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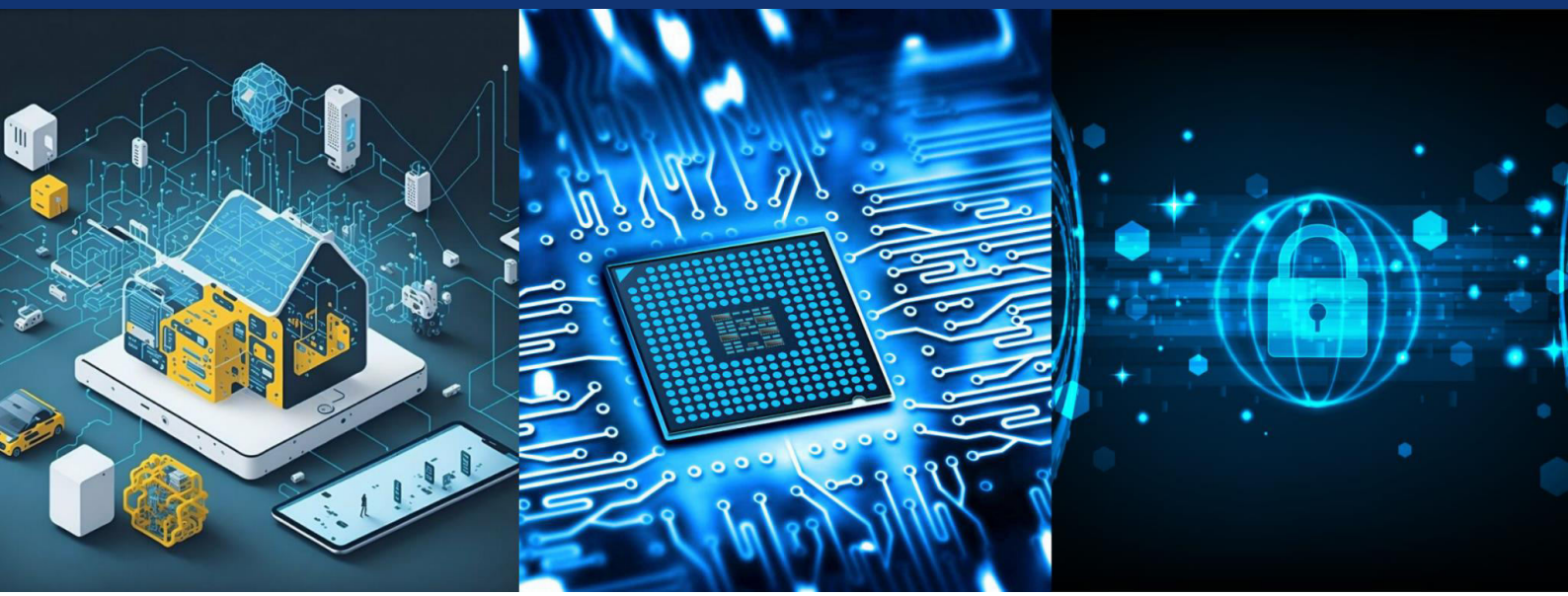

