VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JNANA SANGAMA", BELAGAVI-590018, KARNATAKA

AI Mini Project (BCS515B) - IA2 component
Report on

"CROP RECOMMENDATION SYSTEM"

Submitted in the partial fulfillment of the requirement for the award of degree of

BACHELOR OF ENGINEERING

in

COMPUTER SCIENCE AND ENGINEERING

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DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

SAI VIDYA INSTITUTE OF TECHNOLOGY

(Approved by AICTE, New Delhi, affiliated to VTU, Belagavi | Recognized by Govt. of Karnataka)

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CERTIFICATE

Certified that the mini project work entitled **"** ***Crop Recommendation System*** **"** carried out by **, Manju (1VA22CS069), Meghana A (1VA22CS071), Pooja M H (1VA22CS088), Rakshitha V (1VA22CS099),** bonafide students of **SAI VIDYA INSTITUTE OF TECHNOLOGY**, BENGALURU, in partial fulfillment for the award of Bachelor of Engineering in **COMPUTER SCIENCE AND ENGINEERING**, **VISVESVARAYA TECHNOLOGICAL UNIVERSITY**, BELAGAVI during the Academic Year 2024-25. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the report deposited in the departmental library. The Artificial Intelligence Mini Project (BCS515B) IA-2 component Assessment report has been approved as it satisfies the academic requirements in respect of Mini Project work prescribed for the said Degree.

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ABSTRACT

Agriculture plays a vital role in ensuring food security and economic stability worldwide. However, farmers often face challenges in selecting the most suitable crops for cultivation due to fluctuating environmental conditions, limited resources, and market uncertainties. This project presents an AI-based crop recommendation system designed to assist farmers in making data-driven decisions.

The system leverages machine learning algorithms and data analytics to analyze key factors such as soil properties, weather patterns, water availability, and market trends. By processing this data, the system recommends crops that are best suited for a given region and season, ensuring optimal yield and resource efficiency.

The proposed solution aims to enhance agricultural productivity, promote sustainable farming practices, and boost economic gains for farmers. Additionally, it addresses issues like overuse of fertilizers, water wastage, and poor crop planning. The system is designed to be user-friendly, scalable, and accessible via mobile and web platforms, making it a practical tool for modern agriculture.

Through intelligent decision-making support, this project seeks to transform traditional farming into a more sustainable and efficient practice.

Table of Contents

List of Figures

List of Tables

CHAPTER 1
INTRODUCTION

Agriculture is a significant area for the Indian economy and human survival. It is one of the primary occupations which is essential for human life. It likewise contributes a huge part to our day-to-day life . In most cases, Farmers commit suicide due to production loss because they are not able to pay the bank loans taking for farming purposes . We have noticed in present times that the climate is changing persistently which is harmful to the crops and leading farmers towards debts and suicide . These risks can be minimized when various mathematical or statistical methods are applied to data and by using these methods, we can recommend the best crop to the farmer for his agricultural land so that it helps him to get maximum profit .

In India today, agriculture has made significant advancements. Precision farming's secret weapon is "area specific" cultivation. Although improvements have been made, there are still some problems with precision cultivation.

Precision agriculture focuses on identifying these parameters in an area-specific way to identify issues. Not all the results given by precision agriculture are accurate to result but in agriculture, it is significant to have accurate and precise recommendations because in case of errors it may lead to heavy material and capital loss. Many research works are being carried out, to attain an accurate and more efficient model for crop prediction .

Machine Learning focuses on the algorithm like supervised, unsupervised, and Reinforcement learning and each of them has its advantages and disadvantages. Supervised learning the algorithm assembles a mathematical model from a set of data that contains both the inputs and the desired outputs. An unsupervised learning-the algorithm constructs a mathematical model from a set of data that contains only inputs and no desired output labels. Semi-supervised learning algorithms expand mathematical models from incomplete training data, where a portion of the sample input doesn't have labels .

