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Web-Based Soil Health & Fertilizer Advisory System

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ABSTRACT: Agricultural productivity largely depends on soil health and proper fertilizer management. However, many farmers still rely on traditional practices and may not have clear knowledge about soil nutrient conditions. This paper presents a Web-Based Soil Health and Fertilizer Advisory System that helps farmers analyze soil parameters and obtain suitable fertilizer recommendations. The system collects soil data such as Nitrogen (N), Phosphorus (P), Potassium (K), and pH values and processes the information to determine nutrient deficiencies. Based on the analysis, the system suggests appropriate fertilizers and quantities required to improve soil fertility. The system is implemented using a web-based platform that allows users to easily access the advisory service. The results show that the system can provide quick and useful recommendations, helping farmers improve crop productivity and maintain healthy soil conditions.

KEYWORDS: Soil Health, Fertilizer Recommendation, Precision Agriculture, Web Application, Soil Nutrient Analysis, Sustainable Agriculture.

I. INTRODUCTION:

Agriculture plays a vital role in food production and economic development. The productivity of crops largely depends on soil quality, nutrient availability, and proper fertilizer usage. Soil nutrients such as Nitrogen (N), Phosphorus (P), Potassium (K), and pH levels significantly influence crop growth and agricultural yield. However, many farmers still depend on traditional farming knowledge rather than scientific soil analysis when selecting crops and fertilizers.

This often leads to improper fertilizer application, soil nutrient imbalance, and decreased crop productivity. Additionally, soil test reports are usually complex and difficult for farmers to interpret without expert assistance.

To address these issues, digital agricultural advisory systems can assist farmers in making better farming decisions. A web-based soil advisory platform can analyze soil parameters and provide simple fertilizer recommendations that farmers can easily understand and apply. The objective of this research is to develop a Web-Based Soil Health and Fertilizer Advisory System that helps farmers analyze soil conditions and select appropriate fertilizers to improve crop productivity and maintain soil fertility.

II. PROBLEM STATEMENT:

Agricultural productivity is highly dependent on soil health and proper fertilizer usage. However, many farmers do not have easy access to accurate soil analysis and often rely on traditional farming practices or general recommendations when selecting fertilizers. This can lead to improper fertilizer application, nutrient imbalance in the soil, and reduced crop productivity. In addition, soil test reports are usually complex and difficult for farmers to interpret without expert guidance. As a result, farmers may not be able to make informed decisions about soil management and fertilizer usage. Therefore, there is a need for a simple and accessible system that can analyze soil nutrient parameters and provide clear fertilizer recommendations to support better agricultural decision-making.

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III. LITERATURE REVIEW:

Several research studies have explored the use of digital technologies and data analysis techniques to improve agricultural productivity and soil management. These studies highlight the importance of soil analysis, crop recommendation systems, and fertilizer advisory platforms for supporting farmers in making better agricultural decisions.

[1] Ramesh K. et al. developed a soil-based crop recommendation system that analyzes soil parameters such as nitrogen, phosphorus, potassium, and pH values. The system uses machine learning algorithms to predict suitable crops based on soil conditions. The study demonstrated that analyzing soil nutrients can help farmers select appropriate crops and improve productivity.

[2] Swetha P. et al. proposed a crop recommendation system using machine learning techniques such as Decision Tree, Random Forest, and Support Vector Machine. The system analyzes agricultural datasets and environmental parameters to recommend suitable crops for cultivation. The results showed improved prediction accuracy; however, the system mainly focused on crop selection rather than fertilizer advisory.

[3] Senapaty M. K. et al. presented an intelligent agricultural system that integrates soil analysis and crop prediction models. The system evaluates soil fertility parameters and uses data analysis techniques to support agricultural decision-making. Their work highlights the importance of data-driven approaches in modern farming practices.

[4] Shettigar C. K. et al. proposed an agricultural monitoring system that combines machine learning techniques with soil and environmental data. The system provides recommendations related to crop growth and soil nutrient management. Although the system improves agricultural monitoring, it requires advanced technological infrastructure for implementation.

