

Developing a Decentralized Land Registry System using Blockchain for Secure and Verifiable Transactions

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Abstract - Land registration is a process that requires a level of trust. Inaccurate records, fragmented documentation, manual checks and unauthorized changes can create disputes. Delay property transactions. This paper introduces a decentralized land registry prototype that combines blockchain technology, smart contracts, decentralized document storage and conventional web tools to give a traceable workflow for land registration and ownership transfer. The prototype uses React with Vite for the user interface Node.js and Express.js for application services MongoDB for off-chain data IPFS for land documents and a Solidity smart contract deployed on a Hardhat network for critical land and transaction functions. JWT-based authentication separates user access according to roles such as seller, buyer, government officer and administrator.. Ethers.js support blockchain wallet interaction and payment. The smart contract coordinates land registration, government verification, purchase requests, seller approval, payment and ownership transfer. Testing covered unit, integration, functional and system-level workflows. The prototype successfully completed the end-to-end purchase sequence, with ownership and transaction information updated after payment. The work shows how combining blockchain immutability with references and a conventional web application can improve traceability reduce reliance on manually maintained records and provide a practical foundation for future integration, with government land databases and production blockchain networks.

Index Terms - Blockchain, Land Registry, Smart Contracts, Ethereum, IPFS, MetaMask, Decentralized Applications, Ownership Transfer.

I. INTRODUCTION

Land records play a role in legal ownership, property deals and public administration. Traditional land registration systems rely on databases, physical papers, manual checks and multiple middlemen. These setups often lead to problems like data, slow verification and difficulty in keeping records synchronized. The project report highlights issues with old methods—lack of transparency, data errors, fraud, manipulation of records and inefficient verification processes.

Digitization helps cut down on paper work. A central digital system still depends on one authority to control data. This creates a point of failure and makes the system vulnerable. Blockchain technology offers a way to build trust by spreading records across a network and making changes nearly impossible to alter. In this system smart contracts are used to enforce the rules of transactions while IPFS handles the decentralized storage of land documents. This approach builds on blockchain strength without storing all data on the chain combining it with familiar web tools for ease of use.

The main goal is to build a working prototype that supports login, land registration, government approval, buyer applications, seller consent, blockchain-based payments and automatic transfer of ownership. The system must keep a tamper-proof history of each transaction while offering a simple web interface, for everyone involved—buyers, sellers, government officers and others. The project report clearly points out the objectives: improving transparency preventing fraud using smart contracts to automate steps and reducing the effort needed to process land deals.

II. RELATED WORK AND BACKGROUND

A. Traditional Land Registration and Digital Land Records

Traditional land registration systems usually rely on government databases and paper documents. These systems can have problems such as not being open enough having records in different places taking too long to check and not keeping good records of who owned the land. Research about land records in India has found problems like not being clear having information in different government offices and taking too long to register and transfer land . Blockchain-based land titles have therefore been suggested as a way to make the records more accurate and easier to track.

Some studies have looked into using blockchain for land management. Thakur et al. [1] Suggested blockchain-based land records for land titles in India showing how distributed records can give clear ownership information. Also blockchain-based land title systems have been suggested to make things more open keep data in sync and make it easier to get information while depending less on central record keeping [2].

Traditional digital land systems still depend a lot on central databases and official processes. These problems lead to the need for a system that uses data management at the application

level along with blockchain for ownership and transaction records.

B. Blockchain-Based Land Registry Systems

Blockchain gives a way to have a distributed record where transactions can be saved in a way that can be followed and can't be changed. Its use for land registration has been looked at in studies. A blockchain-based land registry using Ethereum and smart contracts has been suggested to cut down on activities and delays in land deals [3]. These systems let important land deals be written on the blockchain and can make it clearer between buyers, sellers and government workers.

Banerjee et al. [4] Made a land registry system that uses blockchain and IPFS. Their system saves land records on the blockchain. Uses IPFS for other documents. This way shows how blockchain can keep transaction records while decentralized storage can handle big documents.

Other studies have looked at land transaction systems that use a distributed ledger with trusted nodes and different ways to agree on transactions to make things faster [5]. These ideas show that blockchain works for land management but also show problems like being able to handle more transactions needing a lot of agreement keeping things private and working with old government systems.