This approach aims to recommend the most suitable crop based on input parameters like Nitrogen (N), Phosphorous (P), Potassium (K), PH value of soil, Humidity, Temperature, and Rainfall. This paper predicts the accuracy of the future production of twenty two different crops such as rice, maize, chickpea, kidney beans, pigeon peas, moth beans, moonbeam, black gram, lentil, pomegranate, banana, mango, grapes, watermelon, muskmelon, apple, orange, papaya, coconut and coffee crops using supervised machine learning

approaches and recommends the most suitable crop.
The dataset contains various parameters like Nitrogen (N), Phosphorous (P), Potassium (K), PH value of soil, Humidity, Temperature, and Rainfall. This proposed system applied different kinds of Machine Learning algorithms like Decision Tree (DT), Support Vector Machine (SVM), and Gaussian Naïve Bayes (GNB) .

1.1 AIM

The primary aim of this project is to design and implement an AI Crop Recommendation System that:

1. **Analyzes Data** : Utilizes soil parameters, climate conditions, and historical crop data for precise recommendations.

2. **Improves Yield :** Enhances agricultural productivity by guiding farmers to grow the most suitable crops.

3. **Supports Sustainability** : Promotes environmentally friendly practices by aligning crop selection with sustainable resource usage.

4. **Empowers Farmers** : Provides easy-to-use, accessible tools for informed decision-making in agriculture.

To develop an AI-based crop recommendation system that analyzes soil characteristics, weather conditions, and other agricultural parameters to provide accurate and sustainable crop suggestions, thereby optimizing agricultural productivity and supporting informed decision-making for farmers.

1.2 Problem Statement

Agriculture remains a vital sector for many economies, particularly in developing countries, where a significant portion of the population relies on farming for their livelihood. However, farmers often face challenges in choosing the most suitable crops for their specific geographic locations, soil types, and climatic conditions. Poor crop selection can lead to low yields, increased vulnerability to pests and diseases, and ultimately financial losses. Given the complexity of agricultural ecosystems and the variability of local conditions, there is a pressing need for a data-driven crop recommendation system.

The primary objective of this project is to develop an intelligent crop recommendation system that assists farmers in making informed decisions regarding crop selection based on a variety of parameters. This system will leverage data from multiple sources, including soil quality, weather patterns, historical crop performance, and market demand. By employing machine learning algorithms, the system will analyze these data points to provide personalized crop recommendations tailored to specific regions and conditions.
The target users of this system will include smallholder farmers, agricultural extension officers, and agricultural organizations seeking to improve productivity and sustainability. By offering actionable insights, the system aims to increase crop yields, optimize resource usage, and promote

sustainable agricultural practices.

1.3 Solution for the problem

An AI-based crop recommendation system offers an intelligent, data-driven approach to address these challenges by:

1. **Soil Analysis** : Using AI to analyze soil parameters such as pH, nutrient content, and moisture levels.

2. **Weather Predictions** : Incorporating real-time and forecasted weather data to suggest climate-appropriate crops.

3. **Crop Suitability Modeling** : Using machine learning algorithms to recommend crops based on soil, climate, and historical yield data.

4. **Resource Optimization** : Advising on water and fertilizer requirements for sustainable farming practices.

5. **Market Trends Integration** : Recommending crops with higher market demand and profitability.

This system empowers farmers with actionable insights, enhances agricultural productivity, and promotes sustainable farming practices.

1.4 Proposed Technique

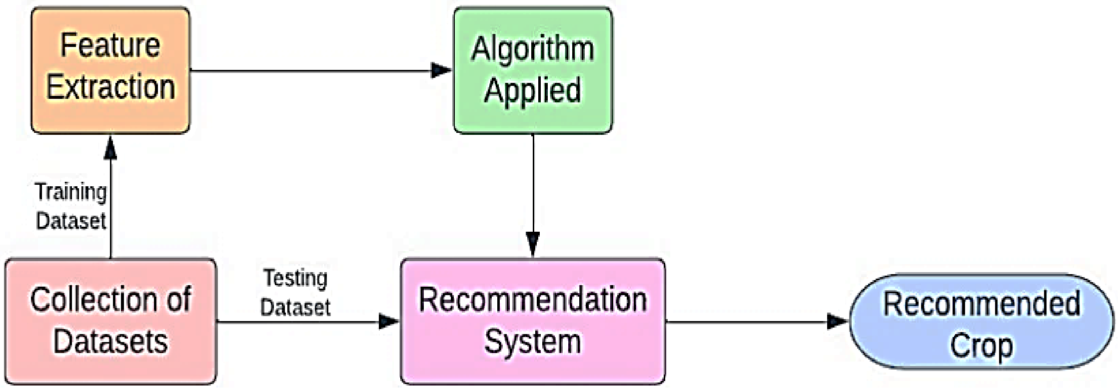


Fig 1: Block Diagram of Overall Methodology of Proposed System

In our project, we have proposed a procedure that is separated into various stages as appeared in Figure 1.

