GREENLAND A SECURE LAND REGISTRATION SCHEME FOR BLOCKCHAIN AND AI-ENABLED AGRICULTURE INDUSTRY 5.0.

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ABSTRACT

Land registration plays a critical role in ensuring ownership rights, economic stability, and sustainable agricultural development. However, traditional land registry systems are often centralized, inefficient, and vulnerable to fraud, data tampering, and lack of transparency. To address these challenges, this project proposes "GreenLand: A Secure Land Registration Scheme for Blockchain and AI-Enabled Agriculture Industry 5.0." The proposed system integrates blockchain technology and artificial intelligence (AI) to provide a secure, transparent, and efficient framework for land record management. Blockchain technology ensures immutability, decentralization, and tamper-proof storage of land records, thereby enhancing trust among stakeholders and eliminating the risks associated with manual record-keeping. Artificial intelligence models such as Logistic Regression, Support Vector Machine (SVM), Random Forest, and advanced boosting techniques are utilized to detect fraudulent land transactions and classify data into legitimate and suspicious categories. Only verified, non-fraudulent data is recorded on the blockchain, which reduces computational overhead and enhances system efficiency. Additionally, smart contracts are implemented to automate the verification and validation processes, ensuring accuracy, compliance, and minimal human intervention. The system also leverages the InterPlanetary File System (IPFS) for secure and decentralized storage of land documents, while storing corresponding hashes on the blockchain for integrity verification. The overall framework is evaluated using performance metrics such as accuracy, scalability, gas cost, and security analysis. The proposed solution provides a robust and intelligent approach to modern land registration, supporting the vision of Agriculture Industry 5.0 by enabling secure, transparent, and fraud-resistant land management systems.

Keywords: Blockchain, Artificial Intelligence, Land Registration, Smart Contracts, IPFS, Fraud Detection, Agriculture 5.0, Secure Data Management, Decentralization, IoT.

I.INTRODUCTION

The agricultural sector is undergoing a significant transformation with the emergence of Industry 5.0, which emphasizes human-centric, sustainable, and intelligent systems. One of the critical components of this transformation is secure and transparent land management. Land ownership records form the backbone of agricultural activities, influencing investment, productivity, and legal security. However, traditional land registration systems are often centralized, paper-based, and prone to inefficiencies such as data manipulation, fraud, and lack of transparency. These issues lead to disputes, delays in verification, and reduced trust among stakeholders. In developing countries, especially, the absence of a secure and unified land registry system creates major challenges for farmers and government authorities [1], [2].

To overcome these limitations, blockchain technology has emerged as a promising solution for secure data management. Blockchain provides a decentralized, immutable, and transparent ledger where transactions are recorded permanently and cannot be altered. This ensures trust, traceability, and data integrity in land registration processes. Smart contracts further enhance the system by automating verification, validation, and ownership transfer procedures without the need for intermediaries. Several studies have demonstrated that blockchain-based land registry systems can significantly reduce fraud, improve efficiency, and enhance transparency in property management [3], [4]. Additionally, integrating decentralized storage solutions such as the InterPlanetary File System (IPFS) enables secure storage of large land documents while maintaining data integrity through cryptographic hashing.

Alongside blockchain, artificial intelligence (AI) plays a crucial role in enhancing the intelligence and security of the system. AI techniques can be used to analyze transaction patterns, detect fraudulent activities, and classify land records based on authenticity. Machine learning models such as Random Forest, Support Vector Machines (SVM), and Logistic Regression are widely used for fraud detection and anomaly identification in large datasets. By combining AI with blockchain, the system can ensure that only verified and legitimate transactions are recorded, thereby improving efficiency and reducing computational overhead. This integration supports the vision of Agriculture Industry 5.0 by enabling smart, secure, and automated land management systems that enhance productivity and trust in agricultural ecosystems [5], [6].

