



KRISHI-UNNATI: AN INTEGRATED PLATFORM FOR FARMER EMPOWERMENT & PROFITABILITY USING BLOCKCHAIN

¹Hemant A. Akotkar, ²Santosh G. Kandalkar, ³Pallavi N. Ingle, ⁴Neha S. Katkhede, ⁵Mr. C. R. Ingole

¹Student, ²Student, ³Student, ⁴Student, ⁵Professor
Department of Computer Science & Engineering,
Prof Ram Meghe College of Engineering & Management Badnera
Amravati, India

Abstract: Agriculture remains a primary livelihood for a large portion of the global population; however, farmers continue to face challenges such as price uncertainty, market fluctuations, and limited trust in existing trading systems. In many cases, traditional supply chains depend on intermediaries and centralized databases, which can reduce farmers' profit margins and restrict transparency. Issues such as data inconsistency and lack of reliable market information further complicate decision-making. This paper presents Krishi-Unnati, a digital platform designed to improve transparency and support better decision-making in agricultural trading. The system integrates blockchain technology, artificial intelligence, and mobile computing within a hybrid architecture. Transactional data, including trade records, is stored on a blockchain ledger to ensure integrity, while other operational data is maintained off-chain to improve efficiency. The platform provides two main functionalities. First, a crop price prediction module based on Random Forest Regression is used to estimate future market prices. Second, a buyer recommendation engine analyzes historical transaction data to suggest suitable trading partners. Together, these components assist farmers in making more informed choices regarding crop sales and market participation. The mobile application is developed using React Native, with a backend built on Node.js, Express.js, and MongoDB. System evaluation indicates improvements in transparency, access to market information, and overall decision support. The proposed approach contributes toward a more reliable and data-driven agricultural trading ecosystem.

Keywords: Blockchain, Smart Agriculture, Price Prediction, Buyer Recommendation, Supply Chain Transparency, Smart Contracts, Agriculture Technology.

I.INTRODUCTION

Agriculture continues to play a key role in the global economy, particularly in developing regions where it supports livelihoods and ensures food security. A large portion of the population still depends on agriculture as a primary source of income. However, despite its importance, the sector faces several long-standing challenges that affect both efficiency and fairness in trade.

One of the major concerns is the lack of price stability and transparency in agricultural markets. Crop prices often fluctuate due to changing demand, seasonal variations, and external factors, making it difficult for farmers to decide the right time and place to sell their produce. In addition, traditional trading systems heavily rely on intermediaries. While these intermediaries facilitate transactions, they often reduce farmer's profit margins and delay payments, which creates financial uncertainty.

Another issue lies in the way information is managed and distributed. Most existing systems are centralized, meaning that access to important data such as market prices, buyer demand, and transaction records is limited. Farmers, especially those in rural areas, frequently operate without complete or timely information. This lack of visibility affects their ability to negotiate and, in many cases, leads to dependency on middlemen.

Recent advancements in technology offer potential solutions to these challenges. Blockchain technology, for instance, provides a decentralized and secure method of recording transactions. Since data stored on a blockchain cannot be easily altered, it improves trust and accountability among participants. At the same time, artificial intelligence and machine learning techniques have shown strong capabilities in analyzing historical data and identifying patterns. In the context of agriculture, these techniques can be applied to predict crop prices and understand market trends.

Although both blockchain and artificial intelligence have been explored in agricultural applications, often they are implemented separately. Systems focusing on blockchain mainly address transparency and security, while AI-based solutions focus on prediction and analytics. There is limited work that combines these technologies into a single, practical system for real-world agricultural trading.

To address this gap, this paper presents Krishi-Unnati, a platform that integrates blockchain and artificial intelligence to improve transparency and support better decision-making. The system uses blockchain to securely record trade-related information, ensuring data integrity and traceability. At the same time, it avoids the complexity of cryptocurrency-based systems by enabling transactions through existing banking infrastructure, making it more practical for farmers.

In addition, the platform includes two key components: a crop price prediction model and a buyer recommendation system. The prediction model uses historical data to estimate future price trends, while the recommendation system helps farmers identify suitable buyers based on past interactions and preferences. Together, these features aim to provide meaningful support in decision-making.

The objective of this work is to design a system that not only improves transparency in agricultural trade but also empowers farmers with reliable information. By combining decentralized data management with intelligent analytics, the proposed approach aims to reduce dependency on intermediaries and promote a more efficient and trustworthy ecosystem. The rest of the paper discusses the system design, methodology, and evaluation of the proposed solution.

II. LITERATURE REVIEW

The integration of emerging technologies such as blockchain, artificial intelligence (AI), and machine learning (ML) has gained significant attention in the domain of smart agriculture. These technologies are increasingly explored to address challenges related to transparency, efficiency, and data-driven decision-making within agricultural systems.

Blockchain technology, in particular, has been widely investigated for improving transparency and traceability in agricultural supply chains. Studies such as [1] highlight its capability to provide secure and tamper-resistant data storage, enabling end-to-end tracking of agricultural products. Similarly, [10] discusses the broader impact of blockchain in supply chain management, emphasizing its decentralized nature and its role in enhancing transaction reliability. However, challenges related to scalability, integration with legacy systems, and data handling remain critical considerations for real-world implementation.

