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A Survey on Agricultural E-Commerce Application for Small Scale Farmers with Crop Yield Prediction

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ABSTRACT—The agricultural industry has come to understand more and more in recent years how crucial technology is to improving farming operations' profitability and efficiency. The creation of user-friendly agricultural e-commerce platforms that help small-scale farmers sell their produce directly to customers or work together for bulk sales is the focus of this research review, which aims to maximize profitability. Additionally, the incorporation of machine learning models for agricultural yield prediction is investigated, emphasizing the importance of vari- ables like soil quality, climate, and resource availability. These tools help farmers make educated decisions about planting and harvesting by giving them predicted insights. The survey also emphasizes how these platforms help buyers access markets more easily by providing a wide selection of regional agricultural products and expediting transactions. Through the removal of middlemen, these tech-based solutions advance equitable pricing, fortify regional farming communities, and eventually improve the agriculture industry as a whole.

Index Terms—Agricultural E-commerce, Machine Learning in Agriculture Yield Prediction, Random Forest Regression, Soil Quality, Climate Impact on Agriculture, Small-scale Farmers, Sustainable Farming, Direct-to-Consumer Sales, Agricultural Profitability, Market Access for Farmers, Equitable Pricing, Tech- based Farming Solutions, Regional Agricultural Products, Digital Agriculture Platforms

I. INTRODUCTION

The rapid progress of digital technologies has resulted in a considerable shift in the agriculture economy in recent years. The need for effective, sustainable farming methods has grown as the world's food need rises. In order to address these issues, cutting-edge solutions like machine learning (ML) models and e-commerce platforms have become essential instruments in revolutionizing conventional farming practices. Platforms for agricultural e-commerce have completely changed how farm- ers, especially small-scale producers, may now access markets. By providing a direct line of communication between farmers and consumers, these platforms do away with the need for mid- dlemen, lower transaction costs, and allow for more equitable pricing. These platforms enable greater coordination of bulk sales and give farmers a centralized marketplace to sell their produce, increasing overall profitability. Additionally, they increase the variety of local and regional agricultural products available to consumers, which supports rural economies and encourages sustainable consumption. Accurately forecasting

crop yields is one of the most difficult problems facing the agriculture sector, and machine learning algorithms are helping to solve this problem. Large datasets that take into consideration a number of variables, such as soil composition, weather patterns, and resource availability, are used in machine learning techniques like Random Forest regression and other sophisticated algorithms. These models help farmers make data-driven decisions, maximize resource use, and reduce risks related to changing environmental circumstances by offering accurate production estimates. By reducing waste and enhancing harvest planning, this move toward predictive analytics in agriculture not only increases productivity but also promotes food security. Reviewing the state of the art in these two revolutionary fields—machine learning-based yield prediction models and agricultural e-commerce platforms—is the goal of this overview article. The study will examine the major technological developments, the implementation obstacles, and the effects of these advances on farmers and consumers by conducting a thorough assessment of the body of available literature. To further improve agricultural decision- making and market access, the study will also indicate topics for future research and development, especially in the areas of merging predictive models with e-commerce platforms. This study aims to give a thorough overview of how digital technologies are changing the agricultural environment and promoting increased efficiency, profitability, and sustainability by looking at current trends and the efficacy of different approaches.

A. Background and Context

The economy depends heavily on the agricultural sector, especially for small-scale farmers who make substantial con- tributions to food production and rural life. However, these farmers frequently deal with issues like restricted access to markets, volatile prices, and a lack of resources. One game- changing answer is the incorporation of digital technologies, such as machine learning and e-commerce platforms. Farmers can now sell directly to customers thanks to e-commerce, which lowers their dependency on middlemen and increases their profit margins. In the meantime, machine learning pro- vides predictive analytics that can improve crop management choices, ultimately resulting in higher yields and sustainability.

B. E-commerce in Agriculture

Direct transactions between farmers and consumers are made easier by e-commerce platforms designed specifically for the agricultural industry, which improves market accessibility. These systems offer attributes like:

- Real-time Market Data: Farmers may make well-informed decisions about when to sell by using the most recent pricing and demand patterns.
- Coordination of Bulk Sales: Farmers can work together to sell more, strengthening their negotiating position.
- Customer Engagement: Farmers can establish relationships with customers through direct contact channels, which pro- motes repeat business and loyalty. Despite these benefits, many small-scale farmers still face obstacles like access to technology and digital literacy.

C. Machine Learning Techniques in Agriculture

One of the most important tools for forecasting agricultural results is machine learning. Complex datasets are analyzed using a variety of methods, such as Random Forest, Support Vector Machines, and Neural Networks. Important uses consist of:

- Crop Yield Prediction: Machine learning models can predict yields by examining past data, weather trends, and soil char- acteristics. This aids farmers in organizing their planting and harvesting plans.
- Disease Detection: By evaluating multisensor data, machine learning systems can detect crop illnesses early and allow for prompt actions.
- Resource Optimization: By minimizing waste and increas- ing productivity, predictive models help to optimize fertiliza- tion and irrigation schedules.Studies reveal that models like Random Forest perform better than conventional techniques, demonstrating that machine learning can greatly increase the accuracy of yield estimates.