The project proposed here follows the basic idea but uses a simpler web-based way to register land using Ethereum compatible blockchain, Solidity smart contracts, MongoDB, IPFS, MetaMask, React and Node.js/Express.

C. Smart Contracts, for Land Registration and Ownership Transfer

Smart contracts are a part of blockchain-based land registration systems because they allow rules to be carried out automatically. Panda et al[6] . Introduced a contract based land registry using Ethereum, where smart contracts are used to support land transactions and ownership transfer.

Smart contracts have also been used to automate registration, verification and transfer processes in blockchain-based land systems. [7]Studies have shown that smart contracts can reduce work and provide a clear way to enforce transaction conditions

In the proposed system the LandRegistry Solidity smart contract handles the blockchain operations[8]. These include land registration, government verification, purchase requests, seller approval, payment, ownership transfer and ownership history[9]. The buyers payment is made through MetaMask and the smart contract updates the ownership once the required purchase conditions are met.

This method creates an automated transaction process:

Land Registration → Verification → Purchase Request → Seller Approval → Payment → Ownership Transfer

D. IPFS-Based Land Document Storage

Land registration involves documents such as ownership proofs and supporting property documents[10]. Storing documents directly on a blockchain is inefficient because blockchain storage is expensive and not suitable for large files[11]. For this reason decentralized storage systems like the InterPlanetary File System (IPFS) have been examined for storing land-related documents.

Banerjee et al[12]. Proposed a land registry system that combines blockchain and IPFS. In this system blockchain is used to store transaction records while IPFS handles the storage of land-related documents[13]. Similarly other research on blockchain-based land registries has used IPFS to store property documents keeping their references or hashes on the blockchain.

In the proposed system land documents are uploaded through a web application[14]. Stored using IPFS. The IPFS reference is then linked to the corresponding blockchain land record. This approach separates document storage from transaction and ownership records, which reduces the need to store documents directly on the blockchain[15].

E. Authentication and Role-Based Land Management

A land registration system must support different levels of access because buyers, sellers and government authorities perform different tasks[16]. Most existing blockchain land registry research focuses on blockchain transactions while authentication and role management at the application level can be handled separately.

The proposed system uses JWT-based authentication with role-based access for users such as Buyer, Seller and Government Officer[17]. User account details are stored in MongoDB while blockchain wallet addresses are linked to users for blockchain transactions.

This system separates application-level authentication from blockchain authorization[18]. JWT is used to manage application sessions while MetaMask wallet authentication and blockchain transactions are used for operations that require interaction with the blockchain.

F. Blockchain-Based Payment and Transaction Processing

Blockchain-based payment allows for the integration of payment and ownership transfer into one automated transaction workflow[19]. Existing Ethereum-based land registry systems have explored using cryptocurrency and smart contracts to transfer property ownership when predefined conditions are met[20].

The proposed system includes a purchase workflow where a buyer submits a purchase request for verified land. The seller. Approves the request. Then the buyer pays the required amount in ETH using MetaMask[21]. The smart contract then processes the payment. Updates the land ownership.

This creates a sequence:

Purchase Request → Seller Approval → Buyer Payment → Ownership Transfer

G. Comparative Synthesis and Research Gap

Existing research shows that blockchain, smart contracts and IPFS can help make land registration and ownership management[22]. There are still many problems with how these systems work. Some of the problems include relying on systems handling documents making sure things are secure making everything work together handling more users keeping things private and making it easy to use in real life [23]. The main areas where more work is needed are:

- G1: Traditional land systems do not show clearly what is happening and depend on one place to keep records.

- G2: Checking land details and moving ownership by hand can slow things down. Take more work.
- G3: Big land documents cannot fit directly on blockchain. Need a good way to store them in a decentralized way.
- G4: Blockchain systems need to work with user login and web programs.
- G5: Many systems are ideas or early versions and need to bring together registration, checking, buying and moving ownership into one process.
- G6: Using these systems in life needs to think about government rules, legal systems handling more users keeping things private and making it work outside of small tests[24].