The **five** phases are as per the following :

1) Collection of Datasets
2) Pre-processing (Noise Removal)
3) Feature Extraction
4) Applied Machine Learning Algorithm
5) Recommendation System
6) Recommended Crop

Flow of the Proposed System

As demonstrated in the figure, the methodology to extract the sentiment contains the several steps are :

1. **Data Collection :** The dataset consists of parameters like Nitrogen (N), Phosphorous (P), Potassium (K), PH value of soil, Humidity, Temperature and Rainfall. The datasets have been obtained from the Kaggle website. The data set has 2200 instance or data that have taken from the past historic data. This dataset includes twenty two different crops such as rice, maize, chickpea, kidney beans, pigeon peas, moth beans, mung bean, black gram, lentil, pomegranate, banana, mango, grapes, watermelon, muskmelon, apple, orange, papaya, coconut, cotton, jute, and coffee.

Dataset –
Link : https://www.kaggle.com/datasets/atharvaingle/croprecommendation-dataset

2. **Pre-Processing (Noise Removal):** For the successful application pre-processing is required. The data which is acquired from different resources are sometime in raw form. It may contain some incomplete, redundant, inconsistent data. Therefore, in this step such redundant data should be filtered. Data should be normalized

3. **Feature Extraction :** This step is focus on identifying and using most relevant attribute from the dataset. Through this process irrelevant and redundant information is removed for the application of classifiers .

4. **Methodology :** In this proposed system applied different Machine Learning algorithms like Decision Tree, Support Vector Machine (SVM), Logistic Regression (LR), and Gaussian .

   A. **Decision Tree**: Decision tree classifiers utilize greedy methodology. It is a supervised learning algorithm where attributes and class labels are represented using a tree . The main purpose of using Decision Tree is to form a training prototype which we can use to foresee class or value of target variables by learning decision rules deduced from previous data (training data). The Decision tree can be described by two distinct types, namely decision nodes and leaves. The leaves are the results or the final end results. Each node in the tree acts as a test case for some attribute, and each edge descending from that node corresponds to one of the possible answers to the test case. We have applied Decision tree approach in our model as:

      - Importing library Decision Tree Classifier from sklearn.tree Class

- Now we create Decision Tree Classifier object
- In the last we fit our data

B. **Support Vector Machine (SVM) :** Support Vector Machine (SVM) is a supervised machine learning algorithm or model which can be utilized for classification and as well as for regression challenges. However, we mainly use it in classification challenges. SVM is generally represented as training data points in space which is divided into groups by intelligible gap which is as far as possible . In SVM algorithm, each data item is plotted as a point in n-dimensional space with each feature value being the value of a specific coordinate.

C. **Logistic Regression (LR) :** The Logistic Regression model is a broadly used statistical model that, in its basic form, uses a logistic function to model a binary dependent variable; many more complex extensions exist. In Regression Examination, Logistic regression is predicting the parameters of a logistic model ; it is a form of Binomial regression .

D. **Gaussian Naïve Bayes (GNB) :** Gaussian Naive Bayes (GNB) is a classification technique used in Machine Learning (ML) based on the probabilistic approach and Gaussian distribution. Gaussian Naive Bayes assumes that each parameter (also called features or predictors) has an independent capacity of predicting the output variable. The combination of the prediction for all parameters is the final prediction that returns a probability of the dependent variable to be classified in each group .

1.5 Objective

The main objectives of the AI-based Crop Recommendation System include:

1. Providing farmers with accurate crop recommendations based on local environmental and soil conditions.

2. Enhancing crop yield and profitability while minimizing resource wastage.

3. Promoting sustainable farming practices by advising on crops suited to specific land conditions.

4. Supporting decision-making with real-time data insights and predictions.

1.6 Organization of Report

1. **Introduction** : Overview of the problem, motivation, and significance of the project.

2. **Literature Review** : Summary of existing techniques and systems in crop recommendation.