Several research efforts have also examined the integration of blockchain with complementary technologies. For instance, [4] proposes a blockchain-enabled framework combined with Internet of Things (IoT) systems for precision agriculture, demonstrating improvements in both data security and operational efficiency. Likewise, [8] presents an AI-enabled blockchain approach for agricultural supply chains, suggesting that combining these technologies can significantly enhance system performance compared to standalone solutions.

Artificial intelligence and machine learning techniques have independently shown strong potential in agricultural applications, particularly in predictive analytics and decision support. In [3], a machine learning-based model is developed for crop prediction, achieving high accuracy through advanced optimization techniques. Similarly, [5] introduces energy-efficient AI models for crop yield prediction and resource management, emphasizing sustainability alongside performance. These approaches demonstrate the effectiveness of data-driven models in improving agricultural productivity.

In addition to predictive capabilities, recent research has focused on developing explainable and human-centered AI systems. Studies such as [2] and [9] emphasize the importance of transparency and interpretability in AI-driven agricultural applications, particularly when integrated with blockchain frameworks. The concept of human-centered AI, as discussed in [7], further highlights the need to design systems that support user understanding and practical usability, especially for farmers.

From a supply chain perspective, [6] analyses stakeholder participation in agricultural traceability systems, indicating that incentives and perceived value play a key role in adoption. This insight is essential for designing systems that are not only technically sound but also practically viable.

Recent advancements also point toward the development of integrated platforms that combine multiple technologies into a unified solution. For example, [11] presents an ecosystem that leverages both blockchain and AI to support agricultural operations, while [12] explores optimized data integration techniques to enhance system efficiency and reduce operational costs. These studies reinforce the importance of combining technologies to achieve better outcomes.

Despite these advancements, a significant research gap remains. Most existing studies focus either on blockchain for secure data management and transparency or on AI/ML for prediction and analytics. Limited work has been done on developing a comprehensive system that integrates both aspects specifically for agricultural trading. Furthermore, many proposed solutions lack practical deployment considerations, such as user-friendly interfaces and real-world usability for farmers.

To address these limitations, this research proposes Krishi-Unnati, an integrated platform that combines blockchain technology with AI-based predictive and recommendation systems. Unlike existing approaches, the proposed system emphasizes practical applicability by integrating mobile applications, backend services, and intelligent models into a single framework. The objective is to enhance transparency, reduce dependency on intermediaries, and enable data-driven decision-making in agricultural trade.

III. PROBLEM STATEMENT

Agriculture plays a vital role in supporting livelihoods, particularly in developing economies. Despite its importance, the current agricultural trading ecosystem in fig (1) faces several structural challenges that directly affect farmers' income and overall market efficiency. One of the primary issues is the lack of reliable price information. Market prices for agricultural produce are highly dynamic and often unpredictable, making it difficult for farmers to determine the optimal time and location for selling their crops. As a result, many farmers are forced to sell under unfavorable conditions, leading to financial losses.

Another critical limitation is the heavy dependence on intermediaries such as brokers and agents. These entities often control access to buyers and influence pricing decisions, which reduces the bargaining power of farmers. In many cases, this results in lower profit margins and delayed payments. Additionally, most

traditional trading systems rely on centralized databases managed by a single authority. Such systems are vulnerable to data manipulation, lack transparency, and reduce trust among stakeholders.

The absence of end-to-end traceability further complicates the situation. Once agricultural produce enters the supply chain, it becomes difficult to track its movement, verify transactions, or ensure accountability at different stages. This lack of visibility not only affects transparency but also limits the ability to identify inefficiencies within the system.

