based, user-friendly web interface allows multiple stakeholders landowners, government officials, and legal personnel to interact with the system securely. The system also incorporates provisions for future integration with Artificial Intelligence (AI) for fraud detection, Geographic Information Systems (GIS) for spatial land validation, cloud computing for scalability, and IoT-based smart devices for real-time monitoring. This paper describes the architecture, methodology, system design, implementation, and evaluation of the proposed solution, demonstrating its effectiveness as a scalable and trustworthy alternative to traditional land record management.

II. PROBLEM STATEMENT AND EXISTING SYSTEMS

Traditional land record management systems are predominantly centralized, paper-based, or reliant on outdated digital infrastructure. These systems are highly vulnerable to data manipulation, unauthorized access, and record loss. Key issues include: • Loss or duplication of land ownership records due to poor physical and digital archiving practices.

- Lack of a unified, tamper-proof audit trail for property transactions, enabling fraud and illegal transfers.
- Lengthy and opaque administrative verification processes involving multiple government departments.
- Absence of real-time visibility into land transaction status, reducing public trust.
- Interoperability gaps between revenue offices, municipalities, banks, and legal authorities.
- Susceptibility to corrupt practices owing to centralized control over sensitive records.

Digitization efforts in several Indian states have introduced online portals, but the underlying architecture remains centralized, exposing systems to server failure, cyberattacks, and database corruption. Critical concerns such as tamper-proof logging and decentralized verification remain unaddressed. As property transactions grow exponentially in urbanizing regions, these limitations are increasingly untenable.

III. PROPOSED SYSTEM

The proposed Land Record Security System introduces a modern, decentralized platform built on blockchain technology. Unlike traditional centralized databases, the system stores every property related transaction in an immutable distributed ledger, ensuring records cannot be altered, forged, or deleted. The platform allows citizens, officers, and legal departments to access property records in a secure and transparent environment.

A. Core Architecture

The architecture employs a permissioned blockchain framework enabling controlled network participation. Each land record is stored as a unique block containing ownership information, digital signatures, timestamps, and a complete transaction history, cryptographically linked to the preceding block. This guarantees a tamper-proof, auditable chain of custody for every land parcel.

B. Smart Contract Layer

Solidity-based smart contracts deployed on Ethereum automate land registration, ownership verification, title mutation, and dispute resolution. Once conditions encoded in a smart contract are satisfied, execution is automatic and irreversible, eliminating intermediaries and the risk of manual error or corruption. Whenever a transaction is completed, the updated information is reflected across the connected blockchain nodes.

C. Web Interface and Access Control

A React.js-based web application provides intuitive dashboards for Admins, Officers, and Public Users. Role-Based Access Control (RBAC) ensures that sensitive operations such as ownership transfer approvals and record deletion are restricted to authorized personnel. Citizens can verify land ownership and transaction history without requiring intermediary assistance. The interface communicates with the blockchain network via Web3.js, enabling real-time, secure interactions.

D. Off-Chain Storage

Auxiliary metadata such as user profiles, login sessions, and transaction logs are maintained in a PostgreSQL or MongoDB database. Critical ownership records are stored on-chain for immutability, while supporting documents (PDFs, GIS data) can be managed via IPFS, with only cryptographic hash references stored on the blockchain.

IV. SYSTEM DESIGN

A. System Architecture

Figure 1 illustrates the overall system architecture. Admins, Officers, and Public Users interact with a Flask-based web application, which connects to a central relational database for session and metadata management. The application interfaces with the blockchain network for immutable record operations including land registration, ownership transfer, and audit trail generation.

The distributed ledger synchronizes across multiple nodes using a consensus mechanism, ensuring fault tolerance and eliminating any single point of failure. Smart contracts govern all critical operations on-chain, while the Flask backend handles API routing, authentication, and off-chain data management.

B. Module Design

The system is organized into the following functional modules:

- User Interface Module – Responsive React.js dashboards for all stakeholder roles.
- Land Registration Module – Accepts property details and triggers smart contract execution for on-chain storage.
- Smart Contract Module – Core Solidity logic for land registration, ownership transfer, and record verification.
- Ownership Transfer Module – Manages identity verification and approval workflows before blockchain update.
- Verification & Audit Module – Enables querying of land ownership using Land ID or transaction hash.
- Database & Metadata Logging Module – Off-chain storage for sessions, logs, and non-critical data.
- Notification & Alert Module – Real-time stakeholder alerts via email, SMS, or in-app push notifications.

