



Crop Recommendation System

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Abstract— Agriculture is a primary source of livelihood for the majority of the Indian population and an important component of their economy. As the environmental and economic conditions change, there is a need for a system that can guide farmers in planning their agricultural activities to maximize their return on investment. This project aimed at developing a simple crop recommendation system that utilizes soil and environmental parameters to suggest the most suitable crop to plant. The soil parameters such as nitrogen, phosphorus, potassium content and the soil pH were utilized along with environmental factors such as rainfall, temperature and humidity. The system provides five suitable crop recommendations that are ranked based on their market value. Additionally, current weather conditions are provided to assist the farmer in making the best possible decision. The system offers a simple and effective way to select the best crop to plant based on relevant data.

Keywords—market value, LLM gpt-2, crop recommendation.



I. INTRODUCTION

Agriculture is a very significant sector which sustains the food production and economic growth in many countries. Modern agriculture has increasingly become dependent on the implementation of Precision Agriculture where data and technology can be harnessed for making informed decisions to improve crop productivity and sustainability. Choosing the right crop which can be responded to well to the Soil nutrients as well as to environmental conditions is very crucial for improving the Yield and Sustainability.

Traditionally crop selection has been a manual and relatively hit-and-miss process. However, as AI and Machine Learning have entered the agricultural domain, intelligent systems are now capable of analyzing a complex set of parameters and suggesting crops that will thrive under specific agricultural conditions.

This project involves building an LLM Based Crop Recommendation System for Precision Agriculture that uses a transformer model (GPT-2 Transformer) to suggest the right crops based on Soil and Climate parameters.

II. LITERATURE SURVEY

Literature survey is an important part of the research process. It helps to know existing methodologies, know limitations of past research and to identify gaps in current research before starting to conduct research. The knowledge acquired in this process forms the basis for the research. In preparing this project, a number of relevant research papers were read and studied. Below are summaries of these studies, grouped by the title of the work, techniques/ algorithms used, and results obtained from each.

A. [1] Muhammad Abu Bakr (2025)

"An Evaluation of Learning Based Crop Recommendation Models in Smart Agriculture" In this paper, we have tried to experiment different models like GPT-2, BERT, KNN, Random Forest, Decision Tree, SVM, Naive Bayes, MLP etc. and deep learning models like LSTM, Bi-LSTM, and CNN-LSTM for crop recommendation system. GPT-2 model gives the best accuracy of 99.55% but it has very high computational requirements and needs more training time as compared to traditional machine learning models.

[2] Kanda Sorn-In (2026)

"Smart Crop Recommendation for Precision Agriculture: A Comparative Study between Ensemble Learning and Deep Learning Approaches using Soil and Environmental Data" In this work, we experimented with several models including XGBoost, LightGBM, Random Forest as well as Recurrent Neural Networks like GRU and LSTM. Surprisingly enough, we even tried a transfer learning approach where we fine-tuned a pre-trained ResNet-18 backbone on the dataset. After several experiments, the results showed that XGBoost and LightGBM achieved an accuracy of 99.77%. It seems that traditional deep learning models are not as effective on structured tabular data.

[3] Devendra Dahiphale (2025)

"Smart Farming: Crop Recommendation Using Machine Learning Technique along with Challenges and Future Ideas. In this research a multi-layer neural network (deep neural network) made up of ReLU activated hidden neurons and Softmax output neurons has been trained and tested on a dataset of examples of sound classification. Its results have then been compared to that of more commonly used machine learning approaches (Random Forest) and in terms of raw classification accuracy the latter have achieved approximately 99.5% with some room for error due to limited examples in the training set and the inherently difficult task of approaching real world variability. However, the network has still achieved an accuracy of approximately 97.73%.

B. [4] H. Gunasekaran (2025)

"Physics-Aware Ensemble Learning for Superior Crop Recommendation in Smart Agriculture".

In this study, a physics informed neural network was utilised alongside traditional models such as Random Forest, Extra Trees and XGBoost to predict the likelihood of winter herbicide application. The models performed with high accuracy of approximately 99.50% with all models demonstrating good precision and recall. Although high accuracy was achieved, the models do have limitations, particularly in respect to the factors that the models take into consideration, where temperature and pH were the primary agricultural environmental parameters considered, and further agricultural data validation was required.



C. [5] Md. Shahriar Hossain Apu (2025)

"IoT-based Crop Recommendation System using Machine Learning via Mobile Application for Precision Agriculture in Bangladesh".

