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FarmConnect: Smart Agricultural Marketplace Using AI and MERN Stack

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Abstract: *Agriculture is the backbone of the Indian economy, yet farmers face significant challenges in marketing their produce and receiving fair compensation. The presence of intermediaries often reduces farmers' profits and limits direct access to consumers. To address this issue, this paper proposes FarmConnect, a web-based e-commerce platform that enables farmers to sell their products directly to consumers without the involvement of middlemen.*

The platform provides a virtual marketplace where farmers can create profiles, list products, set prices, and manage sales independently. Consumers can easily browse, search, and purchase fresh agricultural produce at affordable prices through a user-friendly interface. The system is developed using the MERN stack, ensuring scalability, dynamic interaction, and efficient data management through MongoDB.

Additionally, FarmConnect includes separate login modules for farmers and consumers, secure payment functionality, and a guidelines module that educates farmers about crop cultivation, soil types, and best practices. The proposed solution aims to improve transparency, enhance farmer income, and promote a sustainable and technology-driven agricultural ecosystem.

Index Terms—*AgriTech, E-commerce for Farmers, Direct Farmer-to-Consumer, Online Marketplace, Food Supply Chain, Digital Agriculture, Farmer Empowerment, Fresh Produce Dis-tribution*

I. INTRODUCTION

The Indian economy is primarily composed of agriculture as its foundation; therefore, agriculture impacts many Indians (farmers) in rural areas and is their sole livelihood [1]. Unfortunately, a high number of farmers do not generate enough revenue due to the many layers of intermediaries, such as middlemen, that take a large portion of the profit [2]. This causes farmers to be unable to maximize their income and upsets the balance of the agricultural supply chain [5].

Direct access to markets is another major issue for farmers, who typically lack up-to-date market pricing on their products. This lack of current price information can lead to poor decision-making and financial losses. As a result, farmers often have to sell their crops for low market prices since they have no other options available [5]. In recent years, several digital solutions that offer weather-based agricultural apps and Internet of Things (IoT) systems have entered the marketplace; however, they mainly provide crop monitoring or storage, rather than being a solution to the core issue of providing farmers with access to marketing [1], [2].

Digital platforms & e-Commerce have been viewed as potential solutions to create direct connections between producers & consumers. For example, AGRIMART allows users to communicate with each other through bot technology; thus enabling easier communication between users who may encounter language difficulties [3]. Mobile apps similarly allow farmers to view price information & connect with retail stores more easily [4]. Unfortunately, many of these digital platforms lack scalability; thus providing less than an ideal integrated comprehensive solution for the user experience, ultimately resulting in a less than satisfactory user experience through lack of available features for the current digital platform/e-Commerce technologies being utilized today [5].

Modern agricultural systems are becoming increasingly reliant on new technologies such as Machine Learning (ML), Cloud Computing (CC), and Data Analytics (DA) for improvement [6]. ML can be used to analyze data about crops and predict market prices for different crops to provide valuable information to aid farmers when considering what crops to produce or sell. CC enables applications to run at a much higher level of performance and can be accessed by many users simultaneously (e.g., farming in multiple locations) [8]. Furthermore, secure systems play an important role in data preservation/integrity and are critical to establishing confidence among farmers/consumers when developing a supply chain for agricultural goods [9].

Despite many advancements, there are still no companies or organizations that provide all the necessary components of an agricultural retail system into one non-threatening user-friendly solution [10].

This leaves many business-to-consumer (B2C), business-to-business (B2B) companies, and/or farmers with multiple choices; thus, creating a gap in the market for combining several functions in one place and making it easy for both sides of the transaction to utilize the services provided [12].

To fill this hole, this research proposes a web application (i.e., FarmConnect) that directly connects farmers to the consumer via several features, including: (1) Geolocation based search and secure authentication; and (2) Transparent rating systems for customers, farmers, or corporations that provide services to the farmer (e.g., input suppliers) or helpful to the customer [11]. All of these are important features for successful agri-business marketing [13], [14].