C. Data Flow

User requests for land transactions, property searches, or ownership verification are routed through the application server, validated for completeness, and dispatched to the blockchain via smart contract calls. Approved transactions are securely recorded with timestamps and stored permanently within the blockchain ledger. The admin dashboard receives real-time status updates and maintains comprehensive audit logs for all system activities.

D. Technology Stack

The system is implemented using Python (Flask) for backend logic, Solidity for smart contracts, React.js for the frontend, PostgreSQL/MongoDB for off-chain storage, Web3.py/Web3.js for blockchain communication, Ganache/Infura for Ethereum testing, and JWT/SSL for secure authentication and data transmission.

V. METHODOLOGY

The development methodology followed a systematic, iterative approach encompassing data preparation, feature engineering, smart contract implementation, user segmentation, and rigorous evaluation.

A. Data Collection and Preprocessing

A simulated dataset of approximately 9,000 land records was generated to mirror real-world land registry formats. Each record includes a unique Plot ID, owner name, geographic location, land area, registration date, and full transaction history. Preprocessing involved median imputation for missing values, removal of irrelevant identifiers, and normalization of numerical fields such as land area and property value to ensure uniform scaling during smart contract validations.

B. Feature Extraction and Dimensionality Reduction

Principal Component Analysis (PCA) was applied to reduce data dimensionality and identify the most discriminative features for efficient smart contract processing. Key features retained include land valuation, plot area, and transaction frequency. This reduced on-chain computational overhead and improved query efficiency while preserving data integrity.

C. Smart Contract Implementation

Smart contracts were written in Solidity and deployed on an Ethereum private network using Ganache. Contracts handle the complete lifecycle of land record management: registerLand(), transferOwnership(), verifyRecord(), and generateAuditTrail(). Each function enforces access control, validates input data, emits blockchain events, and returns cryptographic hashes for external verification.

D. User Segmentation

A behavioral segmentation analysis categorized system users into six clusters: Property Buyers, Property Sellers, Government Authorities, Real Estate Agents, Auditors, and High-Risk Stakeholders. Customized access policies, interface layouts, and security protocols were designed for each cluster, improving both usability and systemic security.

E. Evaluation Metrics

The system was assessed using the following metrics: Transaction Latency (time to record a transaction), Transaction Throughput (TPS under load), Blockchain Integrity (resistance to tampering), Smart Contract Accuracy (execution correctness), Security Breach Rate (unauthorized access attempts), and Cluster Visualization (2D PCA scatter plots for transaction pattern analysis).

VI. RESULTS AND DISCUSSION

The Land Record Security System was successfully developed and evaluated on an Ethereum private test network. Core functionalities including land registration, ownership transfer, record verification, and audit trail generation were all validated through comprehensive testing. The experimental outcome indicates that the proposed system improves record security, transparency, and reliability compared with conventional methods with significant improvements over traditional methods.

A. Admin Portal

Figure 1 shows the Admin Portal, which serves as the central control interface. Administrators can manage the complete land record lifecycle, monitor real-time blockchain transactions, and access comprehensive audit trails. Role-based access ensures that administrative operations remain secure and fully accountable.

Fig. 1. Admin Portal – Central control interface for land record administration

B. Monitor Records

Figure 2 illustrates the Monitor Records interface, enabling authorized users to review registered land records, track full transaction histories, and verify ownership details. The dashboard integrates real-time blockchain status updates, ensuring immediate visibility of any newly recorded transactions or flagged anomalies.

Fig. 2. Monitor Records – Real-time tracking of registered land records

C. Officer Dashboard

Figure 3 presents the Officer Dashboard designed for land registry officers. This interface displays the total number of records, pending ownership transfer requests, and recent activity logs. Officers can review, approve, or reject land registration and transfer requests with full traceability maintained on the blockchain.

Fig. 3. Officer Dashboard – Management panel for land record officers

D. Adding Land Record

Figure 4 illustrates the Add New Land Record form, through which authorized officers register new land parcels. The form collects survey number, Khata number, owner name, village, address, property size, and geo-location. Upon submission, the details are validated and committed to the blockchain via smart contract execution, generating a unique cryptographic hash.


details, and approve or reject land registration and transfer actions. Real-time status updates and transaction logs support secure and efficient monitoring of property records.

8.4 Adding Land Record

Figure 8.4: Adding Land Record

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Fig. 4. Adding Land Record – Smart contract-based land registration form

E. Land Registry Dashboard

Figure 5 shows the public-facing Land Registry Dashboard, providing citizens with access to owned properties, listed properties, pending transfer requests, and a property search function. Each entry is linked to its blockchain transaction hash for instant authenticity verification, enabling transparent self-service access to property records.


number, location, land area, and owner details.