D. Integration of E-commerce and Machine Learning

The combination of machine intelligence and e-commerce has the potential to completely transform farming methods. Machine learning can be used by e-commerce platforms to: Customize Suggestions: Platforms can improve user experi- ence by making product recommendations based on individual buyer interests and purchase patterns.

Dynamic Pricing Models: By using machine learning to de- termine the best rates based on demand projections, producers may be guaranteed competitive pricing.

Data-Driven Insights: Using predictive analytics, farmers can obtain actionable insights that help them choose crops and manage their resources. In addition to giving farmers more control, this integration improves market efficiency generally and supports sustainable farming methods.

II. LITERATURE REVIEW

Manisha Bhende et al. [1] created a digital marketplace platform with the aim of improving communication between farmers, retailers, the government, and final consumers, ul- timately filling in holes in the agricultural supply chain. This technology gives farmers access to real-time market data through mobile and online applications, allowing them to sell their goods directly and receive higher prices. The utilization of geographic data and agricultural databases to provide customized recommendations based on particular crop demands is one of the key features, along with a complaint box for reporting pricing disparities and encouraging open- ness. Their research shows how digital technologies have the power to revolutionize the agriculture industry and increase its efficiency and responsiveness to consumer needs.

Sunil et al. [2] developed an Internet of Things-based architecture to enhance agricultural practices by gathering information from sensors such as soil moisture, temperature, and humidity sensors. Real-time monitoring and analysis are made possible via the framework's mobile application for farmers. With the help of this system, farmers may optimize resource use and boost output by using current data to get insights for crop management and irrigation.

Potnuru Sai Nishant et al. [3] created a thorough crop yield forecast model specifically suited for Indian agriculture using cutting-edge machine learning techniques. Their study highlights the significance of basic factors like region, sea- son, state, and district that help farmers accurately forecast crop yields. To improve prediction accuracy, the study uses advanced regression techniques including Lasso, Elastic Net (ENet), and Kernel Ridge. It also uses stacked regression. The authors hope to close the gap between complicated agricultural data and useful applications for farmers by concentrating on elements that are simple to comprehend, which will ultimately help farmers make better crop management decisions.

Kummari Venkatesh and K Jairam Naik (2021) [4] con- ducted research using machine learning techniques integrated with the IOT framework to identify nutrient deficiencies in groundnut crops for precisely predicting crop yield. The goal of the study was to create a technique for detecting shortages of essential nutrients like nitrogen, potassium, phosphorus, and zinc, necessary for increasing plant growth, crop yield, and productivity.The image data captured from groundnut fields using an ESP32 camera is given as input to the VGG16 Convolutional Neural Network (CNN) for classifying nutrient deficiencies based on visible symptoms which are the col- ored patterns like yellow or brown spots identifying certain deficiencies. The K-Means clustering algorithm was used to quantify nutrient deficiencies by analyzing color pigmentation in the images. This method allowed the identification of the extent of affected areas through pixel clustering. This was useful in overcoming the time-consuming and labor-intensive methods traditionally used by the producers.The use of IOT sensors in gathering data on various key environmental factors such as soil moisture, soil pH levels, temperature, and nitrogen, potassium, and magnesium levels in soil, has resulted in a 92.39

Monika et al. [5] introduced a method for forecasting appropriate fertilizer types using machine learning techniques such as multiple linear regression and lasso regression. Their strategy takes into account variables like temperature, humid- ity, soil type, and current nutrient levels (nitrogen, potassium, phosphorus). This research indicates that lasso regression gives more precise predictions, with an accuracy of 89%, which in turn makes it a more suitable option for personalized fertilizer recommendations.

Huang et al. [6] designed and implemented an e-commerce platform specifically for the sale of characteristic agricultural products from Jilin Province. The article emphasizes how quickly information technology is changing the world, espe- cially with regard to the move from offline to online buying. Using SSM (Spring, Spring MVC, MyBatis), the authors created a B2C electronic mall to efficiently combine resources and promote local agricultural products. This platform seeks to increase farmers' access to markets, boost their profitability, and support community development and self-realization.

A. Reyana et al. [7] provide a unique Multisensor Machine- Learning Approach (MMLA) that enhances agricultural yield estimates and provides cultivation guidance by classifying multisensor data via categorization. This study helps farmers overcome crop disease and weather variability by using the Internet of Things (IoT) to integrate data from several sensors and make well-informed decisions regarding irrigation, soil nutrition, and climate adaptation. The technique classifies eight crop types: gram, cotton, maize, groundnut, rice, moong, wheat, and sugarcane using three machine learning algorithms: Hoeffding Tree, J48 Decision Tree, and Random Forest. Metrics like F-measure, recall, and precision are used to evaluate the efficacy of the approach. The model demonstrates enhanced accuracy in crop classifications and recommenda- tions, with the Random Forest algorithm achieving an RMSE of 13%, RAE of 38.66%, and RRSE of 44.22%, indicating its superior performance compared to the other algorithms. Research findings suggest that multisensor data fusion and machine learning can effectively address global food security challenges, increase crop yields, and promote sustainable farming practices. However, further development of prediction models that incorporate additional agricultural parameters will be necessary.

