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Blockchain-based Land Records Verification System with Multiple Sales Fraud Detection using Decision Trees

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***Abstract*— The problem of land ownership fraud, especially the multiple sales of the same land parcel, has become a major challenge in property deals. Traditional land registration systems are often based on paper, centralized, and easy to tamper with, forge, or modify without approval. These outdated systems lack transparency, rely heavily on manual checks, and are open to insider fraud. This leads to disputes, legal issues, and financial loss for buyers.**

To tackle these problems, this paper suggests a blockchain-based framework for secure verification of land records, combined with a machine-learning fraud detection system. The blockchain provides decentralized, tamper-proof storage of land transactions by using smart contracts on the Ethereum network. Each land record is uniquely stored. Any change or duplication is impossible without agreement. In addition, the system uses a Decision Tree algorithm to spot fraudulent sales patterns based on transaction history, ownership legitimacy, and time-related features, allowing for early fraud detection before a transaction is finalized.

The proposed solution makes land transactions secure and clear. Only verified owners can start a sale, and every transaction undergoes a fraud analysis before it is recorded on the blockchain. MetaMask handles user authentication and digital signatures, while Ganache offers a local Ethereum testing environment. Smart contracts manage land transfers, control access, and create unchangeable transaction logs.

Thorough design analysis and simulated testing show that the system improves transparency, boosts fraud detection, and greatly reduces reliance on intermediaries. This research sets the groundwork for a decentralized, smart, and fraud-resistant land registry system that governments can adopt to ensure reliable and efficient property ownership verification in the digital age.

***Index Terms*— Blockchain, Land Records, Smart Contracts, Decision Tree, Ethereum, Fraud Detection, MetaMask, Decentralized Verification.**

I. INTRODUCTION

Land ownership is a key part of property rights and economic growth in any society. In countries like India, land is not just a valuable asset; it is also a crucial resource linked to identity, livelihood, and family wealth.

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However, keeping land records and proving property ownership is a significant challenge. The issue of land fraud, especially the repeated sales of the same land to different buyers, has led to thousands of disputes, legal battles, and a decline in trust in government systems.
Traditional land registration methods are usually centralized, paper-based, and manual. These systems are prone to tampering, forgery, human error, and corruption. Once registered, land ownership records can be changed illegally by altering physical documents or by influencing officials. Furthermore, land records are not easily accessible or verifiable by buyers or legal authorities, making it tough to confirm the legitimacy of property transactions in real time.
To tackle these issues, this research suggests a blockchain-based system for verifying land ownership that ensures secure, tamper-proof, and transparent storage of data. Blockchain, as a decentralized and unchangeable ledger, is an ideal solution for documenting important transactions that should not be modified after validation. By using the Ethereum blockchain and smart contracts, land ownership can be registered, verified, and transferred with complete auditability, without relying on third-party authorities.
However, while blockchain provides secure data storage, it cannot completely prevent fraud, such as unauthorized repeated sales of the same land. To bolster security, the proposed system incorporates a Decision Tree machine learning algorithm to spot suspicious patterns in land sale requests. The algorithm examines transaction history, time gaps between sales, and ownership mismatches to assess the risk of fraud. This intelligent layer serves as a predictive safeguard, blocking malicious transactions before they are recorded on the blockchain.
Users interact with the system through MetaMask, a secure cryptocurrency wallet that verifies identity and adds digital signatures during transactions. The backend blockchain environment is simulated using Ganache, a local Ethereum test network that mimics real blockchain behavior. Smart contracts written in Solidity enforce ownership rules, register land data, and transfer ownership after fraud checks are completed. The frontend interface, created using Streamlit or HTML/JavaScript, lets users—buyers, sellers, and government officials—perform actions smoothly.
The main contributions and objectives of this paper are:

- To develop a secure framework for managing land ownership that resists fraud through blockchain.
- To automate the detection of multiple sales fraud using a Decision Tree model.
- To remove reliance on manual verification and paper records, making property transactions smoother.
- To design a tamper-proof land record system that builds public trust and government transparency.
- To create a modular, scalable model that can be implemented in various regions with little adaptation.

The rest of the paper is organized as follows: Section II offers a review of previous research on blockchain-based property management and fraud detection. Section III describes the system methodology, including smart contract implementation, blockchain simulation, and machine learning model development. Section IV covers experimental setup and presents results on fraud detection accuracy, system responsiveness, and data integrity. Section V concludes with main insights, contributions, and ideas for future improvements to scale the system for real-world use.

