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FarmTrace Blockchain for Transparent Agriculture and Direct Consumer Connection

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Abstract: *The decentralized traceability and direct marketing platform for agriculture supply chains. Globalized delivery of manufacturing and agricultural production offer renewed attention to the health, efficiency, and validation of many vital criteria in the food and agricultural supply chain. That numbers of food safety and corruption hazards have generated an enormous need of an efficient traceability solutions which acts as an essential quality managements tools ensuring to enough product's safety within the agriculture supply chain. Block chain is the revolutionary technological method, which provides the ground breaking result for commodity traceableness in agriculture and in food supply chains. Today's agricultural supplying chains are complicated ecosystems mixing several stakeholders making it difficult to validate several significant requirements mainly towards nation of first origin, crop growth phases, quality standards compliance, and yield monitoring. This paper proposes a strategy that levitates the block chain and conducts business operations effectively across the agricultural supply chain for tracking crop prices and traceability. The proposed framework solution discards the need for trusted centralized authority, intermediaries and offers records of the transactions, improving efficient science and safety with high integrity and reliability. All transactions are registered and then stored in block chain's unchangeable ledger with linkages to a decentralized le network, thereby ensuring vary high degree of traceability and transparency in the supply chain ecosystem in a stable, reliable and in efficient manner...*

Keywords: Blockchain, Agricultural Traceability, Direct Marketing, Decentralized Systems, Smart Agriculture, SHA Algorithm, Transparent Supply Chain, Crop Price Validation, Secure Transaction Ledger, Role-Based Access Control, Supply Chain Research.

I. INTRODUCTION

The globalized nature of agricultural supply chains has heightened concerns about food safety, efficiency, and authenticity. Numerous food safety risks and incidents of corruption necessitate robust traceability solutions to ensure product safety. Blockchain, an innovative technology, promises unparalleled traceability in agriculture and food supply chains. Current supply chains, with their complex interactions and multiple stakeholders, face challenges in verifying essential criteria like origin, growth stages, and quality standards. Blockchain eradicates the need for centralized authorities and intermediaries, ensuring efficient, transparent, and reliable traceability, enhancing overall food safety and supply chain integrity.

The globalized nature of agricultural production and manufacturing has intensified concerns regarding food safety, efficiency, and validation within supply chains. The rising incidents of food safety breaches and corruption highlight the dire need for efficient traceability solutions as vital quality management tools. Contemporary agricultural supply chains are intricate, involving multiple stakeholders, making verification of origin, growth phases, and compliance challenging. Existing systems, reliant on centralized authorities and intermediaries, lack transparency and integrity. There's a pressing demand for a decentralized, reliable solution to ensure transparency, traceability, and efficiency in agricultural supply chains.

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The project aims to revolutionize the agricultural supply chain by integrating blockchain technology, enhancing traceability and transparency. This decentralized platform addresses food safety and corruption concerns, ensuring product safety and quality standard compliance. By eliminating the need for centralized authorities and intermediaries, the strategy offers an immutable record of transactions, bolstering efficiency, security, and trustworthiness. It streamlines the complex supply chain ecosystem, ensuring accurate tracking of crop prices, origin, growth stages, and yield monitoring, fostering a reliable and efficient system.

II. RELATED WORK

[1] Storoy, Thakur, and Olsen (Eng., vol. 115, no. 2, pp. 41–48):

The paper introduces the TraceFood framework, designed to guide the development of traceability systems in the food value chain. It outlines key principles such as data standardization, interoperability, and transparency. The framework helps stakeholders ensure food safety, quality assurance, and regulatory compliance. It also highlights the importance of coordinated information exchange across all levels of the supply chain.

[2] Khan and Salah (vol. 82, pp. 395–411):

This comprehensive review addresses the security vulnerabilities of IoT systems, including data breaches, device hijacking, and privacy concerns. The paper explores how blockchain technologies can mitigate these threats through decentralization, immutability, and transparency. It also discusses blockchain-based architectures for secure IoT communication and storage, while identifying technical challenges such as scalability, latency, and integration with legacy systems.