The proposed Blockchain-Based Land Registration System solves these issues by using React and Vite for the end Node.js and Express.js for the back end MongoDB to store information JWT to check who is using the system IPFS to store land documents Solidity smart contracts to manage land actions, Ethereum and Hardhat to run the blockchain, Ethers.js to talk to the blockchain and MetaMask to handle payments, through wallets[25].

III. THREAT MODEL AND SYSTEM ARCHITECTURE

A. Threat Model

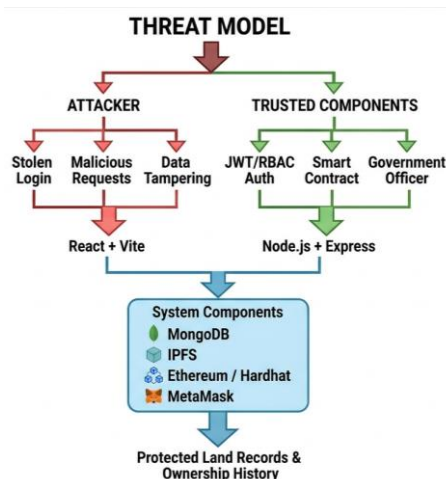


Figure. 1. Threat model of the proposed land-registration system showing attacks, trusted components, authentication, IPFS document storage, government verification, smart-contract validation blockchain payment and secure ownership transfer.

Adversary capabilities

The adversary is an attacker who may try to gain unauthorized access to the land-registration system by stealing valid user credentials. The adversary may also send requests submit false land details or try to alter land records and uploaded documents. The attacker might target the React/Vite frontend, Node.js/Express backend, database or other parts of the system to carry out actions such as fake purchase requests or changes to ownership without permission.

Trust assumptions

The JWT/RBAC authentication mechanism, Solidity smart contract and authorized Government Officer are considered

components, in the system. JWT authentication and role-based access control are assumed to limit user actions based on their assigned roles. The smart contract is trusted to check and record land registration, verification, payment and ownership transfer activities. MongoDB is trusted to store application data and user information. IPFS is used to store land-related documents. Ethereum/Hardhat is trusted to keep a record of blockchain transactions. MetaMask is trusted to approve and authorize blockchain transactions and payments.

Representative scenario

Figure. 1 Shows the threat model of the proposed land-registration system. An attacker may first attempt to steal a user's login credentials send requests or change land information. The React/Vite. Node.js/express backend process and check user requests using JWT authentication and role-based access control. Land documents are saved using IPFS while application data is stored in MongoDB. The Government Officer reviews registered land records. The Solidity smart contract manages land registration, purchase approval, payment and ownership transfer. Blockchain transactions are recorded on the Ethereum/Hardhat network and MetaMask is providing wallet authorization. These mechanisms help protect land records and ownership history from access and modification.

B. Architecture Overview

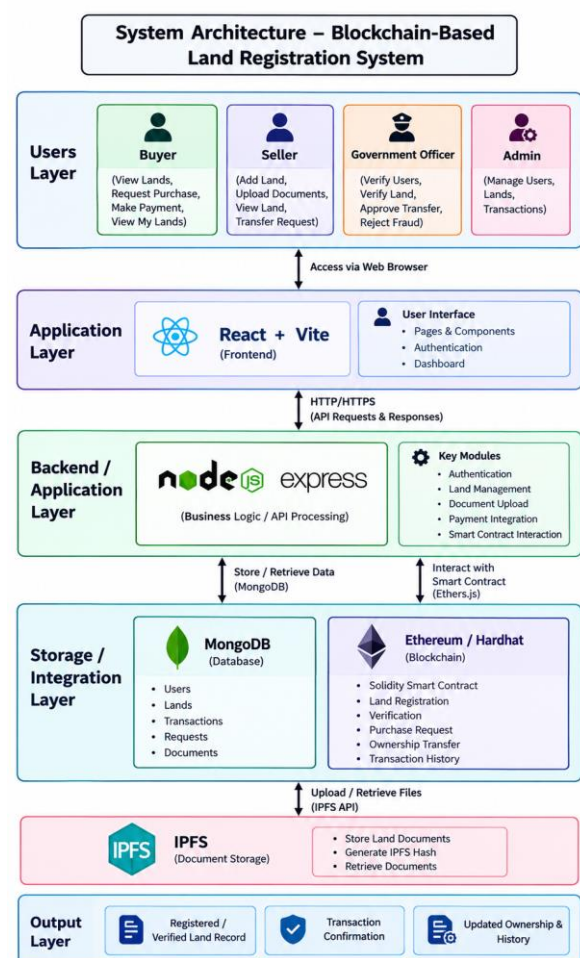


Figure.2 System Architecture. Developing a Decentralized Land Registry System Using Blockchain for Secure and Verifiable Transactions