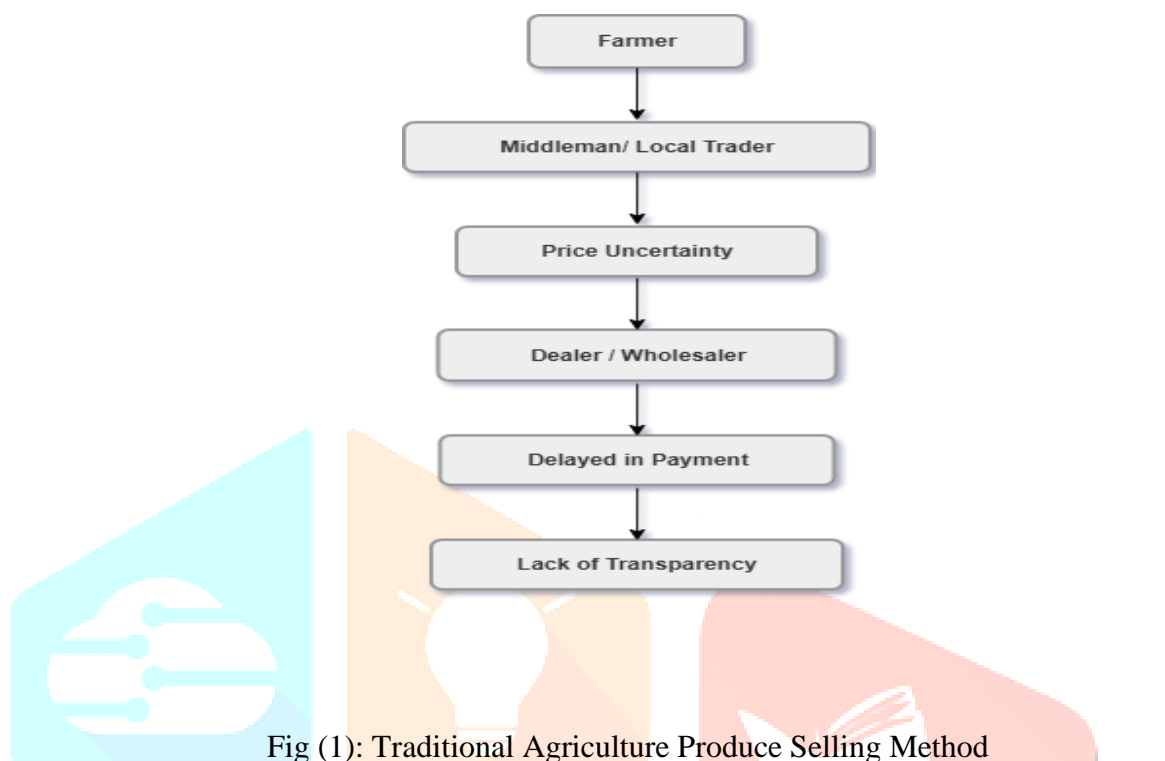


Fig (1): Traditional Agriculture Produce Selling Method

Although emerging technologies such as blockchain and artificial intelligence offer promising solutions, their adoption in agriculture remains limited. Existing approaches often focus on isolated capabilities either improving data security through blockchain or enhancing decision-making using AI-based models. However, few systems provide an integrated solution that addresses both transparency and intelligent decision support. Furthermore, many available platforms are not designed with usability in mind, making them less accessible for farmers, especially in rural areas.

These challenges highlight the need for a unified system that can simplify agricultural trading while improving transparency, efficiency, and trust. Such a system should enable farmers to access accurate market information, reduce dependency on intermediaries, and support informed decision-making regarding pricing and buyer selection.

To address these issues, this study proposes the Krishi-Unnati platform fig (2), which integrates blockchain technology with artificial intelligence-based models. The system is designed to provide a secure and transparent environment for agricultural transactions while ensuring efficient data management. By leveraging blockchain, trade-related data can be recorded in an immutable and verifiable manner, reducing the risk of manipulation. At the same time, AI-driven components enable price prediction and buyer recommendation, assisting farmers in making data-driven decisions.

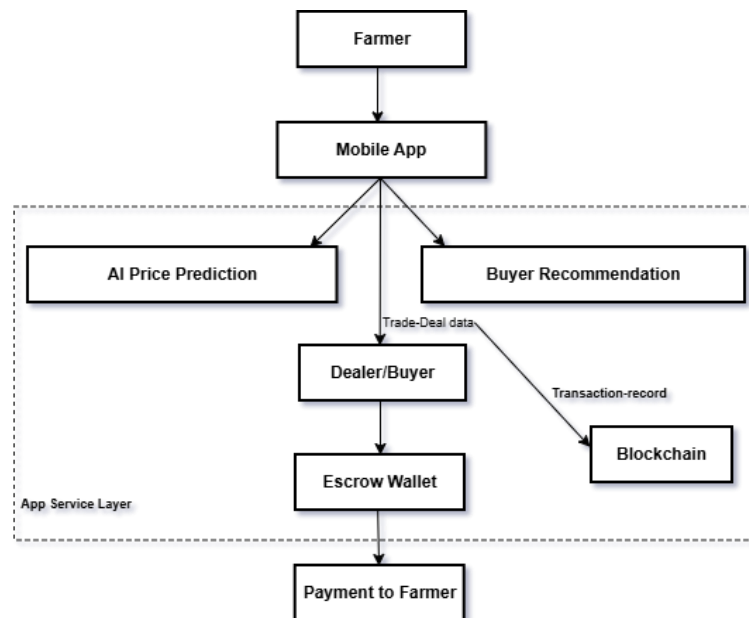
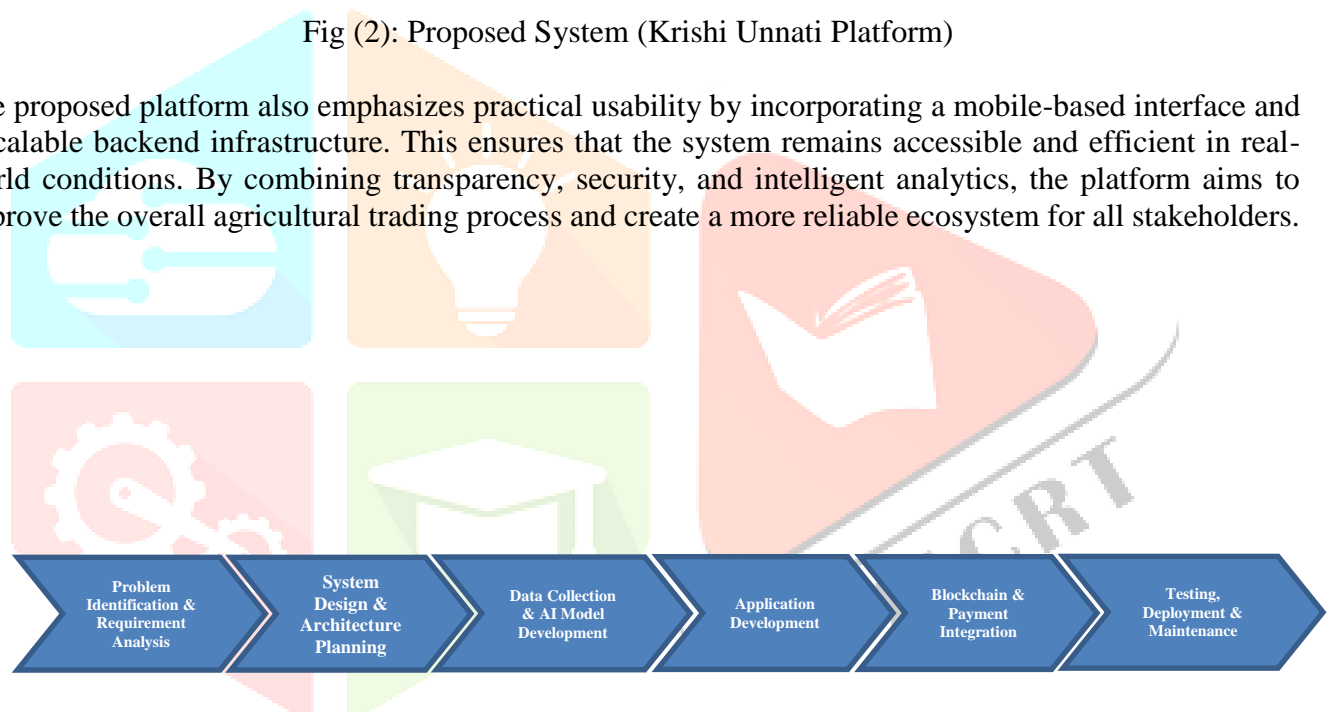


