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FARMING FUTURE WITH GENERATIVE AI

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Abstract: Agriculture is very important for the growth of the economy and ensuring that people have enough food, especially in countries that are still developing, like India. Even though it's important, the productivity of farming is often affected by things like changes in the weather that are hard to predict, choosing the wrong crops, and not using water efficiently. Artificial Intelligence (AI) has become a good solution for these problems. Now, Generative AI has become popular because it can not only look at data but also explain and suggest things in a way that's easy for people to understand. This review paper looks at how Generative AI is being used in modern farming for helping farmers decide which crops to grow, predicting harvests, and making farming more sustainable. It looks at the different machine learning methods currently used in agriculture, points out their weaknesses, and explains how Generative AI can make these tools easier to use, more clear, and build trust among farmers. The paper ends by saying that combining tools that predict the future with Generative AI can change traditional farming into a smarter, more explainable, and more sustainable way of growing food.

Index Terms - Generative Artificial Intelligence, Smart Agriculture, Crop Yield Prediction, Crop Recommendation, Decision Support Systems.

I. INTRODUCTION

Agriculture has always been a big part of India's economy, helping to ensure food security, providing jobs, and supporting rural areas. Many people in India rely on farming either directly or indirectly for their income. But now, the agriculture sector is facing several problems that make it hard to keep up and stay productive. Things like climate change, unpredictable rain, higher temperatures, poor soil quality, not enough water, pests, and unstable prices are making farming more difficult and uncertain. These issues not only lower the amount of crops grown but also cause stress and financial strain on farmers. For a long time, Indian farmers have used traditional knowledge, personal experience, and wisdom passed down through generations. They decide what crops to grow, when to water them, and how much fertilizer to use based on past weather patterns and seasonal changes. While these methods worked well in the past, they are not as reliable anymore because the environment is changing quickly. Unpredictable weather has changed the usual patterns, making it harder to know when it will rain or how hot it will get. This often leads to poor choices in crops and lower production. In recent years, more agricultural data has become available, and technology has improved a lot. This has allowed farmers to use data-driven methods in their work. AI and ML are being used to analyze information about soil, weather, how crops grow, and past harvests. These tools can predict crop yields and suggest which crops grow best in certain soil and weather conditions. Because of this, AI-based systems can help make better decisions, use resources more efficiently, and boost farming productivity. Even though these AI and ML models are accurate, most of them are 'black-box' systems. That means they can make predictions but don't explain how they came up with those predictions. This lack of clarity is a big problem for farmers, especially those who aren't very tech savvy. When farmers don't understand why a suggestion is being made, they lose trust in the system, which limits how useful the technology is in real farming situations. Generative AI offers a better solution by adding explainable and interactive features to traditional AI models. Generative AI can turn complex data into simple, easy-to understand explanations and personalized suggestions. Instead of just giving numbers, it can explain why a certain crop works well, offer alternatives based on new conditions, and provide clear, everyday language advice. This increased transparency helps farmers trust the system more and encourages them to use smart agricultural tools. This paper looks at how Generative AI can help modern agriculture, especially in making smart decision tools for crop recommendations and yield predictions. 1 It reviews existing ML methods used in farming, points out their shortcomings in terms of clarity and usability, and explains how Generative AI can fix these issues. By combining accurate predictions with clear communication, Generative AI has the power to turn traditional farming into a more intelligent, farmer-focused, and sustainable way of growing food.

II. LITERATURE REVIEW

A literature survey is a key part of any research project, because it helps researchers understand what has already been studied and find areas that still need more attention. In farming, many studies have looked at using machine learning, data mining, and artificial intelligence to help increase crop production, predict how much crops will grow, and help farmers make better choices. This section gives an overview of important research in areas like crop recommendations, estimating crop yields, and using smart technology in agriculture.

Ponce-Guevara and their team created Green Farm-DM, a tool based on data mining that helps analyze vegetable crop data collected from greenhouses.

They used the C4.5 decision tree algorithm to classify crop conditions and showed results using pictures. The study showed that data mining can be helpful for agricultural analysis, but the system didn't have advanced prediction tools and didn't explain why certain decisions were made.

Jheng and their team worked on predicting agricultural output using a mix of Support Vector Regression models.