The system is implemented by using multiple models like Naive Bayes classifier and also it is integrated with lot of IoT devices and also a mobile application is designed for that. The accuracy of the model that is designed is around 99.55%. The major drawback with the model is that it assumes feature independence and it is solely dependent on internet connectivity which is a real drawback in rural areas.

D. [6] Murali Krishna Senapaty (2024)

A Decision Support System for Crop Recommendation Using Machine Learning Classification Algorithms".

In this study, SGDC approaches together with SMOTE were employed in order to balance the classes in the dataset and compared with several alternative approaches in terms of their accuracy levels and performance. The method achieved an accuracy rate of almost 100%, but had problems in identifying certain classes correctly.

E. [7] Saritha Vemulapalli (2024)

"An Experimental Analysis of Machine Learning Techniques for Crop Selection Recommendation.

In this work we have tried to compare a couple of learning models such as Random Forest, Decision Tree, XGBoost and KNN where Random Forest gave best accuracy around 99.5%. However, the dataset used in this work is mainly made with crops grown in India. Hence the accuracy rate might change for crops grown in other countries.

III. PROPOSED SYSTEM

The proposed system aims at providing an efficient crop recommendation service for farmers. The existing systems such as Crop Recommendation System for Small Farmers and Crop recommendation system for farmers based on seasonally available crop selection, provide crop recommendations based on factors like rainfall, temperature and soil nutrients. But the proposed system combines the factors of soil, environmental as well as the market price of the crop for optimal crop recommendation for a farmer. This tool has limitations because it cannot consider all soil parameters, environmental factors and market price but it considers very important parameters like soil content of nitrogen (N), phosphorus (P) and potassium (K) as well as the soil's pH. Additionally, it considers weather parameters such as rainfall and temperature and lastly it considers the prices of crops in the market to suggest crops that are suitable and beneficial for farmers.

The system stores Farmer information including name and the total area he owns land. Based on the village where the crop will be cultivated, the system extracts data regarding soil and weather information of that particular area and based on these information pattern suggests a list of best crops to be cultivated for the farmer.

A total number of 2200 records of soil and environmental attributes were obtained from Kaggle and used for this research. In order to enhance the performance of the system, data augmentation techniques were incorporated in the workflow to increase the size of the dataset in order to enhance training and testing of the system.

Based on the given parameters, we have listed down 5 crops that you can consider planting on your land. In addition, we have ranked the crops based on their current market price so that you can decide which one can bring in the most profit for your farm.

Instead of strictly using agricultural suitability in the land suitability assessment, the proposed system incorporates market relevant information, which results in a more practical system for the farmers than current methods.

IV. DATA SET

The system processes input parameters such as soil pH, content of nitrogen (N), phosphorus (P), and potassium (K), current temperature, humidity and rainfall, and recommends the appropriate crops for planting.

The model is capable of selecting crops from a provided list of crops such as rice, maize, chickpea, kidneybeans, pigeonpeas, mothbeans, mungbean, blackgram, lentil, pomegranate, banana, mango, grapes, watermelon, muskmelon, apple, orange, papaya, coconut, cotton, jute and coffee. The selected crop list is relevant to the datasets used in this research.

The data for this problem was collected from a number of real world scenarios consisting of input from farmers and weather data. This real world data ensures that the developed system will be able to suggest actual crop types to farmers as opposed to ideal conditions on the web.

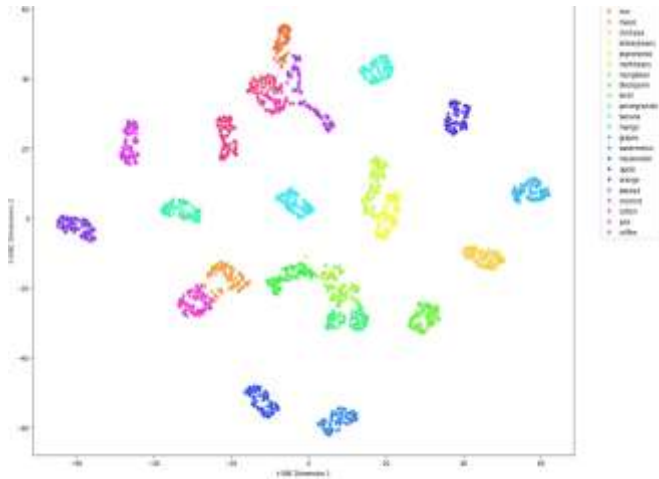


Fig. 1 The figure shows well-separated crop clusters.