II. Literature Survey

The traditional land registration and record management systems in India face several challenges. These include fraud, a lack of transparency, outdated processes, and a heavy reliance on middlemen. These issues often lead to legal disputes, confusion over ownership, and unauthorized land transfers. As demand grows for secure, tamper-proof systems, researchers have proposed various blockchain-based models to update land records management.
Md. Samir Shahariar et al. [1] developed a blockchain-based Land Record Management System (LRMS). This system aims to convert existing paper-based records into digital form while ensuring privacy and data integrity through asymmetric encryption. Their framework introduced a character-to-integer (C2I) mapping scheme that reduced conversion overheads by 33% compared to ASCII. The system enabled secure land transactions and improved transparency and speed using blockchain's decentralized structure.
Raushan Kumar et al. [2] tackled the problems of India's land record infrastructure. They pointed out issues like data loss during natural disasters and unclear ownership due to the absence of a centralized, verifiable system. Their research showed how blockchain technology could provide unchangeable records, verify property history, and rebuild public trust. They also suggested using smart contracts to automate and validate transactions, which would greatly reduce the risk of property fraud.
Shushma R. and Dr. Nagaraj S. R. [3] proposed a decentralized Ethereum-based blockchain model to enhance the reliability of land registration. Their system used cryptographic security, transparency, and distributed

storage to eliminate middlemen and combat corruption. By automating ownership transfers and making transaction history easy to access, they showed a decrease in legal disputes related to property transactions.

Lokendra Singh Umrao et al. [4] proposed a secure and scalable blockchain framework that aligns with India's Digital India Land Records Modernization Programme (DILRMP). Their system addressed departmental silos and data fragmentation through smart contracts and digitized geographic metadata. They stressed the need to integrate Geographic Information Systems (GIS) for better property identification and transparent access for stakeholders.

Kuldeep Vayadande et al. [5] introduced a hybrid blockchain architecture that allowed the public to view land ownership data, while keeping secure private layers for administrative updates. Their approach addressed common issues like document tampering and redundancy by providing a tamper-proof digital ledger. The authors also considered future features such as 3D property visualization, machine learning-assisted authenticity checks, and digital payments through cryptocurrency.

A. Identified Gap and Our Contribution

While these studies clearly show the benefits of using blockchain for secure land records, they mainly focus on data integrity and process improvement. However, one important gap remains: none of the reviewed systems have a proactive fraud detection method that uses machine learning. Our proposed system addresses this gap by incorporating a Decision Tree classifier into the blockchain land record framework. This approach not only ensures secure and permanent record storage but also adds an intelligent fraud prediction layer that can identify suspicious transactions, especially multiple sales of same land parcel, before they are added to the blockchain. By combining the reliability of decentralized storage with the power of predictive analytics, our framework provides a crucial new aspect to secure land management systems: real-time, automated fraud detection.

III. METHODOLOGY

This section describes the method used to create the Blockchain-based land sale verification system that includes machine learning for fraud detection. The solution is modular. It combines user authentication, transaction validation, smart contract execution, and predictive fraud analysis.

A. System Architecture Overview

The system architecture, shown in Figure 1, consists of multiple layers that ensure secure and transparent land registration, prevent fraud, and facilitate ownership transfer. It includes user roles such as Admin, Seller, and Buyer, who interact through a decentralized portal built with Streamlit or HTML/JavaScript. The architecture includes the following components:

- User Interface Layer: This frontend interface allows Admins to register land parcels, Sellers to start land sales, and Buyers to track status.
- MetaMask Authentication: All user actions are verified through MetaMask, which provides wallet-based login and digital signature features.
- Backend Server: Developed using Flask and connected with Web3.py, it handles the logic for validating ownership, interacting with smart contracts, and running fraud detection.
- Feature Extraction Engine: This layer extracts key transaction details from each request before fraud analysis.
- Fraud Detection Engine: A trained Decision Tree Classifier evaluates the extracted features to spot suspicious transactions.
- Smart Contract Layer: Smart contracts written in Solidity are deployed on the Ethereum blockchain through Ganache, managing land registration and ownership transfer.
- Blockchain Ledger: A decentralized storage system that permanently and unchangeably stores all verified land transactions.

