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Crop Recommender System Using Machine Learning Approach

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Abstract - The agricultural industry is the key source of livelihoods for many people that live in rural areas of India; however, it has many issues which affect the efficiency of the industry through non-optimized crop yield production and non-use of data in decision-making. The reliance on experience in farming means that there are difficulties experienced by farmers who can be negatively affected financially due to rapid movements in climate. This article discusses how the intelligent Crop Recommender System was developed through the use of machine learning (ML) to provide accurate forecasts of yields and crops to grow. Through the implementation of two separate ML predictive modules, namely the Crop Yield Predictor and Crop Recommender that utilized the Random Forest algorithm in a Python and Flask environment, the Crop Yield Predictor achieved an accuracy rate of 96.84% for yield predictions and the Crop Recommender achieved an accuracy rate of 87.56% for recommendation based on analysis of the 94 375 records in the data set. The Crop Recommender System allows users to enter their regional parameters e.g. soil type, season, area etc., which will provide the user with actionable information on growing crops. Additionally, the Crop Recommender System contains a fertilizer timing module which enables farmers to optimally apply resources. The migration from manual experience to automated predictive analytics will therefore allow farmers to enhance productivity, reduce crop losses and thus increase food security in the ever-changing agricultural sector.

Keywords—Agriculture, Crop recommendation, Crop yield prediction, Flask, Machine learning, Python, Random Forest algorithm.

I. INTRODUCTION

Modern agronomy and rural development are supported through the establishment of smart agriculture practices by using crop selection and yield prediction technologies to support agronomy practices. With the rapid growth of mobile technology and internet access, farmers want to use digital technology for agronomic decision making. Currently, traditional agriculture requires many hours of effort using intuition and the experience of others for all tasks required for crop cycle processing. These problems prevent farmers who have limited access to resources from using the operational functions of a system that would require the analysis of large amounts of data to operate efficiently. By providing stakeholders with automated web- based services, farmers can receive better service from their technical service providers through a seamless introduction process. The introduction of online recommendation platforms improves access to services that allow users to evaluate soil suitability, compare available crop options, and produce yield forecasts remotely, enhancing user satisfaction and efficiency within the agronomy sector. [1].

Online farming tech platforms are now changing the way farmers plan their growing seasons.[2] These online 'recommender' systems let farmers easily monitor soil conditions, decide what crops to plant, and find out how much fertilizer to use, all in one place.[3] This helps farming businesses run more smoothly, and farmers get predictions that are both timely and accurate.[4] Right now, researchers are studying yield patterns of major crops grown in India using organized data.[5] This helps them build better farming management systems.[6] Researchers tried using smart suggestion systems and data analysis to improve farming platforms by giving custom advice and helping users make good decisions.[7] These tech improvements are helping the farming business by providing better results because of faster, more precise prediction systems. Plus, these improvements are making things easier for everyone in the farming world.[8]
This study shows that web-based systems for managing crops and yields make things run more smoothly.[9] They have tools that automatically give suggestions and handle data about soil and yield.[10] The system lets managers control farm info, deal with data sets, and keep tabs on all prediction processes from one dashboard.[11] Current farming platforms put these things together with digital suggestion tools, which makes for efficient systems for farming businesses that also scale well.[12] Studies have shown that web-based prediction setups are easier to use.[13] That helps cut down on the amount of manual work farm managers have to do.[14] Creating specialized crop suggestion systems makes things even better.[15] They have features aimed at village settings, like fertilizer management and yield tracking.[16]

Because digital farming tech is always getting better, prediction platforms now use safe backend systems and system setups that can be expanded to handle more users.[17] Current studies say that strong, scalable setups are important for crop prediction systems, so the system can give good service and work well even when things get busy.[18] New trends show that Python mobile systems are popular in online business and have made data analysis and online farming platforms work better together.[19] What's happening now in tech shows how new ideas help make today's farming systems more efficient, safe and able to handle more.[20]

Based on these things, this study suggests a web-based system that helps people pick crops and predict how much they'll grow.[21] People can look at different crops, see yield predictions, and get suggestions all in one place.[22] The system also handles yield management automatically, gives soil-based tips, uses Random Forest-based predictions, and has dashboards for admins to manage the system well.[23] The goal of this platform is to make it easier for farmers to make decisions and give researchers and agricultural staff the tools they need to handle farming tasks well.[24]

II. LITERATURE SURVEY

These days, farming and rural areas are getting a boost from cool systems that give smart advice on how to manage crops and guess how much they'll produce. Over the past few years, many researchers have built machine learning tools and digital farming systems that take over picking tasks. They give farmers better help and let businesses run smoother. This piece looks at some key studies about crop advice systems, digital farming setups, and ways to analyze farm data.