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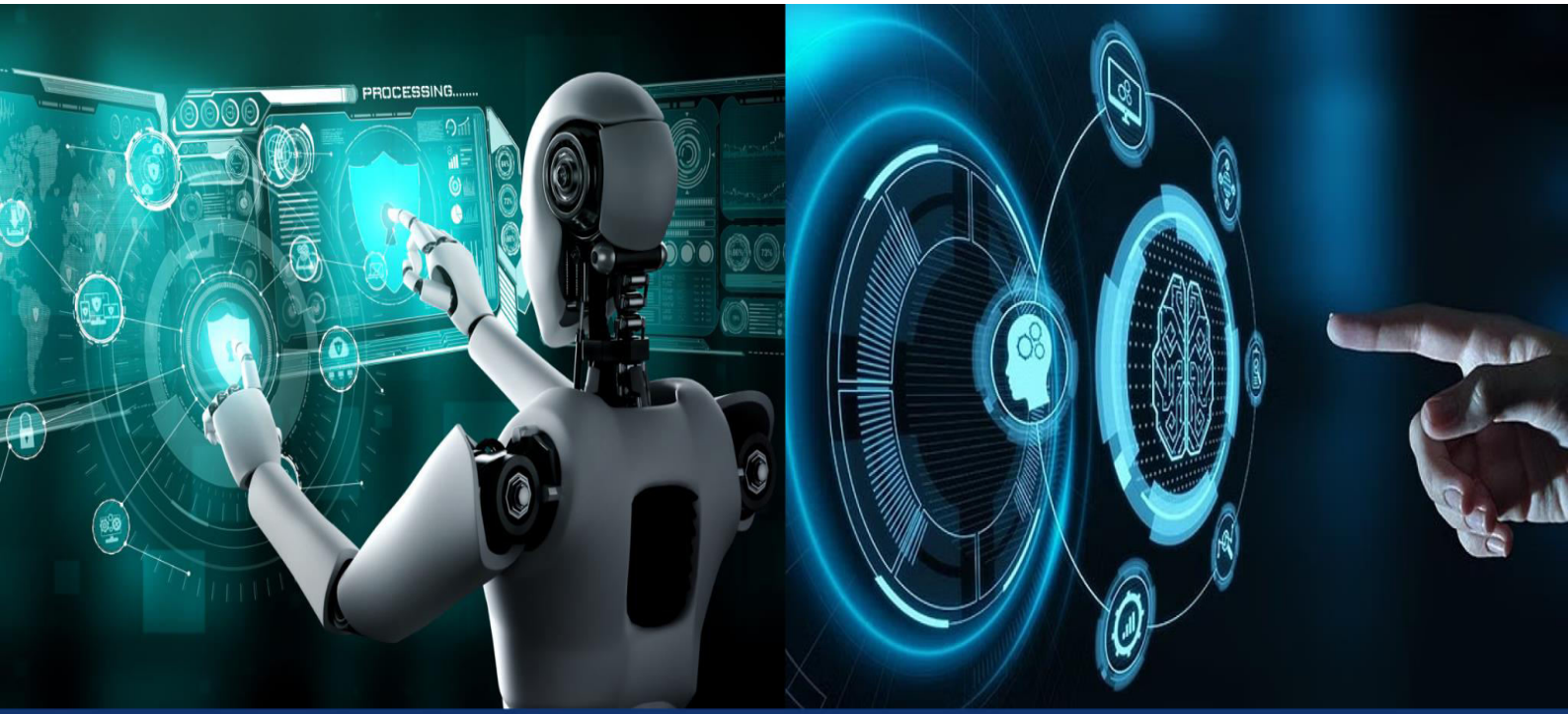

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Decentralized Land Ownership and Transfer using Blockchain Technology

Manjunath Gowda R[1], Mohammed Ghouse[2], Naddana Yashwanth[3], Pavan G B[4], Dr. Srinivasa A. H. [5]

Students, Department of Computer Science and Engineering, Dr. Ambedkar Institute of Technology, Bangalore, Karnataka, India [1,2,3,4]

Associate Professor, Department of Computer Science and Engineering, Dr. Ambedkar Institute of Technology, Bangalore, Karnataka, India[5]

ABSTRACT: The land registration process in India and many parts of the world suffers from inefficiencies, fraud, and lack of transparency. The current system relies heavily on manual record-keeping, leading to loss of documentation, fraudulent transactions, and prolonged court cases due to disputes. To address these issues, this paper proposes a blockchain-based Land Registration System that provides a secure, immutable, and decentralized method for storing and transferring land ownership records. The system leverages the Ethereum blockchain using smart contracts developed in Solidity and the Truffle Suite. The platform offers features such as land ownership transfer, buyer-seller verification, and land inspector approval, ensuring trust, transparency, and accelerated transactions. A React-based frontend integrated with Metamask facilitates secure user interactions. By incorporating blockchain technology, this system reduces intermediaries, mitigates fraudulent transactions, and ensures the integrity of land records.

KEYWORDS: Blockchain, Land Ownership Transfer System, Smart Contracts, Solidity, Ganache, Metamask, React, Decentralized Applications (DApp).

