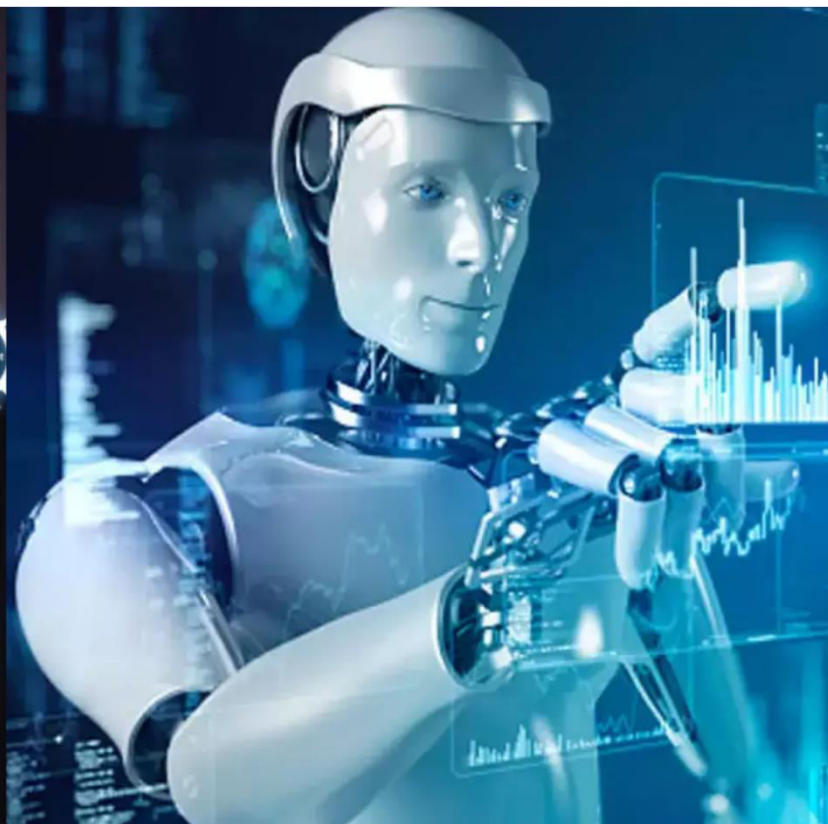




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CropLink: Intelligent, Secure and Transparent Agriculture Marketplace

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ABSTRACT: The Decentralised Farmers Marketplace is a blockchain-based platform designed to connect farmers directly with consumers, eliminating intermediaries to ensure transparency and fair pricing. This project aims to address the inefficiencies in the traditional agricultural supply chain by leveraging blockchain for tamper-proof transaction records and smart contracts for secure, automated payments. A key feature of the marketplace is a dynamic pricing mechanism that adjusts crop prices in real-time based on supply-demand statistics, external market data from mandis, and trusted oracle data feeds. The system comprises a comprehensive web and mobile application, offering dedicated panels for farmers, consumers, and administrators. Farmers can manage listings and track orders, while consumers can browse produce, verify authenticity, and track deliveries. By integrating a MERN stack with Solidity smart contracts and decentralized storage (IPFS), the platform provides a secure, scalable, and user-friendly ecosystem. The ultimate goal is to maximize farmer profits, provide consumers with transparent prices, and create a fully traceable and efficient agricultural supply chain.

The traditional agricultural trading system in India relies heavily on intermediaries, resulting in price manipulation, limited transparency, and reduced profit margins for farmers. These challenges create financial instability, making it difficult for farmers to receive fair compensation for their produce. To address this issue, the proposed Decentralised Farmers Marketplace with Dynamic Price introduces a blockchain-enabled platform that directly connects farmers with consumers, thereby eliminating middlemen and ensuring transparent transactions. The system leverages smart contracts to secure payments through escrow mechanisms, ensuring that funds are released only after successful delivery, reducing the risk of fraud and disputes.

A dynamic pricing model is integrated into the platform, which automatically adjusts produce prices based on key factors such as real-time supply-demand fluctuations, external mandi market data, and seasonal variation trends. This model ensures fair and competitive pricing for both farmers and consumers. Additionally, the use of IPFS decentralized storage allows secure upload and verification of product certifications and quality documents, enhancing buyer trust and traceability. The platform is developed using the MERN stack for application interfaces and Solidity for smart contract implementation on the Polygon blockchain.