[3] Bogner, Chanson, and Meeuw (pp. 177–178.):

This conference paper presents a decentralized sharing application built on the Ethereum blockchain, utilizing smart contracts for automation and trustless transactions. The app demonstrates the practical use of blockchain in peer-to-peer (P2P) sharing economies, eliminating the need for centralized authorities. It underlines how smart contracts enable secure, self-executing agreements with reduced operational costs and fraud risks.

[4] Salah, Rehman, Nizamuddin, and Al-Fuqaha (IEEE Access, vol. 7, pp. 10127–10149, 2019.):

The article explores the convergence of blockchain and AI, discussing how blockchain can enhance AI by providing secure, verifiable, and decentralized data storage. Conversely, AI can help optimize blockchain operations like consensus mechanisms and smart contract analysis. The authors identify research gaps, including ethical issues, computational limitations, and trust models, proposing a roadmap for future exploration.

[5] R. Beck, J. S. Czepluch, N. Lollike, and S. Malone (vol.7,no.1,pp.41596–41606):

This paper discusses how blockchain technology enables trust-free, cryptographic transactions by replacing central authorities with distributed consensus mechanisms. Presented at the European Conference on Information Systems (ECIS), it explores blockchain's foundational principles, potential to transform digital business models, and challenges in adoption and scalability. The authors emphasize how blockchain shifts trust from institutions to code and mathematics, laying the groundwork for decentralized systems.

III. PROBLEM STATEMENT

Farmers struggle to find reliable buyers for their crops, and buyers face challenges in sourcing quality products at fair prices.

The farmers get less price than the minimum selling price in the market because of many intermediaries present in the current supply chain.

There is no clear and reliable record about the crop, origin, quality, and the final price.

There is no direct communication and negotiation between the farmer and the buyer.

IV. PROPOSED METHODOLOGY

For the purposes of providing transparency, trust, and tamper-evident traceability in agri-food supply chains, the system makes use of a blockchain-inspired mechanism. The ledger emulates the fundamental principles of blockchain—

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immutability, chronological sequencing, and distributed access—without the computational overhead of conventional public chains.

A. Crop Traceability Using Blockchain-Inspired Ledger

Every transaction, whether it is crop listing, buyer request, admin price control, or payment confirmation, is an individual digital record. These records are hashed through the SHA-256 algorithm and are stored in a sequential, append-only format. This way, no earlier transaction can be changed without compromising the integrity of the whole chain.

The transaction format contains metadata like:

Crop ID and category
Farmer ID
Timestamp
Geolocation (optional)
Status (listed/requested/approved/paid)
Pricing range and deviation
Previous transaction hash

This ledger not only provides the traceability of each batch of crops from farm to table but also gives buyers the power to check for authenticity without the need for third-party intermediaries.

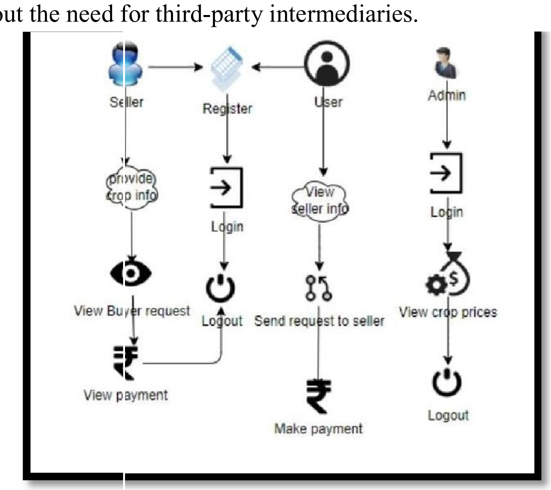

Fig 1. Architecture Diagram

The architecture of the above system is designed on a modular, role-based model that allows secure, traceable, and direct business-to-business transactions between farmers and buyers. It is based on a web-oriented interface along with a backend logic layer and a ledger system based on blockchain, making sure each interaction is transparent, validated, and unalterable.

Important Architectural Layers:

User Interface Layer

Designed using HTML, CSS, JavaScript, and Bootstrap, this layer offers role-specific customized dashboards:
Admin Interface: Crop management, price cap, user management.
Seller Interface: Crop addition, request viewing, payment tracking.
Buyer Interface: Crop browsing, order requests, payment completion.