IV. SYSTEM ARCHITECTURE AND WORKFLOW:

System Architecture:

The Web-Based Soil Health and Fertilizer Advisory System follows a modular architecture designed to analyze soil parameters and provide fertilizer recommendations through an online platform. The system integrates web technologies, soil data processing modules, and a recommendation engine to support efficient agricultural decision-making. The architecture ensures smooth interaction between the user interface, application logic, and database components.

The overall architecture consists of several functional layers that work together to collect soil information, process the data, generate fertilizer recommendations, and display results to the user.

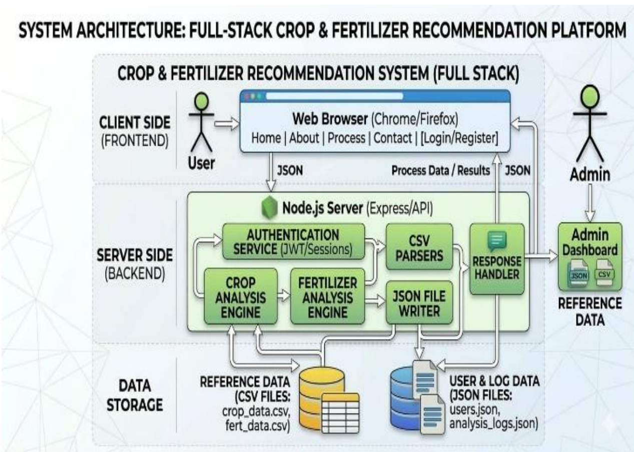

Figure 1   6.1 System Architecture

Presentation Layer (User Interface)

The presentation layer represents the front-end interface of the system through which users interact with the platform. It is developed using web technologies such as HTML, CSS, and JavaScript. Through this interface, farmers or users can enter soil parameters including nitrogen (N), phosphorus (P), potassium (K), and pH values. The interface is designed to

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be simple and user-friendly so that users can easily provide soil data and view fertilizer recommendations without requiring technical knowledge.

Application Layer

The application layer acts as the core processing unit of the system. It manages communication between the user interface and the backend processing modules. This layer handles user requests, processes input data, and sends the information to the soil analysis module for further evaluation. The application layer ensures smooth system functionality and controls the execution of different system components.

Soil Data Processing Layer

The soil data processing layer is responsible for analyzing the input soil parameters provided by the user. It evaluates soil nutrient levels such as nitrogen, phosphorus, potassium, and pH values. The system compares the input data with predefined agricultural guidelines and identifies nutrient deficiencies or imbalances in the soil. This analysis helps determine the appropriate fertilizer recommendations required to improve soil fertility.

Recommendation Engine

The recommendation engine is the decision-making component of the system. Based on the analysis of soil parameters, this module generates suitable fertilizer recommendations for the user. The system determines the type and quantity of fertilizers required to maintain balanced soil nutrients. The recommendation engine ensures that the suggestions provided to farmers are clear, accurate, and easy to understand.

Database Layer

The database layer stores important system data including soil parameters, fertilizer recommendations, and user inputs. The database helps maintain records for future analysis and ensures that the system can retrieve stored information efficiently. It also supports data management and improves the reliability of the advisory system.

System Workflow:

The system workflow describes the sequence of steps followed by the Web-Based Soil Health and Fertilizer Advisory System to process soil data and generate fertilizer recommendations. The workflow ensures that user input is properly analyzed and converted into useful advisory results.

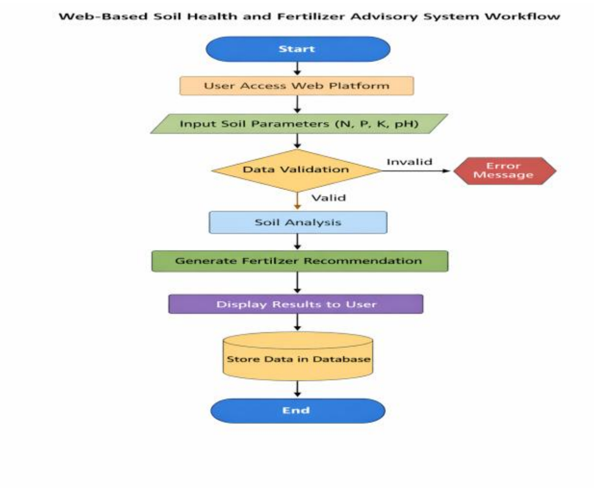

Figure 2 6.2 System Workflow

Step 1: User Access

The process begins when the user accesses the web-based platform through a browser. The user opens the system interface to enter the required soil information.