Fig (2): Proposed System (Krishi Unnati Platform)

The proposed platform also emphasizes practical usability by incorporating a mobile-based interface and a scalable backend infrastructure. This ensures that the system remains accessible and efficient in real-world conditions. By combining transparency, security, and intelligent analytics, the platform aims to improve the overall agricultural trading process and create a more reliable ecosystem for all stakeholders.



IV. PROPOSED METHODOLOGY

The Krishi-Unnati platform is designed to address key challenges in agricultural trading by integrating blockchain technology, artificial intelligence, and mobile-based application services. The development process follows a structured approach, beginning with problem identification, followed by system design, implementation, and validation. The overall architecture adopts a modular and scalable design, where individual components operate as independent services and interact through well-defined interfaces.

A. AI-Based Price Prediction and Buyer Recommendation

The platform incorporates a crop price prediction module to support data-driven decision-making. This module is developed using Python and deployed as a microservice using FastAPI. A Random Forest Regression model is employed due to its robustness in handling non-linear relationships and diverse agricultural datasets. The model is trained on publicly available crop price data, followed by preprocessing steps such as data cleaning, normalization, and feature selection to improve performance. Once trained, the model is exposed as an API, allowing real-time prediction requests from the application.

In addition, a buyer recommendation system is implemented to assist farmers in identifying suitable trading partners. This module is based on collaborative filtering using Singular Value Decomposition (SVD), which analyses historical transaction data and user interaction patterns. The recommendation engine is also deployed as a microservice, enabling independent scaling and efficient integration with other system components.

B. Frontend and Backend Architecture

The frontend of the platform is developed using React Native with JavaScript and TypeScript, enabling cross-platform compatibility across Android and iOS devices. The user interface is designed with a focus on simplicity and accessibility to ensure usability for farmers with varying levels of technical familiarity. Core functionalities include crop listing, price visualization, prediction access, buyer suggestions, order placement, and transaction tracking.

The backend is implemented using Node.js and Express.js, providing a scalable environment for handling application logic and API requests. A RESTful architecture is adopted to facilitate communication between the frontend, database, AI services, and blockchain modules. MongoDB is used as the primary database due to its flexibility in handling semi-structured data, including user information, transaction records, and order details. This architecture enables modular development, allowing individual components to be updated or scaled without affecting the overall system.

C. Blockchain Integration and Payment Simulation

Blockchain technology is integrated to enhance transparency and trust in transactions. The system is built on the Ethereum framework using Solidity for smart contract development and Hardhat for local blockchain simulation. Smart contracts are used to record and validate transaction data, ensuring immutability and auditability. The backend interacts with the blockchain using the ethers.js library.