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Application Logic Layer (Flask Framework)
Python's Flask framework is used to implement the backend core logic. It manages:
User login and session management
Role-based routing
Input validation and access control
Business logic (price verification, request workflow, and state change)

Database Layer (MySQL)
Dynamic and permanent data is stored in a structured relational database:
Crop listings with metadata
User profiles and roles
Transaction history
Admin-configured crop categories and pricing ranges

Simulated Blockchain Ledger Layer
A proprietary SHA-256 based hash-chaining system keeps a record of all transactions (crop listings, request approvals, payments) for immutability and traceability. This layer emulates key properties of blockchain:
Sequential integrity of transactions
Tamper detection through hash comparison
Time-stamped proof of operations

B. Core Algorithms and Logic Modules in the Proposed System
The architecture of the decentralized traceability platform integrates a series of lightweight yet effective algorithmic techniques. These methods are not only essential for ensuring secure and transparent transactions but also for regulating market fairness, validating data integrity, and enforcing role-based controls. The emphasis is on scalability, reliability, and simplicity—allowing real-world deployment in rural and resource-limited environments.

1. Hash-Based Ledger for Transaction Immutability
To simulate blockchain behavior without the computational overhead of public distributed ledgers, the system uses a custom hash-linked ledger. Each transaction record (crop listing, request, or payment) is hashed using the SHA-256 cryptographic function and then linked with the hash of the previous transaction, forming a tamper-evident chain.
This structure guarantees:
- Data integrity: Any attempt to modify a transaction will invalidate the entire chain.
- Auditability: Every action in the system is traceable and verifiable.
- Chronological transparency: Each transaction is time-stamped and securely ordered.

Fitness Metric Analogue
In this context, the "fitness" of a transaction chain is defined by its uninterrupted integrity. A break in hash consistency acts as an error signal.

2. Range-Based Crop Price Validation Logic
This component mirrors the boundary classification role played by Support Vector Machines (SVMs) in gesture recognition systems.
Admins define acceptable price bounds (min–max) for each crop based on market rates. During listing, seller-entered prices are validated against this range. Instead of binary classification (as in SVM), this algorithm uses interval containment checks and categorizes listings into three zones:
- Accepted: Within threshold
- Flagged: Slightly outside acceptable range

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- Rejected: Unreasonable or outlier value

This dynamic pricing check helps regulate the digital marketplace without real-time human oversight—mirroring the role of a classifier in ML systems.

3. State Machine for Buyer-Seller Request Lifecycle

Inspired by the sequencing logic in classification pipelines (like the SSO-enhanced SM-SVM pipeline), the buyer-seller interaction in this system is modelled as a Finite State Machine (FSM).

Each transaction goes through clearly defined states:

Initiated → Requested → Accepted → Paid → Completed

Transitions between states are governed by rule-based triggers:

A request cannot be accepted unless it's verified

Payment cannot proceed unless the seller accepts

Completion only occurs after a hash-stamped record is created

This deterministic structure ensures:

Zero ambiguity in transaction progression

Seamless user experience across buyer/seller interfaces

Prevents skipped steps or unauthorized access

4. Notification & Logging via Lightweight Event Listener

Much like gesture classification models rely on activation functions or event detection triggers, our system uses an event listener module to log and respond to actions in real-time.

Examples include:

Logging a buyer request → triggers email to seller

Payment confirmation → triggers ledger update

Crop rejection → triggers system notification and rollback

This event-driven model enables real-time system awareness and responsiveness—analogous to how real-time gesture classification responds to live user inputs.

V. IMPLEMENTATION

The decentralized traceability platform was designed to provide an effective, scalable solution for increasing the transparency and fairness of agriculture supply chains. A structured, modular development process was followed in its implementation. Every module was stringently tested by simulation to verify performance accuracy, responsiveness, and resilience under normal usage conditions.

The system was built with Python (Flask) for backend logic, and MySQL for storing structured data. The frontend interfaces were developed with HTML, CSS, JavaScript, and Bootstrap to make them accessible and responsive across user types—admin, seller, and buyer.