- N - ratio of nitrogen content in soil.
- P - ratio of phosphorus content in soil.
- K - ratio of potassium content in soil.
- Temperature - temperature (Celsius).
- Humidity - relative humidity (percent).
- pH - soil pH value.
- Rainfall – total rainfall received (in millimeters).

N	P	K	temperatu	humidity	ph	rainfall	label
90	42	43	20.87974	82.00274	6.502985	202.9355	rice
85	58	41	21.77046	80.31964	7.038096	226.6555	rice
60	55	44	23.00446	82.32076	7.840207	263.9642	rice
74	35	40	26.4911	80.15636	6.980401	242.864	rice
78	42	42	20.13017	81.60487	7.628473	262.7173	rice
69	37	42	23.05805	83.37012	7.073454	251.055	rice
69	55	38	22.70884	82.63941	5.700806	271.3249	rice
94	53	40	20.27774	82.89409	5.718627	241.9742	rice
89	54	38	24.51588	83.53522	6.685346	230.4462	rice
68	58	38	23.22397	83.03323	6.336254	221.2092	rice
91	53	40	26.52724	81.41754	5.386168	264.6149	rice
90	46	42	23.97898	81.45062	7.502834	250.0832	rice
78	58	44	26.8008	80.88685	5.108682	284.4365	rice
93	56	36	24.01498	82.05687	6.984354	185.2773	rice
94	50	37	25.66585	80.66385	6.94802	209.587	rice
60	48	39	24.26209	80.30026	7.042299	231.0863	rice
85	38	41	21.58712	82.78837	6.249051	276.6552	rice
91	35	39	23.79392	80.41818	6.97086	206.2612	rice
77	38	36	21.86525	80.1923	5.953933	224.555	rice
88	35	40	23.57944	83.5876	5.853932	291.2987	rice

Fig. 2 This figure displays the values for the dataset showing the amounts for different parameters that can be used to predict suitable crops for a field.

V. PROPOSED WORK

Our system is delivered as a web-based application comprising several integrated functions which together utilise data and process information to produce the best crop recommendation for a given field. The application is accessed through a web interface and follows a step by step process from inputting data to finalising the crop choice.



Step 1: Farmer Data Input:

We first collect basic information (name, land area in acre, village name etc) of the farmer. The village name is significant as it gives us an idea about the general weather of that region.

Step 2: Weather Data Collection

Once you have located your location, you can enter in the current environmental data such as the temperature, humidity and rainfall. This information can help determine which crops are best suited to grow in your area.

Soil related information is also incorporated in the Kisan Platform through the Soil Health Card Scheme, supported by the Government of India. The platform utilizes a dataset that comprises around 45 lakh soil samples collected from various parts of the country. The system incorporates crop recommendations generated from a combination of environmental and soil data sources to produce the most applicable results.

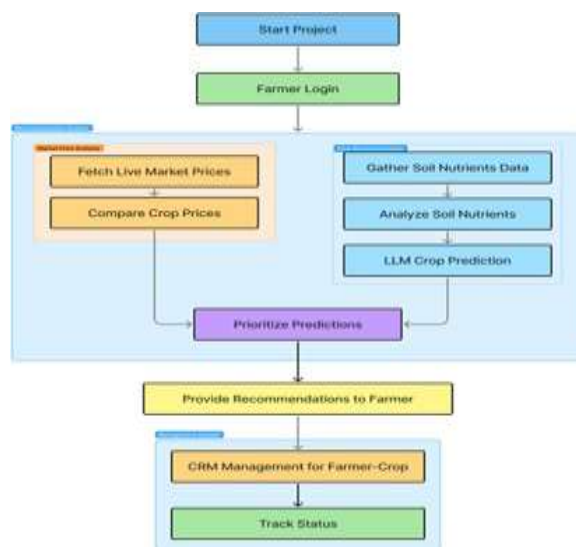
Step 3: Soil and Environmental Inputs

Along with the weather forecast, we look at some critical parameters of soil such as nitrogen, phosphorus, potassium and the soil pH. These factors give us a complete input to come up to the correct crop yield.

Step 4: Prediction Process

After collecting the required data, it is sent to the prediction module of the system where a trained model processes the input and predicts the most suitable crop by matching it with the learned patterns from the data.