II. LITERATURE SURVEY

In recent years, technology has started playing an important role in agriculture. Many researchers have tried to solve different problems faced by farmers using digital tools and systems. These solutions focus on areas like weather prediction, storage management, communication, security, and online selling. However, most of these systems solve only one part of the problem, not the complete agricultural process.

J. Xiao et al. developed a smart weather-based application that provides real-time weather updates and crop-related information to farmers. This helps farmers take better decisions in farming activities like irrigation and harvesting. However, this system is limited only to weather support and does not help farmers in selling their products directly [1].

X. Li et al. introduced an IoT-based storage system that monitors conditions like temperature and humidity to protect crops from spoilage. This improves storage efficiency and reduces losses. But the system mainly focuses on storage and does not provide any solution for connecting farmers with buyers [2].

P.A.M. proposed AGRIMART, an online platform with a voice-based chatbot that helps farmers communicate easily with buyers. This is especially useful for farmers who face language barriers. However, it does not include features like price prediction or advanced data analysis [3].

P. Shriram et al. created a mobile application that connects farmers with retailers and shows live market prices. This improves market awareness among farmers. Still, the system has limitations in scalability and lacks strong security features [4].

G. Abishek et al. developed a web and mobile-based system where farmers can sell products directly to buyers and also receive ratings. This helps in building trust and transparency. However, the system does not have proper backend support and centralized data management [5].

A. Aravathigam et al. used machine learning techniques to analyze crop data and predict market prices. This helps farmers plan better and make informed decisions. But this approach is mainly analytical and is not implemented as a complete real-time selling platform [6].

W.-K. Chen et al. proposed a system for better data presentation in web applications. It improves how data is displayed and understood. However, the technology used is outdated and not suitable for modern agricultural platforms [7].

J. Kiruthika et al. worked on improving the quality and performance of cloud-based e-commerce systems. This ensures better reliability and system efficiency. But the system is complex and not specifically designed for agricultural applications [8].

Thilagam and Aruna developed a secure system using encryption and machine learning to protect data from cyber threats. This improves data safety but requires high computational resources, which may not be practical for small farmers [9].

Epoka explored the use of natural language processing to understand and analyze text data. This can improve communication and automation in systems. However, it needs proper integration with agriculture-related data to be useful in this field [10].

Karthick J. et al. proposed a direct selling platform where farmers can sell their products through web and mobile applications. This improves market reach for farmers. However, it lacks advanced features like demand prediction and intelligent recommendations [11].

Delos Reyes et al. developed a location-based system that connects farmers with nearby buyers. This helps reduce transportation cost and time. But it works only in limited regions and depends on accurate location data [12].

Pothula et al. studied the use of blockchain technology to improve transparency in agricultural transactions. This reduces fraud and builds trust. However, blockchain systems are complex and require strong technical infrastructure [13].

Hinojosa et al. introduced AgroTIC, a mobile-based platform that connects farmers with experts and merchants. It improves communication and knowledge sharing. But it does not provide a full marketplace solution for buying and selling [14].

Bhende et al. created a simple digital marketplace where farmers can list and manage their products. This is useful for basic operations. However, it lacks scalability and modern features like analytics and delivery integration [15].

From the above studies, it is clear that most existing systems focus on solving specific problems like storage, communication, or analysis. But there is still a need for a complete system that combines all features into one platform.

Therefore, FarmConnect is proposed as a solution that integrates direct selling, real-time updates, secure transactions, and an easy-to-use interface for both farmers and consumers.

III. METHODOLOGY

FarmConnect is an integrated system intended to be a completely integrated digital solution for agricultural marketing by combining web technologies with artificial intelligence to remove the middleman by allowing farmers and buyers to meet via an online marketplace for direct purchase and sale of agricultural products. Additionally, the system will include AI-based crop recommendation, fertilizer prediction, and the detection of plant diseases to help farmers make better informed decisions [11].

The system has been developed using a modular/scalable architecture in which all of the components of the system (front-end, back-end, database, and ML models) work together to provide seamless functionality. The system will also provide real-time weather and pest prediction data to give farmers advance notice of possible pest infestation and weather conditions that may impact the productivity of their operations by reducing crop loss [6]. Secure authentication and role-based access to the system will ensure a reliable and easy-to-navigate platform for all users [9].