They combined different types of regression to make predictions more accurate. Although the results were good, the system needed technical knowledge to understand the results, which made it hard for farmers to use directly.

Manjunatha and Parkavi did a detailed study on predicting crop yields in different areas of Karnataka. They looked at methods like fuzzy logic, decision trees, linear regression, and Random Forest. Their findings showed that Random Forest worked better because it could handle complex and non-linear data, making it useful for predicting yields. Shakoor and their team studied using supervised machine learning methods like ID3 decision trees and K-Nearest Neighbors to predict crop yields. Their results showed that these models can predict yields well based on past data. However, the system mostly focused on accuracy and didn't consider how easy it was for people to understand or use. Grajales and their team proposed a system for planning crops using climate data and maps.

They used tools like PostgreSQL, PostGIS, and mapping libraries to analyze and show agricultural data. This approach helped understand how climate affects crop planning, but it needed a lot of computing power and expert knowledge, which made it hard for regular farmers to use. Shah and their team developed an agricultural system using Spark, which is good for handling big data. Their work showed how important big data frameworks are for managing large amounts of agricultural data.

However, the system didn't focus on giving personal crop recommendations or helping farmers make decisions. Afrin and their team looked at soil and climate data to predict crop yields and classify different farming areas. They used clustering methods like K-means and DBSCAN along with regression models. While this helped with area specific analysis, it didn't provide helpful or easy-to understand information for farmers. Sekhar and Sekhar studied how to improve agricultural productivity using big data tools like Hadoop, Hive, and Sqoop.

Their work focused on handling and storing big data efficiently but didn't pay much attention to making the tools easy for farmers to use or help them make decisions. Sahu and Chawla created a Random Forest model using Hadoop for crop yield prediction. Their results were more accurate than older methods.

However, the system didn't explain how predictions were made, making it a bit like a black box. Garg and Garg introduced a fuzzy time series model using regression to predict rice yields. The model improved accuracy, but it was only good for rice in specific areas, making it less useful for other crops or places. Looking at all these studies, most focus on making predictions more accurate using machine learning and big data. But not much attention is given to making the systems clear, interactive, or trustworthy for farmers.

This gap shows the need for using Generative AI in agriculture. Such systems can not only make predictions but also explain them clearly and offer personalized advice. Combining Generative AI with traditional machine learning can make agricultural decision tools more effective and easier for farmers to use.

Sr. No.	Author(s), Year	Journal	Approach	Findings
1	Pankaj Bharti, P. K. Kumar, B., 2024	Discovery Sustainabil ity	Systemati c review of ML & DL for crop yield predictio n	Identified ML/DL methods and key environme ntal and vegetation features for yield estimation
2	Pankaj Bharti, P.	Discovery Sustainabil ity	Boosting- enabled ML for	Boosting algorithms improved
	K. Kumar, B., 2023		crop yield predictio n	yield prediction accuracy using texture and spectral features
3	Chitra K. & Leena K. V ., 2024	Journal of Propulsion Technolog y	Systemati c review of ML in crop yield predictio n	Highlighte d SVM and Random Forest usage and discussed data quality limitations
4	VijayLa x mi & Gaura v Singla , 2025	RRJoAST	Review of ML/DL techniqu es for crop yield forecasti ng	Compared RF, SVM, ANN, and LSTM models; addressed generalizat ion and data heterogene ity issues
5	Sharma R. K., Kaur J., & Feng G., 2025	Discover Agricultur e	Crop- specific ML models for maize and soybean	Identified key features such as temperatur e, rainfall, NDVI, and soil pH
6	Abdel-Salam e t al., 2024	Neural Computin g & Applicatio ns	Hybrid feature selection with optimized SVR	Enhanced prediction accuracy through hybrid selection and optimizatio n
7	Patil e t al., 2024	IJ Design & Nature	Feature selectio n with regressi on models	Feature selection significantl y impacts prediction accuracy
8	Mohan R. N. V. J., Rayanot h ala P. S., & Sree R. P., 2025	Frontiers in Plant Science	AI integrated with Explaina ble AI (XAI)	RF and LightGBM with SHAP/LI ME improved transparen cy and achieved $R^2 \approx 0.92$
9	Zhang X. et al., 2024	Drones (MDPI)	UAV remote sensing with ML	UAV multispectr al imagery improved yield

III. PROPOSED METHODOLOGY

The proposed system's method is focused on creating a smart and easy-to-understand tool to help make decisions in farming. It uses Machine Learning and Generative Artificial Intelligence to help farmers make better choices. The process is done step by step, starting with collecting data, then cleaning and preparing it, building models, adding Generative AI, and finally showing the results to users.