Step 2: Input of Soil Parameters

The user enters soil parameters such as nitrogen (N), phosphorus (P), potassium (K), and pH values through the web interface. These parameters serve as the primary input data required for soil analysis.

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Step 3: Data Validation

After receiving the input values, the system validates the data to ensure that all required fields are correctly entered. This step helps prevent errors and ensures accurate processing of soil data.

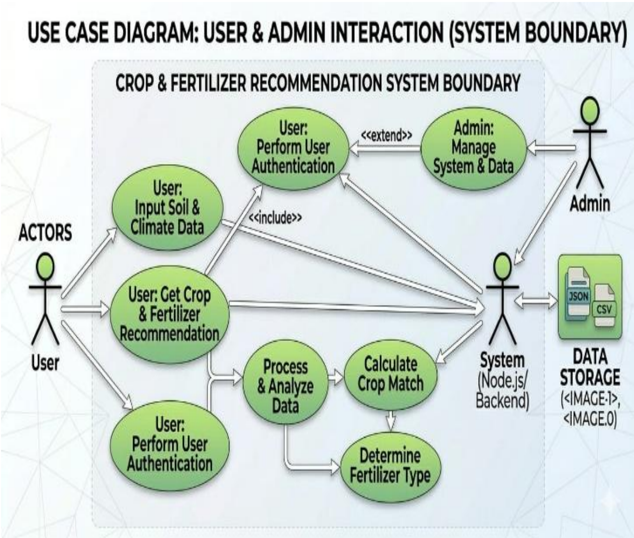

Figure 3   6.2.1 Use Case Diagram

Step 4: Soil Analysis

The system analyzes the input soil parameters and evaluates the nutrient levels present in the soil. It identifies whether the soil contains sufficient nutrients or if there are any deficiencies that need
to be addressed.

Step 5: Fertilizer Recommendation Generation

Based on the soil analysis results, the system generates suitable fertilizer recommendations. The recommendation includes the type of fertilizer required and the nutrients needed to improve soil fertility.

Step 6: Result Display

The generated fertilizer recommendations are displayed to the user through the web interface. The system presents the results in a clear and understandable format so that farmers can easily apply the recommendations.

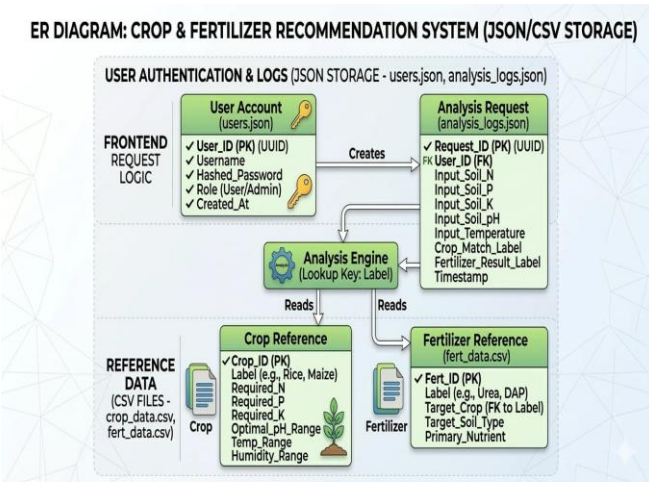

Figure 4   6.2.2 ER   Diagram

Step 7: Data Storage

Finally, the system stores the input soil parameters and generated recommendations in the database for future reference and analysis.

V. PROPOSED METHODOLOGY:

Data Collection:

The proposed system collects soil and environmental parameters from users through a web-based input form. These parameters are essential for analyzing soil fertility and identifying nutrient deficiencies. The collected data is stored in the system database and used for generating fertilizer recommendations.