A. System Architecture

FarmConnect is a multi-layer architecture that consists of five key architecture layers:

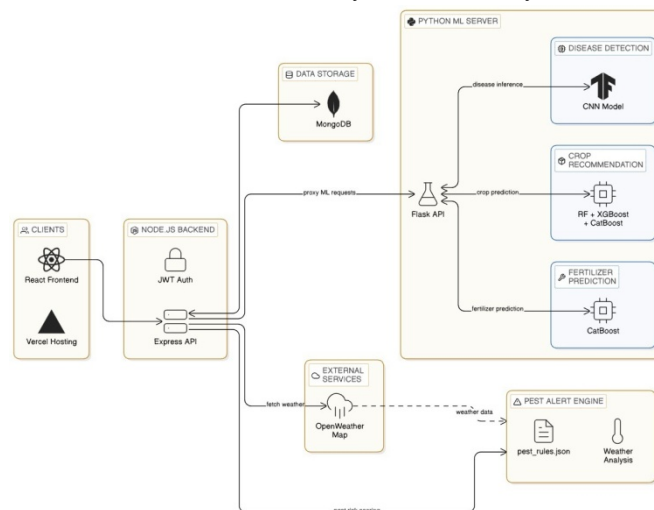


Fig.1. System Architecture of FarmConnect

- **Frontend Layer** The frontend is built using React, TypeScript, and Tailwind CSS, allowing for ease of use with features to provide users with easy access to all functionalities provided by the system including product browsing, dashboards, and other basic interactions.
- **Backend Layer** The backend is built on Node.js with Express.js and is where API-based communications, user authentication (JWT), and business logic occur. The backend layer is responsible for linking the frontend and database layers with the ML layer.
- **Database Layer** The storage of user information, products, and orders are stored in a MongoDB database and the database offers a flexible and scalable way of storing data.
- **ML Server Layer** The ML server layer has been developed using Python Flask. The purpose of this layer is to provide recommendations for crops based on weather and soil conditions; to recommend fertilizer types based on weather and soil conditions; and to detect plant diseases based on images of the plants. The ML server contains pre-trained ML models for MobileNetV2 and ensemble ML techniques.
- **External APIs** Weather data is obtained from the Open-WeatherMap API to provide pest prediction and environmental analysis.

Architecture Performs the Following Steps (How it Works):

- Users register or login via the frontend layer to be authenticated by the backend.

- Once authenticated, the backend processes the request, with the backend communicating with the database to perform data operations as per the business logic defined in the backend layer.
- When AI-based features are to be performed (e.g., crop prediction), the backend communicates with the ML server to obtain predictions/results.
- The predictions/results returned from the ML server to the backend are then returned to the user via the frontend layer.

B. Module-Wise Algorithms

1) Crop Recommender: Algorithm Steps:

- Input required parameters (N, P, K, temperature, humidity, pH, rainfall).
- Preprocess and normalize the input data.
- Use the normalized data as input to the trained Ensemble ML model.
- The model predicts which crop is best suited for the given parameters.
- The prediction is returned to the user. Explanation:

This module utilizes machine learning algorithms such as

Random Forest, XGBoost, and CatBoost to analyze soil and environmental conditions. It helps farmers identify the most suitable crop to grow, thereby increasing productivity and reducing risk factors in farming [6].

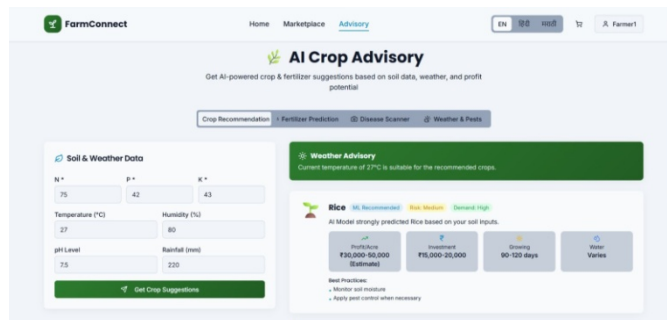


Fig.2. AI Crop Advisory Interface – Crop Recommendation Module

2) Fertilizer Recommender: Algorithm Steps:

- Input soil type, crop type, nutrient values, temperature, and moisture level.
- Encode categorical values provided by the user.
- Send the processed input to the trained CatBoost model.
- The model predicts the most suitable fertilizer.
- Display the predicted fertilizer to the user.

