Proceedings of the 3rd International Conference on Self Sustainable Artificial Intelligence Systems (ICSSAS-2025)
IEEE Xplore Part Number: CFP25DN7-ART; ISBN: 979-8-3315-3884-2

2025 3rd International Conference on Self Sustainable Artificial Intelligence Systems (ICSSAS) | 979-8-3315-3884-2/25/$31.00 ©2025 IEEE | DOI: 10.1109/ICSSAS66150.2025.11081037

Agricultural Supply Chain Management System using Blockchain

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Abstract: The utilization of blockchain technology, particularly Ethereum's smart contract functionality, presents a groundbreaking approach in the agricultural sector. This abstract delves into the innovative method of efficiently tracing and tracking crops while ensuring complete security and seamless business operations. By leveraging distributed software design and robust computing power, this method eradicates the necessity for intermediaries, transaction records, and centralized authorities. Through blockchain's inherent features, including immutability and decentralized architecture, safety and efficiency in agricultural supply chains are markedly enhanced. Smart contracts play a pivotal role in governing interactions and transactions among various stakeholders within the agricultural ecosystem, ensuring transparency and accountability. All activities are meticulously recorded on the immutable ledger of the blockchain, coupled with the utilization of the Interplanetary File System (IPFS) for decentralized file storage. This integration enables the transparent recording of data pertaining to images and locations submitted by supply chain participants, thereby ensuring unparalleled traceability and transparency throughout the crop lifecycle. In summary, this method epitomizes a paradigm shift in agricultural supply chain management, ushering in an era of heightened reliability, integrity, and efficiency.

Index Terms: Ethereum, Smart Contract, Solidity, Inter Planetary File System, Blockchain

I. INTRODUCTION

The global food sector struggles to ensure product quality and safety, especially in light of potential contamination and public health risks. One key policy tool to address these issues is agricultural supply chain traceability. Current agricultural traceability systems are flawed due to data fragmentation and centralized restrictions. This vulnerability leaves data vulnerable to manipulation and unauthorized changes, threatening tracing attempts. [1].

Accurate product origin identification and smooth information sharing across the agricultural supply chain are necessary for efficient traceability. Traceability throughout a food supply chain is complicated and time-consuming. [2] The food supply chain is complicated, involving farmers, manufacturers, processors, and end-users. The food and agriculture supply chain is long and complicated, making it difficult to trace a product's origins. This has piqued the scientific community's attention.

Recently developed technologies, such as blockchain technology, can be used to securely track nation of origin, farming methods, and food product safety without a third party. Blockchain's decentralized, tamper-resistant infrastructure ensures transaction integrity and immutability, improving traceability. [3] This transparency and reliability have earned the supply chain and logistics community's trust.

The complex food supply chain makes blockchain's use in agriculture extremely important. Blockchain transactions' immutability and openness provide stakeholders confidence in supply chain data. This article examines how blockchain technology can improve food supply chain traceability and visibility [4].

Blockchain technology in agriculture provides practical answers without a trusted central authority. Transaction immutability and transparency reassure stakeholders about origin, organic or non-GMO certification, agricultural yields, and more. [5] With its programmable smart contracts and Ethereum Virtual Machine (EVM), the Ethereum blockchain is ideal for agricultural traceability systems.

This study develops, constructs, and analyses a blockchain-based food supply chain traceability and visibility architecture. The research proposes an automatic revert system in the blockchain framework to reverse transactions if one stakeholder denies another's request. This function keeps supply chain participants safe and fair, preventing disputes and protecting stakeholders [6].

We conclude that traceability is crucial to food quality and safety in the agricultural supply chain. It shows the limitations of current traceability solutions and emphasizes the necessity for a secure, decentralized solution. Blockchain technology, its acceptability in the supply chain, and the suggested food supply chain traceability architecture suggest dramatic agricultural advances. Blockchain integration solves problems and makes the global food supply chain more transparent, efficient, and safe.

II. LITERATURE SURVEY

Recently, blockchain technology has garnered attention as a potential solution for agricultural supply chain traceability and transparency. Numerous research have examined blockchain's use in crop traceability and supply chain management in agriculture. This literature survey summarizes the significant studies in this field, including their methods, conclusions, and implications.