The collected data is fed to the prediction part of the system where a pre-trained GPT-2 language model is used to predict the crop which would grow best under the given soil and environmental conditions. Soil parameters such as N, P, K and pH and environmental parameters like temperature, humidity and rainfall were considered as inputs to the model.



The crop recommendations are generated by the GPT-2 model, trained on the provided inputs and a large dataset of similar entries. Compared to earlier models, GPT-2 excels in analyzing multiple inputs and discovering complex relationships there between to better understand and predict the context. It specifically combines data about soil and environment to arrive at the most suitable crop for the given circumstances.

The changes outlined above make the system more robust and able to provide relevant, feasible crop suggestions for a real farm.

Step 5: Crop Recommendation

Based on the provided soil and environmental details, 5 different crops have been suggested to the farmer along with ranking on the basis of market price so as to support the farmer to select best crop options that can provide higher returns. We use SerpAPI to pull market price information for The latest crop price recommendations we provide are agronomically and economically sound using online sources for our crop price data.



Step 6: System Overview

The dashboard provides a simple overview of the system and provides the user with clear information. It includes farmer details, recent activity on the platform, and current status of the system, also showing recent predictions and information such as the number of farmers added.

Step 7: Management and Security

The system also provides options for managing data and system performance. You can update Farmer information, check System Status and perform other system functions as required. The Logout option allows you to end your session, returning to the Login screen.

VI. RESULTS

This is a screenshot of the crop recommendation system's dashboard.

The page displays information such as farmer details, system status and recent activities.

An easy to use interface is provided to monitor and control the system.

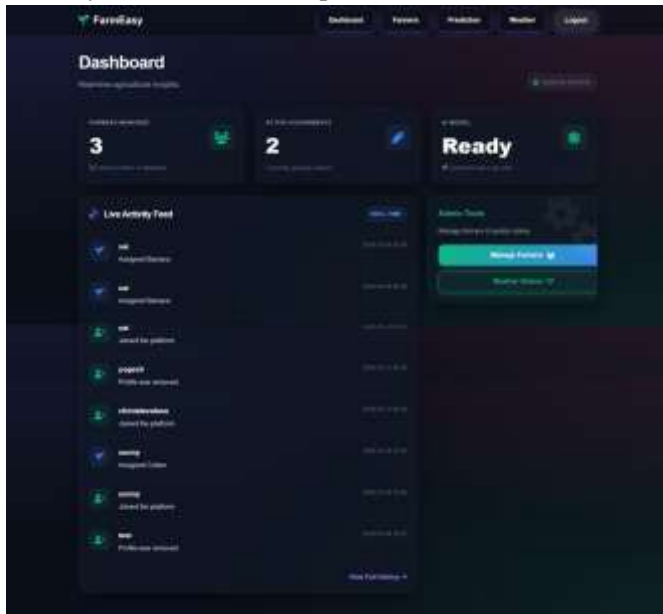


Fig.1 Dashboard of the crop recommendation system for farmers, showing information of farmers, system status and system activities.

This is the farmer management section where all the information about the farmers is stored in the form of a table. Information such as name, address, acreage, crop and status is included.

It also has options for adding, viewing, editing and managing individual farmer records.

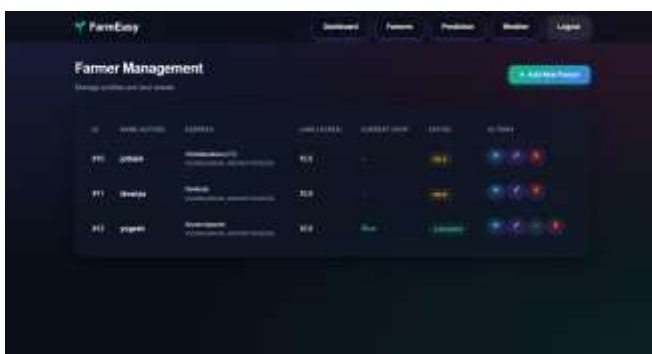


Fig.2 Farmer management interface showing farmer details, land information, and crop status.

This image shows the prediction engine used to generate crop recommendations based on input parameters.

Data for soil and surrounding environment is provided and using this AI gives crop suggestions and ranking of market prices. The tool's interface helps farmers select the most profitable crop types that would be suitable for their given circumstances.