Umamaheswari et al. [1] developed a blockchain system for IoT in agriculture. This lets people involved confirm data and handle sensor info using platforms that aren't controlled by one central source. The system showed that digital monitoring can help farms cut down on manual labor and boost how well things run. Jain [2] did a study on why rice production in India isn't always stable. Scientists use it to study yield patterns and make better farming systems. The study showed that when companies look at data, they can figure out how growth works and create better ways to predict it.

Manjula and Djodiltachoumy [3] came up with a way to guess how much of a crop you'll get by using association rule mining. It's like giving smart tips to make farming platforms better. They looked at old environmental stuff and gave specific advice to help crop growth. By adding smart advice systems, it helps people find the right answers for farming and makes guessing platforms easier to run.

Today, digital analytics are a key part of how agricultural services work. Sagar and Cauvery [4] looked at how big data analytics can help guess crop yields in different weather conditions. Their work showed that online platforms use data analysis to build prediction systems that are safe and simple to use. Wolfert [5] studied why farmers decide to use smart farming systems, noting that these systems offer easy ways to handle data. Digital farming now relies heavily on these sorts of technologies.

Jones et al. [6] came up with an agricultural tool that combines system modeling and data knowledge using cool scientific tech. Their work showed how knowledge-based platforms can make farming easier and help researchers and agricultural folks talk better. Johnson et al. [7] suggested a loss management setup focused on production, aiming to make harvest decisions better through digital platforms. Their research showed how ag tech makes stronger producer ties and improves their harvesting.

Kumar and Singh [8] came up with a crop selection method that helps managers get the most out of their crops. It uses a machine learning system to deal with land area and production info. The system made it clear that digital platforms can cut down on manual labor and make farm management run more smoothly. Sriram Rakshith et al. [9] built a crop prediction system that mixes machine learning with easy-to-use prediction tools. Their research showed that digital systems are now super important for managing farm services well.

Recent studies are trying to make predictions in digital farming systems more accurate and dependable. For example, Veenadhari et al. [10] came up with a weather forecasting system to help better predict crop yields on digital farming platforms. Their work showed that better forecasting can make these systems more reliable. Also, Ghadge et al. [11] looked at how new farming industries have started using prediction systems and found that accurate data and easy-to-use systems are key to getting people to adopt these technologies.

Priya and her team [12] made a system that guesses how much crops will grow. It mixes computer programs with data systems in the back. This helps people in charge control how much things are grown and makes guessing amounts easier. Pavani and Beulet [13] looked at guessing platforms to show how online crop amount systems changed farming. They did this by giving farmers easier ways to see how much they might grow.

Recent research shows that agricultural prediction systems can use scalable architecture solutions, which scientists have been looking into in their latest work. For example, Nishant et al. [17] created a crop prediction platform that uses Indian agriculture datasets. This platform helps the system work better by making it more accurate, reliable, and fault-tolerant. Their work showed that current software setups allow recommendation systems to handle high user demand. Also, Kale and Patil [18] looked at how farming companies use machine learning systems because these systems help their customers quickly and safely predict yields.

III. METHODOLOGY

We built an online system to help manage crop suggestions, and we wanted it to be simple and easy to use. Our method creates a structure where web systems can mix forecasts with soil data and management tasks. The system is built in pieces, with each piece doing a specific job, like handling data, managing crops, dealing with yields, and checking predictions. We're using web tools like Python and Flask to build the behind-the-scenes part that takes care of user requests and manages the database. People can get to the system through webpages that make up the user interface.