Khaled Salah et al. [1] examined agricultural supply chain blockchain-based soybean traceability. Their investigation showed that blockchain can track soybean production, providing supply chain transparency and accountability. Blockchain technology would give stakeholders real-time soybean origin and travel information, boosting supply chain trust and efficiency.

Fran Casinoa et al. [3] examined blockchain-based food supply chain traceability in the dairy industry. Their research showed that blockchain improves traceability, especially dairy product legitimacy and quality. Blockchain allowed stakeholders to verify dairy product provenance, reducing fraud and contamination.

Mohammad Hossein Ronaghi [4] suggested an agricultural supply chain blockchain maturity model. This approach assessed agricultural organization blockchain readiness and identified implementation difficulties and opportunities. Ronaghi examined major aspects affecting blockchain adoption in agricultural supply networks, providing practitioners and scholars with significant insights.

A systematic literature review by Shuchih E. Chang and Yichian Chen [5] examined blockchain's evolution and prospective supply chain management applications. They synthesized information on blockchain adoption across numerous industries, including agricultural, and found diverse use cases and trends. Chang and Chen reviewed many research works to provide a complete overview of blockchain-enabled supply chain management.

A thorough literature review by Vineet Paliwal, Shalini Chandra, and Suneel Sharma [6] examined blockchain technology for sustainable supply chain management. They categorized studies by theme, such as traceability, transparency, and environmental sustainability. Paliwal et al. highlighted blockchain's difficulties and prospects for sustainable supply chain management through a systematic study of scholarly literature, providing useful insights for future research.

A comprehensive mapping study by Conscribes et al. [7] examined blockchain's use in supply chain management. Their literature review identified blockchain-enabled supply chain management research gaps and trends. Tribis et al. synthesized results from several sources to present a complete overview of blockchain usage throughout industries, including agricultural.

Huilin Chen et al. [8] suggested a deep reinforcement learning-based blockchain-based agri-food supply chain management architecture. Their study showed deep reinforcement learning systems can optimise supply chain processes and improve traceability and transparency. Chen et al. innovatively addressed agri-food supply chain management issues by combining blockchain and AI.

Giovanni Mirabelli [10] reviewed blockchain-enabled agriculture supply chain traceability research trends and future problems. They identified major research areas and new technologies in the sector by analyzing literature. Mirabelli shed light on blockchain adoption for agricultural supply chain traceability and suggested future research by synthesizing information from several sources.

Caro MP et al. [11] demonstrated blockchain-based traceability in agri-food supply chains. Their research showed how blockchain technology improves agri-food traceability and transparency. Blockchain might give stakeholders real-time food product origin and trip information, enhancing supply chain trust and efficiency.

III. METHODOLOGY

The proposed agricultural supply chain crop tracing system uses Blockchain [1], smart contracts, and IPFS to solve existing system limitations. Blockchain's integrity and reliability boost safety and efficiency. The suggested system regulates and oversees agricultural supply chain ecosystem communications and transactions using smart contracts Fig 1. The blockchain's immutable ledger and IPFS decentralised file system store all transactions. IPFS uses picture and location data from supply chain players to ensure crop transparency and traceability. The technology eliminates intermediaries, transaction records, and trusted central authorities. Thus, Blockchain's trustworthiness and integrity boost safety and efficiency.

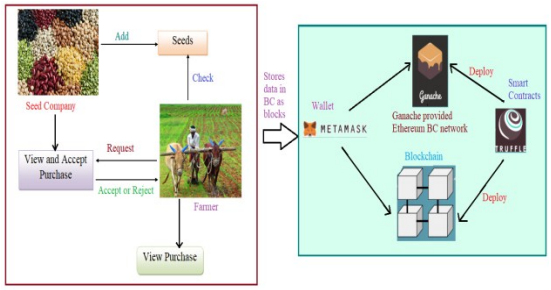

Fig1 Proposed Architecture

In system architecture has two key modules: Seed Company and Farmer. Seed Company Modules let seed corporations add seeds to the Blockchain [1] and inspect, accept, or reject farmer purchase requests. However, Farmer Modules let farmers browse seeds, buy them, and track their requests. Blockchain technologies like Ganache, Metamask, Truffle, and Blockchain hold transactional data in blocks. Ganache is a local blockchain network for testing and development, whereas Metamask is a secure Ethereum wallet. Blockchain stores transactional data safely and openly, whereas Truffle develops and deploys smart contracts. This architecture provides decentralised data storage, secure transactions, and seamless agricultural supply chain stakeholder interaction.