Due to practical constraints during development, a local blockchain network is used for testing purposes. Key transaction details, such as transaction hashes and block information, are recorded on-chain, ensuring data integrity. A simulated payment mechanism is also implemented to demonstrate secure financial transactions. The system follows an escrow-based model, where funds are temporarily held in a virtual wallet and released upon successful transaction completion. This approach reflects real-world payment workflows and highlights the role of secure transaction handling in agricultural trade.

D. Development Approach

The system is developed using a hybrid methodology combining elements of the Waterfall and incremental models. Initial phases focus on requirement analysis and data preparation, followed by model development and system implementation. Subsequent phases involve integration of individual modules, including frontend, backend, AI services, and blockchain components. This phased approach allows for iterative testing and refinement, improving system stability and performance.

E. Testing and Validation

To ensure system reliability, both unit testing and integration testing strategies are applied. Individual components, including AI models and blockchain modules, are tested independently before system-level validation. The performance of the prediction model is evaluated using standard regression metrics, while the blockchain component is tested for consistency and data integrity. Usability testing is also conducted to assess the effectiveness of the user interface under practical conditions.

F. Implementation Resources

The implementation utilizes a combination of modern development tools and frameworks. The frontend is built using React Native, JavaScript, and TypeScript. Backend services are developed using Node.js and Express.js, with MongoDB as the database. AI modules are implemented using Python, FastAPI, and Scikit-learn. Blockchain integration is achieved using Ethereum, Solidity, Hardhat, and ethers.js. A simulated escrow-based payment model is incorporated to demonstrate transaction handling.

The proposed methodology demonstrates a practical approach to integrating decentralized systems and intelligent analytics for agricultural applications. By combining modular system design with real-world

considerations such as usability and scalability, the platform provides a foundation for improving transparency, efficiency, and decision-making in agricultural trading.

V.SYSTEM ARCHITECTURE

The architecture of the Krishi-Unnati Platform (KUP) follows a modular and microservice-oriented design, integrating multiple system components to enable efficient and transparent agricultural trading operations.