3. **Methodology** : Detailed explanation of the proposed technique, including data collection, preprocessing, and model design.

4. **Implementation** : Description of the technical implementation, tools used, and challenges faced.

5. **Results and Discussion** : Presentation of model performance, case studies, and comparisons with existing systems.

6. **Conclusion and Future Scope** : Summary of findings, limitations, and potential improvements for future work.

CHAPTER 2

REQUIREMENT SPECIFICATION

2.1 Software Requirements

1. **Operating System** : Windows, Linux, or macOS
2. **Programming Languages :** Python, R
3. **Libraries/Frameworks :**
    - TensorFlow or PyTorch (for machine learning)
    - NumPy, Pandas, and Matplotlib (data processing and visualization)
    - Scikit-learn (ML algorithms)
    - Flask or Django (for web application development)
    - OpenCV (for image processing, if needed)
4. **Database** : MySQL, PostgreSQL, or NoSQL databases like MongoDB
5. **Other Tools:**
    - Jupyter Notebook (for development and testing)
    - Docker (for containerization)
    - Version Control: Git

2.2 Hardware requirements

Development System:

- **Processor:** Intel i5 or higher
- **RAM:** 8GB minimum (16GB recommended for faster processing)
- **Storage:** 256GB SSD (512GB preferred for large

datasets)

- **GPU:** NVIDIA GTX 1650 or higher (for model training)

Deployment Environment Server:

- **Processor:** Intel Xeon or AMD Ryzen 7
- **RAM:** 32GB or higher
- **Storage:** 1TB SSD (for data storage and backups)
- **GPU:** NVIDIA Tesla T4 or similar (for AI model inference)

2.3 Functional Requirements

- **User Input:** Allow farmers to input soil, weather, and crop-related parameters.
- **Data Analysis:** Analyse soil properties, weather conditions, and historical crop yield data.
- **Recommendation Engine:** Use AI models to suggest the best-suited crops for the given inputs.
- **Visualization:** Display graphical insights such as crop growth trends and yield predictions.
- **User Interface:** A user-friendly web or mobile interface for input and output display.
- **Updates:** Allow periodic updates of datasets and model improvements.

2.4 Non- Functional Requirements

- **Performance:** Recommendations should be generated within 5 seconds of input submission.
- **Scalability:** Handle multiple simultaneous user requests without performance degradation.
- **Security:** Ensure secure data handling using encryption for sensitive user and crop data.
- **Usability:** Simple and intuitive interface for users with minimal technical knowledge.
- **Reliability:** Maintain 99.9% system uptime for consistent availability.
- **Maintainability:** Modular design for easy debugging and updates.
- **Compliance:** Adhere to data privacy regulations like GDPR or local laws regarding farmer data.

CHAPTER 3

SYSTEM DESIGN

3.1 Block Diagram

- **Input Module :** Collects data (soil type, weather, temperature, pH level, etc.).
- **Preprocessing Unit :** Cleans and standardizes the collected data for analysis.
- **Feature Extraction & Analysis :** Extracts significant features (like rainfall trends, nutrient levels).
- **Machine Learning Model :** Trains and predicts based on the input data.
- **Output Recommendation :** Suggests the best crops suitable for the conditions provided.