Data collected in the system includes:

- Soil Nitrogen (N) value
- Soil Phosphorus (P) value
- Soil Potassium (K) value
- Soil pH level
- Soil type
- Crop type (if provided by the user)
- Geographic location or region information
- Soil fertility status
- Fertilizer recommendation output data

These parameters are widely used in agricultural advisory systems because nutrient values such as N, P, K and soil pH strongly influence crop growth and fertilizer requirements.

Data Preprocessing:

Before analyzing the collected soil data, preprocessing steps are performed to improve data quality and ensure accurate system output.

A. Data Cleaning

The system removes incorrect or incomplete values entered by the user. Invalid entries such as negative nutrient values or missing fields are detected and corrected before further processing.

B. Data Validation

Input validation checks whether soil parameters fall within acceptable agricultural ranges. For example, soil pH values normally range between **0 and 14**, and nutrient values must be positive numbers.

C. Data Normalization

To ensure consistent analysis, soil parameter values are standardized into comparable ranges. This step helps improve the accuracy of the recommendation logic used in the system.

D. Data Formatting

All input data is converted into structured format suitable for system processing and database storage. This enables efficient retrieval and analysis of soil parameters.

Feature Engineering:

Feature engineering involves selecting and transforming relevant soil parameters into meaningful variables used by the advisory system.

Key engineered features include:

- Soil nutrient level classification (Low / Medium / High)
- Nutrient deficiency indicators
- Soil fertility score
- pH balance classification
- Recommended fertilizer type

By deriving these features from raw soil data, the system can more effectively analyze soil conditions and generate accurate fertilizer recommendations.

Model Development:

The system uses rule-based analysis and machine learning concepts to evaluate soil nutrient conditions and generate fertilizer recommendations.

Possible models used in the system include:

- Decision Tree Model
- Random Forest Model
- Support Vector Machine (SVM)
- Rule-Based Fertilizer Recommendation Engine

These models analyze soil nutrient data and identify patterns that determine the appropriate fertilizer dosage and nutrient correction strategy.

Model Training and Evaluation:

The model is trained using agricultural soil datasets that contain nutrient values and corresponding fertilizer recommendations. During the training process, the model learns relationships between soil parameters and nutrient requirements.

The model performance is evaluated using common evaluation metrics such as:

- Accuracy
- Precision
- Recall
- F1-Score

Testing is performed using different soil parameter inputs to ensure that the system generates correct fertilizer suggestions for various soil conditions.

Integration with Web Application:

After model development, the trained model is integrated into the web-based advisory platform.

The integration process involves:

1. Connecting the prediction model with the backend system.
2. Creating a user interface for soil data entry.
3. Sending input values from the website to the model.

4. Processing the data through the recommendation engine.
5. Returning fertilizer suggestions to the user interface.

This integration enables farmers to easily access soil analysis results through a web browser.

Result Generation and Report Creation:

Once the soil data is analyzed, the system generates a fertilizer advisory report.

The report includes:

- Soil nutrient status
- Identified nutrient deficiencies
- Recommended fertilizer type
- Suggested fertilizer dosage
- Soil improvement recommendations

The results are displayed on the web interface in a clear and easy-to-understand format so that farmers can take appropriate agricultural actions.

Methodology Summary:

The overall methodology of the proposed system involves collecting soil parameters from users, preprocessing the data, analyzing nutrient conditions, and generating fertilizer recommendations through a web-based platform. The system combines soil data processing, rule-based analysis, and machine learning techniques to support agricultural decision-making. By providing real-time fertilizer advisory information, the system helps farmers improve soil fertility management and optimize crop productivity.

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VI. IMPLEMENTATION AND EVALUATION:

A. Technology Stack

The proposed **Web-Based Soil Health and Fertilizer Advisory System** is implemented using a set of web technologies that support efficient data processing and user interaction. The system is designed as a web-based application so that users can access it easily through an internet browser without requiring specialized software.