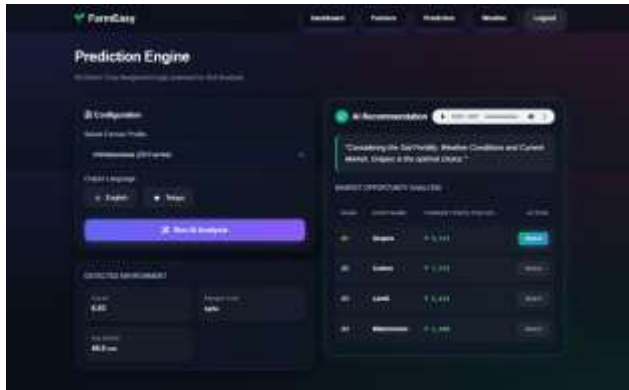


Fig.3 Interface of the Prediction Engine displaying proposed crop selections in accordance with soil, weather, and prevailing market conditions.

This is a view of the weather module displaying actual weather conditions for a location.

The data also includes temperature, humidity, rainfall, soil moisture levels and air quality.

This data can be used for further analysis. Also note that this data can be used for crop selection recommendations.



Fig.4 Displays an example of the weather monitoring interface, including current local weather conditions as well as relevant analytics intended to aid agricultural decision-making.

ACCURACY IN TERMS OF NUMBERS:

- Accuracy = 0.99772

This report outlines the performance of the crop prediction model for all crop classes, including precision, recall, F1 score and accuracy.

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN}$$

Where:

- TP (True Positives): Correctly predicted positive cases
- TN (True Negatives): Correctly predicted negative cases
- FP (False Positives): Incorrectly predicted positives
- FN (False Negatives): Incorrectly predicted negatives



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--- Detailed Classification Report ---
precision    recall  f1-score   support

 apple       1.00    1.00    1.00     9
 banana     1.00    1.00    1.00    12
 blackgram  1.00    1.00    1.00    13
 chickpeas  1.00    1.00    1.00    13
 coconut    1.00    1.00    1.00    15
 coffee     1.00    1.00    1.00     9
 cotton     1.00    1.00    1.00     6
 grapes     1.00    1.00    1.00     6
 jute       1.00    1.00    1.00    11
 kidneybeans 1.00    1.00    1.00    13
 lentil     1.00    1.00    1.00     7
 maize     0.92    1.00    0.96    12
 mango     1.00    1.00    1.00     4
 millettas  1.00    0.93    0.95    11
 mungbean   1.00    1.00    1.00    10
 muskmelon  1.00    1.00    1.00     7
 orange    1.00    1.00    1.00     9
 papaya    1.00    1.00    1.00    12
 pigeonpeas 1.00    1.00    1.00    12
 pomegranate 1.00    1.00    1.00    10
 rice      1.00    1.00    1.00     6
 watermelon 1.00    1.00    1.00     6

 accuracy   1.00    1.00    1.00    220
 macro avg  1.00    1.00    1.00    220
 weighted avg 1.00    1.00    1.00    220

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Fig.5 Classification report indicating performance for various crop classes.

VII. CONCLUSION

A web-based system for crop recommendation for farmers was developed and tested. The system incorporates soil and weather data along with current market prices of crops, to provide appropriate crop recommendations for cultivation. The system is user friendly and provides economically viable crop recommendations for farmers. Using real world data such as soil information, weather makes the system more practical. By incorporating data from the market also, a farmer would be able to decide which crop to plant to gain more return on investment. The system is user friendly and is implementable with the steps it follows. The proposed system is intended to be simple and effective to assist farmers in choosing the crops that will be best to plant from agricultural and economic perspectives.

VIII. FUTURE WORK

While the proposed system achieves state-of-the-art results for agricultural inference, there are many avenues for further enhancing the system. By incorporating predictive market intelligence that constantly analyzes real-time commodity price fluctuations and trends, the system can make crop recommendations that are economically beneficial to the farmer. Additionally, integrating a multi-modal AI architecture that can consume drone and mobile images in real-time, the system can detect early warnings for crop diseases, pests, and nutrient deficiencies. By analyzing real-time weather and seasonal patterns, the system can also provide timely alerts and actionable recommendations. Moreover, by porting the system on edge computing architectures that utilize lightweight, optimized, and offline capable models, the system can provide always-on rural agricultural intelligence to small and marginal farmers in remote rural locations with little to no internet connectivity.

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