Overall, this system provides a transparent, efficient, and economically sustainable solution for agricultural commerce. It not only enhances income opportunities for farmers but also offers consumers access to authentic, traceable, and fairly priced produce, promoting a more equitable supply chain ecosystem.

KEYWORDS: Blockchain, SmartContracts, Decentralized Application (dApp), Dynamic Pricing, Agricultural Technology (AgriTech), MERN Stack, IPFS, Supply Chain Management, Ethereum, Solidity.

I. INTRODUCTION

The Agriculture continues to serve as the backbone of many national economies, particularly in developing regions where a large proportion of the population depends on farming for livelihood. Smallholder farmers, who form the majority of this workforce, often depend on a short seasonal window to sell their produce in order to generate income,

repay agricultural loans, and invest in future crop cycles. However, despite the critical role they play in the food supply chain, these farmers frequently face systemic challenges that restrict their ability to receive fair market value for their produce.

Traditional agricultural marketplaces are characterized by fragmented trading systems, limited transparency, and strong information asymmetry between farmers, traders, and consumers. Intermediaries often exploit these conditions to engage in opportunistic pricing, leading to depressed farm-gate prices and disproportionate profit distribution across the supply chain. Furthermore, the lack of real-time pricing mechanisms contributes to price volatility, logistical inefficiencies, and even food wastage, as farmers may be forced to sell at unfavorable rates to avoid spoilage.

To address these challenges, this project proposes a “Decentralised Farmers Marketplace with Dynamic Price”, a hybrid solution that integrates blockchain-based decentralized ledgers with off-chain computational services. The system is designed to enhance market transparency, support verifiable and tamper-proof transactions, and allow for dynamic price discovery based on real-time demand, supply, and quality metrics. Instead of attempting to replace existing supply chains, the platform introduces an auditable and accessible marketplace layer that can function alongside current market practices while gradually improving efficiency and trust.

Stage-I of this project focuses on establishing the foundational components of the system. This includes formal requirement analysis, architectural design, development of core smart contracts, implementation of an initial off-chain pricing engine, and creation of functional web and mobile interfaces deployable on a testnet environment. The resulting prototype aims to demonstrate key market flows, validate feasibility, and provide a scalable base for future enhancements such as identity verification, logistics integration, credit scoring, and large-scale deployment.

The agricultural sector is a vital contributor to rural livelihoods, yet farmers often face challenges in receiving fair prices for their produce due to the involvement of middlemen and lack of transparent market information. Traditional mandi-based markets are characterized by price manipulation, delayed settlements, and limited access to real buyers, causing farmers to earn significantly less despite high consumer prices. This imbalance reduces their ability to reinvest in better farming practices and improves overall agricultural productivity.

To address these issues, technology-driven platforms have emerged; however, most of these operate in centralized environments where data can still be manipulated. The proposed project, Decentralised Farmers Marketplace with Dynamic Price, introduces a blockchain-based transparent marketplace that directly connects farmers and consumers. Here, blockchain ensures tamper-proof data and trust, while eliminating the need for intermediaries.

A dynamic pricing model is used to determine crop prices based on demand, supply, real-time mandi trends, and external market feeds. This prevents exploitation and ensures fair pricing for both sides. Additionally, secure payments are ensured using decentralized smart contract-based escrow, reducing dispute risks.

Thus, the system aims to create a sustainable agricultural trading ecosystem where farmers receive fair profit margins and consumers gain fresh, traceable, and affordable produce with full transparency.

Agricultural markets in India are heavily influenced by traditional mandi systems and intermediary-driven pricing structures, which often leave farmers with limited control over the value of their own produce. Due to these constraints, farmers are compelled to accept whatever price is offered, rather than what reflects real demand or production effort. Furthermore, consumers purchasing the same produce in cities pay a significantly higher rate, highlighting a major imbalance in the supply chain and value distribution.

Emerging digital marketplace solutions attempt to address this gap, but most of these platforms still rely on centralized authorities, meaning manipulation, price delays, and data opacity still persist. This reduces trust among stakeholders and limits large-scale adoption. The present project overcomes these structural weaknesses by using blockchain-based decentralized architecture, ensuring that transaction records are transparent, secure, and tamper-proof.