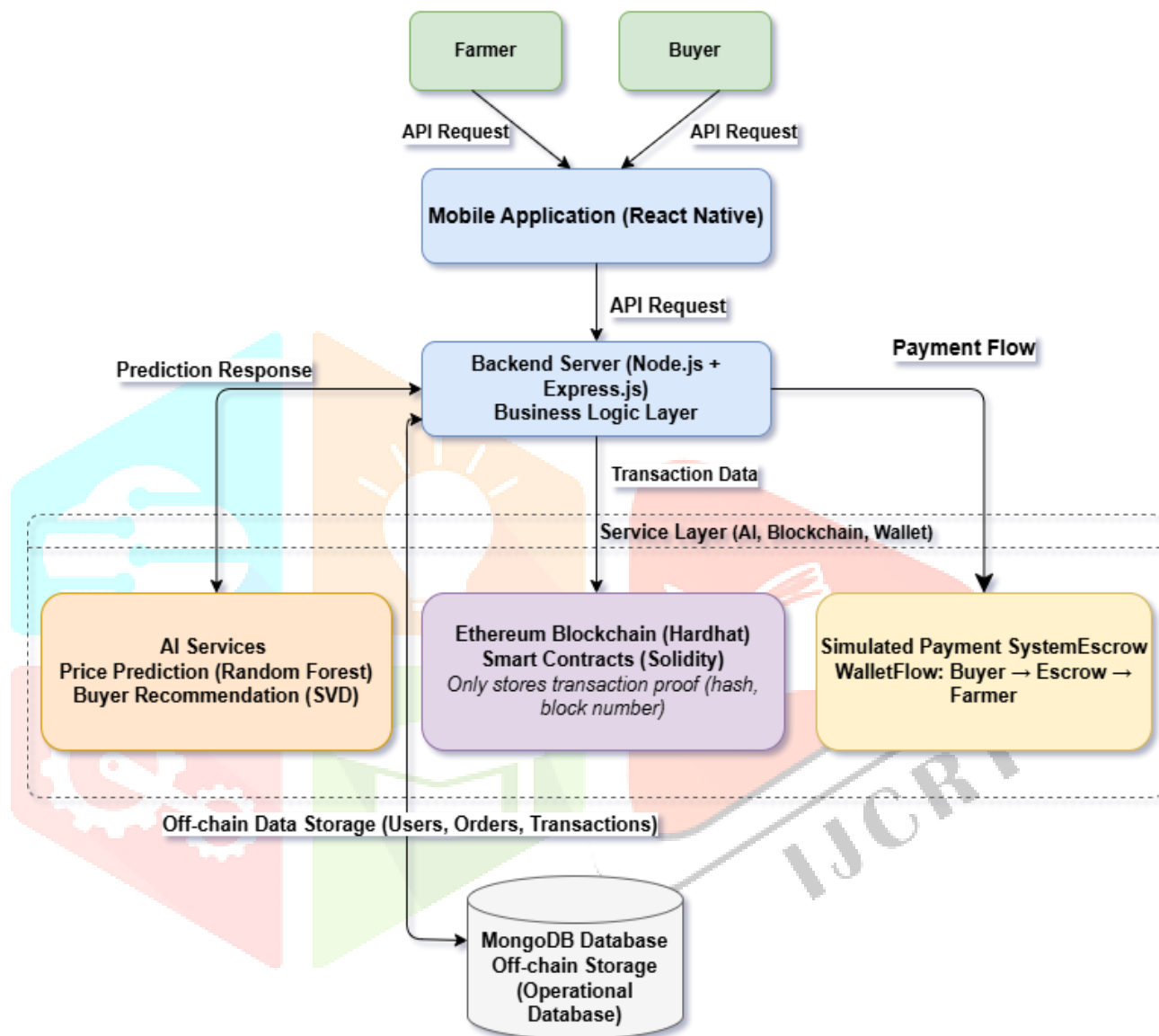


Fig (3): Krishi Unnati Platform System Architecture

The system consists of four primary layers: frontend, backend, artificial intelligent (AI) services, and blockchain infrastructure in fig (3). The frontend is implemented as a mobile application, which interacts with backend services through RESTful APIs. This layer provides users with functionalities such as crop listing, price prediction access, buyer recommendations, and transaction tracking. The backend, uses Node.js and Express.js, acts as the central coordination layer. It handles request processing, business logic execution, and communication between different modules. It also manages data exchange with AI-based microservices and the blockchain network. Artificial intelligence components are deployed as independent microservices and are responsible for price prediction and buyer recommendation.

These services process user inputs and historical data to generate real-time insights, which are then returned to the application via API calls. The system incorporates a blockchain layer based on Ethereum to ensure secure and immutable transaction recording. Smart contracts are used to validate and store key transaction details, enhancing transparency and trust among participants. In addition, an escrow-based wallet mechanism is integrated into the system to manage payments. Funds are temporarily held within the system and are released only after successful transaction completion, ensuring fairness for both buyers and farmers. MongoDB is used as the off-chain database to store non-critical data such as user profiles, product listings, and transaction metadata. This hybrid approach balances performance with data integrity by combining off-chain storage with on-chain verification.

Overall, the architecture enables seamless interaction between components while maintaining scalability, security, and reliability in real-world deployment scenarios.

VI.RESULTS

The Krishi-Unnati Platform was implemented and evaluated to assess its effectiveness in improving transparency, decision-making, and efficiency in agricultural trading. The system integrates mobile application services, backend infrastructure, AI-based models, and blockchain components into a unified framework. The mobile application provides an accessible interface through which users can perform key operations, including crop listing, price monitoring, buyer discovery, and transaction tracking. The backend system ensures seamless communication between components using RESTful APIs, while MongoDB is used for managing off-chain data such as user profiles and transaction records.

Test Case	Crop	Quality	State	Season	Organic Certified [0 – false, 1-true]	Predicted Price (Rs)	Min Price (Rs)	Max Price (Rs)	Confidence %
1	Cotton	High	Maharashtra	Rabi	0	6431.07	5990.56	6871.59	95.0
2	Rice	Low	Punjab	Kharif	1	4108.15	3096.51	5119.79	83.58
3	Soyabean	High	Madhya Pradesh	Kharif	1	6045.58	5551.32	6539.84	94.54
4	Wheat	Medium	Karnataka	Rabi	0	2126.98	1749.24	2504.71	88.16
5	Chana	Low	Uttar Pradesh	Rabi	1	6520.03	4581.53	8458.54	80.17
6	Tur	Medium	Rajasthan	Zaid	0	5015.05	4549.38	5480.72	93.80
7	Jowar	Medium	Karnataka	Rabi	1	4172.71	3395.53	4949.09	87.58
8	Chana	Low	Maharashtra	Zaid	0	4043.94	3319.68	4768.2	88.06
9	Sugarcane	Low	Karnataka	Rabi	0	253.72	217.61	289.83	90.51
10	Cotton	High	Punjab	Kharif	1	9231.11	7324.25	11137.97	86.22

Table (1): Crop Price Prediction Model Evaluation Across Multiple Test Cases

Rank	Farmer (FarmerId)	Buyer (BuyerId)	Company Name	State	Requirement	Total Deals	Score	Confidence %
1	F251026085412662	B251026091032766	EcoTraders	Telangana	Cotton	0	0.88	0.173
2	F251026085412662	B251026091032438	RuralConnect	Telangana	Cotton	0	0.88	0.173
3	F251026085412662	B251026091032664	AgroLogistics	Telangana	Cotton	0	0.87	0.1713
4	F251026085412662	B251026091032116	AgroFoods	Telangana	Cotton	0	0.87	0.1713
5	F251026085412662	B251026091032135	AgroSupply Co	Telangana	Cotton	0	0.87	0.1713
1	F251026085412337	B251026091032454	RuralExporters	Bihar	Cotton	0	0.88	0.1963
2	F251026085412337	B251026091032715	FreshTraders	Bihar	Cotton	0	0.87	0.1944
3	F251026085412337	B251026091032525	OrganicExporters	Bihar	Cotton	0	0.86	0.1924
4	F251026085412337	B251026091032250	FreshSupply Co	Bihar	Cotton	0	0.83	0.1868
5	F251026085412337	B251026091032300	FreshTraders	Bihar	Cotton	0	0.83	0.1868
1	F251026085412263	B251026091032429	FarmHub	Madhya Pradesh	Wheat	0	0.88	0.1696