In the study by Sri Sai Ram Jasti et al. [8] , a machine learning-based method to assist farmers in selecting the best crops based on meteorological and soil information is pro- vided. The system integrates GRU (Gated Recurrent Units), a kind of Recurrent Neural Network (RNN), for accurate weather forecasting, focussing on significant variables includ- ing wind speed, temperature, and humidity. Furthermore, the Random Forest algorithm classifies and recommends crops based on weather data and soil characteristics like temperature and precipitation. Results show that Random Forests perform more accurately than decision trees, which might help farmers plan planting dates and choose crops.

Priyanka Sharma et al. [9] try to develop an effective approach to yield the agricultural produce by viewing data obtained from official government websites. The authors use machine learning and deep learning models to elevate various metrics for accuracy and reduce test losses. Their research details how far such models become applicable to predictions in crop yield using an extensive dataset from the period 1997 to 2020, with variables also including state and district names, types of crops, and environmental conditions.The study uses three predictive models: Decision Trees, Random Forest, and Convolutional Neural Networks. The authors claim that the minimum loss encountered by their CNN model was 0.00060, while the overall accuracy of their predictions was at 98.96% with mean absolute error at 1.97 and RMSE at 2.45. Other Decision Trees performed impressively with an accuracy of 89.78%, which assumes their capability to process the dataset and make good guesses. However, the authors conclude determining that the Random Forest algorithm actually bested all other methods into competing for the accuracy and proved its superior predication capability. Results indicate that such an approach holds good for the accurate prediction of crop productivity while being tested with the real-time data and interaction from the stakeholders.

In the study presented by Mitra et al,[10] the aim was to explore the usage of ML techniques for predicting cotton yield in the southern cotton belt within the United States: focusing on impacts of climate change and different agri- cultural factors. Both historical field data acquired during the 1980s and 1990s and synthetic data from the GOSSYM process-based cotton model were utilized in order to reflect recent climatic changes from 2017 to 2022.Mitra et al.[10] recognized crop yield prediction as a challenging task because of the nonlinear effects of many factors such as cultivar responses, soil types, and levels of management practices applied in the field on crop yield. They indicated temperature as one of the significant variables influencing cotton growth and provided a technique to make their model computationally less demanding in terms of processing time-series weather data as a scalar quantity termed as accumulated heat. This way, analysis became somewhat more effective without losing the predictiveness of the model.The authors tested many machine learning algorithms, including those of the regressor types of Random Forest (RF), Support Vector Regression (SVR), and Light Gradient Boosting Machine (LightGBM), among others. The RF regressor had the highest accuracy, reaching an incredible 97.75% and with an R^2 of about 0.98. Such accuracy shows the good potential that ML methods may have in agricultural applications, especially in climate-smart agriculture.Another closely related study by researchers talks about the relevance of synthetic data in agricultural research. They also emphasize the use of synthetic data when datasets publicly available in scenarios are very limited in number. They further extended their methodology to include a larger variety of locations and conditions that may improve the robustness of the model.

III. CHALLENGES

The broad use of e-commerce and machine learning in agriculture is hampered by a number of issues, despite the potential advantages:

Technological Barriers: The inability of many small-scale farmers to obtain digital devices and reliable access to the internet limits their use of e-commerce platforms.

Economic constraints: Initially, implementing new technolo- gies can be very expensive, particularly for farmers with limited resources.

Data Privacy Issues: Due to concerns about data exploitation or a lack of transparency in data processing, farmers may be reluctant to disclose critical information.

Market Rivalry: Due to their greater resources and established market presence, larger agricultural producers frequently face difficulties competing with small-scale farmers.

IV. FUTURE DIRECTIONS

Future research in the following areas is advised to optimise the effects of e-commerce and machine learning in agriculture: Technological Innovations: It's critical to keep creating user-friendly platforms that are tailored to the unique requirements of small-scale farmers.

Policy Support: Governments ought to enact measures that encourage digital literacy and offer funding to encourage the use of new technologies.

Encouraging collaborations among engineers, agricultural spe- cialists, and policymakers can result in more effective solutions that are customised for specific local situations.

Focus on Sustainability: Research should look into how these technologies might be used to support environmentally con- scious farming methods that increase output while resolving environmental issues.

V. CONCLUSION

In conclusion, the integration of machine learning tech- niques and e-commerce solutions in agriculture has the poten- tial to revolutionize farming practices. By leveraging advanced algorithm like Random Forest, farmers can achieve greater accuracy in crop yield prediction and classification, enabling more informed decision-making regarding planting and re- source management. Additionally, user-friendly e-commerce platforms facilitate direct sales between farmers and con- sumers, eliminating intermediaries and ensuring fair pricing. This technological synergy not only empowers farmers but also enhances market efficiency and promotes sustainable agricultural practices, contributing to the overall resilience of the agricultural sector.

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