3.1 Collecting Data

The first step is to gather agricultural data from trusted sources. This data includes information about soil such as pH level, nitrogen (N), phosphorus (P), and potassium (K), as well as weather factors like temperature, humidity, and rainfall. It also includes past crop yields and other agricultural data to make the models more accurate. This data is the base for training and testing the models.

3.2 Preparing the Data

Raw data can have missing numbers, mistakes, and inconsistencies. So, we clean the data by removing errors and making it consistent. We also scale the numbers to fit within a standard range and choose the most important features that affect crop growth and what crops are suitable. Better prepared data leads to better model results.

3.3 Choosing Important Features

We pick the most relevant features to reduce the amount of data and remove any that don't help. We use methods like looking at how features are related and using statistics to select important ones such as soil nutrients, rainfall, temperature, and humidity. Choosing the right features makes the models more accurate and faster to run.

3.4 Creating Machine Learning Models

Once the data is cleaned and the right features are selected, we build machine learning models to predict crop yields and suggest which crops to grow. The main method used is the Random Forest algorithm, which is strong at handling complex agricultural data. We also use regression models to estimate yields. These models are trained using past data and checked using accuracy and error rate to see how well they work.

3.5 Adding Generative AI

To make the system more transparent, we include a Generative AI module that explains the results in plain language. It tells farmers why a specific crop is recommended, how soil and weather affect the prediction, and gives useful farming tips. This helps users understand the system better and trust the predictions.

3.6 Showing Results and Supporting Decisions

The final step is to display the results in an easy-to-understand way. Users see which crops to grow, how much they might produce, and get advice through a simple interface. The results are shown in both numbers and text, making it easier for users to follow and apply the recommendations.

3.7 Testing the System

The system is tested by comparing the predicted crop yields with real past data. We use accuracy and error reduction to check how good the model is. The Generative AI part is also checked based on how clear the explanations are and how easy they are to understand. Overall, this method helps in making accurate predictions, giving clear explanations, and supporting better decisions. It's designed to help with smart and sustainable farming practices.

4. Propose system

Even though there have been improvements in using AI for agriculture, there are still some problems to solve: • It's hard to choose the right crops because there isn't enough local data to help make decisions. • Farmers often struggle to understand the predictions made by machine learning tools. • There's not enough access to expert advice on farming practices. • Most farmers don't use AI tools because they are too complicated and not easy to use. These issues show that we need a smart, simple, and clear system that can help farmers make better decisions.

5. Role of Generative AI in Agriculture

Generative AI extends traditional AI by generating text-based explanations, recommendations, and guidance. In agriculture, Generative AI can act as a virtual farming assistant that explains why a particular crop is suitable, suggests improvements, and provides step-by-step farming advice. When combined with predictive models such as Random Forest and regression algorithms, Generative AI can improve farmer trust and system adoption. Instead of presenting raw predictions, the system can explain results in simple language, making advanced technology accessible even to non-technical users.

6. Proposed System Concept

A standard Generative AI-based smart farming system includes these parts: 6.1. Data Collection Module Gathers information about soil, like pH level, moisture, nutrients, and weather factors such as temperature, rain, and humidity. 6.2. Data Preprocessing Module Tidy up the data, make it consistent, and pick the most important details from the information. 6.3. Machine Learning Prediction Module Uses methods like Random Forest to suggest which crops to grow and uses regression to predict how much crop will be produced. 4 6.4. Generative AI Explanation Module Original agricultural data can have missing parts, errors, and noisy information. Creates easy-to-understand explanations and tailored advice based on the predictions. 6.5. User Interface Module Offers a simple website or app so farmers can easily use the system. Putting all these parts together makes the system more accurate and easier to use.