Figure.2 shows the structure of the Blockchain-Based Land Registration System that is being created. The architecture brings together a web application, backend services, traditional database storage, smart contracts that run on blockchain and storage that is decentralized to create a secure and easy to track system for land registration. The whole design separates the ways users interact how the application works, how data is stored and what the final results of a transaction are.

1. Users Layer: The system has four user roles: Buyer, Seller, Government Officer and Admin. Buyers have the ability to see land that's available ask to buy it make payments and check on the properties that they have registered. Sellers can add information about land upload documents that support their listings see details about their properties and deal with requests to transfer ownership. Government officers check people and land details say yes to transfers and say no to fake ones. The Admin is in charge of managing people, land records and all the transactions that happen.

2. Application Layer: The users get to the system by using a web browser. The front end is built with React and Vite. It gives pages helps with signing in and offers dashboards that change based on the role a user has. This part is the way that users connect with the services for land registration.

3. Backend/Application Layer: The back end uses Node.js and Express.js to handle requests and set up the rules that the system follows. Important parts include making sure people are who they say they are handling land details uploading documents connecting with payment systems and working with contracts. This part links the end with both the database and the blockchain parts of the system.

4. Storage and Blockchain Integration Layer: The system uses MongoDB to keep track of information that is organized like users, land details, transactions, requests and references to documents. At the time Ethereum and Hardhat blockchain tools run smart contracts made in Solidity. These smart contracts take care of land registration checking details handling requests to buy, changing ownership and keeping a history of all the actions. This way the system can work with data and also with records that are stored on a blockchain. This kind of setup is often used to keep information off the blockchain but keep the important parts like who owns what and the checks on that information on the blockchain.

5. IPFS Document Storage Layer: The system uses IPFS to store and get land-related papers. Of putting the whole documents on the blockchain the system uses a way to store things that is not controlled by one person and keeps a reference or a code that shows the documents. This helps make sure the documents are not changed and also keeps the amount of data that is stored on the blockchain from getting too big.

6. Output Layer: Once all the checks and the steps of a transaction are done the system creates three results: a land record that has been registered and checked confirmation that a transaction happened and a new version of who owns what. So the whole structure offers a path, from when a user starts using the system and sends documents to when the checks are done the transaction is handled with blockchain and the records of who owns what are updated ownership records.

IV. METHODOLOGY AND IMPLEMENTATION

A. Methodology

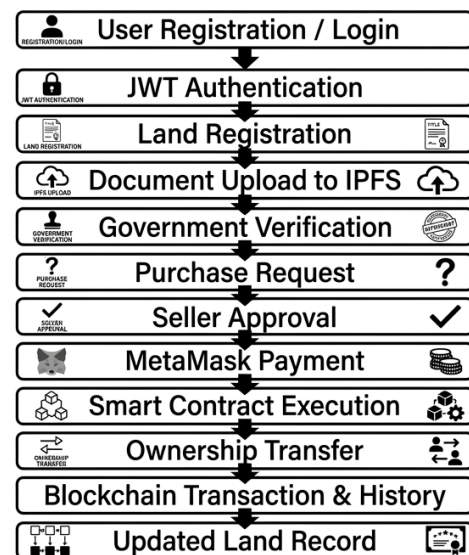


Figure.3 shows the workflow of the blockchain-based land registration system, covering authentication, document verification, payment processing and secure ownership transfer.

A. User Authentication and Role Management. The system allows users to register and log in. Different roles have access levels. User authentication is managed using JWT and user and application data are stored in MongoDB.

B. Land Registration and Document Handling. A seller inputs details like land location, area, price and document information. The supporting documents are uploaded to IPFS and a reference link to the file is saved with the land record. A smart contract handles the registration on the blockchain.