A) Modules:

a) Seed Company Modules

i) Seed Company registration:

In the Seed Company Registration module, seed companies establish their presence on the blockchain platform by submitting requisite details for the creation of a distinct identity within the network. This process involves furnishing necessary information to generate a unique profile, ensuring seamless integration into the blockchain ecosystem.

ii) Seed Company Login:

Following registration, seed companies access the blockchain platform through the Seed Company Login module. Employing secure authentication methods, companies log in to their accounts, ensuring a protected and authenticated entry into the blockchain system. This step grants them access to their dedicated accounts, facilitating engagement and interaction within the platform securely and efficiently.

iii) Add Seeds:

In the Add Seeds module, seed companies input information pertaining to the seeds they produce or distribute onto the blockchain platform. This process entails providing comprehensive details such as seed type, origin, and any other relevant information deemed essential for stakeholders. By populating the blockchain with this data, companies contribute to the creation of a transparent and traceable record of seed supply, enhancing accountability and trust within the agricultural ecosystem.

iv) View, Accept/Reject Purchase requests:

In the View, Accept/Reject Purchase Requests module, seed companies access and review purchase requests submitted by farmers. These requests contain pertinent information such as seed quantity, delivery preferences, and other relevant details. Seed companies have the option to either accept or reject these requests, considering factors such as inventory availability and logistical constraints. This functionality streamlines the procurement process, enabling efficient management of seed distribution within the agricultural supply chain.

b) Farmer Modules

i) Farmer Registration:

In the Farmer Registration module, farmers initiate their presence on the blockchain platform by supplying essential details to create their identity and participate in the network. This process involves submitting requisite information to establish a unique

profile within the blockchain ecosystem. By registering, farmers gain access to various functionalities and services offered on the platform, facilitating their engagement and interaction within the agricultural community in a secure and transparent manner.

ii) Farmer Login:

After completing registration, farmers access the blockchain platform through the Farmer Login module. Utilizing secure authentication methods, farmers log in to their accounts, ensuring a protected and authenticated entry into the blockchain system. This step grants them access to their dedicated accounts, enabling them to utilize various features and services provided on the platform securely and efficiently.

iii) Check Seeds and make purchases:

In the Check Seeds and Make Purchases module, farmers navigate through the available seeds listed on the blockchain, accessing details provided by seed companies. After reviewing the information, farmers can proceed to submit purchase requests for desired seeds, specifying the required quantity. This streamlined process facilitates farmers in sourcing seeds efficiently while ensuring transparency and accountability in transactions conducted within the agricultural supply chain.

iv) View Purchase:

Following the submission of a purchase request, farmers utilize the View Purchase module to monitor the status of their requests on the blockchain platform. Here, they can access information regarding accepted requests and any pertinent details associated with their transactions. This functionality empowers farmers with visibility into the progress of their requests, ensuring transparency and facilitating informed decision-making throughout the procurement process within the agricultural supply chain.

C) Blockchain Integration:

Blockchain's distributed software design transforms agriculture supply chain information exchange. Decentralisation and security are achieved by storing data across a network of nodes. This reduces a single point of failure and strengthens information sharing.

Ethereum smart contracts provide secure crop tracing and transparent interactions. Smart contracts make crop tracing secure, transparent, and tamper-resistant. This builds agricultural supply chain trust.

The immutable ledger of blockchaincannot be changed. Linking with IPFS adds security and decentralisation. IPFS stores and retrieves stuff via a content-addressed system. This data is kept in blocks. Every blockchain block has a unique Hashcode. Multiple nodes or servers store these blocks. Before storing new entries, blockchain verifies block Hashcodes. Any block data modification generates a new Hashcode, triggering security alarms and assuring data integrity and immutability. Blockchain and IPFS establish a tamper-resistant record of conversations by combining blockchain's immutability with IPFS' distributed and content-addressed properties.

The agricultural supply chain uses blockchain technology to eliminate intermediaries, transaction records, and centralised authorities. Blockchain allows participants to directly transact and share information without a trusted intermediary. This cuts expenses, fraud, and supply chain inefficiency.