2	F251026085412263	B251026091032422	AgroExporters	Madhya Pradesh	Wheat	0	0.88	0.1696
3	F251026085412263	B251026091032680	HarvestLogistics	Madhya Pradesh	Wheat	0	0.88	0.1696
4	F251026085412263	B251026091032730	AgroFoods	Madhya Pradesh	Wheat	0	0.87	0.1679
5	F251026085412263	B251026091032210	RuralLogistics	Madhya Pradesh	Wheat	0	0.86	0.1662

Table (2): Buyer Recommendation Results Based on Collaborative Filtering

A key component of the platform is the crop price prediction model based on Random Forest Regression. The model generates price estimates along with confidence intervals, allowing users to better understand potential market variations. Sample outputs of the prediction module are illustrated in Fig (a) and test with multiple case in Table (1). The predicted prices may vary depending on factors such as market demand, transportation constraints, quantity, and regional conditions. The results presented are derived from historical datasets and selected input parameters. The evaluation results indicate that the model maintains consistent performance across different crops and regions. Confidence levels above 80% suggest reliable predictive capability. Higher confidence values are observed for crops with richer historical datasets, such as cotton and soybean. The inclusion of price ranges further provides insight into market uncertainty, supporting more informed decision-making.

The buyer recommendation module utilizes collaborative filtering to identify suitable trading partners based on historical interactions. The output of this module is shown in Fig (b), where relevant buyer suggestions are generated to reduce search effort and improve matching efficiency. The buyer recommendation system generates ranked suggestions based on historical transaction patterns and product matching criteria. In Table 2 presents sample outputs of the recommendation engine across different test cases. Each entry includes buyer identification, location, requirement matching, and a computed confidence score.

The results indicate that the system consistently prioritizes buyers with matching product requirements and minimal geographical distance. The higher ranked entries are corresponded to better alignment between farmer offerings and buyer demand. The confidence score reflects the strength of the recommendation based on interaction patterns and similarity metrics.

In most cases, top-ranked buyers exhibit strong product compatibility and proximity, indicating effective recommendation performance.

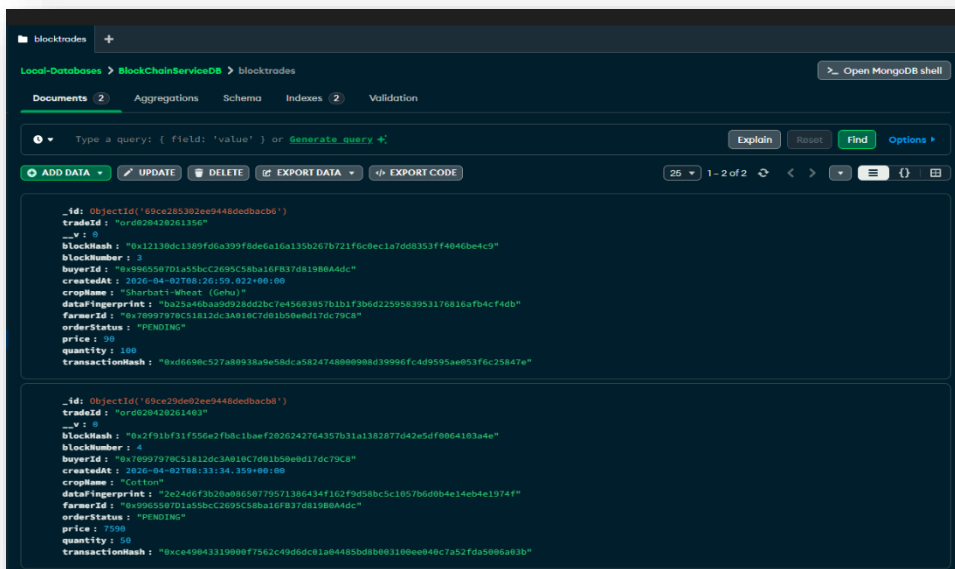


Fig (d): Order/Trade Data Off-Chain (Exact hashes are stored from Blockchain)

The platform also incorporates an escrow-based payment mechanism. As shown in Fig (e), funds are initially held within a controlled environment and are released only after successful transaction completion. The execution of payment flow and order tracking is demonstrated in Fig (f) and Fig (g), ensuring transparency and fairness for both buyers and farmers.