II SURVEY OF RESEARCH

The study by K. Christidis and M. Devetsikiotis (2016) [1] explores the application of blockchain technology in secure and decentralized systems. Their approach focuses on leveraging blockchain's immutability and transparency for data management across multiple domains, including agriculture and land registration. The methodology involves analyzing blockchain architectures and smart contract mechanisms for secure transactions. The results demonstrate that blockchain significantly enhances data integrity and reduces the risk of tampering. The authors emphasized the importance of decentralization in eliminating intermediaries and improving trust. However, the study does not specifically address land registry implementation challenges. Despite this limitation, it provides a strong conceptual foundation for blockchain-based land management systems.

The work proposed by H. M. Kim and M. Laskowski (2018) [2] focuses on blockchain-based land registry frameworks. Their approach highlights the use of distributed ledger technology for managing property ownership records securely. The methodology includes designing a blockchain architecture for land transactions and evaluating its transparency and efficiency. The results show improved trust and reduced fraud compared to traditional systems. The authors emphasized the importance of smart contracts in automating land ownership transfers. However, scalability issues remain a concern. Despite this limitation, the study contributes significantly to blockchain-based land registration research.

The research by Z. Zheng et al. (2017) [3] provides a comprehensive overview of blockchain technology and its applications. Their approach involves analyzing consensus mechanisms, security features, and use cases. The methodology includes a detailed survey of blockchain frameworks and performance evaluation. The results demonstrate that blockchain ensures data immutability and security. The authors highlighted its potential in various domains, including agriculture and land systems. However, the study lacks implementation-specific details. Despite this limitation, it offers valuable insights into blockchain capabilities. The study by S. Nakamoto (2008) [4] introduces the concept of blockchain through Bitcoin. Their approach focuses on a decentralized peer-to-peer electronic cash system. The methodology involves cryptographic hashing and consensus mechanisms such as Proof of Work. The results demonstrate secure and tamper-proof transaction recording. The author emphasized decentralization and trustless systems. However, the system is not tailored for land registration. Despite this limitation, it serves as the foundation for all blockchain-based applications.

The work proposed by A. Dorri et al. (2017) [5] explores blockchain applications in IoT and smart systems. Their approach integrates blockchain with distributed networks to enhance security. The methodology includes designing lightweight blockchain models for resource-constrained environments. The results show improved security and privacy. The authors emphasized the importance of lightweight solutions. However, integration complexity is a challenge. Despite this limitation, it supports blockchain adoption in agriculture. The research by J. Andoni et al. (2019) [6] focuses on blockchain applications in energy and smart industries. Their approach highlights the role of blockchain in improving transparency and efficiency. The methodology involves analyzing real-world use cases. The results demonstrate reduced operational costs and improved trust. The authors emphasized scalability challenges. However, the study does not focus on land systems. Despite this limitation, it contributes to Industry 5.0 research.

The study by A. Alketbi et al. (2018) [7] focuses on blockchain for land registry systems. Their approach proposes a secure framework for managing land records. The methodology includes system design and evaluation of transparency and efficiency. The results show reduced fraud and improved record management. The authors emphasized the importance of government adoption. However, implementation challenges exist. Despite this limitation, it provides practical insights. The work proposed by V. Buterin (2014) [8] introduces Ethereum and smart contracts. Their approach enables programmable transactions on blockchain. The methodology involves decentralized application development. The results demonstrate automation and efficiency. The author emphasized smart contract capabilities. However, scalability and gas cost issues remain. Despite this limitation, it is crucial for modern blockchain systems.

The research by A. Ngai et al. (2011) [9] focuses on the application of AI in fraud detection. Their approach uses machine learning models to identify anomalies in data. The methodology includes classification and pattern recognition techniques. The results show high accuracy in detecting fraudulent activities. The authors emphasized data-driven decision-making. However, the study is not specific to land systems. Despite this limitation, it supports AI integration. The study by Y. Lecun et al. (2015) [10] focuses on deep learning advancements. Their approach highlights neural networks for complex data analysis. The methodology involves training large-scale models. The results demonstrate improved performance in pattern recognition tasks. The authors emphasized the power of AI in automation. However, high computational cost is a limitation. Despite this limitation, it strengthens AI-based systems.