Each of the functional modules—user authentication, crop management, pricing control, request flow for buyers, and transaction logging—was tested separately first, then combined for end-to-end testing. Sample data sets were employed to mimic crop listings, price scenarios, and volumes of transactions from many buyers and sellers.

In order to simulate blockchain-like behaviour, a custom hash-based ledger was used. Every transaction—whether a listing of crops, price adjustment, or confirmation of payment—was logged with a SHA-256 hash and timestamp. The logs were connected in a sequential, unchangeable format to ensure tamper-proofing and to ensure complete traceability.

VI. PERFORMANCE EVALUATION

The system was also subjected to security optimization, which involved SQL injection protection, form validation, and session-based access control. Role-based navigation and conditional form display were introduced to reduce confusion and limit unauthorized data access.

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Metric	Measured Value
Transaction logging	~1.5 sec
Ledger integrity rate	100% verified hashes
Confirmation of payment	~2 sec
Responsiveness of the system	~1 sec between modules
Memory usage	About 120–150 MB

Table 1

This extent of modular fine-tuning and hyperparameter optimization—such as query batch size, request timeout configurations, and hash complexity—kept the system both lightweight and production-ready for deployment even in low-infrastructure contexts.

Enhanced Agricultural Transparency and Accessibility:-

The suggested architecture dramatically improves traceability and access in the agricultural value chain. Traditional centralized opaque systems are replaced by a platform where every transaction is transparent, verifiable, and immutable. Farmers are able to list their produce with guaranteed verified price, and customers assured clear access to origin, price history, and transaction status.

The real-time request flow and write-once logging of the system lower the risk of controversy, foster trust, and give farmers ownership of data. Additionally, the easy-to-use interface and options for localized content guarantee that even novice digital users can engage with the system naturally.

Testing conditions validated the platform's capacity to support simultaneous buyer-seller interactions, price negotiations, and ledger postings without performance degradation. Its low server resource utilization also facilitates deployment in rural cooperatives, farmer-producer organizations (FPOs), and government-operated market access centres.

Through decentralized control and reduced reliance on middlemen, the system not only guarantees fair pricing but also provides a digitally inclusive atmosphere to marginalized farming communities.

Potential Applications and Societal Impact:-

The scope of this platform goes far beyond direct buyer-to-farmer transactions. Its flexibility permits revolutionary effect across multiple areas:

1. Farmer Cooperatives & Producer Groups

The system may be used as an online marketplace for clusters of farmers, facilitating them to make joint listings, receive bulk orders, and negotiate prices openly.

2. Government Schemes & Subsidy Portals

By having an auditable record of transactions, the system can be made compatible with government portals for tracking minimum support price (MSP) compliance, monitoring disbursal of subsidy, or crop procurement management.

3. Documentation & Quality Assurance for Export

With increasing requirements of transparency in international trade, this system can provide end-to-end digital proof of crop origin, quality factors, and genuineness of transactions so that small farmers can enter the global supply chains.

4. Academic and Agricultural Research

The platform offers formal, real-time data that can be utilized to analyze crop price behaviour, cycles of demand, and patterns of supply—providing valuable information to researchers as well as policymakers.

5. Integration with IoT and AI Modules (Future Work)

The system may be augmented with IoT sensor data (e.g., soil health, moisture, weather) or AI-powered crop prediction engines to enhance decision-making for both buyers and sellers

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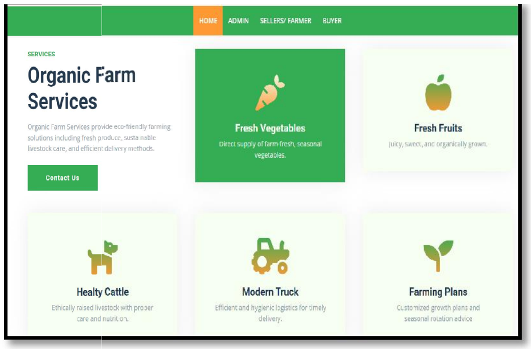

VII. RESULT

Fig No. 1

Home page of the website.