Explanation:

This module recommends appropriate fertilizer based on soil and crop conditions. It helps improve soil fertility and reduces excessive use of fertilizers, thereby enhancing farming efficiency and sustainability.

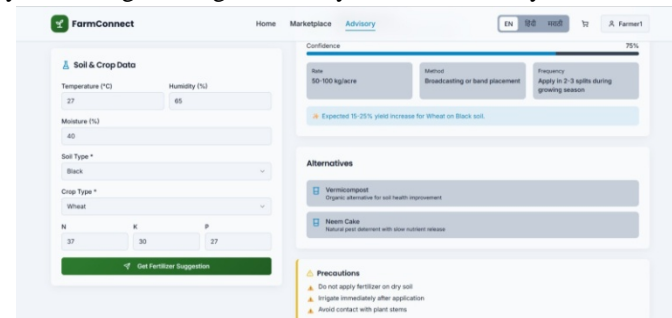


Fig.3. Fertilizer Prediction Interface – Fertilizer Recommender Module

3) *Detection and Identification of Plant Diseases: Algorithm Steps:*

- An uploaded image is received from a user.
- The image is resized to 224×224 pixels.
- Pixel values are normalized.
- The image is passed to a convolutional neural network (MobileNetV2).
- Extracted features are used to predict the disease.
- The disease name, confidence level, and suggested mitigation are returned.

Explanation:

This module uses deep learning techniques, specifically a convolutional neural network with MobileNetV2 architecture, to identify plant diseases from leaf images. It provides fast and accurate diagnosis along with treatment suggestions, helping farmers take timely action and reduce crop losses [10].

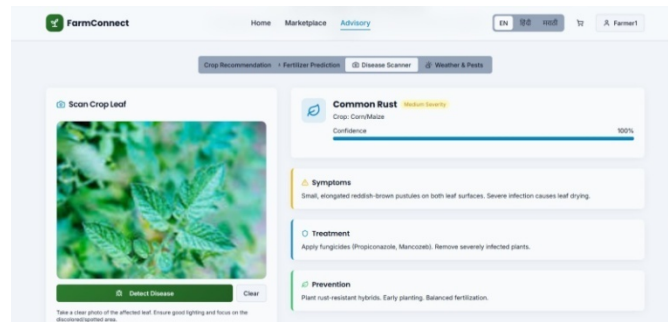


Fig.4. Disease Scanner Interface – Plant Disease Detection Module

4) *Predicting Pest Attacks Based on Weather Data: Algorithm Steps:*

- Retrieve weather data including temperature, humidity, and rainfall.
- Compare these parameters with predefined pest conditions.
- Calculate the risk score based on environmental factors.
- Classify risk into low, medium, high, or critical levels.
- Send pest alerts along with preventive measures to farmers.

Explanation:

This module analyzes weather conditions to predict potential pest attacks. By comparing real-time environmental data with predefined thresholds, it helps farmers take preventive actions and minimize crop damage, improving overall agricultural productivity [6].

5) *Marketplace and Order Management: Algorithm Steps:*

- Farmer lists the product with price and available quantity.
- Buyer searches and selects the required product.
- An order is created and stored in the database.
- Payment is processed using UPI (Unified Payments Interface).
- Order status is updated and tracked throughout the transaction.

Explanation:

This module enables direct interaction between farmers and buyers through an online marketplace. It ensures transparent transactions, secure payments, and efficient order tracking, thereby eliminating intermediaries and improving farmer income [5].

6) *Authentication and Security Module: Algorithm Steps:*

- User registers or logs in using credentials.
- Backend validates user credentials.
- A JWT (JSON Web Token) is generated upon successful authentication.
- Token is used for secure API access.