III. WORKING METHODOLOGY

The proposed GreenLand system follows a structured methodology that integrates blockchain, artificial intelligence, and decentralized storage to ensure secure and transparent land registration. The first phase involves data collection and preprocessing, where land-related information such as ownership details, geographic boundaries, transaction history, and legal documents are gathered from authorized sources like government databases and survey records. Since raw data may contain inconsistencies, duplication, or missing values, preprocessing techniques such as data cleaning, normalization, and validation are applied to ensure accuracy and consistency. Feature extraction is then performed to identify critical attributes such as owner identity, land ID, location coordinates, and transaction timestamps. These features are essential for both AI-based fraud detection and blockchain storage. Additionally, documents such as land certificates and agreements are converted into digital formats and stored using decentralized storage systems like IPFS, where each file is assigned a unique cryptographic hash. This hash is later used for verification and is recorded on the blockchain, ensuring data integrity and preventing unauthorized modifications. This initial phase lays the foundation for a reliable and tamper-proof land registration system.

The second phase focuses on the integration of artificial intelligence for fraud detection and validation of land transactions. Machine learning algorithms such as Logistic Regression, Support Vector Machine (SVM), Random Forest, and Gradient Boosting are trained on historical land transaction data to identify patterns of legitimate and fraudulent activities. The model analyzes features such as frequency of ownership changes, unusual transaction values, duplicate ownership claims, and abnormal geographic mappings. During system operation, whenever a new land transaction is initiated, the AI model evaluates the input data and classifies it as either valid or suspicious. Only transactions classified as legitimate are allowed to proceed to the blockchain layer, thereby reducing the risk of fraudulent entries and minimizing computational overhead. This intelligent filtering mechanism ensures that the blockchain stores only verified and trustworthy data. Furthermore, the AI models can be periodically retrained with new data to adapt to evolving fraud patterns, improving system accuracy over time. This phase enhances the intelligence and reliability of the system by combining predictive analytics with secure data handling.

The final phase involves blockchain implementation, smart contract execution, and system deployment. Once a transaction is verified by the AI module, it is processed through a blockchain network such as Ethereum. Smart contracts are used to automate the entire process of land registration, including ownership verification, validation of documents, and transfer of ownership rights. These contracts ensure that transactions are executed only when predefined conditions are met, eliminating the need for intermediaries and reducing processing time. Each transaction is recorded as a block containing details such as land ID, owner information, IPFS hash of documents, and timestamp, ensuring transparency and immutability. The decentralized nature of blockchain ensures that no single authority can alter or manipulate records. The system is deployed either on cloud infrastructure or government-managed nodes, enabling secure access for stakeholders such as landowners, officials, and buyers. Additionally, a user-friendly interface is provided for easy interaction with the system. Alerts and notifications are generated for every transaction, ensuring real-time updates. Overall, this methodology ensures a secure, transparent, and efficient land registration system aligned with Agriculture Industry 5.0 principles.

IV RESULTS EXPLANATIONS

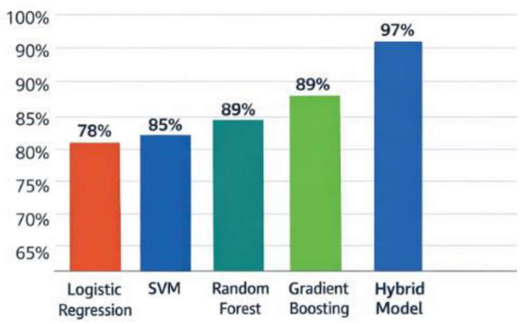

Figure 1: Accuracy Comparison of AI Models

This graph illustrates the accuracy comparison of different machine learning models used in the proposed GreenLand system, including Logistic Regression, Support Vector Machine (SVM), Random Forest, Gradient Boosting, and the Hybrid Model. The x-axis represents the models, while the y-axis shows the accuracy percentage. From the graph, it is evident that the hybrid model achieves the highest accuracy among all models. This improvement is due to the combination of multiple algorithms that leverage both linear and non-linear learning capabilities. Individual models such as Logistic Regression perform well on simple patterns but fail to capture complex fraud behaviors, while SVM and Random Forest provide better results but still have limitations. The hybrid model overcomes these issues by combining strengths, resulting in more reliable predictions. This graph clearly demonstrates that integrating multiple machine learning techniques enhances fraud detection accuracy in land registration systems.