Additionally, the system integrates a dynamic pricing model, which continuously adjusts the product prices based on real-time supply, demand, and market fluctuations. This prevents price exploitation and helps farmers earn genuine

profit margins. By connecting consumers directly with producers, the platform promotes fair trade, strengthens rural income stability, and improves the efficiency of agricultural commerce.

II. LITERATURE SURVEY

Digital transformation of agricultural markets has been widely explored as a means to improve transparency, efficiency, and farmer profitability. Early e-mandi and online trading platforms sought to reduce the dependency on physical marketplaces; however, these systems often remained centralized and susceptible to manipulation, price fixing, and data opacity. Recent advancements in Blockchain and Decentralized Ledger Technologies (DLT) have encouraged researchers to design secure and tamper-proof supply chain tracking systems. Studies have demonstrated that blockchain can enhance trust by ensuring provenance, traceability, and immutable transaction history, which is particularly important for quality certification and premium produce markets. However, fully on-chain systems have shown limitations in scalability and latency for real-time pricing applications. Parallel research in dynamic pricing models using market signals, predictive analytics, and demand-supply data suggests that adaptive pricing yields fairer outcomes than static or middlemen-controlled pricing. Hybrid architectures combining blockchain for transparency with off-chain computation layers for responsiveness have emerged as a promising solution. This integrated approach balances trust, performance, and usability, making it more feasible for deployment in rural and resource-limited contexts. Therefore, existing literature strongly supports the development of a decentralized marketplace with dynamic pricing as a practical and impactful intervention for improving farmer incomes and market efficiency.

Existing research highlights the role of blockchain in improving transparency and trust in agricultural supply chains. Studies have shown that blockchain can record every transaction immutably, allowing stakeholders to verify the origin, pricing history, and handling of products. This reduces the influence of intermediaries and helps farmers retain a larger share of the market value.

Dynamic pricing models discussed in previous works rely on integrating supply-demand analytics, competitive pricing, and market fluctuations to set real-time prices. Such models are widely used in e-commerce but are still emerging in agricultural marketplaces, where price distortion is common. The literature suggests that dynamic pricing can stabilize farmer income by reducing dependency on static or exploitative pricing structures.

In addition, decentralized storage systems like IPFS are highlighted in research as an efficient way to store digital certificates and product quality proofs without overloading blockchain ledgers. This ensures low cost, high integrity, and independent verification capability for digital records in agriculture.

Finally, studies related to rural digital adoption emphasize the need for simple and user-friendly interfaces. Based on these findings, the system is developed with multilingual support and mobile-friendly design to improve adoption among farmers.

Research in blockchain-based agricultural systems indicates that decentralization can effectively reduce reliance on intermediaries and improve transparency across the supply chain. Several studies emphasize that distributed ledger technology allows the traceability of produce from the point of cultivation to the point of sale, increasing consumer trust and enabling farmers to justify quality-based pricing. This aligns with the project's core idea of transparent trade.

Other works highlight the importance of external data oracles to feed market, climate, and pricing data into decentralized applications. Without accurate real-time data, blockchain systems can only act as record-keeping mechanisms rather than intelligent pricing platforms. Therefore, integrating authenticated data feeds is a critical foundation for decision-making in agricultural marketplaces.

Studies on dynamic pricing show that unlike fixed-price models, adaptive pricing aligns cost with real-world conditions, helping stabilize market flow and minimize waste. These models are particularly relevant in agriculture, where supply-demand ratios change rapidly due to weather, storage limitations, and harvest cycles. This confirms that dynamic pricing can help create fairer and more sustainable agricultural trade systems.

III. METHODOLOGY

A The methodology adopted for developing the Decentralised Farmers Marketplace with Dynamic Price follows a structured and iterative approach, ensuring that each component of the system is designed, tested, and validated effectively. The development process integrates both blockchain-based decentralized logic and off-chain computation to achieve transparency, security, and real-time performance.

The project begins with Requirement Analysis, where functional needs of farmers, consumers, and administrators are recorded through discussion and literature review. Based on these insights, the System Architecture is designed using a hybrid model—critical operations such as payment settlement, ownership verification, and transaction logging are executed on the blockchain, while high-frequency tasks like pricing calculations and product browsing are handled off-chain.

