Smart AgriTech: An IoT and Machine Learning-Based Crop Recommendation and Soil Monitoring System with Telugu Chatbot Support

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Abstract. Agriculture is a key contributor to the economy of the Telangana region and also provides jobs for a large part of its rural population. However, agriculture traditionally relies on farmers' years of experience and does not incorporate scientific principles into the decision-making process. As a result, agriculture is affected by climate change, soil erosion, and less productive crops due to poor farming practices. This paper discusses the development of a smart agritech system that uses the Internet of Things (IoT) and machine learning to support data-driven decisions in agriculture. The system includes data analysis based on nutrient levels, including nitrogen (N), phosphorus (P), and potassium (K) so that farmers can be given recommended N, P, and K for the different crops they plan to plant and how best to allocate their land to each crop. Five different types of machine learning models were tested for this study using various performance metrics, including Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), and R^2 score. The results of the study confirmed that the gradient boosting algorithm performed best in providing the most reliable predictions and in providing the highest accuracy. The Smart AgriTech system is provided through a web-based application that is available to local farmers (in their local language of Telugu) to promote the adoption of sustainable farming practices.

Keywords: Crop recommendation, machine learning, IoT, NPK analysis, smart agriculture, precision farming.

1 Introduction

Agriculture is really important for people in Telangana. It helps people in Telangana earn a living and find jobs in agriculture. Many farmers in Telangana still use ways of farming in agriculture. They choose crops. Use fertilizers and manage land based on what they have always done, not on facts and data about agriculture. This can waste resources. Make less food in Telangana. Farming in Telangana is getting harder because

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of changes in the environment around Telangana. Rain does not come on time in Telangana; it gets hotter in Telangana. Soil in Telangana gets weaker. This makes farming in Telangana more uncertain and risky for people in Telangana. Old farming ways in Telangana are not enough anymore for agriculture. We need solutions for agriculture in Telangana. Technologies like artificial intelligence and machine learning can help people in Telangana with agriculture. They look at lots of farm data about agriculture in Telangana. Give advice about agriculture to farmers in Telangana. Our Smart AgriTech system uses these technologies and the Internet of Things to help farmers in Telangana with agriculture. The system is easy to use. Speaks Telugu so local farmers in Telangana can understand it and use it for agriculture. It wants to make farming in Telangana more reliable and kinder to the environment in Telangana. It gives advice based on data about agriculture in Telangana. The goal is to give farmers in Telangana tools and knowledge about agriculture. This way, they can grow food in Telangana. Keep farming in Telangana sustainable for people in Telangana. The Smart AgriTech system will help farmers in Telangana make choices about agriculture in Telangana. Farmers in Telangana will use agriculture and technology to improve agriculture in Telangana. This will make agriculture in Telangana better for people in Telangana. Farmers in Telangana are the backbone of Telangana's agriculture. Agriculture in Telangana helps them. They do agriculture in Telangana every day for people in Telangana. Objectives of the Project.

2. Objectives of the Project

The main goal of this project is to help farmers make decisions when they are farming. Instead of just relying on what they already know, this project uses information to help farmers pick the right crops. This project mainly looks at the things in the soil like nitrogen, phosphorus, and potassium. Based on these things, it tells farmers which crops are best for their soil. It also tells farmers how good things their soil needs for a certain crop so they can get their land ready before they plant it. This project also helps farmers plan how to use their land in a way. It gives them some ideas on how to plant crops so they can get more from their land and not waste anything. We made this project into a website that farmers can use easily. It is in the Telugu language. This way local farmers can use this project without needing to know a lot about computers. The main idea of this project is to help farmers use information to farm in a way and to help them take care of the earth. This project wants to give farmers helpful ideas so they can farm better.

3. Literature Review

Recent research shows that machine learning is very important in agriculture. Machine learning helps farmers in ways. In [2] and [3], various algorithms like decision trees, random forests, support vector machines, and gradient boosting are used for crop prediction and yield estimation. These models help to understand how environmental factors affect crop performance. Soil nutrient analysis, NPK values, is key to determining

crop productivity [1]. Machine learning models that use soil data can accurately predict crops and improve soil health [4]. Rainfall prediction and climate analysis are also important for agriculture. Machine learning techniques like networks and support vector machines are often used for weather forecasting. They can handle data. Most existing systems focus on one task, like crop prediction or rainfall forecasting. There is no system that combines agricultural services. The proposed system fills this gap by combining soil analysis, crop recommendation, and decision support into one system. It helps farmers in a complete way. Machine learning is used in the system to provide results. The system aims to improve productivity.

4. Methodology

In this project, we have built an agriculture system that uses machine learning and IoT to help farmers make the right decisions. The main components of the system are plants, as suggested. The farmer informs us about the soil. We recommend crops suitable for that particular soil. We also provide some relevant advice for enhancing soil conditions. Then we made a part that can be chosen by the farmer. We tell them what elements they need to put in the soil. To do this, we used several machine-learning algorithms, such as Random Forest [5]. In this way, farmers know what to do before planting. We have also come up with a part that helps farmers to decide how to make use of their lands. We examined factors such as the weather. What vegetation occupied the land before? It turned out to work best in our tests, so we used Gradient Boosting to make decisions [6]. We have also made a part that tells farmers the type of crops they need to plant at various times of the year. This part looks at things like how hot or cold it is and how much rain there is. It helps farmers to plan ahead so as not to lose their crops. We accessed information from the field using sensors. These sensors tell us information like temperature and soil moisture content. We use this information to refine the suggestions we make. Before we used the information in computer programs, we ensured that the information was of quality and relevance. We created a website for the system using Flask. We also added support for the Telugu language so local farmers can use it easily. The smart agriculture system is devised to aid farmers. It relies on machine learning and the Internet of Things to achieve this goal. Some of the components of the system include crop recommendation and land allocation [7]. This smart agriculture system can be very useful for the farmers. It uses many instruments like random forests, gradient boosting, etc., for making better suggestions. The smart agriculture system is a web-based application. First, it supports the Telugu language.