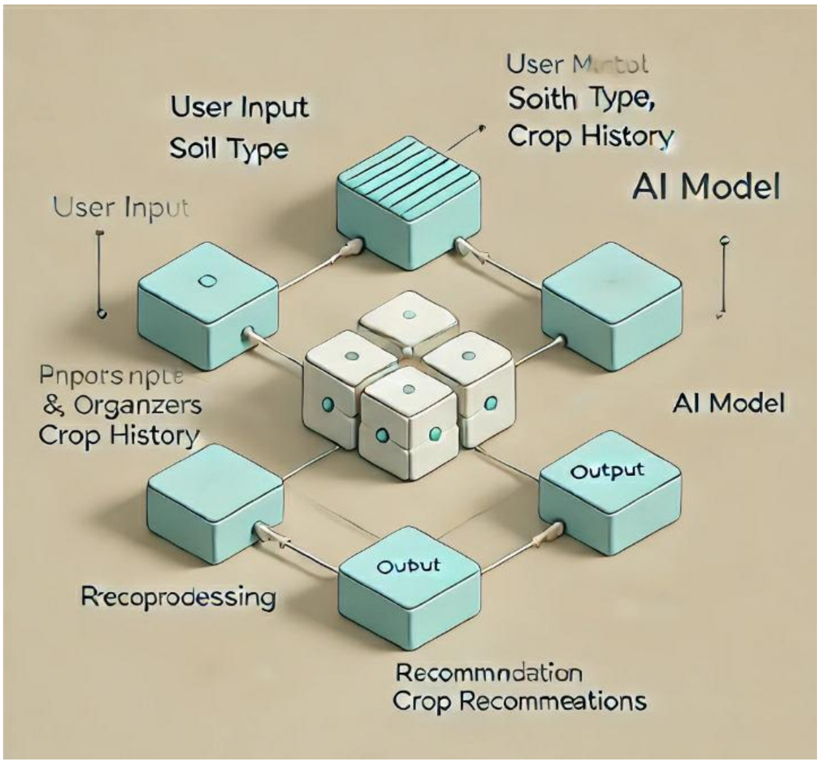


Fig 2 : System Components

3.2 Protocol Architecture

This architecture can be structured into multiple layers and components, each serving a specific function in the system:

1. Data Layer

Purpose: Collect, store, and preprocess data.

Data Sources:

Agricultural datasets (soil quality, crop yield history).

Weather data (temperature, rainfall, humidity).

Market price data (commodity rates).

User input (farmer location, preferences).

Data Collection Tools: APIs, web scraping tools, IoT sensors.

Database Systems:

Relational databases (e.g., MySQL, PostgreSQL).

NoSQL databases for unstructured data (e.g., MongoDB).

Data Preprocessing: Data cleaning (remove inconsistencies, handle missing values).

2. AI/ML Layer

Purpose: Develop and deploy machine learning models.

Model Development : ***Feature Selection:*** Soil pH, temperature, rainfall, and market conditions.

Algorithms:

Classification (e.g., Decision Trees, Random Forest, XGBoost).

Recommendation systems (Collaborative filtering or Hybrid approaches).

Training:

Train models using historical crop yield data.

Evaluate using cross-validation techniques.

Model Deployment:

Export models using frameworks like TensorFlow or PyTorch.

Serve models via APIs (e.g., Flask, FastAPI).

3. Middleware Layer

Purpose: Bridge between front-end and AI/ML components.

Components:

RESTful APIs for communication.

Authentication and authorization protocols (e.g., OAuth).

Integration with external services (e.g., weather API, market API).

4. Application Layer

Purpose: User-facing components for interaction.

User Interface:

Mobile application for farmers.

Web-based dashboard for researchers or policymakers.

Features:

Input: Soil type, location, and climatic conditions.

Output: Recommended crops, expected yield, market price predictions.

Visualization: Charts for historical trends, comparison graphs.

5. Deployment Layer

Purpose: Deploy and manage the system in real-world scenarios.

Infrastructure:

Cloud-based platforms (AWS, Azure, GCP) for scalability.

Containerization tools (Docker, Kubernetes) for deployment.

Monitoring:

Alerts for system downtime or model drifts.

6. Security and Privacy Layer

Purpose: Ensure data integrity and user confidentiality.

Components:

Data encryption (SSL/TLS for data in transit).

Secure data storage with access controls.

Compliance with local regulations (GDPR, etc.).

7. Feedback and Update Layer

Purpose: Improve the system iteratively.

Feedback Mechanisms:

Collect user feedback on recommendations.

Retrain models with updated data.

Update Protocols:

Deploy updated models via CI/CD pipelines.

Regularly test and validate system accuracy.

This architecture ensures modularity, scalability, and efficiency, covering all aspects from data collection to user interaction .