I. INTRODUCTION

Land registration is a critical process for ensuring property rights and legal ownership in any society. However, conventional land registration systems, particularly in countries like India, face significant challenges such as fraudulent transactions, delays in verification, loss of paperwork, and legal disputes over ownership. Managing thousands of records manually exacerbates these inefficiencies, leading to a lack of transparency and trust among stakeholders.

This paper introduces a blockchain-based Land Registration System that aims to revolutionize the traditional process by leveraging the decentralized and immutable nature of blockchain technology. Blockchain serves as a public ledger where all land transactions are recorded securely and transparently. Smart contracts written in Solidity ensure the automation and verification of transactions without intermediaries, thereby minimizing the scope for fraud.

The proposed system utilizes the Ethereum Blockchain, enabling a secure and decentralized environment for land registration. Tools such as Truffle Suite, Ganache, and the MetaMask browser extension facilitate the development and interaction with the blockchain network. The frontend of the application, developed using React.js and JavaScript, provides an intuitive interface for sellers, buyers, and land inspectors to perform tasks such as registration, land verification, ownership transfer, and payment authorization.

The system architecture includes role-based access control where land inspectors act as administrators, verifying buyers and sellers while approving land ownership transfers. Sellers can register lands, approve purchase requests, and receive payments, whereas buyers can view available lands, request ownership, and complete secure payments. All transactions are stored immutably on the blockchain, ensuring transparency and eliminating the possibility of tampering.

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II. RELATED WORK

Smart contracts, as discussed in **Buterin (2013)**, provide a programmable layer on blockchain, automating processes like ownership transfer and payment handling. This significantly reduces the need for intermediaries and accelerates transactions.

Countries like **Sweden** and **Georgia** have pioneered blockchain-based land registration systems, demonstrating the practical feasibility of such systems. These implementations underscore the benefits of decentralization, fraud prevention, and streamlined operations.

Studies like **Wood (2014)** emphasize Ethereum's robustness in ensuring secure and transparent transaction recording, making it suitable for high-stakes applications like land registration. Blockchain networks like Ethereum face challenges in handling a large volume of transactions. **Buterin et al. (2016)** discuss ongoing research in improving blockchain scalability to address such limitations.

Blockchain adoption in India has been explored in reports by **NITI Aayog (2020)**, which identify land registration as one of the critical areas where blockchain can create transformative impact.

Comparative analyses in studies like **Zyskind et al. (2015)** highlight the superior security and transparency of decentralized systems for sensitive data management.

Blockchain-based land registration systems must align with existing legal frameworks, requiring collaboration between governments and technology providers. This integration remains a challenge in countries with rigid or outdated laws. **Digital India and Blockchain Adoption (2021)** project scheme analyzes the potential of blockchain to accelerate the goals of the Digital India initiative, with land registration identified as a key use case.

This study explores how smart contracts can automate land transactions and improve system efficiency and can modernize public records, specifically focusing on land registration systems.

III. PROPOSED SYSTEM

The proposed system leverages blockchain technology to revolutionize the traditional land registration process, addressing its inefficiencies and vulnerabilities. By creating a decentralized, transparent, and secure platform for land registration, this system ensures the integrity of land records while simplifying the process for all stakeholders. Key features of the Proposed System are:

A. Decentralized Ledger

The system uses blockchain to store all land records and transactions on a decentralized public ledger. This ensures that the data is immutable, transparent, and tamper-proof. Unlike centralized systems, no single authority can manipulate the records.

B. Smart Contracts for Automation

Smart contracts are implemented to automate key processes, such as ownership transfer, payment transactions, and record updates. This reduces reliance on intermediaries, speeds up the process, and minimizes human error.

C. Role-Based Access Control

a) Buyers and Sellers: Can register, view available properties, and initiate transactions.
b) Land Inspector: Acts as an administrator, verifying user identities, approving land addition requests, and validating ownership transfer.
c) This role-based structure ensures that users interact with the system only as per their defined responsibilities.

D. Secure Authentication

The system integrates secure authentication mechanisms using a combination of blockchain wallets (such as Metamask) and user registration. This ensures that only verified users can access or modify records.