7. Performance Evaluation

Studies show that Random Forest classifiers work better than other models like Decision Trees and SVM when it comes to suggesting crops. When both soil and weather factors are taken into account, the accuracy of predicting crop yields gets better. Even though Generative AI doesn't make the numbers more accurate, it helps people understand the results better and feel more confident in using them.

8. System Architecture

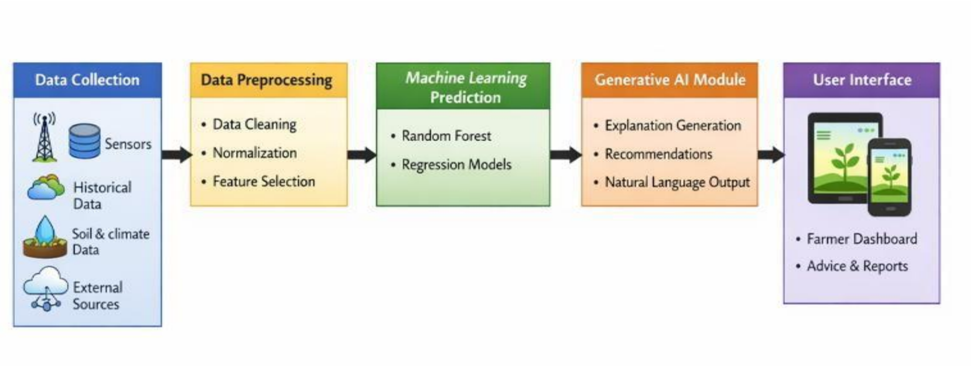

Fig: System Architecture of Farming Future with Generative AI

The architecture diagram shows the full process of the Generative AI-based Agriculture Decision Support System. The system is made to collect agricultural information, use machine learning to process it, and give clear and explained advice through Generative AI.

8.1. Data Collection Module

The Data Collection module is the base of the system. It gathers information from different sources to help with accurate farming analysis. This includes: Sensor data like temperature, humidity, and soil moisture Historical data about past crop harvests and farming activities Soil and climate data such as nutrient levels and weather conditions External sources like government farming databases or weather websites This data is then sent to the next step for further cleaning and handling.

8.2. Data Preprocessing Module

The Data Preprocessing module makes sure the data is clean and ready for predictions by doing: Data cleaning to fix mistakes and inconsistencies Normalization to make the data fit within a standard range Feature selection to keep only the most important details Good preprocessing helps make the machine learning models more accurate and trustworthy

. 8.3. Machine Learning Prediction Module

This part uses smart algorithms to analyze the data. In the system, we use: Random Forest Regression Models to predict crop yields and suggest what crops to grow based on the processed information. These models look at soil characteristics, weather, and past farming records to make accurate forecasts.

8.4. Generative AI Module

The Generative AI module helps by making the system's advice easier to understand and use. It does: Explanation generation to show why a certain crop is suggested Personalized advice based on the input conditions Natural language output so users can easily read and understand the results This part turns complex results from the machine learning models into simple and useful insights.

8.5. User Interface Module

The final results are shown through the User Interface module, which has: A farmer dashboard with predictions and recommendations Advice and reports to help farmers make smart decisions

9. Applications

• Smart systems that suggest the best crops to grow • Tools to predict crop output and plan farming activities • Techniques to use resources efficiently in farming 5 • Platforms that offer advice and training for farmers

10. Advantages and Limitations Advantages

Better understanding using simple language explanation • More confidence and involvement from farmers • Can work in different areas and grow with needs Limitations • Relying on good and available data • Need for powerful computers to run Generative AI models • Internet connection might be needed for all features to work properly

11. Future Scope

Future improvements might involve using IoT sensors to gather information as it happens, satellite images to watch over big areas, voice helpers that work in many languages, tools that use computer vision to spot plant diseases, and systems that predict crop prices. These new features can help make farming more sustainable and smarter.

IV. CONCLUSION

This review paper shows how Generative AI can change agriculture for the better. By using machine learning that gives accurate predictions along with explanations and interactive features, Generative AI helps create better decision support systems. These systems help farmers make smarter choices, give them clear advice, and support farming in a more sustainable way. As technology keeps improving, Generative AI is likely to be a key part of the future of smart farming..

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