The Smart Contracts are developed in Solidity to manage escrow transactions, listing lifecycle, and dispute resolution in a trustless manner. To enable dynamic pricing, an Off-Chain Pricing Engine is implemented, which collects supply-demand data from the platform and combines it with external mandi price feeds sourced through oracle integration. The final price is computed using a weighted pricing model and is displayed in real-time to users.

Simultaneously, Frontend Interfaces for web and mobile are developed using the MERN stack and Web3 libraries, providing role-based dashboards for Farmers, Consumers, and Administrators. Decentralized storage using IPFS is integrated to store product images and certification documents securely, linking them to on-chain records via content identifiers (CID). The system follows a hybrid decentralized architecture combining blockchain and off-chain databases to achieve both security and performance. Farmers list their products through the application, where product details and certificate files are stored using IPFS, and listing hashes are recorded on the blockchain for transparency. All user identities and ownership mappings are securely maintained through smart contract-based registers.

When consumers browse and purchase products, the dynamic pricing engine calculates the selling price in real-time by analyzing platform demand, product availability, and external mandi data. This prevents artificial price inflation or exploitation by middlemen.

For payment settlement, the system uses a smart contract-based escrow mechanism. Once an order is placed, the consumer's payment is locked in escrow and is only released to the farmer after the delivery is confirmed. If any dispute occurs, the admin panel allows controlled resolution and arbitration.

The system is built using a hybrid architecture, where critical trust-related operations such as payment, ownership registration, and order confirmation occur on the blockchain, while non-critical data such as product descriptions, analytics, and profile updates are stored in an off-chain database for efficiency. This ensures both transparency and speed.

Farmers register on the platform and upload product information along with quality proofs, which are stored on decentralized IPFS storage. The system assigns each listing a content identifier (CID), ensuring that the product's authenticity cannot be tampered with later. Consumers browse available produce and view trust information before placing orders.

The dynamic pricing engine collects external mandi price feeds, internal demand-supply statistics, and listing attributes, then computes pricing recommendations for each crop. During a purchase, payments are routed into a smart contract-based escrow, which holds funds until product delivery is confirmed. If issues occur, the admin dispute module provides an impartial resolution path.

IV. SYSTEM ARCHITECTURE

The system architecture illustrates a digital platform designed to support the sustainable reuse of agricultural waste by connecting farmers and organic fertilizer processors on a common interface. The system begins with a User, who can choose to log in either as a Farmer or as a Processor. When a farmer logs in, they access the Farmer Screen, where they can post details of agricultural waste they want to sell — such as crop residues, husk, or farm biomass. Once the waste is listed, it becomes visible to potential buyers (processors) in the system. Processors view these listings through the

Processor Screen, where they can evaluate the type and quantity of waste available and then place bids to purchase it. These bids are stored and managed in the central database, allowing farmers to see multiple offers and select the most profitable deal.