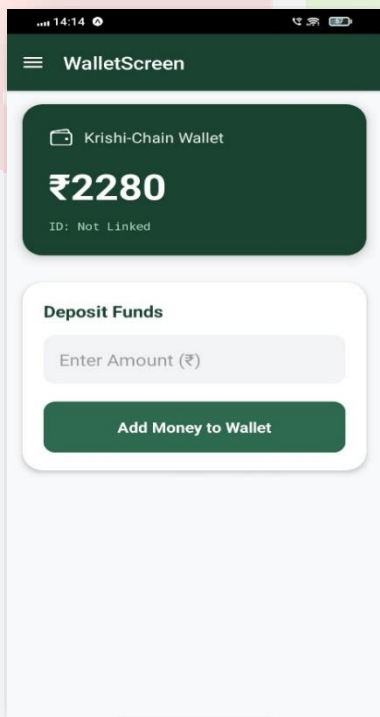


Fig (e): Wallet Screen (Separated as per user role)

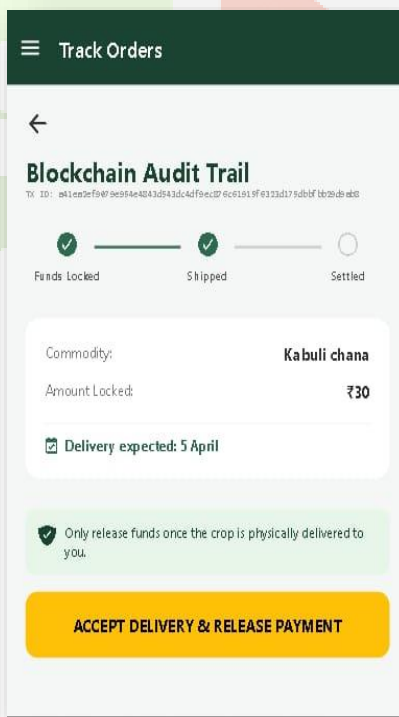


Fig (f): Escrow Payment Status (Before releasing funds)

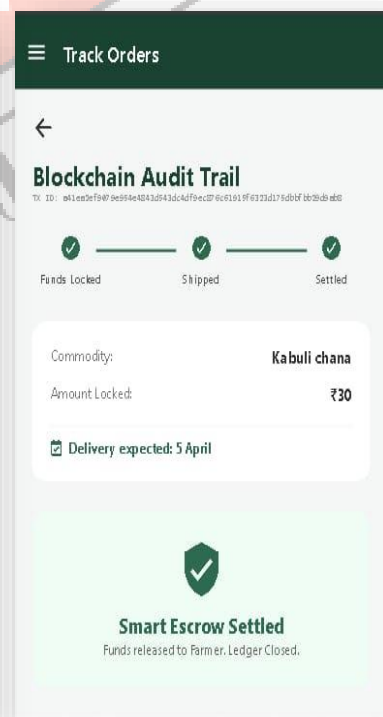


Fig (g): Escrow Payment Status (After released funds)

Overall, the integrated system demonstrates stable performance across its components. The combination of AI-driven insights, blockchain-based transparency, and user-friendly application design contributes to a more efficient and reliable agricultural trading process.

VII.CONCLUSION

This paper presents Krishi-Unnati, an integrated platform for agricultural trading that combines blockchain technology and artificial intelligence to address key challenges that are faced by farmers. The system provides a transparent and user-friendly environment, enabling farmers to participate more effectively in market activities. By bringing multiple technologies into a unified framework, the proposed solution improves trust, operational efficiency, and decision-making within the agricultural supply chain.

The platform incorporates an intelligent component to support farmer decision-making. The price prediction model enables estimation of future crop prices based on historical data, allowing farmers to make more informed selling decisions. In addition, the buyer recommendation system assists in identifying suitable trading partners, improving market accessibility and requirements. The mobile-based interface ensures usability, while the escrow-based payment mechanism demonstrates a secure and transparent transaction process without intermediaries.

Despite these contributions, certain limitations remain. The current implementation relies on a simulated blockchain environment and a prototype payment system, which need to be extended to real-world deployments. Furthermore, the performance of the AI models depends on the availability and quality of data, which may vary across different regions and conditions. The existing model also does not incorporate dynamic factors such as real-time transportation costs, distance variations, and quantity-based pricing and other parameters.

Future work will focus on deploying the system in real-world environments, integrating live market data, and enhancing model accuracy by incorporating additional variables. Further improvements can also be made in scalability, system optimization, and user adoption in rural areas.

Overall, the Krishi-Unnati platform demonstrates the potential of integrating decentralized systems with intelligent analytics to improve transparency, reduce dependency on intermediaries, and enable data-driven agricultural trading.

VIII.FUTURE SCOPE

Future work can focus on extending the platform with some additional functionalities to improve its practical applicability and impact. One major enhancement is the development of a real-time payment tracking and dispute resolution mechanism, that which can address issues related to delayed or failed transactions and improve trust and transparency among participants.

Another potential direction involves the integration of credit scoring models for farmers. Such models can support access to financial services, including loans and insurance, thereby strengthening the agricultural financial ecosystem. Further, integration with government subsidy schemes can enable a more comprehensive Agri-fintech framework, improving accessibility to institutional support.

Advanced analytical features can also be incorporated, such as demand forecasting and crop recommendation systems, to assist farmers in planning production and market strategies. In addition, the integration of Internet of Things (IoT) devices can enable real-time data collection from farms, supporting more accurate predictions and monitoring.

These enhancements have the potential to improve productivity, sustainability, and overall efficiency in agricultural operations. By combining transparency, intelligent analytics, and accessibility, the platform can evolve into a robust solution for modernizing agricultural trading systems. With further development

and real-world deployment, it can contribute toward building a more reliable and data-driven agricultural ecosystem.

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