C. Government. Purchase. Once land is registered a government officer reviews it. Only land that passes verification can move to the purchase phase. A buyer submits a purchase request and the seller reviews and approves it. The smart contract tracks the purchase status throughout the process.

D. Payment and Ownership Transfer. After approval the buyer connects a MetaMask wallet. Pays the required amount in ETH. The smart contract receives the payment. Once all conditions are met updates the current owner. The system also keeps a record of ownership and all past transactions. The core smart-contract functions are registerLand() verifyLand() requestPurchase() approvePurchase() makePayment() transferOwnership() getLand() getOwner() getHistory() and getPurchaseRequest().

E. Technology Stack. The system is built using React with Vite, Node.js, Express.js, MongoDB, Mongoose, JWT, Solidity, Hardhat, Ethereum, Ethers.js, MetaMask, IPFS, npm and other development tools. The report outlines these technologies as the implementation stack, for the prototype.

B. Implementation

The Blockchain-Based Land Registration System uses four parts:

1. User Authentication and Management Module: The system gives users a place to sign up and sign in. Users are split into Seller, Buyer, Government Officer and Admin. JWT keeps

users safe. All user details and data go into MongoDB. Role rules let each user do what they should.

2. Land Registration and Document Module: The Seller can register land by providing:

- Land location
- Land area
- Land price
- Land document

Land documents are put into IPFS. The IPFS address is linked to the land record. Land details go through the Solidity contract. Users can see the land that's on record.

Algorithm Steps:

1. User logs into the system.
 2. Seller chooses land registration.
 3. Seller enters land location, area and price.
 4. Seller uploads the needed land document.
 5. Document is stored in IPFS.
 6. Land is registered by the contract.
 7. Data is put into MongoDB.
 8. The system shows the registered land details.
3. Land Verification and Purchase Module: The Government Officer can see the land that's on record and check it. Checked land can move to buying.

Algorithm Steps:

1. Government Officer sees the land that's on record.
 2. Government Officer checks the land record.
 3. Buyer sees the checked land.
 4. Buyer sends a purchase request with the offered price.
 5. Seller gets the purchase request.
 6. Seller approves the purchase request.
 7. The system updates the purchase status.
4. Blockchain Payment and Ownership Transfer Module: The buyer pays with MetaMask after the request is okay. The payment goes through the Solidity contract. The transaction is stored on the Ethereum chain using the Hardhat network. When the payment goes through the ownership moves to the buyer. The system writes the owner and keeps a record of all changes. The React page shows the info.

Algorithm Steps:

1. Buyer receives purchase approval.
2. Buyer connects to MetaMask.
3. Buyer pays the ETH.
4. Smart contract checks the payment.
5. Payment is stored on the blockchain.
6. Ownership moves to the buyer.
7. Ownership and history are updated.
8. The system shows the updated results, to the user.

V. DATABASE STRUCTURE

A. Users Table

Table 1. Users Table

Field	Data Type	Description	Key Type
_id	ObjectId	_id field	Primary Key
name	String	name field	None
email	String	email field	Candidate Key
password	String	password field	None
role	String	role field	None
walletAddress	String	walletAddress field	Candidate Key
phone	String	phone field	None

B. Lands Table

Table 2. Lands Table

Field	Data Type	Description	Key Type
_id	ObjectId	_id field	Primary Key
OwnerName	String	ownerName field	None
CurrentOwner	String	currentOwner field	Foreign Key
previousOwner	String	previousOwner field	Foreign Key
surveyNumber	String	surveyNumber field	Candidate Key
location	String	location field	None
area	String	area field	None
marketValue	Number	marketValue field	None
owner	String	owner field	Foreign Key
document	String	document field	None
verified	Boolean	verified field	None
history	Array<Object>	history field	Embedded Data
createdAt	Date	createdAt field	None

C. Transaction History Table

Table 3. Transaction History Table

Field	Data Type	Description	Key Classification
_id	ObjectId	_id field	Primary Key (PK)
landId	ObjectId	landId field	Foreign Key (FK)
fromOwner	String	fromOwner field	Foreign Key (FK)
toOwner	String	toOwner field	Foreign Key (FK)
transactionHash	String	transactionHash field	Unique Attribute (Candidate Key)
status	String	status field	Standard Field

Field	Data Type	Description	Key Type
_id	ObjectId	_id field	Primary Key
name	String	name field	None
email	String	email field	Candidate Key
password	String	password field	None
role	String	role field	None
createdAt	Date	createdAt field	None
timestamp	Date	timestamp field	Standard Field

D. Admin Table

Table 4. Admin Table

VI. WORKFLOW DIAGRAM

The workflow of project that explains how the process of land registration using blockchain occurs.