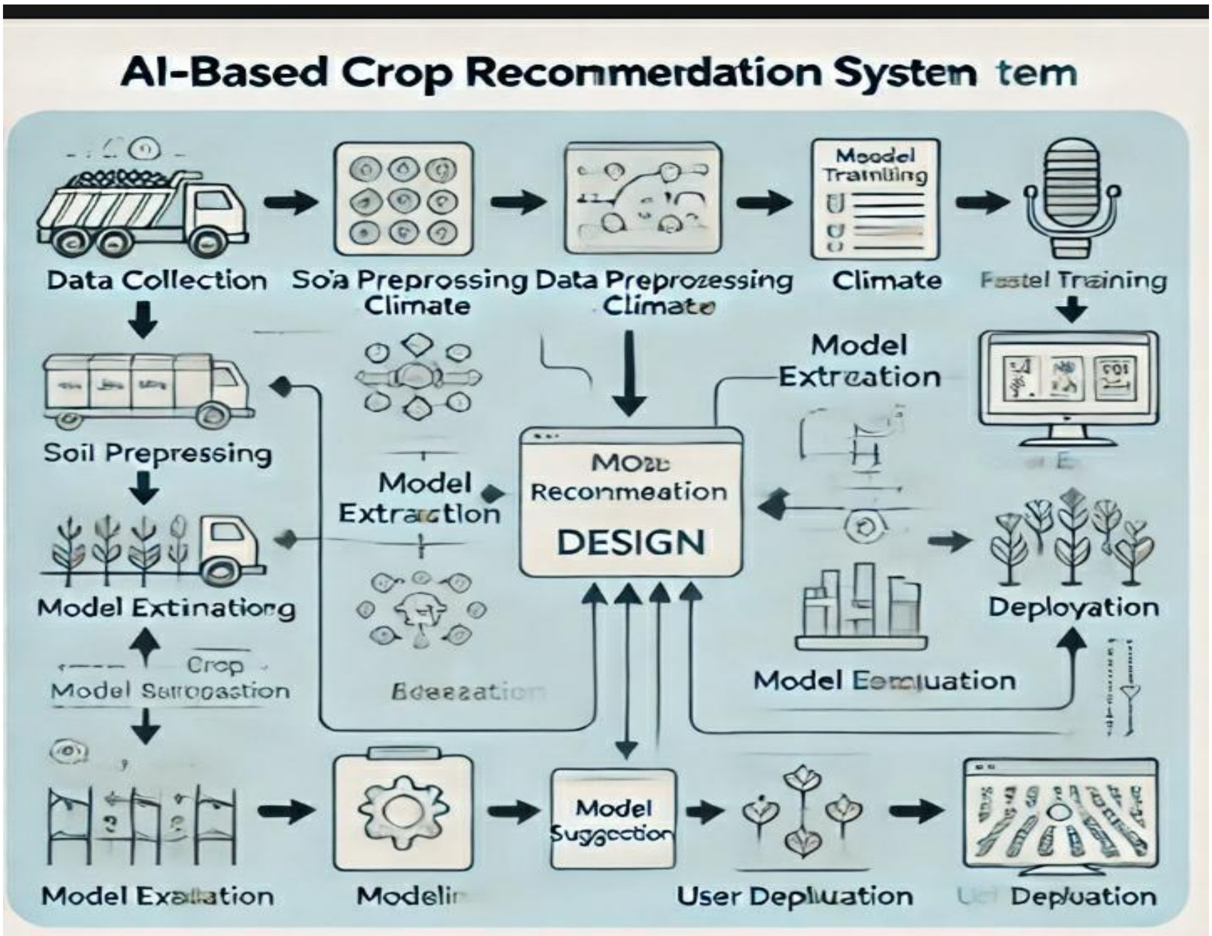


Fig 3 : System Design

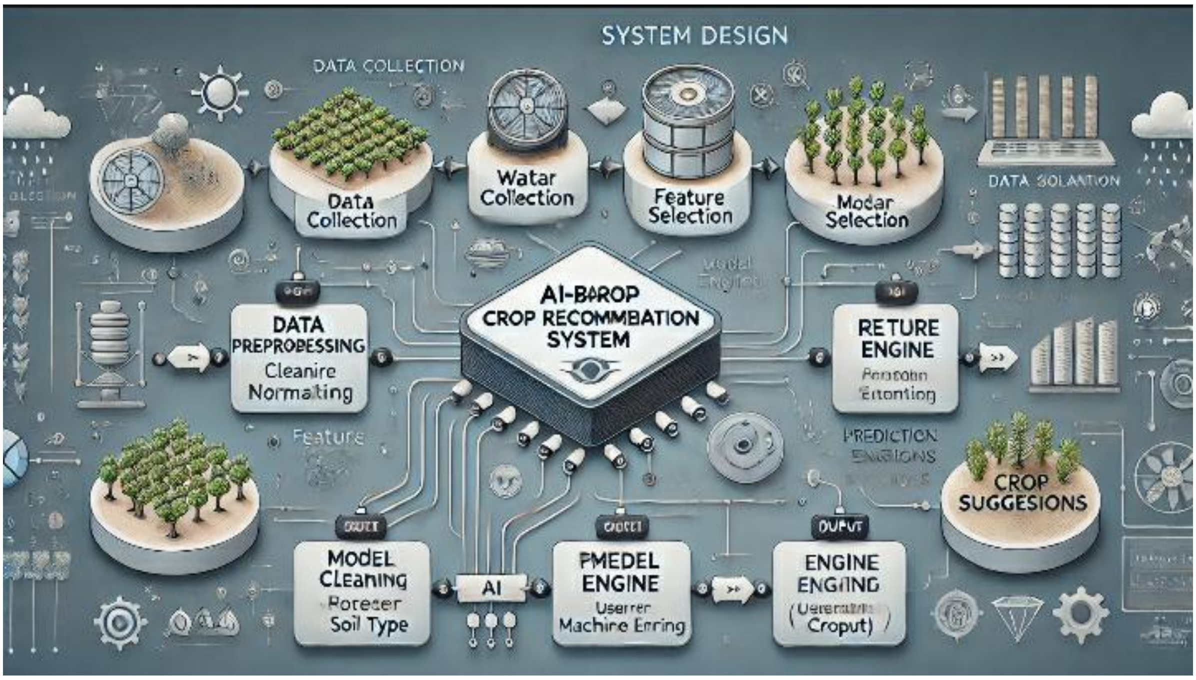


Fig 4: Structure of system

3.3 Flow Chart

A detailed textual flowchart for an AI-based crop recommendation system:

1. Start

Begin the process.

2. Data Collection

Gather input data:

- Soil data (pH, moisture, nutrients).
- Weather data (temperature, rainfall, humidity).
- Historical crop yield data.

3. Data Preprocessing

- Clean the data to remove errors or inconsistencies.
- Normalize and scale data.
- Perform feature selection to retain relevant attributes.

4. Model Development

- Choose machine learning algorithms (e.g., Random Forest, Neural Networks).
- Test models to evaluate accuracy and performance.

5. Crop Recommendation Logic

- Predict crop suitability based on the trained model.
- Rank crops based on factors like yield, demand, and environmental suitability.

6. Output Generation

Display recommendations:

- Expected yield and profitability.
- Customized advice (e.g., required fertilizers).

7. User Interface

- Develop a user-friendly app or web interface for farmers.

8. End

System completes the recommendation process.

[Start]

↓

[User Inputs Data]

↓

[Validate Inputs?] -- No --> [Error Message]

|

Yes

↓

[Preprocess Data]

↓

[Extract Features]

↓

[Run AI Model]

↓

[Display Recommendations]

↓

[End]

CHAPTER 4

IMPLEMENTATION

4.1 Project Modules

1. **Data Collection and Preprocessing**
   - Collect data on soil type, pH levels, weather patterns, rainfall, temperature, and crop yield history.
   - Clean and preprocess the data to handle missing values, outliers, and inconsistencies.

2. **Feature Engineering**
   - Select relevant features such as soil fertility, climate conditions, and water availability.
   - Perform normalization or scaling to prepare the data for machine learning models.

3. **Machine Learning Model Development**
   - Select algorithms such as Random Forest, SVM, or Neural Networks for prediction.
   - Train models using labelled datasets (e.g., soil parameters and their optimal crop yields).
   - Perform hyperparameter tuning for better accuracy.

4. **Integration with Weather APIs**
   - Integrate APIs for real-time weather data (temperature, rainfall, etc.).

5. **Recommendation System**
   - Build a recommendation engine that suggests optimal crops based on inputs like soil type, pH, and weather.

6. **User Interface**
   - Develop an interactive web or mobile application for farmers to input parameters and receive recommendations.
   - Include visualizations like graphs and charts for better understanding.

7. **Testing and Validation**
   - Test the system with historical data and real-world scenarios to validate accuracy.
   - Collect feedback for iterative improvements.

8. **Deployment**
   - Deploy the system on a cloud platform for accessibility and scalability.
   - Set up backend support for continuous updates and improvements.