The system architecture shown above illustrates the complete design of the proposed Blockchain-based Land Verification System, which integrates machine learning for fraud detection. The architecture has a modular structure that separates user interaction, backend logic, fraud analysis, and blockchain execution layers. Users interact with the system via a decentralized web interface, where they perform specific operations—Admins register land, Sellers start sales, and Buyers check ownership status. MetaMask, a commonly used Ethereum wallet extension, acts as the secure authentication tool and allows users to digitally sign transactions, providing both identity verification and non-repudiation.

The backend server, developed using Python Flask and connected with Web3.py, links the user interface with the blockchain and fraud detection modules. When a land sale request is received, the backend retrieves the relevant land record from the blockchain and checks the seller's legitimacy. It then extracts important details such as the number of previous sales, the time since the last transaction, and whether the current seller matches the on-chain owner. These extracted features are sent to a Decision Tree classifier created with the scikit-learn library. This classifier is trained on a labeled dataset of past transactions and acts as an intelligent layer for spotting potential fraud. Based on the model's prediction, the transaction is either blocked or sent to the blockchain for execution.
All verified land transactions are processed by smart contracts written in Solidity and deployed on the Ethereum test network (Ganache). These contracts include key functions for land registration and ownership transfer. Once completed, transactions are permanently recorded on the blockchain, ensuring transparency, traceability, and immutability. This architecture not only secures land records but also actively detects fraudulent transactions, making it strong and trustworthy for real-world use.

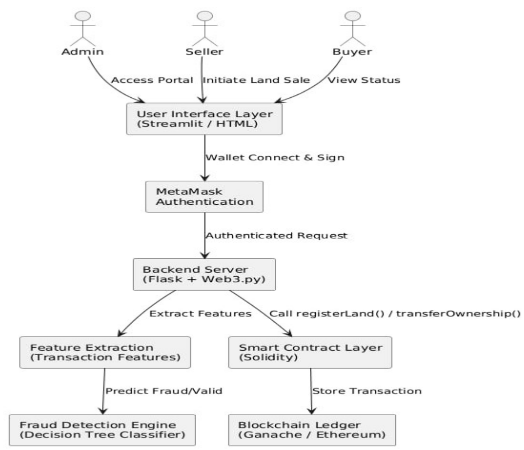

Figure 1. System Architecture of Blockchain-Based Land Verification with ML

B. User Interface and Wallet Integration

Users access the platform through a web-based interface. The first step is to connect a MetaMask wallet, which verifies identities securely. Once authenticated, users are given access based on their roles:

- Admin: Registers land by entering land ID, owner name, and other details.
- Seller: Requests to sell a specific land ID.
- Buyer: Checks ownership status and verifies transactions.

Every interaction with the blockchain, including land registration, sale, and ownership transfer, is digitally signed using MetaMask to maintain accountability and authenticity.

C. Backend Logic and Feature Extraction

When a user submits a transaction request, the backend system validates it through these steps:

- The backend retrieves the land record from the blockchain using Web3.py.
- It checks if the seller's Ethereum address matches the current owner of the land on-chain.
- If everything checks out, it collects these features for fraud analysis:
  - num_previous_sales – Count of past transactions for the land ID.
  - days_since_last_sale – Time (in days) since the last transfer.
  - ownership_mismatch – Boolean flag (1 = mismatch, 0 = match).

D. Decision Tree-Based Fraud Detection

The fraud detection module uses a Decision Tree Classifier created with the scikit-learn library. The classifier is trained on a dataset with both legitimate and fraudulent transactions. The logic follows:

- If ownership_mismatch = 1, the transaction is immediately classified as fraudulent.
- If num_previous_sales > 2, the transaction is flagged as high risk.
- If days_since_last_sale < 10, further investigation is required.

Extracted features are passed to the classifier, which returns: 1 – Fraudulent transaction, 0 – Valid transaction

If fraud is detected, the transaction is blocked, and an alert is shown to the seller. Otherwise, the process continues to the blockchain layer.

E. Smart Contracts and Blockchain Storage

Smart contracts handle land registration and ownership transfers using Solidity. The Ethereum test network is simulated with Ganache. The main functions are:

- registerLand(): Registers a land parcel with its details and owner wallet address.
- transferOwnership(): Transfers ownership to the buyer after validation.

F. End-to-End Transaction Flow

The complete transaction flow is as follows:

- User logs into the portal and connects MetaMask.
- Admin uses registerLand() to save new land details.
- Seller initiates a land sale by submitting the land ID.
- System checks if the seller is the current owner.
- If valid, features are extracted for fraud detection.
- Decision Tree Classifier determines transaction validity.
- If predicted valid, the transferOwnership() smart contract is called.
- Ownership is updated on the blockchain, and the buyer is notified.
- If predicted fraudulent, the system blocks the transaction and raises an alert.