The system we've built works in a few steps. It starts with planning the system's design, then moves on to creating features and putting the model together. It wraps up with handling how recommendations are made. This setup has different parts that all work together to keep the predictions reliable and working well.

A. System Architecture

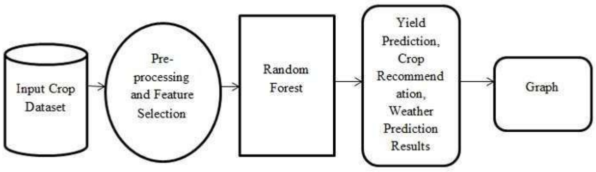

Fig 1: Overall System Architecture

The system works using a client-server setup. Users get to the web interface, and the Flask server takes care of what they ask for and chats with the Random Forest models. There are three main parts to how it's built: what the user sees, what the app does, and where the data lives.

The user sees the system through web pages that show crop types and yield info, helping farmers decide what to plant. The application part makes sure everything works right by checking the data, figuring out how much crops will grow, and taking into account local rules and soil conditions. The information is kept safe and sound in a database and organized files. This setup is great since it lets the system grow, keeps the science correct, and makes sure all the parts talk to each other well. Admins and researchers can use special dashboards to keep an eye on things and run the farming operation.

B. System Modules

The system divides its functions into multiple modules which users can access according to their specific system permissions.

1. Farmer Module

The farmer module is like the main screen farmers see. It's made to be super easy to enter info, which helps get good guesses about harvests. Farmers just go through some simple web pages and pick where they are (like state and area) and type in stuff like when they're planting and what kind of dirt they have. It's made with HTML and CSS so it's easy for anyone to use, even in the countryside. They can put in how big their fields are, and then the system figures out how much they'll probably grow.

After the farmer enters their details, the module sends it to the Flask server in the back to get the prediction going. The result shows up clearly on the screen, either telling them which crops are good to plant or guessing how many kilograms per acre they'll get. This way, farmers can move away from just guessing and actually use data to help them make better choices.

2. Recommendation and Prediction Module

This part of the system is where the main thinking happens. It uses machine learning to look at 94,375 pieces of information from the farm data. It makes use of the Random Forest Classifier to check things like soil and weather. Then, it tells farmers what crop is the best choice for their land. Because it gets the right suggestion about 87.56% of the time, farmers can trust it to help them make good choices about what to grow in their fields.

3. Administrator Module

The admin area is where you can control the system's data and keep it up-to-date with what's happening in agriculture. People with permission can upload new data, change crop info, and get rid of old stuff to keep our predictions accurate. This control helps us adjust the system for different weather and expand it to new areas.

4. Research and Fertilizer Module

This research part is like a special add-on to the system. It checks if the math is right and comes up with new stuff to do. Researchers can use it to try out different machine learning models, like SVM, ANN, and KNN, and see how they do compared to what we're using now, which is Random Forest. By always checking things out, we can be sure the system is using the best methods to stay accurate.

C. Database Design

The system uses a relational database to store and handle farm data. It keeps track of records and how they link to other things using tables that are all tied together. For example, the User table holds info on registered people, like their name, email, password, and what they do in the system. Then there's a State table that has details on each region, such as its name, boundaries, and soil types.

The Crop table has info on different crop types, when they grow best, how much each region makes, and how much land is open for farming in each state. The Prediction table keeps track of analyses, like who ran them, where, what kind of soil, when they planted, how much land they used, and what the expected harvest is. The Performance table stores math stuff, like how accurate the predictions are and the model settings. Plus, the system uses other tables like Fertilizer and Climate to deal with the farming science stuff. This setup makes sure we can get to the data fast and that the system works well.

D. Prediction Workflow

The farmers use the platform to predict their yield:

First, they pick a region on the state selection page based on where they want to farm and what resources they have.

Next, the system shows them all the crops they can grow. It gives details about production and updates on how each crop is doing this season.

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Then, the farmer picks a soil type and enters data like area size, season, and total acres.

The system then figures out the yield based on the production rate, season length, and acres selected.

If the farmer enters a valid code, the system gives a suggestion and adjusts the final list.

After that, the system shows a result view with digital analysis, helping farmers understand their prediction.