- Role-Based Access Control manages user permissions.

Explanation:

This module ensures secure access to the platform by implementing authentication and authorization mechanisms. It protects user data, maintains system integrity, and ensures that only authorized users can access specific features [9].

IV. EVALUATION PLAN AND SYSTEM ASSESSMENT FRAMEWORK

The evaluation of the proposed FarmConnect system looks at how effective the system is at improving agricultural marketing, increasing farmer income, and providing AI-based features that provide intelligent decision support. The FarmConnect system is a direct marketplace, has UPI-based payment methods, an AI-based crop advisory, an AI-based means of detecting disease, and a means of predicting pests based on weather. Therefore, it is very important to assess the technical performance and real-world impact of the FarmConnect system as a whole. The evaluation framework will evaluate the multiple aspects of the FarmConnect system such as pricing efficiency, system responsiveness, user interaction and data security to ensure that the FarmConnect platform will provide a dependable, adaptable, and user-friendly experience for both farmers and consumers (buyers).

A. Evaluation Metrics

1) Pricing Effectiveness

Evaluates how well the platform enables fair pricing by directly connecting farmers with buyers. This ensures that farmers can achieve higher profit margins compared to traditional systems involving intermediaries.

2) Matchmaking Performance

Assesses the platform's ability to connect farmers with potential customers based on location, product availability, and user preferences. It also considers how effectively the system facilitates successful transactions between users.

3) System Performance

Analyzes system response time, scalability, and its ability to handle multiple users and real-time requests efficiently.

4) Operational Behavior

Examines the workflow of the system, including product listing, order processing, UPI payments, and delivery tracking.

5) Safety and Reliability

Focuses on two key aspects: secure handling of user data through authentication mechanisms such as JWT, and the overall reliability and stability of the system during operation.

B. Discussion and Expected Findings

The FarmConnect platform is anticipated to revolutionize the conventional agricultural supply chain by facilitating direct interaction between farmers and consumers. Through the elimination of intermediaries, farmers need not rely upon 'middlemen' to sell their product, allowing them to sell for fairer prices and retain higher profit percentages while helping consumers reduce prices and acquire fresh product from local producers. With the integration of a digital marketplace and UPI-based payments, transactions will be faster and more transparent by lessening transaction time, thereby increasing trust between users. This direct connection will also improve market access for small and marginal farmers who previously had little access.

In addition to the marketplace, the implementation of AI-based modules will provide significant value to this system. The modules will provide features such as crop recommendations, fertilizer estimations, and disease detection, which will allow farmers to make decisions based on real-time data and scientific analyses. The use of machine learning and deep learning algorithms, including ensemble-based and MobileNetV2 techniques, will also enhance the quality of predictions and the accuracy of forecasts. Furthermore, the module contains a weather-based pest alert feature which will allow the farmer to receive advanced warning of a potential pest threat, to allow them to take preventative action against potential crop loss. Overall, the combination of these intelligent features is expected to increase agricultural productivity and sustainability.

From a system perspective, the FarmConnect platform is scalable, secure, and user-friendly. Due to the use of modern technologies such as React, Node.js, MongoDB, and Flask, the system is expected to deliver seamless performance with the ability to support multiple users and real-time requests. Additionally, secure authentication using JWT ensures protection of user data, while role-based dashboards enhance usability for farmers, buyers, and administrators.

Overall, the FarmConnect system is expected to provide a reliable and efficient platform that improves farmer income while promoting transparency and technological advancement in the agricultural sector.

V. RESULTS AND DISCUSSION

A. Evaluation Metrics

1) Pricing Performance:

Quantifies how well the platform helps farmers improve their earnings by eliminating intermediaries and allowing them to sell directly to buyers. Users of the system should be able to see the prices at which they sell and gain profit margins substantially greater than those typically associated with standard supply chain transactions.

2) Scalability Quality:

Quantifies the capacity of the application to accommodate an increasing number of users, products, and transactions. Modern technologies such as Node.js and MongoDB will allow scalability without compromising performance.