8.5 Land Registry Dashboard

Figure 8.5: Land Registry Dashboard

Land Registry Dashboard provides a consolidated view of all registered land records within the system. It enables users to quickly access ownership details, transaction history, land status, and verification results through a streamlined interface. The dashboard supports search and filtering functions to efficiently locate specific land entries. Real-time blockchain updates ensure transparency and accuracy, allowing users, officers, and administrators to monitor ongoing

Fig. 5. Land Registry Dashboard – Citizen-facing interface for property management

F. Performance Evaluation

Performance testing confirmed the following results across all evaluation metrics:

- Transaction Latency: Average of 5–20 seconds per transaction, within the target threshold of 3 seconds for simple operations and 20 seconds for complex ownership transfers.
- Transaction Throughput: The system sustained over 100 TPS under normal load, and up to 200 parallel requests under stress testing without performance degradation.
- Smart Contract Accuracy: 100% correctness in ownership verification and registration; zero incorrect executions during 500+ test transactions.
- Blockchain Integrity: All tamper attempts and duplicate ownership claims were automatically rejected by smart contract logic; 0 unauthorized modifications recorded. • Processing Efficiency: Compared to traditional land management, the proposed system achieved an estimated 60– 65% reduction in processing time for registration and transfer operations.
- Scalability: Architecture supports district, state, and national level deployment with horizontal scaling and Layer 2 rollup compatibility.

Stress testing involving hundreds of simultaneous user sessions confirmed stable performance and consistent data synchronization across blockchain nodes. Backup and recovery tests demonstrated data persistence even under simulated node failures, attributable to distributed ledger replication.

VII. LITERATURE REVIEW

Extensive research has explored blockchain-based land record systems over the past decade, consistently demonstrating their superiority over traditional centralized models. Key contributions are summarized below.

Kaur et al. [1] proposed an Ethereum-based framework using IPFS for off-chain document storage, achieving a 70% reduction in property registration processing time with full auditability through immutable transaction logs. Thakkar et al. [2] demonstrated a Hyperledger Fabric implementation with transaction confirmation times below three seconds, high accuracy, and tamper-resistant audit trails. Kumar et al. [3] achieved 98% smart contract execution accuracy and sub-0.5% error rates using Ethereum test networks, with significant improvements in auditability.

Sharma and Mehta [4] conducted a comparative performance evaluation across Ethereum, Hyperledger Fabric, and Corda, finding that

Hyperledger Fabric outperformed with over 200 TPS and lowest latency, while Ethereum offered stronger decentralization at higher transaction costs. Bhoite et al. [10] explored consensus protocol trade-offs for decentralized land registries, demonstrating how cryptographic hashing eliminates common fraud vectors in centralized databases.

Singh et al. [13] demonstrated Ethereum-based smart contracts for automating complex workflows including property freezing and multi-party ownership verification. Yadav and Kushwaha [14] implemented a specialized consensus algorithm (MRRCM) with IPFS integration, significantly reducing query latency compared to linear search approaches. Shukla et al. [11] proposed a hybrid blockchain and ML model for accurate property valuation alongside secure ownership records.

International pilots in Georgia and Sweden [8] have validated blockchain's viability for government land administration, while Gaur et al. [22] specifically addressed India's land administration challenges, proposing a GIS-integrated blockchain solution to improve spatial accuracy of ownership records. The broad consensus across literature affirms that blockchain offers superior immutability, transparency, and automation for land governance, though challenges remain in regulatory adoption, legacy system integration, and digital literacy.

VIII. CONCLUSION AND FUTURE SCOPE

This paper has presented a comprehensive blockchain-based Land Record Security System that addresses the critical limitations of traditional centralized land management systems. The proposed solution leverages Ethereum smart contracts, role-based access control, cryptographic hashing, and a citizen-centric web interface to deliver a secure, transparent, and immutable platform for land governance.

Key outcomes validated through development and testing include: 100% correctness in smart contract execution; resilience against data tampering, duplicate ownership, and unauthorized access; 60– 65% improvement in processing efficiency compared to traditional systems; scalable architecture supporting simultaneous high- volume transactions; and a user-friendly interface accessible to stakeholders across technical backgrounds. The system is built using open-source technologies including Solidity, Web3.py, React.js, Flask, and PostgreSQL, ensuring costeffectiveness and ease of future maintenance. Future enhancements will include: GIS mapping integration for geospatial land boundary visualization; Layer 2 blockchain solutions (e.g., Polygon) for reduced gas fees and faster confirmation; IPFS-based decentralized document storage; Aadhaar/biometric-based identity verification; AI-driven fraud detection and predictive analytics; multilingual and offline-capable interfaces for rural and underserved communities; and integration with national e-governance platforms and revenue department APIs.