Once the analysis is done, farmer uses the output code to submit prediction for verification.

The researcher then looks at the technical details to check the recommendation.

After the check, the system makes a report and updates the prediction status in the database.

This process makes sure the recommendations are accurate and that all checks and records are properly handled.

E. System Implementation

This system uses a modern web framework, giving it quick backend processing and smooth dataset support. The backend server is in charge, handling requests, checking users, verifying predictions, and running machine learning. The frontend lets users play around with the different parts. To keep things secure, the system uses authentication to control access for admins, researchers, and farmers. Models are protected with serialization, letting users keep their prediction status during use through session management with the Pickle library. The system's modular design makes it easy to add features, like fertilizer management, real-time weather tracking, and connections to mobile apps.

IV. RESULTS AND DISCUSSIONS

The project's homepage is where farmers start when they visit the site. It has a clean layout with simple choices like Home, Login, and Upload. Farmers can easily find what they need for their work by browsing the different sections.

Admins can use the navigation buttons to upload new data and show off certain preview results. This feature helps the system do more and gets users to pay attention to the analytics.

A. User Authentication and Login

When a user wants to get into restricted management areas, the system takes them to a secure login page. The page shows the user's login info, like their username, encrypted password, and a way to submit the login.

The section about who can log in shows different roles, like Admin and User, what they are allowed to do, and whether they are logged in or not. People who have an interest in the system use all of this to keep their data safe and handle their own tools that predict what might happen.

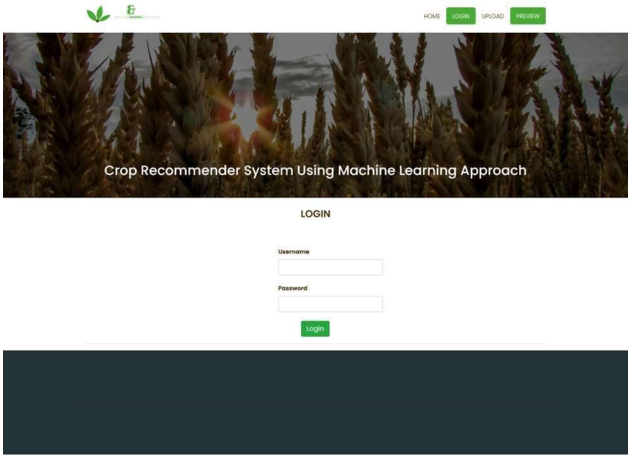

Fig 3: Data Upload Interface

The upload form in the system is how admins add data.

B. Data Preview Interface

Once a dataset uploads to the server, the system takes users to a detailed preview page. This page gives all the details on the dataset, like column names, features, and how many records are there.

In the preview, you'll see data columns such as State Name and Soil Type, with their values and numbers. Stakeholders can look at this data, check out the options, and pick the parameters they want for building models.

Admins can also use this interface to check that all 94,375 records are correct before starting training. This organized way of seeing the data helps in quickly getting to records and keeps the system working well for predictions.

Fig 4: Data Preview Interface

C. Yield Prediction Interface

After picking what they want to grow, users see their analysis choices on the prediction screen. To get a estimate, farmers need to type in their state, soil type, and how many acres they're planting.

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The system figures out the total expected yield by looking at production rates and the size of the land. If there's a good Random Forest model, the system uses a regressor on all the data. Farmers put in this info through a prediction form on the system.