D) Ganache:

Ganache is a user-friendly interface for monitoring Ethereum blockchain activities. It simplifies tracking of accounts, transactions, and smart contracts, making it accessible even for users without in-depth blockchain expertise. Ganache offers detailed transaction information, including sender, receiver, amounts, gas usage, and success status, aiding debugging and ensuring transaction accuracy. It also tracks smart contract deployments, confirming correct deployment and functionality. This transparency simplifies monitoring and verification processes.

Ganache lets us dive into the details of each block on the Ethereum blockchain. We can find out when a particular block was added, what transactions took place within it, and how much computing power (gas) was used. Ganache also enables data retrieval from stored blocks, allowing developers to access and analyze specific block information.

e) Metamask:

Metamask is both an Ethereum wallet and a browser extension. It simplifies cryptocurrency management and provides direct access to DApps, making interactions with blockchain applications easier.

In the project, Metamask ensures secure Ethereum transactions, promoting transparency by showing the deduction of ETH as fees. This transparency maintains

accuracy and ensures confident, reliable financial interactions within the system.

IV. EXPERIMENTAL REULTS

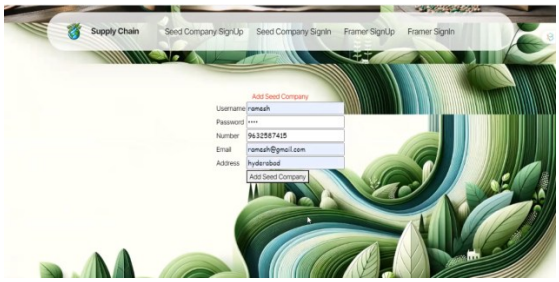

Fig2 Seed Company Signup Page

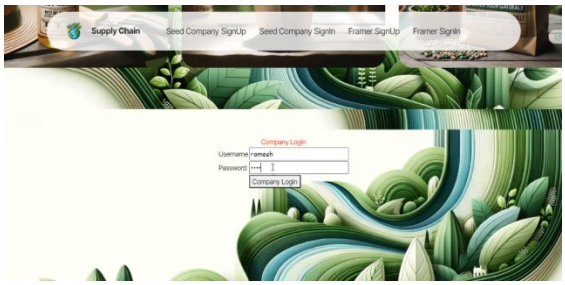

Fig3 Company Login Page

Fig4 Add Seeds Screen

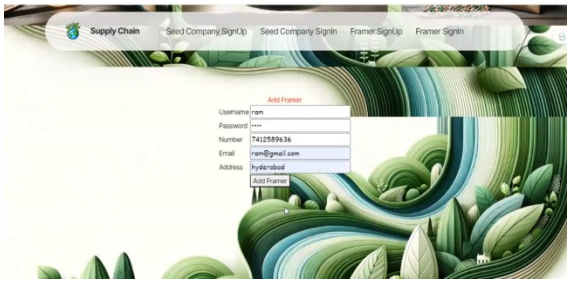

Fig5 Add Farmer Screen

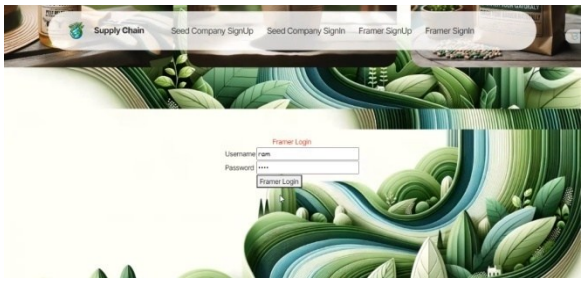

Fig6 Farmer Login Page

Fig7 Product Details

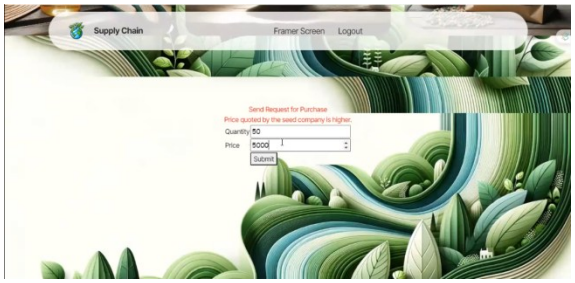

Fig8 Send Request for Purchase

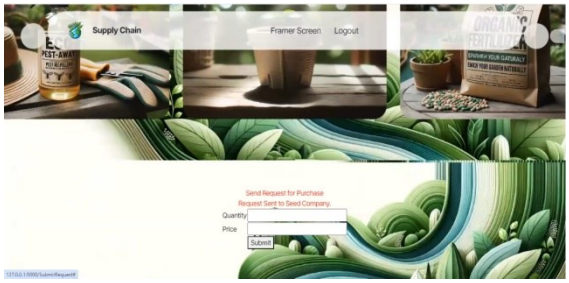

Fig9 Request Sent Seed Company

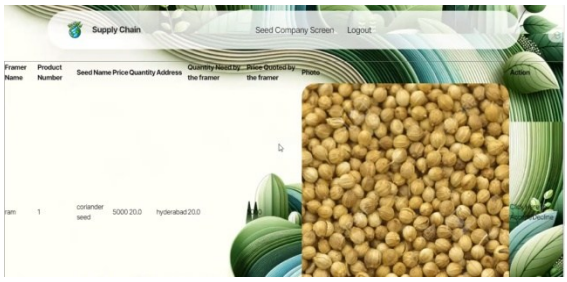

Fig10 Output Screen