Overall, the study demonstrates that blockchain can be effectively used to develop a modern and dependable land record management system.in India and globally, delivering trust, transparency, efficiency, and citizen empowerment at scale.

REFERENCES

[1] A. Kaur, R. Sharma, and P. Arora, "Blockchain-Based Land Record Management Framework Using Ethereum and IPFS," *International Journal of Computer Science and Engineering*, vol. 11, no. 4, pp. 153–157, 2023.

[2] D. Thakkar, C. Modi, and D. Patel, "Blockchain-Powered Land Registration Using Hyperledger Fabric," *International Journal of Engineering and Advanced Technology (IJEAT)*, vol. 11, no. 4, pp. 201–207, 2023.

[3] V. Kumar, N. Rani, and S. Bansal, "Ethereum-Based Blockchain System for Land Registration and Ownership Management," *Soft Computing*, vol. 27, pp. 4531–4545, 2021.

[4] A. Sharma and R. Mehta, "Comparative Performance Evaluation of Ethereum, Hyperledger Fabric, and Corda for Land Records," *IEEE Access*, vol. 12, pp. 10234–10249, 2024.

[5] A. Kumar, P. Singh, and R. Verma, "Blockchain-Based Land Ownership System Using Ethereum and IPFS," *Journal of Computer Science and Technology*, vol. 22, no. 3, pp. 45–55, 2022.

[6] N. Agarwal, A. Jain, and K. Sharma, "Secure Blockchain-Based Land Registry Using Hyperledger Fabric," *International Journal of Engineering and Advanced Technology*, vol. 12, no. 5, pp. 300–308, 2023.

[7] S. S. Bhoite, S. S. Gavade, A. R. Beloshe, and A.

C. Jagadale, “Blockchain-Based Land Registration Using Smart Contracts and Cryptographic Hashing,” *International Journal of Advanced Research in Computer and Communication Engineering (IJARCCE)*, vol. 11, no. 6, pp. 88–96, 2022.

[8] S. Gupta *et al*., “Land Registry Using Blockchain: Framework and International Pilots,” in *Proc. IEEE International Conference on Blockchain*, 2022, pp. 102–110.

[9] S. M. Kulkarni *et al*., “Modernized Land Registry Using Blockchain with Unique Plot Identities,” in *Proc. IEEE International Conference on Computing, Communication and Networking Technologies (ICCCNT)*, 2021, pp. 1–7.

[10] V. Shukla, A. R. Raipurkar, and M. B. Chandak, “Hybrid Blockchain and Machine Learning for Land Registry Accuracy,” *IEEE Transactions on Engineering Management*, vol. 71, pp. 1234–1245, 2024.

[11] S. M. Gupta and J. M. Kolambkar, “Decentralized Land Record Governance Using Blockchain,” *International Journal of Advanced Computer Science*, vol. 13, no. 8, pp. 500–510, 2023.

[12] M. Singh *et al*., “Smart Land Record System Using Ethereum Blockchain,” in *Proc. IEEE International Conference on Advances in Electrical, Computing, Communication and Sustainable Technologies (ICAECT)*, 2023, pp. 1–8.

[13] A. S. Yadav and D. S. Kushwaha, “Query Optimization in Blockchain-Based Land Registry Using MRRCM,” *IEEE Transactions on Services Computing*, vol. 16, no. 3, pp. 2100–2114, 2022.

[14] R. K. K. V., R. G. A., and V. N. Kumar, “Land Registration on Ethereum Using Solidity Smart Contracts,” *International Journal of Research in Computer Applications and Information Technology (IJRCAIT)*, vol. 5, no. 2, pp. 88–95, 2022.

[15] F. Amri, P. Sihombing, and S. Efendi, “Blockchain Technology for Land Title Certificate Security in Agrarian Reform,” *Journal of Theoretical and Applied Information Technology*, vol. 103, no. 4, pp. 1120–1130, 2025.

[16] S. Gaur, S. Lamba, and A. Patel, “Secure Land Ownership Using Blockchain for India’s Land Administration Challenges,” *International Journal of Computer Applications*, vol. 186, no. 21, pp. 34–42, 2024.

[17] L. S. Umrao, S. C. Patel, and S. Kumar, “Blockchain Framework for Land Registration Information Systems in India,” *Journal of King Saud University – Computer and Information Sciences*, vol. 34, no. 6, pp. 3456–3465, 2022.