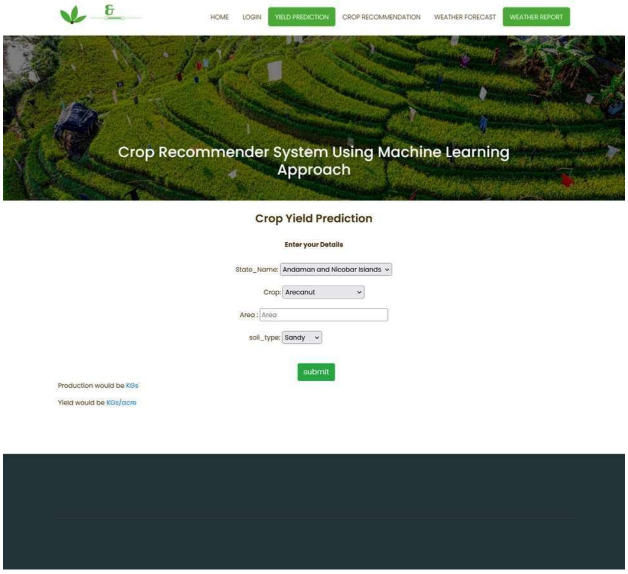

Fig 5: Yield Prediction Interface

D. Crop Recommendation Interface

The recommendation tool uses machine learning to pick the best choices for you. Once the soil details are set, the tool shows a suggestion list that farmers can see on their phone or computer. Farmers can enter what they need in their internet browser to make their selection.

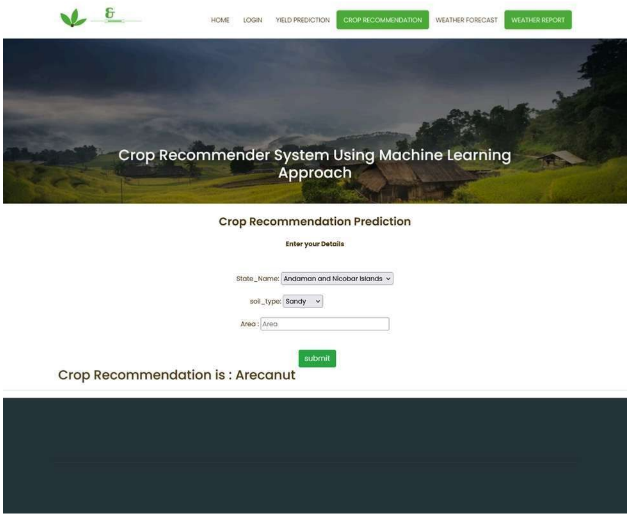

Fig 6: Crop Recommendation Interface

After they submit, users will get a report to prove their recommendation. Then, a recommendation page shows up on the website.

E. Weather Forecast Interface

The weather tool checks the weather info and confirms what's normal for each season. It starts predicting by asking the main server for info about a specific region. After farmers share where they are, the system looks at what the atmosphere is like right now to see the current climate and finish the report. The platform's research team can search for forecasts using regional codes, which helps them adjust their recommendations for planting.

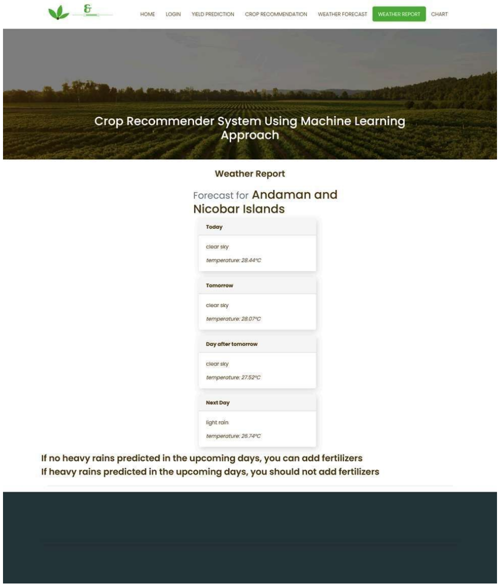

Fig 7: Weather Forecast Interface

Basically, the weather interface is there to double-check the conditions outside.

V. CONCLUSION

This research paper talks about a web system that helps people figure out what crops to plant. It also gives admins and researchers some helpful tools to work with. People can use the system to look for crops, see how well they might grow, and even get predictions from machine learning about how much they can harvest. The system also lets them double-check those predictions.

With this system, farmers can easily look through different crops and see how much they might produce before they decide what to grow. It figures out how much they'll get based on the land they're using, so they know what to expect. The system also uses a special calculation method to guess how well crops will do, and researchers check the results to make sure farmers get good plans.

Admins can use the system's tools to control many things, such as farm data, crop lists, schedules for when to do things, ads, and fertilizer plans. We plan to update the data every so often, so the predictions are correct, and we can make these things happen automatically moving forward.

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Fig 6: Crop Recommendation Interface

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