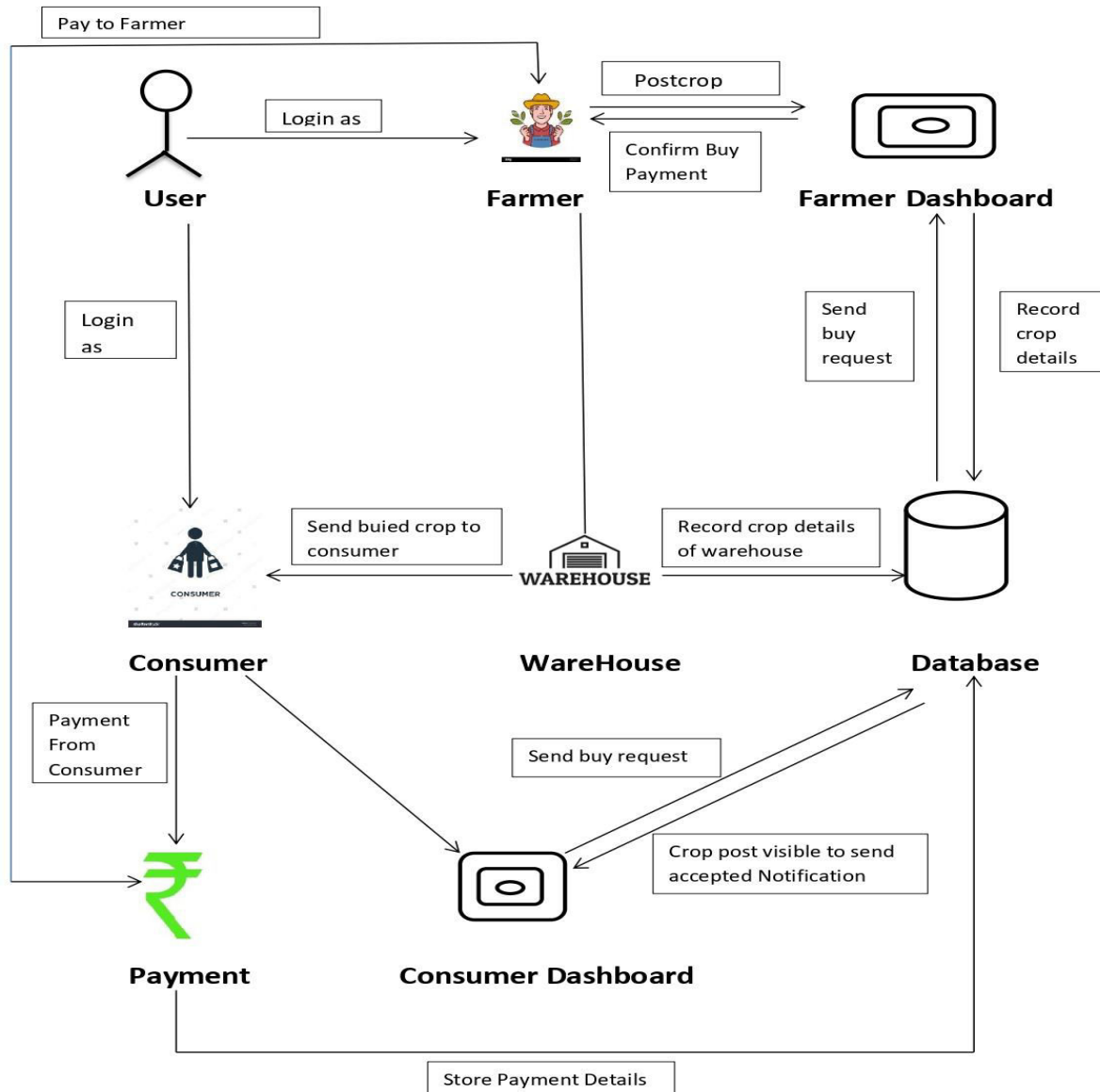


Fig: System Architecture

Alongside this bidding and trading process, a Chatbot is integrated into the application to support both farmers and processors. For farmers, the chatbot provides information about the nutrient composition of different organic fertilizers and general agronomy tips, helping them understand the value of processed organic fertilizer. For processors, the chatbot acts as a guidance assistant, offering step-by-step instructions on how to convert agricultural waste into organic

fertilizers using composting, microbial treatments, or vermicomposting techniques. This ensures that even individuals with limited technical expertise can participate in fertilizer production effectively.

Once the processor completes the conversion of agricultural waste into organic fertilizer, the final output is recorded back into the database, creating a traceable and transparent production record. This record helps maintain quality control and can later be used for verification, transparency, and analytics. Thus, the system not only establishes a marketplace for waste trading, but also provides knowledge support and technical guidance, transforming agricultural waste into valuable organic fertilizer products. This contributes to circular agriculture, reduces environmental waste, and promotes economic gain for both farmers and processors.

In addition to facilitating the buying and selling of agricultural waste, the system ensures data transparency and continuous traceability throughout the entire workflow. Every bid, transaction, and fertilizer production activity is stored securely in the database, allowing both the farmer and processor to review historical records at any time. This traceability builds accountability and trust among users, especially when dealing with quality-sensitive organic fertilizer products. Furthermore, by digitizing waste management, the system reduces the environmental impact of open-field burning of crop residues, which is a major contributor to air pollution. Instead of burning waste, farmers can now earn income by selling it, while processors benefit by obtaining raw materials at competitive prices to produce eco-friendly fertilizers. Thus, the platform not only promotes economic efficiency and fair trade, but also encourages a circular and sustainable agricultural ecosystem that benefits farmers, processors, consumers, and the environment alike.