G. Workflow of the Proposed System

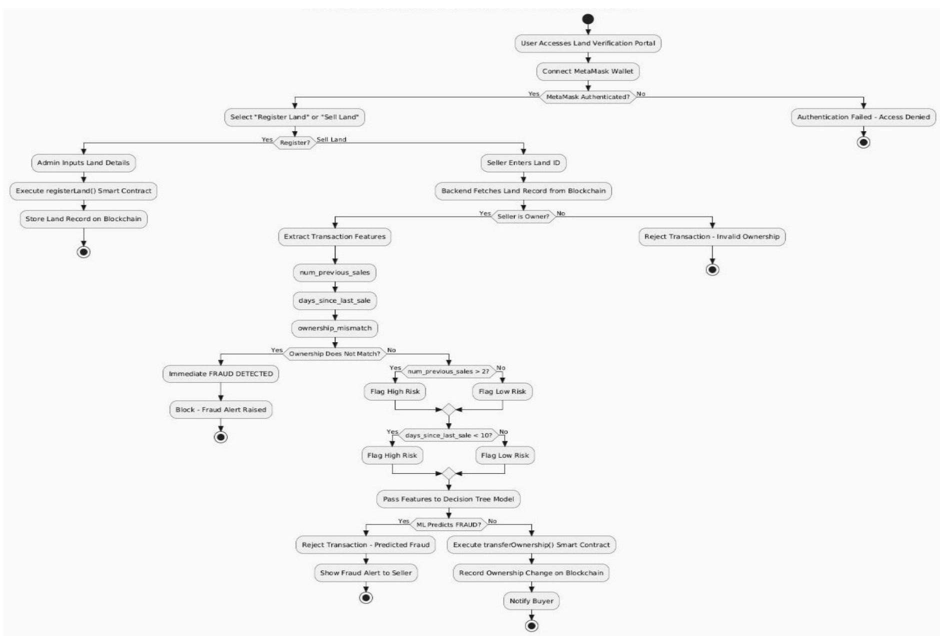

Figure 2. Workflow of the Proposed Blockchain-Based Land Sale Verification

System with ML-Based Fraud Detection

The workflow diagram in Fig 2 presents a detailed visualiza-tion of the transaction life cycle within the proposed system, highlighting each stage from user login to transaction finaliza-tion. The process begins when a user (Admin, Seller, or Buyer) accesses the system and authenticates using MetaMask. This wallet-based login ensures that only verified users can access the platform's functionalities. For example, an Admin can initiate land registration by invoking the registerLand() smart contract, which stores the land ID, owner address, and metadata onto the blockchain.

When a Seller requests a land sale, the system performs a critical validation: it retrieves the existing land record from the blockchain to confirm whether the seller's wallet address matches the registered owner. If there's any mismatch, the transaction is immediately flagged as fraudulent and blocked. If the seller is valid, the system then gathers data on past transactions, the time since the last sale, and a mismatch indicator for ownership. The transferOwnership() smart contract is triggered, transferring the land record to the buyer's Ethereum address. The new ownership information is written to the blockchain, and both the seller and buyer receive confirmation. This workflow ensures a secure, fraud-resistant, and automated transaction process, using both blockchain's lasting nature and the predictive power of machine learning. By bringing together decentralized ledger technology and smart decision-making, the proposed system builds trust, cuts down on fraud, and simplifies the property transfer process.

IV. Results and Discussion

A. Experimental Setup

The system used Flask (Python), Solidity for smart contracts, Ganache as a local Ethereum blockchain simulator, and MongoDB. MetaMask enabled authentication through Ethereum wallets. The fraud detection model employed the Decision Tree Classifier from the scikit-learn library. The frontend was created with HTML, CSS, JavaScript, and Streamlit for administrative interfaces. The experiments took place on a machine with an Intel Core i9, 32 GB of RAM, and SSD storage running Windows 11. A simulated dataset of historical land transactions was used to train and test the fraud detection model.

B. Fraud Detection Model Performance

The Decision Tree model was trained using 80% of the dataset, and the remaining 20% was used for validation. The model was evaluated using standard metrics commonly used in binary classification problems:

- Accuracy: Indicates the overall correctness of the model.
- Precision: Reflects how many transactions marked as fraud were actually fraudulent.
- Recall: Measures the ability to detect actual fraud cases.
- F1 Score: Balances the precision and recall into a single score.
- ROC-AUC Score: Demonstrates the model's ability to distinguish between fraud and non-fraud cases across thresholds.