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E. Transparency and Fraud Prevention

Blockchain's inherent transparency allows all transactions and records to be publicly visible (without compromising sensitive user data). This feature helps prevent fraud, such as duplicate land sales or forged ownership claims.

F. Digital Document

Important property documents and land information are stored securely on the blockchain or linked via decentralized storage systems like IPFS (InterPlanetary File System). This eliminates the risk of document loss or tampering.

IV. SYSTEM ARCHITECTURE

The system architecture of the blockchain-based Land Registration System is designed to address the inefficiencies of traditional land registration processes by integrating modern technologies. It ensures transparency, security, and automation through a layered approach.

A. Overview of Architecture

As shown in the Fig. 1, the architecture is divided into three main layers, ensuring smooth interaction between users and the underlying blockchain technology:

1)Frontend Layer: User interface and interactions.

2)Blockchain Layer: Core system operations and smart contract execution.

3)Backend & Storage Layer: Testing, decentralized storage, and auxiliary data management.

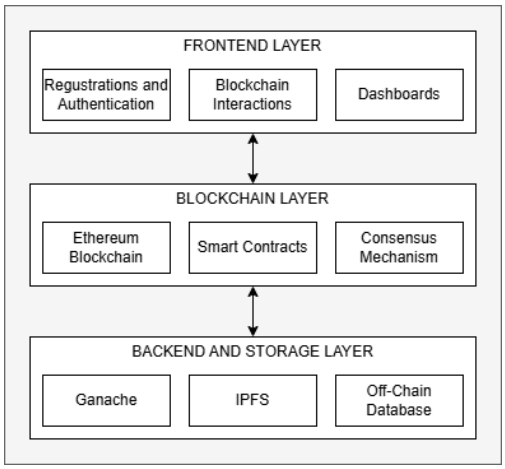

Fig. 1. Components of System Architecture

B. Components of System Architecture

Smart contracts are implemented to automate key processes, such as ownership transfer, payment transactions, and record updates. This reduces reliance on intermediaries, speeds up the process, and minimizes human error.

1. Frontend Layer

This is the user-facing interface that facilitates interaction between the users and the blockchain system. Technologies used and key features are:

a) ReactJS for creating an intuitive and responsive user interface.
b) Metamask for integrating Ethereum wallets and enabling secure blockchain transactions.
c) Registration and Authentication: Buyers and sellers register and log in securely.
d) Dashboards: Provide user-specific functionality, such as adding land, viewing available properties, and approving requests.
e) Blockchain Interaction: All user actions are translated into transactions executed on the blockchain through Metamask

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2. Backend Layer

This is the core of the system, handling all land records and transactions using Ethereum blockchain. Technologies used and key functions are:

a) Ethereum Blockchain: A decentralized ledger to store immutable records of transactions.
b) Smart Contracts: Implemented in Solidity to automate critical operations.
c) Consensus Mechanism: Ethereum's Proof of Stake (PoS) for efficient transaction validation.
d) Land Verification and Addition: Land details added by the seller are verified and approved by the Land Inspector.
e) Ownership Transfer: Smart contracts automate ownership transfer once payment and validation are complete.
f) Payment Processing: Buyers pay sellers via secure blockchain transactions

3. Backend & Storage Layer

This layer provides additional support for blockchain operations and handles decentralized storage. Technologies used and key functions are:

a) Ganache: A local Ethereum blockchain emulator for testing and deploying smart contracts during development.
b) IPFS (InterPlanetary File System): For decentralized storage of property documents and images.
c) Off-chain Database: Stores auxiliary data like user preferences and metadata for faster retrieval.
d) Document Storage: IPFS ensures secure, decentralized storage of large files, with hashes stored on the blockchain for integrity.
e) Development Environment: Ganache facilitates local testing, reducing costs and risks during implementation.

C. Data Flow in Architecture:

The Land Registration System leverages blockchain technology to create a secure, immutable, and transparent mechanism for property registration and ownership transfer. The Data Flow diagram (DFD), Fig. 2 illustrates the step-by-step process through which property information, transactions, and verification are handled within the system. The system ensures reliability by incorporating multiple stages of validation and leveraging the blockchain's distributed ledger.