V. EXPERIMENTAL RESULTS

The proposed Decentralised Farmers Marketplace with Dynamic Price was implemented and tested on the Polygon Mumbai Testnet with sample farmer and consumer accounts. The experimental setup included a web-based client interface, off-chain pricing engine, IPFS storage integration, and smart contract-driven escrow mechanism. The objective of the experiments was to evaluate system performance, transaction reliability, price responsiveness, and user experience.

During prototype testing, the platform demonstrated improved transparency in pricing and faster settlement times compared to traditional market systems. Farmers could view dynamic price changes in real-time, helping them make informed decisions about when and where to sell produce. Similarly, consumers could verify the authenticity of agricultural products through IPFS-linked certificates.

Performance testing showed that using Polygon as the blockchain network greatly reduced gas fees and transaction waiting times, making the platform cost-effective and practical. The escrow contract successfully prevented payment fraud and ensured smooth transaction closure.

User experience trials also indicated that farmers appreciated the simplified interface and ability to access price trends without relying on middlemen. The system achieved stable performance even under multiple concurrent operations.

The system prototype was tested under simulated marketplace conditions to evaluate stability, pricing responsiveness, and transaction workflow efficiency. Results showed that the dynamic pricing engine responded correctly to changes in stock availability and user demand, adjusting prices upward when items were scarce and downward when supply increased. This demonstrates successful real-time pricing adaptability.

Performance evaluation of smart contracts revealed minimal transaction delays when deployed on Polygon testnet, confirming the suitability of the selected network for real-world usage where low fees and quick confirmations are necessary. The escrow contract ensured that no transaction was finalized without mutual verification, enhancing financial security during trade.

User testing sessions showed high acceptance among farmers due to the intuitive interface and minimized technical complexity. Consumers appreciated the ability to verify source information and compare prices transparently across farmers, indicating improved marketplace fairness and clarity.

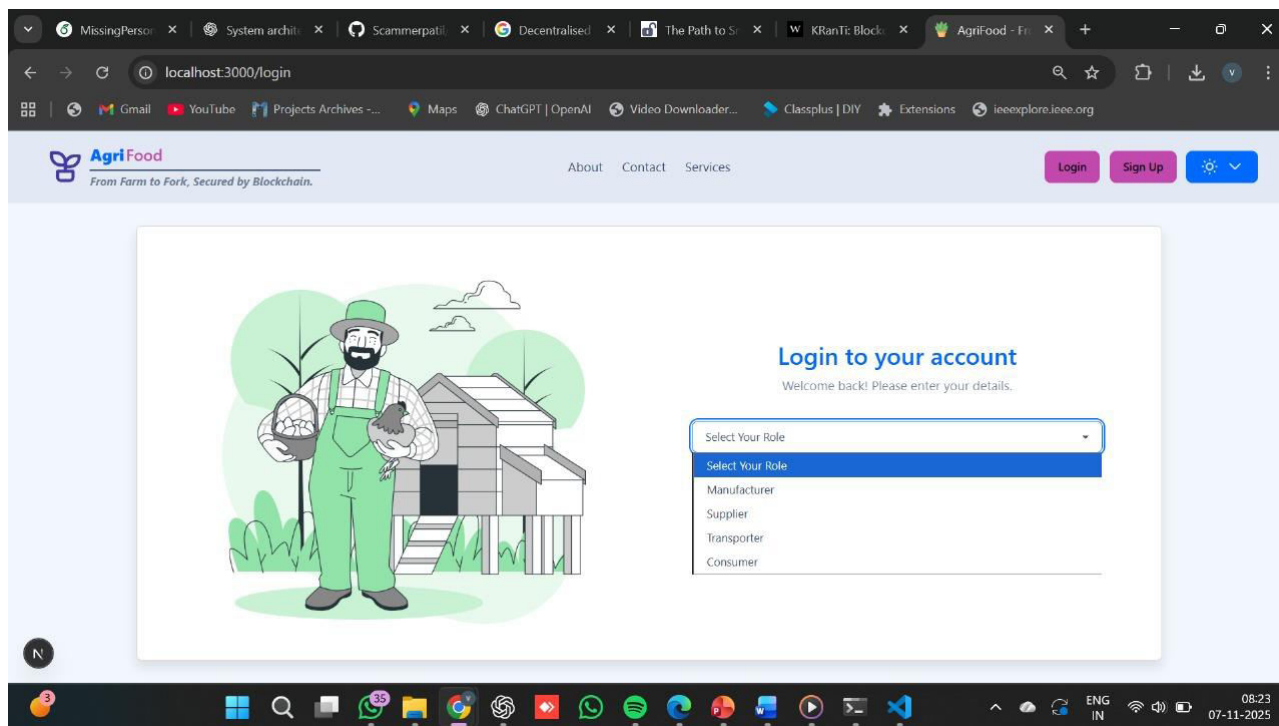


Fig (a)