3) Matchmaking Performance:

Quantifies the platform's ability to connect farmers to buyers based on location, product availability, and preference. Having a strong matchmaking system will contribute to a greater success rate for transactions and a higher degree of satisfaction for users.

4) Operational Behaviour:

Quantifies the efficiency of each product listing, order processing, handling payments through UPI, and tracking deliveries. A well-designed workflow will enhance the usability of the platform and will eliminate delays that occur due to operational inefficiencies.

5) Matchmaking and Database Efficiency:

Quantifies the efficiency with which the application's database responds to queries related to product searches, user data, and order management. Optimizing the database operations will increase response time and reliability of the system.

6) Privacy and Security:

Focuses on ensuring the proper handling of user data by implementing appropriate authentication methods (e.g., JWT) and providing protection from unauthorized user access. Trust in the system and willingness to use the platform will be directly impacted by the protection of user data and the integrity of the system.

B. Model Performance Evaluation

1) *CNN Disease Detection Model*: CNN-Based Plant Disease Detection Model was evaluated by way of important metrics including Training and Validation Accuracy, Precision, Recall and F1-Score which was based upon the model's reliable prediction for Real-time Plant Disease Detection in terms of strong performance as related to the Balance of Accuracies and Very Little Overfit.

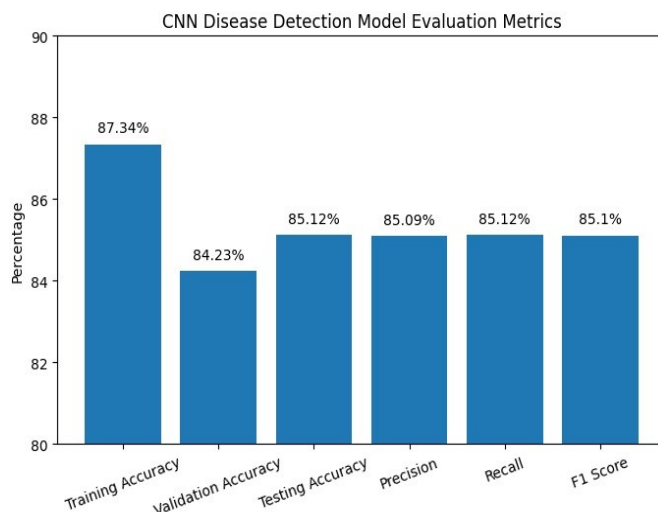


Fig.5. Performance Evaluation of CNN-Based Disease Detection Model

As shown in Fig. 5, the model performs consistently across all evaluation metrics, indicating reliable and accurate disease classification.

1) *Crop Recommendation Model*: To evaluate the performance of four crop recommendation systems, we compare it to an existing system using various measures such as cross-validation accuracy, training accuracy, testing accuracy, precision, recall and F1 score. Our new system demonstrates improvements in performance as well as enhanced predictive capabilities.

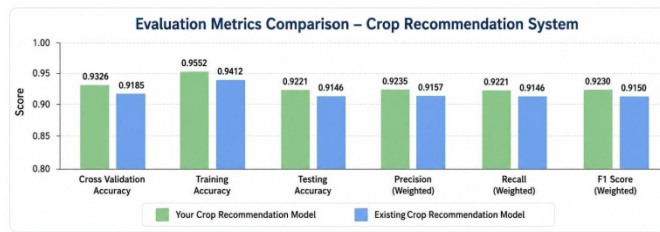


Fig. 6. Comparison of Crop Recommendation Models

As illustrated in Fig. 6, the proposed model achieves better performance than existing systems across most metrics, showing improved reliability and efficiency.

2) *Fertilizer Recommendation Model*: The fertilizer recommendation model was evaluated using many of the same classification metrics. The model also outperformed traditional methods with increased accuracy and improved predictive consistency.