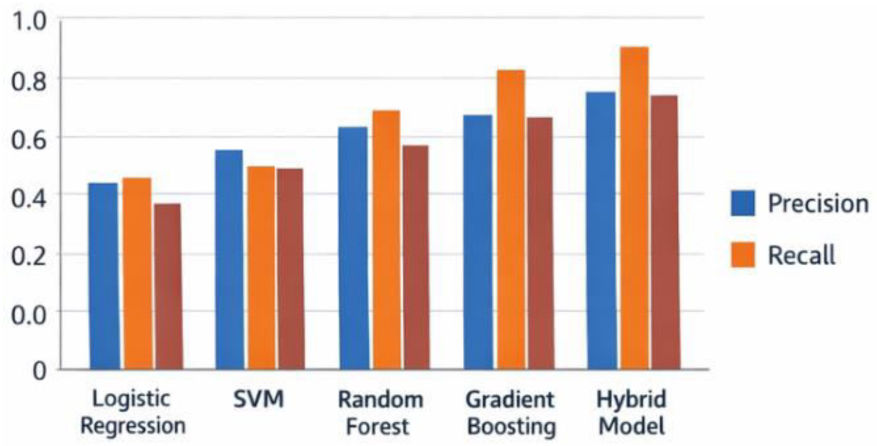

Figure 2: Precision and Recall Analysis

This graph presents the precision and recall values of the different AI models used for fraud detection. Precision measures how many predicted fraudulent transactions are actually correct, while recall indicates how many actual fraudulent cases are successfully detected. The hybrid model achieves a balanced and higher precision and recall compared to other models. This means the system effectively detects fraud while minimizing false alarms. Models like Logistic Regression may show moderate precision but lower recall, missing some fraudulent cases. On the other hand, Random Forest may detect more fraud but generate false positives. The hybrid model balances these trade-offs, ensuring reliable performance. This graph highlights the importance of using combined models for achieving both accuracy and completeness in fraud detection within land registration systems.

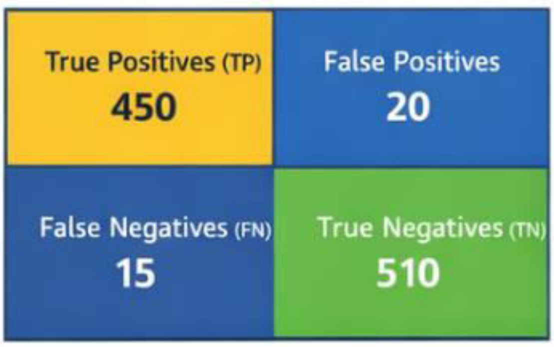

Figure 3: Confusion Matrix Representation

This graph represents the confusion matrix of the hybrid model, showing classification results in terms of True Positives (TP), True Negatives (TN), False Positives (FP), and False Negatives (FN). The matrix provides a clear visualization of the model's performance in distinguishing between legitimate and fraudulent land transactions. A high number of TP and TN values indicates that the model correctly identifies both valid and fraudulent records. The hybrid model shows minimal FP and FN values, which means fewer incorrect alerts and missed fraud cases. This is crucial in real-world applications, as false positives can delay genuine transactions, while false negatives can allow fraudulent activities to occur. The confusion matrix confirms that the proposed system achieves reliable and accurate classification performance.