1. User Interaction:
a) Users (Buyers, Sellers, Land Inspectors) interact through the ReactJS-based web application.
b) User actions, like registering a land or approving a request, are sent as transactions to the blockchain.

2. Transaction Processing:
a) Transactions are authenticated using Metamask and executed on the Ethereum blockchain.
b) Smart contracts validate and execute operations like ownership transfers and payment processing.

3. Data Storage:
a) Land records and transaction logs are stored immutably on the blockchain.
b) Associated documents (e.g., deeds, proofs) are stored in IPFS, with references maintained on the blockchain.

4. Updates and Feedback:
a) The system updates dashboards in real time based on blockchain transactions.
b) Users receive confirmations once operations are successfully completed

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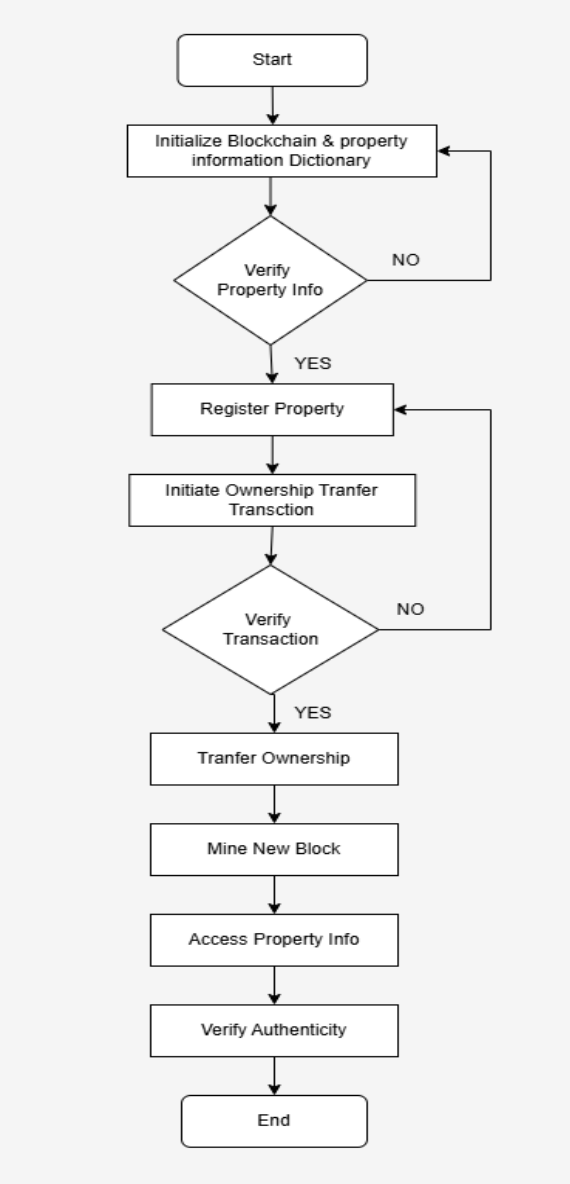

Fig. 2. Data Flow in Architecture

V. RESULTS

The proposed Blockchain-based Land Registration System was implemented and tested using Ethereum's blockchain network, ensuring secure and transparent management of land records. The system utilized smart contracts, IPFS for decentralized storage, and Ethereum's Truffle Suite for development and testing. The key results observed from the system's functionality and performance are Transaction Verification and Security, Simplified Process for Buyers and Sellers through Intuitive Interface, Role-Based Access Control, Speedy Transaction.

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  Contract: Land
    ✓ Initialize with one land (43ms)
    ✓ it initializes the Land Inspector with the correct values (54ms)
    ✓ allows a seller to register (174ms)
    ✓ allows a buyer to register (208ms)
    ✓ allows to verify a seller by Land Inspector (75ms)
    ✓ allows to verify a Buyer by Land Inspector (116ms)
    ✓ allows to add a Land by a verified Seller (172ms)
    ✓ allows to request Land by a Verified Buyer (136ms)
    ✓ allows Seller to approve the Land Request by Buyer (97ms)
    ✓ allows buyer to make payment for the Land after approved request  (93ms)
    ✓ Land Ownership transfer from Seller to Buyer (88ms)
    ✓ allows a registered and verified seller to edit his/her profile (469ms)