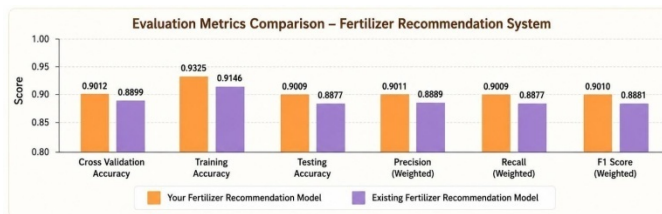


Fig. 7. Comparison of Fertilizer Recommendation Models

Fig. 7 demonstrates that the proposed model improves on all evaluation metrics and would be a viable option for practical use in agriculture.

C. Expected Outcomes and Limitations

The FarmConnect platform is anticipated to be a transformative solution for bridging the gap in agricultural marketing by enabling direct farmer-consumer engagement while eliminating reliance on middlemen. Farmers are expected to benefit from improved pricing for their products, while consumers gain access to fresh and affordable produce. Decision-making is anticipated to improve through the integration of artificial intelligence (AI) features such as crop recommendations, fertilizer predictions, and disease detection, thereby reducing crop losses caused by lack of information. Additionally, timely weather and pest alerts will allow farmers to take preventive measures, ultimately increasing agricultural productivity.

However, the system also presents certain challenges. The accuracy of AI models depends on the quality and quantity of training data, which may vary across different regions. Accessibility may be limited in rural areas due to dependence on internet connectivity. Furthermore, scalability issues may arise when a large number of users access the platform simultaneously. Despite these challenges, the system provides a strong foundation for a technology-driven agricultural ecosystem and can be further enhanced through continuous improvements and real-world deployment.

VI. CONCLUSION

The FarmConnect platform provides an efficient and pioneering approach to addressing the problems of conventional agricultural supply chains through the provision of direct engagement between key stakeholders, specifically farmers and consumers. The removal of intermediaries allows farmers to earn reasonable profits from their products, while also providing consumers with greater access to fresh and affordable food. By combining a digital marketplace with UPI-based payment methods, the system enhances transaction transparency, speed, and user trust. Furthermore, the platform supports small and marginal farmers by offering improved market access through digital channels, reducing reliance on traditional distribution systems.

In addition, the integration of advanced technologies such as machine learning (ML) and deep learning (DL) further strengthens the capabilities of FarmConnect.

Features including crop recommendation, fertilizer prediction, plant disease detection, and weather-based pest alerts assist farmers in making informed decisions, thereby improving productivity and reducing crop losses. Modern web technologies ensure scalability, security, and efficient system performance. As a result, FarmConnect contributes to the development of a transparent, intelligent, and sustainable agricultural ecosystem, with strong potential for real-world implementation and future enhancements.

VII. FUTURE SCOPE

By incorporating future regional advancements and implementing other complex emerging technologies observable today as well as using tangible agricultural products/services onto the FarmConnect Platform it creates an opportunity to add more functionalities. Expanding the Platform into becoming a fully functional mobile application will also make it much more accessible to farmers located in rural geographic areas. Along with these two points, the additional inclusion of regional language options, along with voice recognition technology support within the Application will aid farmers that cannot read such information due to lack of education/training or due to their limited technological literacy levels.

Advancing AI functionalities through the accumulation of greater quantities of historical/social data into mass amounts of datasets using advanced deep learning models will result in increased accuracy regarding crop recommendations, fertilizer predictions, and detection of plant diseases. The incorporation of IoT devices and/or smart sensor technology into this platform will allow for the acquisition of real-time soil and environmental data collection/gathering in order to perform more exact agricultural analyses and auto-monitor systems for ongoing use.

At a future date, the new version/iteration of FarmConnect may have the ability to utilize Blockchain Technology to provide secure transactions with complete traceable transaction histories that can be checked on by any Party (Seller, Buyer or Third-Party), as well as have direct government scheme integrations to provide farmers with agricultural subsidies, assistance with securing a crop insurance policy, and/or providing direct financial assistance when needed. The addition of several logistical/supply chain optimization features could also assist in improving delivery management, as well as aiding in the waste reduction methods associated with food production/distribution. All of these enhancements will greatly enhance the value ratio of FarmConnect; ultimately, transforming the entire Agricultural Ecosystem from all aspects of sustainability, digitalized agricultural development, etc...to smart farming.

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