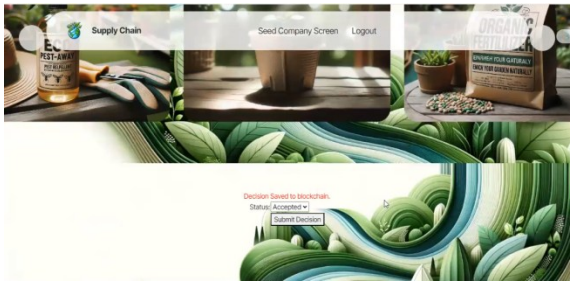

Fig11 Output Screen

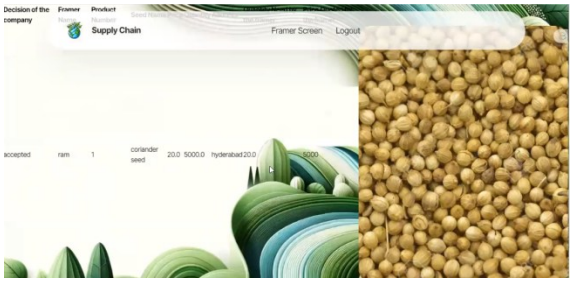

Fig12 Farmer Screen

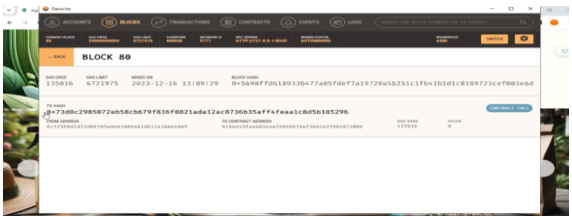

Fig13 Ganache Screen

V. CONCLUSION

Information exchange and transactional processes among varied parties in the agriculture supply chain will change drastically with blockchain technology. The initiative uses Ethereum smart contracts and a tamper-resistant blockchain to guarantee crop tracing and transparent communications, strengthening the supply chain. The project uses Blockchain'sdecentralised nature to eliminate intermediaries, transaction records, and centralised authorities, promoting autonomy, efficiency, and cost reduction in the agricultural ecosystem. The project's immutable ledger and IPFS integration create a solid record-keeping mechanism. Each piece of information is uniquely identified and linked, producing a permanent, tamper-resistant record of communications. This assures supply chain data integrity and transparency, building stakeholder trust and enabling seamless collaboration. Blockchain technology in the agriculture supply chain is a game-changer, revolutionising information management and transactions. The initiative establishes a more safe, efficient, and resilient agricultural ecosystem by using blockchain'sdecentralisation, immutability, and transparency.

The existing system can be improved by adding cryptography to prevent data manipulation. Future advancements may include a blockchain-based agriculture supply chain incentive and recognition system. The system can improve data quality and security and encourage stakeholders to participate in ecosystem growth and sustainability by using cryptography. The agricultural supply chain will become more transparent, trustworthy, and efficient with this evolution, making it more robust and rewarding.

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