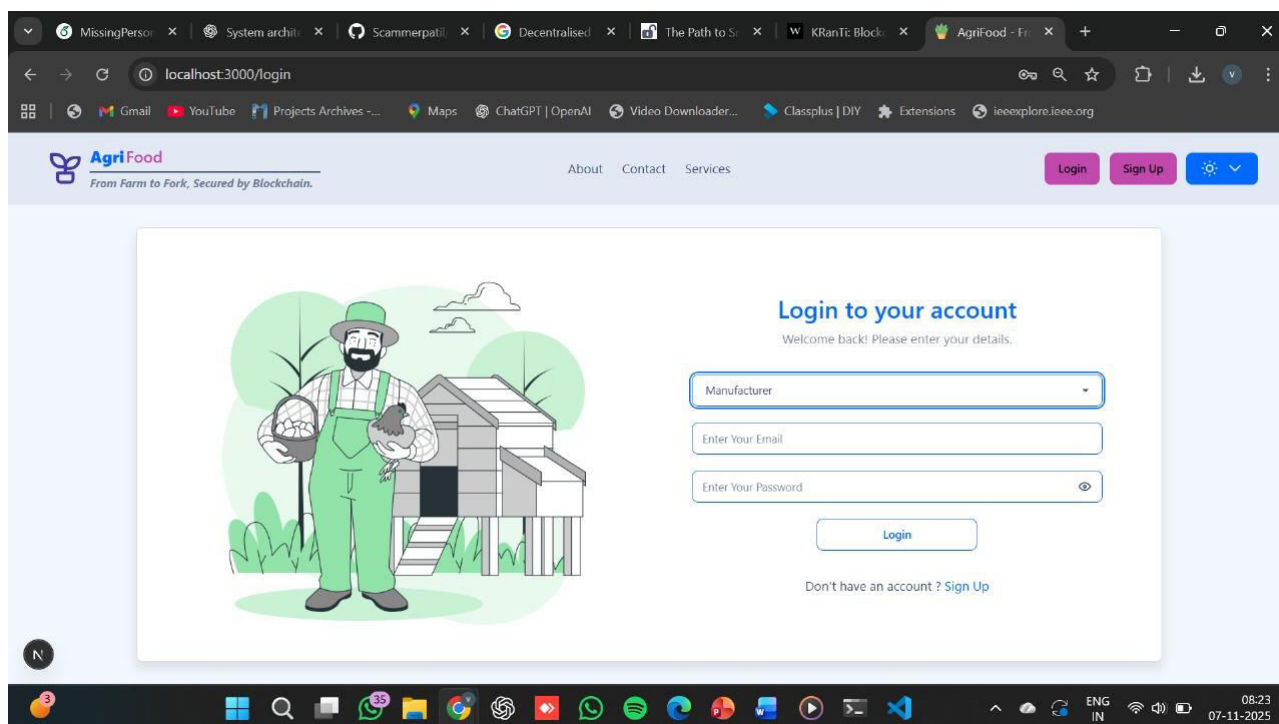


Fig (b)