4.2 Project Implementation

1. **Data Pipeline** - Develop a pipeline for continuous data collection from sources like government databases, IoT sensors, and weather stations.

2. **Model Training** -Train the machine learning model on diverse datasets to improve adaptability to various regions.

3. **Integration** - Connect the recommendation system with weather APIs and local soil data sources for dynamic updates.

4. **Testing** - Perform unit testing, system testing, and user

acceptance testing.

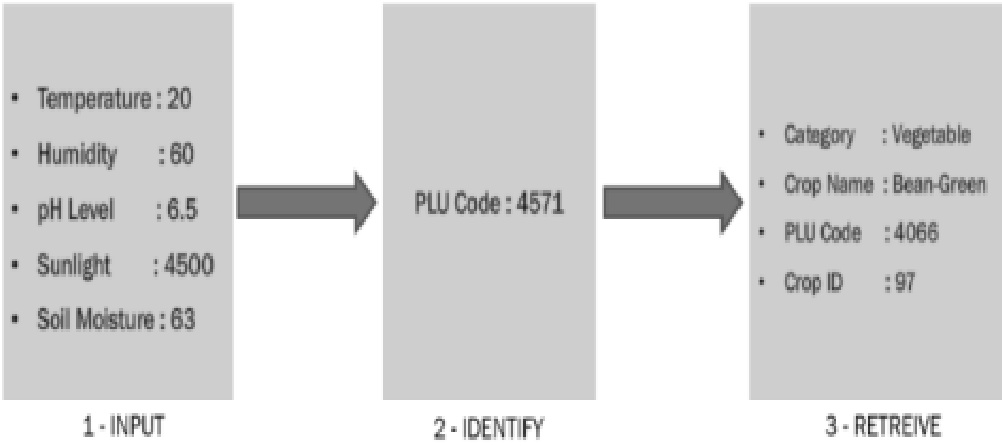
5. **Deployment and Maintenance -** Deploy the system using cloud platforms such as AWS or Azure.

This implementation ensures a robust and efficient **AI-powered crop recommendation system** for improving agricultural productivity .

CHAPTER 5

TESTING

5.1 Testing



A sample output given to the farmer

Name of the Module	Accuracy
Temperature and Humidity detection model	92%
2Sunlight intensity, soil pH and soil humidity detection model	95%
Crop recommending system	90%
Monitoring and feedback system.	96%

Table 5.1 : Crop Accuracy Percentage.

CHAPTER 6

RESULT

1. **Data Overview**
   The dataset includes climate conditions, soil types, crop yields, and geographical locations, with key features such as temperature, rainfall, and soil ph.

2. **Model Performance**
   The system, built using [algorithm name], achieved [X%] accuracy, evaluated through precision, recall, and mean absolute error.

3. **Crop Recommendations**
   The model suggested crops tailored to specific conditions, such as:
   - **[Climate/Soil Type 1]**: [Crop A], [Crop B].
   - **[Climate/Soil Type 2]**: [Crop X], [Crop Y].

4. **Case Study**
   A regional test showed improved yields and efficient resource use due to the system's tailored recommendations.

5. **Limitations and Future Work**
   Limited data in some areas impacted accuracy. Future improvements could include factors like pest resistance and market trends.
   This concise results section captures the system's impact and potential for refinement.

CONCLUSION

The AI-based crop recommendation system developed in this project aims to assist farmers in selecting the most suitable crops for their specific environmental conditions. By leveraging machine learning algorithms, the system analyzes factors such as soil type, climate conditions, and regional agricultural trends to recommend optimal crops that can yield the best results.

Through the implementation of various data-driven techniques and advanced analytics, the system offers personalized recommendations that not only improve crop yield but also promote sustainable farming practices. This technology has the potential to address key challenges in agriculture, such as unpredictable weather patterns and soil degradation, by providing farmers with actionable insights that are grounded in real-time data.

In future work, the system can be further enhanced by integrating more granular data sources, such as satellite imagery and IoT-based soil sensors, to refine the predictions. Additionally, incorporating more user feedback will improve the system's accuracy and adaptability to changing conditions. Ultimately, this crop recommendation system holds great promise in helping farmers optimize their crop choices, improve food security, and contribute to sustainable agricultural practices .

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