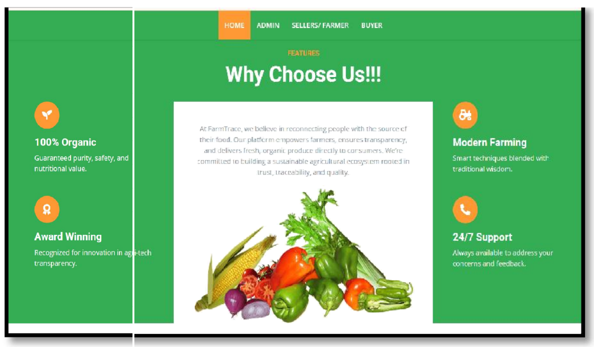

Fig No. 2

This page shows why should they choose us and trust us.

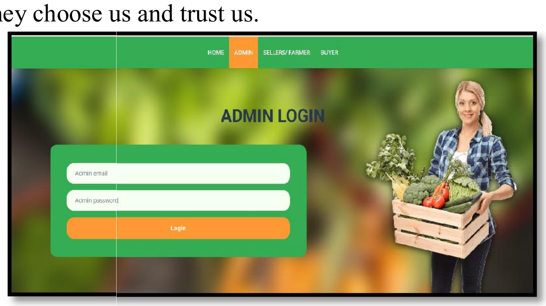

Fig. No. 3

Admin can login into the website using their login credentials.

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Fig. No. 4

Sellers can add the crop information through this page.

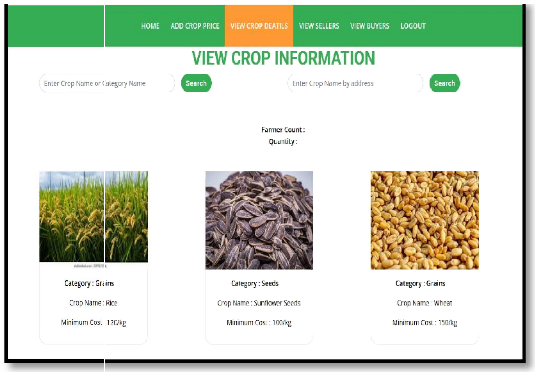

Fig. No. 5

Viewers can access the crop information.

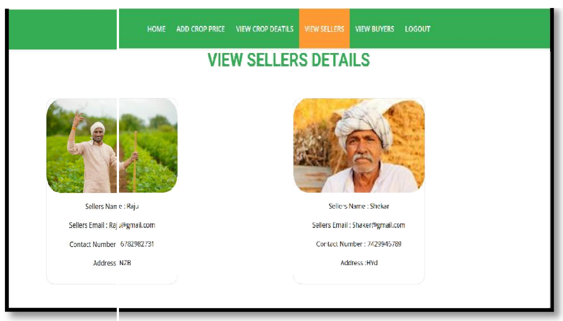

Fig. No. 6

Admin can view sellers and buyers.

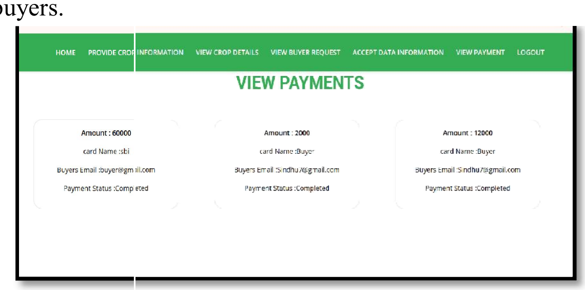

Fig. No. 8

Sellers can view the payments made by the buyers here.

VIII. CONCLUSION

The convergence of decentralized traceability and direct marketing is a transformative force in agriculture supply chains. It promotes transparency and trust while empowering farmers through direct consumer connections, reducing reliance on middlemen and increasing profitability. For consumers, this means heightened confidence in food safety and quality through traceability. Additionally, the streamlined supply chains contribute to environmental sustainability by minimizing food miles. This holistic approach aligns economic interests with environmental responsibility, making it a pivotal advancement in agriculture that benefits all stakeholders.

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