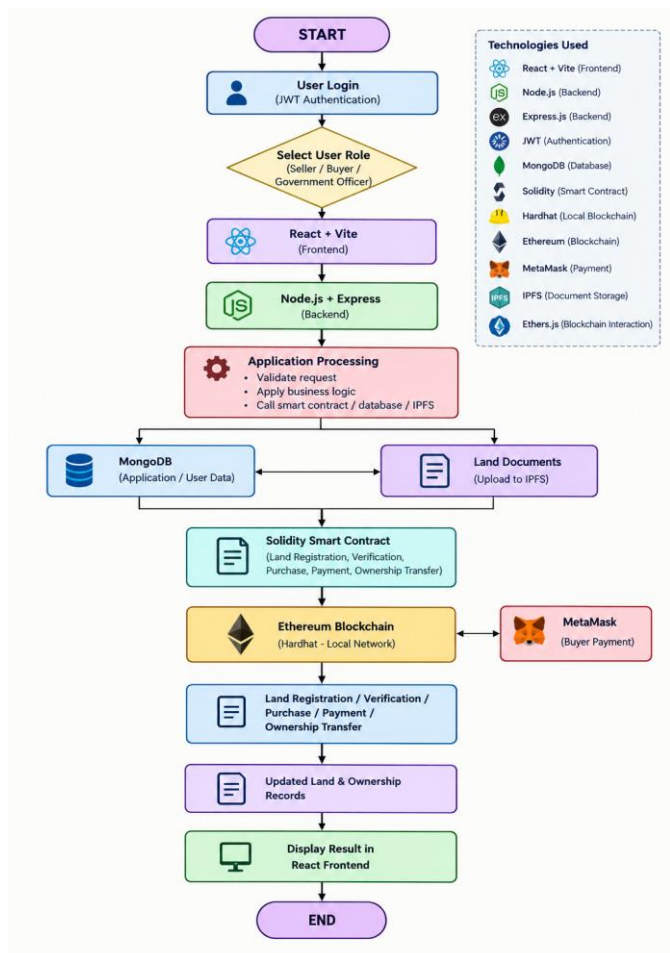


Figure.4 Flowchart Diagram

Figure. 4 illustrates the workflow of land registration using blockchain. The steps are as follows:

Start:

1. Start the System: A person opens the Land Registration Blockchain web application using a browser.

2. User Login: A person types in their email address and password that they have already signed up with to log in.

3. JWT Authentication: The system behind the scenes checks the email and password. If correct it creates a code called a JSON Web Token. This code helps the system know the person is allowed to see parts of the app.

4. Role Selection: The person gets to use the system based on what job they have. They can be a Seller, a Buyer or a Government Officer. Each of these roles has things they can do.

5. React Frontend: The person uses the part of the app that is built with React. They can add details about land look at properties that're for sale upload papers ask to buy land and check land records.

6. Backend Processing: The part of the system that runs on Node.js and Express gets the requests from the person. It checks if the request is allowed and if the person has the right to do what they are asking. Then it does the work that needs to be done.

7. Database Storage: All the information like user details, land information requests to buy and other records are kept in a database called MongoDB.

8. Document Storage Using IPFS: The seller puts up papers like ownership certificates and property records. These papers are stored on a system called IPFS. A special code called a CID is saved in the app so the papers can be found again.

9. Smart Contract Execution: A program written in Solidity runs on the blockchain. This program handles things like registering land checking if it is real handling purchase requests, managing payments and moving ownership based on rules that are already set.

10. Blockchain Recording: details like who owns the land changes in ownership papers linked to the land and transaction records are written on the Ethereum blockchain. The system called Hardhat is used to test and put the contract on the blockchain during the building phase.

11. Payment Through MetaMask: The person uses a wallet called MetaMask. They look at the payment details. Say yes to the transaction or payment that needs to happen on the blockchain.