  12 passing (2s)
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Fig. 3. Test Case Execution Results

The Fig. 3. showcases the successful execution of all test cases designed for the Land Registration System smart contract. Each test case verifies the proper functioning of core features, including the registration and verification of buyers and sellers, the addition of land by a seller, the request and approval process for purchasing land, payment handling, and the final transfer of land ownership. The results also validate that a seller can update their profile details after verification. The system's functionality was tested rigorously using the Truffle framework, and the logs confirm that the expected events were triggered, and all assertions passed successfully. The execution of these tests ensures that the blockchain-based system is robust, reliable, and ready for deployment.

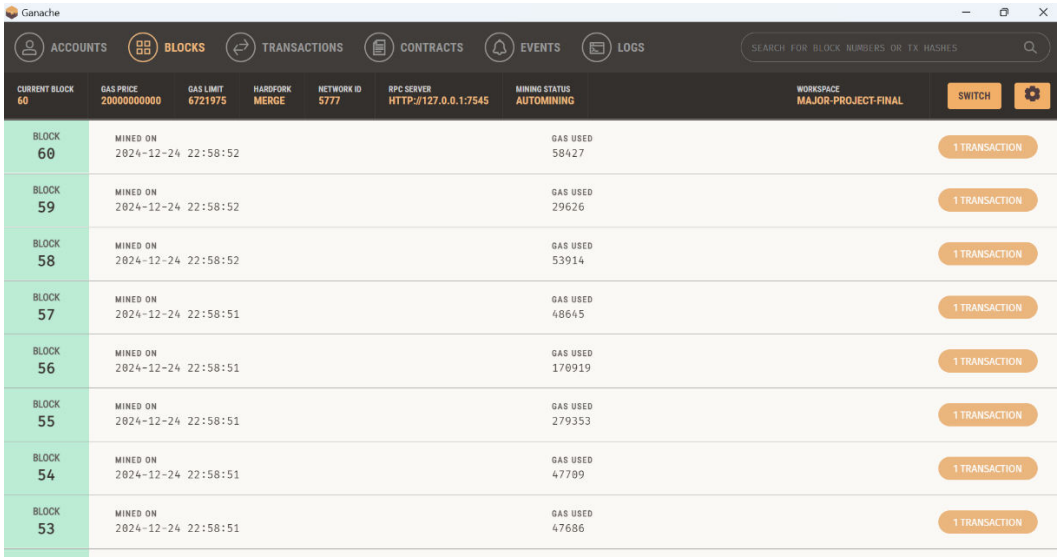

Fig. 4. Blocks Created in Ganache During Transaction Execution

The Fig. 4. depicts the blocks created in the Ganache blockchain network as a result of executing various transactions within the Land Registration System. Each block corresponds to a unique transaction or operation performed, such as registering users, verifying sellers and buyers, adding land records, requesting land, processing payments, and transferring ownership. The mining of these blocks is indicative of the successful implementation and execution of the

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Ethereum-based smart contracts. The figure emphasizes the transparent and immutable nature of blockchain, where every transaction is securely recorded on the distributed ledger, ensuring accountability and tamper-proof data storage.

VI. CONCLUSION AND FUTURE WORK

The Land Registration System using blockchain successfully demonstrates how decentralized and immutable technology can revolutionize traditional processes plagued by inefficiencies, fraud, and lack of transparency. By integrating Ethereum-based smart contracts, the system ensures secure, transparent, and tamper-proof land registration and ownership transfer. The application provides a user-friendly interface for buyers, sellers, and land inspectors, automating critical steps such as verification, payment handling, and ownership transfer while reducing the risk of disputes and data loss. Rigorous testing has validated the robustness and reliability of the system.

In the future, this system can be expanded to include integration with government land records and real-time verification with official documents like Aadhaar or PAN. Features like dynamic pricing based on market conditions, real estate analytics, and integration with IoT for land monitoring can enhance the platform. Additionally, deploying the system on a public blockchain network will further ensure scalability and accessibility for broader adoption.

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