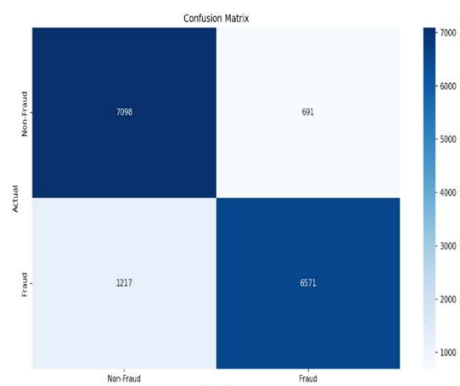

Figure 3. Confusion Matrix of the Decision Tree Classifier

TABLE I. Evaluation Metrics of the Fraud Detection Model

Metric	Value
Accuracy	88%
Precision	90%
Recall	84%
F1 Score	87%
ROC-AUC Score	94%

C. Confusion Matrix Analysis

The confusion matrix shown in Fig. 3 provides a detailed understanding of the model's performance:

- True Positives (TP): 6571 – Fraudulent transactions correctly identified as fraud.
- True Negatives (TN): 7098 – Legitimate transactions correctly classified as non-fraud.
- False Positives (FP): 691 – Legitimate transactions incorrectly marked as fraudulent.
- False Negatives (FN): 1217 – Fraudulent transactions that the model did not detect.

From this confusion matrix, it is clear that while the model performs well in detecting fraudulent activities, it still misses approximately 15% of actual fraud cases, as indicated by the false negatives. However, the number of false positives is relatively low, meaning the model does not unnecessarily block legitimate transactions. This balance is crucial for maintaining user trust, system reliability, and overall usability.

D. Integration with Blockchain Workflow

Although the ML model is currently evaluated independently, the system architecture (refer Figure 1) is designed for seamless integration. During a live transaction, extracted features such as num previous sales, days since last sale, and ownership mismatch are passed from the backend to the trained classifier. Based on the model's prediction:

- If the transaction is flagged as high risk or predicted as fraud, the smart contract execution is halted, and the transaction is logged but not recorded on the blockchain.
- If predicted as valid, the transfer Ownership smart contract is triggered and the new owner is recorded immutably on the blockchain.

This setup allows the ML component to serve as a decision-making middle layer before committing to the blockchain, combining the trust of decentralization with the intelligence of predictive analytics.

E. Comparative Analysis

TABLE II. COMPARATIVE ANALYSIS OF LAND RECORD MANAGEMENT SYSTEMS

Feature	Traditional	Proposed System
Tamper-proof Records	No	Yes
Manual Verification Needed	Yes	No
Ownership Transfer Automation	No	Yes
Fraud Detection	No	Yes
Use of Smart Contracts	No	Yes
Machine Learning Intelligence	No	Yes
Data Transparency	Low	High
Reliance on Intermediaries	High	Low
Scalability	Low	High

As shown in Table II, the proposed hybrid system outperforms traditional and blockchain-only approaches by combining blockchain's tamper-proof, decentralized features with machine-learning fraud detection. Traditional systems lack transparency and face manual errors and fraud, while blockchain-only systems improve security but have no predictive capability. The proposed model offers an automated, secure framework for modernizing land records with better reliability, scalability, and real-time fraud prevention.

V. CONCLUSION AND FUTURE WORK

This research presented an integrated framework that combines blockchain technology with machine learning to tackle land sale fraud. The system uses Ethereum-based smart contracts for secure and unchangeable ownership transfers, with MetaMask for authentication and Ganache for simulation. A Decision Tree classifier detects fraud by analyzing ownership history and transaction patterns, achieving 88% accuracy, 90% precision, and a 94% ROC-AUC, showing strong potential for real-time fraud detection and improved transparency while reducing manual checks and insider manipulation.

The prototype has limitations, as the fraud detection model is not integrated into the live workflow, and government land database integration is pending. Testing with synthetic datasets restricts real-world application. Future work includes integrating the Decision Tree model into the backend, deploying on public Ethereum testnets, using models like Random Forest or XGBoost, and adding explainable AI methods such as LIME or SHAP. With further development and government collaboration, this approach can reduce property fraud and improve transparency in land governance.

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