12. Ownership Transfer: Once the payment is made and everything is checked the smart contract changes the ownership on the blockchain. The new owner gets a confirmation from the transaction and the blockchain.

13. Frontend Update: The part of the app that people see gets the information from the system and the blockchain. It shows the land records, the status of transactions and who owns what to the right people.

14. End of Process: The land registration or ownership transfer is done. The records, on the blockchain make it easy to check. See what

VII. TESTING AND RESULTS

The prototype was evaluated using unit, integration, functional and system testing. Unit tests were used to check components while integration tests examined communication among the frontend, backend MongoDB, smart contract, Hardhat network,

MetaMask and IPFS. Functional tests examined the user-facing operations and system testing considered the workflow.

Integration testing reported communication between the React frontend and Node.js backend, correct MongoDB storage and retrieval successful smart-contract execution confirmed Hardhat transactions, successful MetaMask payment successful IPFS document upload and completion of the purchase workflow.

The end-to-end scenario began with seller land registration, followed by government verification buyer purchase request, seller approval, MetaMask payment and ownership transfer. The final test reported that the buyer became the owner and that transaction and ownership information were updated successfully.

From a usability perspective the implemented interfaces include registration and login screens, seller and buyer dashboards, land-detail views, purchase-request screens and a government officer dashboard. These interfaces provide role- access to the operations represented in the underlying workflow. The results therefore validate the prototype as a demonstration rather than as an isolated smart contract.

VIII. SECURITY, BENEFITS, AND LIMITATIONS

The architecture provides security-oriented benefits. Blockchain records make ownership and transaction history difficult to manipulate after confirmation while smart contracts enforce predefined transaction conditions. JWT-based authentication protects application access MetaMask provides wallet-based signing and IPFS reduces dependence on a centralized document store. These mechanisms collectively improve traceability. Reduce opportunities for unnoticed record changes.

However the current system should be understood as a prototype than a production government registry. The report uses an Ethereum-compatible blockchain supplied by Hardhat for development, testing and demonstration. Real deployment would also require recognition, integration with official land databases stronger identity verification, scalable infrastructure and production-grade payment and security controls. The report identifies interoperability, legal requirements, scalability, identity management and user adoption as adoption challenges.

IX. FUTURE SCOPE

The system can be further enhanced in the following areas:

1. Government Database Integration: Integrate the system with official government land-record databases for real-world adoption.
2. AI-Based Fraud Detection: Introduce AI to identify land records duplicate documents or unusual transactions.
3. Mobile Application: Develop Android/iOS applications so buyers, sellers and government officers can access the system easily.

4. Advanced Document Verification: Use OCR and digital verification techniques to validate uploaded land documents.
5. Multi-Blockchain Support: Support blockchain networks to improve scalability, flexibility and transaction efficiency.
6. Enhanced Government Integration: Provide APIs to connect with government departments and existing land registration portals.
7. Improved Security: Add identity verification, digital signatures, multi-factor authentication and additional access-control mechanisms.
8. Real Payment Integration: Integrate a real-world payment mechanism for actual land transactions while maintaining blockchain-based transaction records.
9. Scalable Deployment: Deploy the system, on cloud infrastructure to support a larger number of users and land records.

X. CONCLUSION

This work demonstrates a practical approach to decentralized land registration by combining blockchain-based transaction management with conventional web technologies and decentralized document storage. The prototype supports the main stages of a land transaction, beginning with authenticated access and land registration and continuing through government verification, purchase approval, payment, and ownership transfer.

The implementation integrates React/Vite, Node.js/Express, MongoDB, IPFS, Solidity, Ethereum-compatible Hardhat infrastructure, MetaMask, and Ethers.js. Testing of the major modules and the complete purchase sequence showed that the intended workflow could be executed successfully, with ownership and transaction information updated after payment. The resulting system provides a working foundation for more secure, transparent, and traceable digital land management.

At the same time, the prototype does not claim to solve the legal, governance, interoperability, or scalability requirements of a national land registry. Those issues remain important directions for future research and deployment. The next stage should therefore focus on connecting the technical workflow with authoritative government records, stronger identity assurance, and a production-ready blockchain and payment environment.

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