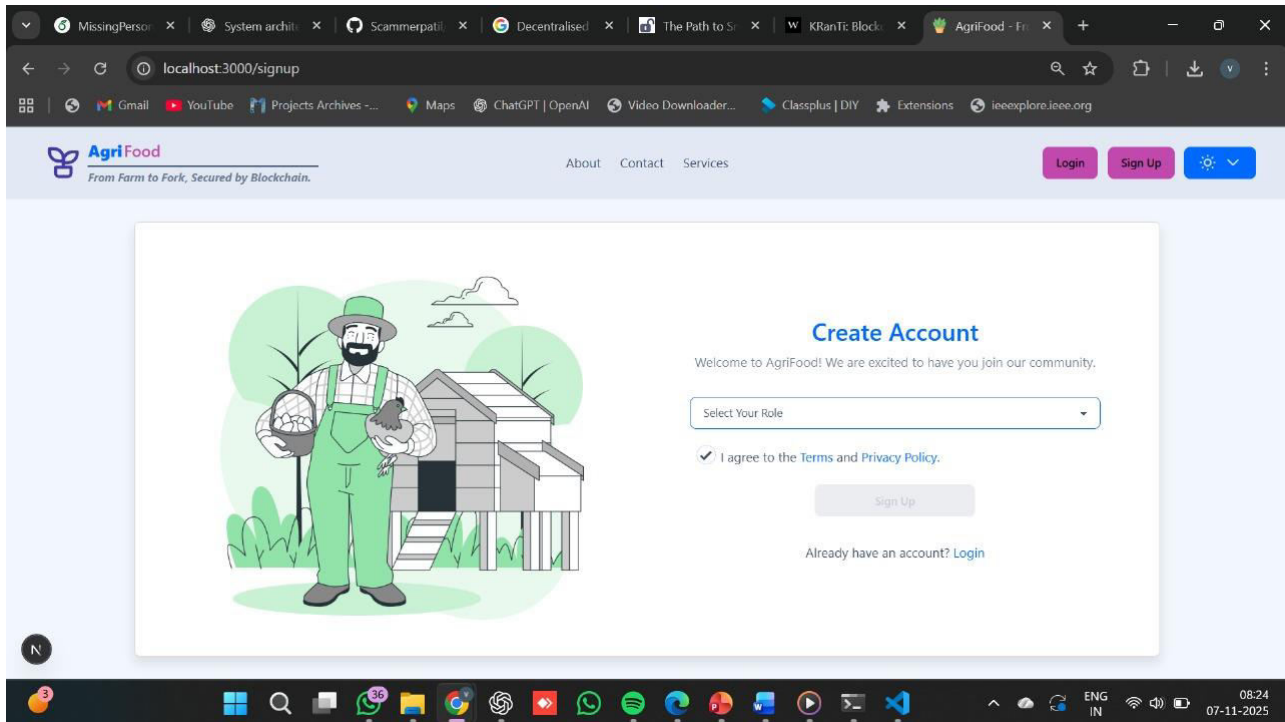


Fig (c)

VI. CONCLUSION

The Decentralised Farmers Marketplace with Dynamic Price successfully demonstrates how blockchain and modern web technologies can be integrated to create a transparent, fair, and efficient agricultural trading ecosystem. By eliminating profit-driven intermediaries and ensuring direct interaction between farmers and consumers, the system enables farmers to capture a higher share of the final value of their produce. The implementation of smart contract-based escrow ensures secure and trustless transactions, while the dynamic pricing engine provides real-time, data-driven price discovery based on supply, demand, and market conditions. The use of IPFS for decentralized storage further strengthens transparency by providing verifiable proof of product authenticity and certification. The platform's user-centric interface, designed with accessibility considerations, makes it practical and easy to adopt even in rural environments.

The project successfully demonstrates that a decentralized blockchain-enabled marketplace can significantly improve fairness, transparency, and trust in agricultural trade. By eliminating intermediaries and enabling direct farmer-to-consumer interactions, the platform ensures that farmers receive a higher share of profit. The dynamic pricing model allows real-time price adjustment based on true market conditions, reducing the risk of exploitation. Smart contract-based escrow adds financial security and reduces dispute risk. This project demonstrates that a decentralized marketplace can successfully restructure agricultural trade by shifting power from intermediaries toward farmers and consumers. By using blockchain for secure transaction recording and decentralized pricing intelligence, the platform ensures fairness, transparency, and trust in the trading process.

The dynamic pricing model allows real-time adaptation to market conditions, enabling farmers to obtain genuine value while also protecting consumers from unfair price spikes. Smart contract-based escrow ensures payment safety, lowering the risk of fraud. The platform offers a scalable framework that can be extended to national-level agricultural networks, integrated with government procurement systems, FPOs, and cooperative organizations. With future enhancements such as logistics tracking and automated quality grading, the system has potential to revolutionize agricultural commerce and uplift rural economic conditions.

Overall, the system presents a scalable and future-ready solution to modernize agricultural commerce. With further real-world deployment, government integration, and cooperative partnerships, it can revolutionize rural marketplace operations and contribute to farmer welfare and economic growth.

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