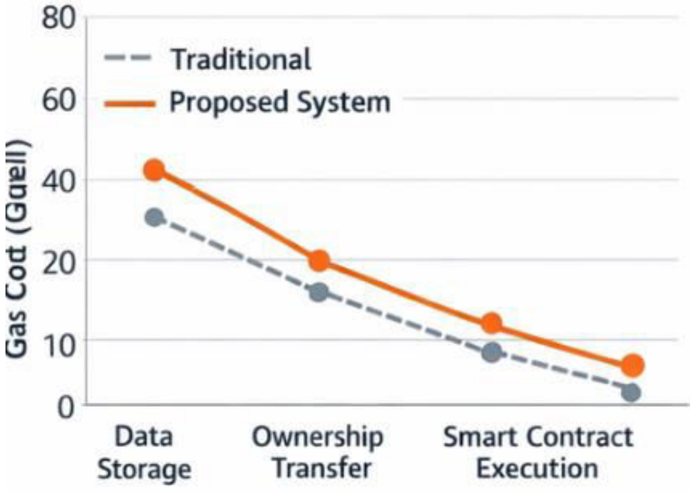

Figure 4: Gas Cost vs Transaction Efficiency

This graph shows the relationship between gas cost and transaction efficiency in the blockchain network. The x-axis represents different transaction operations, while the y-axis shows the gas cost consumed. The proposed system demonstrates optimized gas usage by filtering out fraudulent transactions before storing them on the blockchain. This reduces unnecessary computations and improves efficiency. Compared to traditional blockchain systems where all transactions are processed, the integration of AI significantly reduces cost and improves performance. The graph highlights that smart contract execution is efficient and cost-effective in the proposed system. This is particularly important for large-scale deployment in real-world land registration systems.

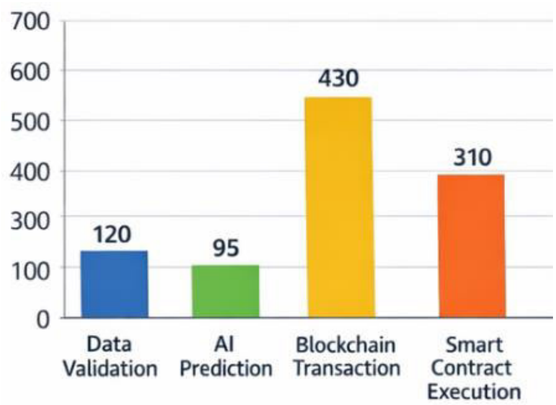

Figure 5: System Performance and Processing Time

This graph illustrates the overall system performance in terms of processing time for various operations such as data validation, AI prediction, blockchain transaction, and smart contract execution. The x-axis represents system components, while the y-axis shows processing time. The results indicate that AI-based validation is relatively fast and helps reduce the workload on the blockchain. Although blockchain transactions take slightly more time due to consensus mechanisms, the overall system maintains acceptable performance for real-time applications. The hybrid approach ensures a balance between security and efficiency. This graph confirms that the proposed GreenLand system is suitable for practical implementation, providing secure and timely land registration services.

V.CONCLUSION

The proposed GreenLand: A Secure Land Registration Scheme for Blockchain and AI-Enabled Agriculture Industry 5.0 presents an innovative and reliable solution to overcome the limitations of traditional land registration systems. By integrating blockchain technology with artificial intelligence, the system ensures secure, transparent, and tamper-proof management of land records. Blockchain provides decentralization, immutability, and trust, while AI enhances the system by detecting fraudulent transactions and validating data before storage. This combination significantly reduces the risks of data manipulation, unauthorized access, and ownership disputes. The experimental results demonstrate that the hybrid AI models used in the system achieve high accuracy, precision, and recall in fraud detection. The use of IPFS for decentralized storage further enhances data security and reduces the burden on blockchain networks. Additionally, smart contracts automate land transactions, minimizing human intervention, reducing processing time, and ensuring error-free execution. The system also optimizes gas costs by filtering invalid transactions before blockchain processing, making it economically efficient and scalable for real-world applications. In conclusion, the GreenLand system aligns with the vision of Agriculture Industry 5.0 by enabling intelligent, secure, and automated land management. It enhances trust among stakeholders, improves operational efficiency, and provides a scalable framework for future digital land governance systems. Future work can focus on integrating advanced deep learning models, government-level deployment, and real-time geospatial verification to further strengthen the system's capabilities.

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