5. Data Analysis

The machine learning models were evaluated on their performance. We used some tests like Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), and R^2 score [8]. These tests enable us to determine whether the forecast is correct or not. The dataset that we used for information about the soil, like nitrogen, phosphorus and potassium. Also, information concerning the environment, such as temperature, humidity, rainfall

and pH levels, obtained from the sensors was used. The data had to be pre-processed by filling in missing values and scaling all the data to a common standard [9]. We also chose the features that were important to use. Then we tried out a bunch of machine learning models like linear regression, support vector regression, decision trees, random forests, and gradient boosting [10]. We compared the models to determine which one was accurate. The machine learning models that worked best were the ones that used learning, with gradient boosting being the best. This is because gradient boosting machine learning models are good at handling data from farms. They can identify several interrelated factors in a nonlinear fashion. With this, gradient boosting machine learning models become very effective for making predictions in agriculture, as shown in Table 1.

Table 1. Performance Metrics of Algorithms

Model	**Error Magnitude (MAE, RMSE)**	**R2 Score**	**Cross-Validation R2 Score**	**Overall Ranking**
Gradient Boosting	Lowest	Highest	Highest	1st (Best Performance)
Random Forest	Low	High	High	2nd (Best Performance)
Linear Regression (Comparable)	Moderate	Moderate	Moderate	3rd
Support Vector Regression	Moderate	Moderate	Moderate	3rd (Comparable)

6. Results

The algorithm we tested was gradient boosting. It was really good at predicting things. The gradient boosting algorithm did a good job of predicting. What this means is that the results from the gradient boosting algorithm were accurate and consistent even when we changed some of the parameters. Compared to the models, the gradient boosting model was better at checking itself and learning from its mistakes. This shows that gradient boosting is an algorithm for making predictions, and it can be useful in a system that recommends crops because things are always changing in the agricultural industry. We can use gradient boosting to solve problems with crop recommendation systems, which can handle information and learn from it. We also looked at how rainfall affects crop yield using a graph. On the graph we put rainfall on one side and crop yield on the other. We found out that when it rains more, the crops grow more, using a kind of graph. There were some points on the graph that did not make sense. Sometimes when it did not rain much, the crops still grew a lot. This shows that rainfall is not the thing that affects how well the crops grow. Other things like the quality of the soil, food for the crops, and how we farm also matter. This graph tells us that we should use machine learning models like gradient boosting because they are good at understanding how things are related. The gradient boosting algorithm is very good at this. It can help

us make sense of relationships between things, which is really useful for predicting crop yields and making recommendations, as shown in Fig. 1.

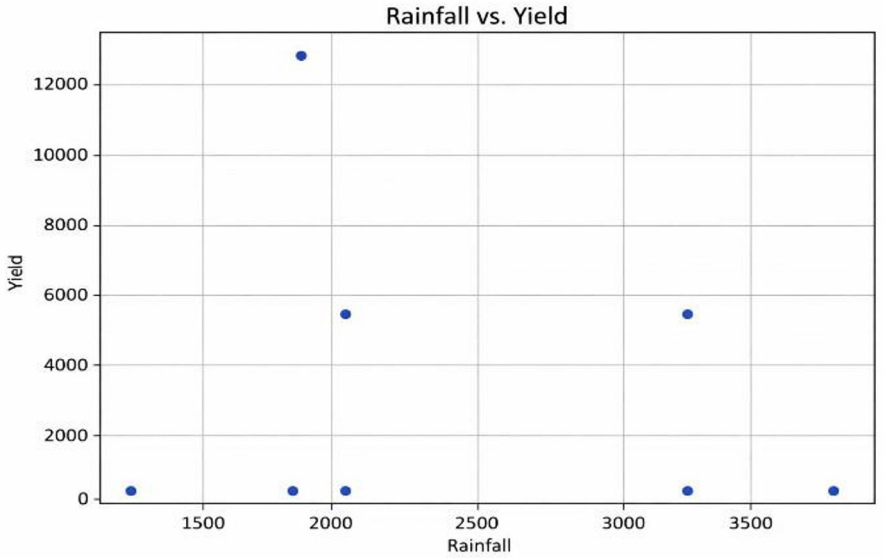

Fig. 1. Scatter plot

7. Conclusion

This paper presented a Smart AgriTech system that helps farmers make decisions. It uses Internet of Things and machine learning technologies. The system looks at things like soil nutrients, weather, and sensor data. It then gives advice on which crops to grow and how to farm. The system tested models and found that gradient boosting worked best. It was accurate and reliable. The results show that machine learning is good at handling data. Checking soil and weather conditions in time with sensors makes the system even more effective. The system has a web application in Telugu, which makes it easy for local farmers to use. Overall Smart AgriTech helps farmers grow more, use resources wisely, and farm in an eco-friendly way. A smart agritech system helps farmers a lot. Farmers can use this system to improve their farms. Future work can focus on adding advanced IoT devices and mobile apps. This will help with real-time monitoring and suggestions.

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