The front-end of the system is developed using **HTML, CSS, and JavaScript**, which are used to design the user interface and manage user interactions. The interface allows users to enter soil parameters such as Nitrogen (N), Phosphorus (P), Potassium (K), and pH values in a structured format. The interface is designed to be simple and user-friendly so that even users with limited technical knowledge can operate the system.

The backend of the system handles data processing and system logic. It processes the input soil parameters and performs soil nutrient analysis based on predefined agricultural rules and soil nutrient standards. The backend also manages communication between the user interface and the database.

A database system is used to store soil data, user inputs, and fertilizer recommendation results. The database helps maintain records for future reference and supports efficient retrieval of stored information. By integrating the front-end interface, backend processing modules, and database system, the overall platform provides reliable soil analysis and fertilizer advisory functionality.

B. Functional Validation

Functional validation is conducted to verify whether the system performs the intended operations correctly. The validation process focuses on testing different components of the system to ensure that soil data input, processing, and fertilizer recommendation generation work accurately.

Several test cases were used to evaluate the system by providing different soil parameter values as input. The system successfully processes the entered values of nitrogen, phosphorus, potassium, and pH, and then analyzes the soil nutrient condition. Based on this analysis, the system generates appropriate fertilizer recommendations that aim to correct nutrient deficiencies and maintain soil fertility.

The system also performs input validation to ensure that users enter valid soil parameter values. If incorrect or incomplete data is entered, the system notifies the user and requests proper input before continuing the analysis process. This helps prevent incorrect recommendations and improves the reliability of the advisory system.

The results of the functional validation demonstrate that the system effectively performs soil data analysis and generates fertilizer recommendations in a consistent and accurate manner.

C. Comparison with Existing Literature

Existing research studies in agricultural advisory systems mainly focus on crop recommendation or general soil analysis. Many of these systems apply machine learning algorithms to predict crop suitability based on environmental and soil parameters. While these approaches provide useful insights, they often require complex computational models or advanced hardware infrastructure.

In contrast, the proposed **Web-Based Soil Health and Fertilizer Advisory System** focuses specifically on analyzing soil nutrient conditions and providing fertilizer recommendations through a simple web-based interface. The system emphasizes accessibility and ease of use so that farmers can obtain advisory information without requiring specialized technical knowledge.

Compared with existing approaches, the proposed system provides a more focused solution for soil health management by directly addressing nutrient deficiencies and fertilizer requirements. The web-based design also improves accessibility, allowing users to access the system from different locations using standard internet-enabled devices.

Overall, the proposed system complements existing agricultural advisory technologies by providing a practical and easy-to-use platform for soil nutrient analysis and fertilizer recommendation.

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VII. RESULTS:

The proposed Web-Based Soil Health and Fertilizer Advisory System was tested using different soil parameter inputs to evaluate its functionality and performance. The system successfully analyzes soil nutrient values such as Nitrogen (N), Phosphorus (P), Potassium (K), and pH level and generates appropriate fertilizer recommendations.

During testing, multiple soil datasets were provided through the web interface to observe how the system processes the input data and produces advisory outputs. The system accurately identified nutrient deficiencies in soil and suggested suitable fertilizers to improve soil fertility.

The results show that the system is capable of providing fertilizer recommendations in a quick and efficient manner. The web interface allows users to enter soil parameters easily, and the system processes the data in a short time to generate recommendations. The output results include soil nutrient status, fertilizer suggestions, and basic soil improvement guidance.

The system also demonstrates good usability, as the interface is simple and easy to understand for users without technical knowledge. Farmers or agricultural users can input soil data and obtain advisory results without requiring expert assistance.

Overall, the testing results indicate that the proposed system effectively supports soil nutrient analysis and fertilizer recommendation. By providing accurate and timely advisory information, the system can assist farmers in improving soil fertility management and promoting sustainable agricultural practices.

VIII. CONCLUSION:

This paper presented a Web-Based Soil Health and Fertilizer Advisory System designed to assist farmers in analyzing soil nutrient conditions and obtaining appropriate fertilizer recommendations. The system analyzes important soil parameters such as Nitrogen (N), Phosphorus (P), Potassium (K), and pH levels to determine soil fertility status and identify nutrient deficiencies.

The proposed system integrates soil data analysis with a web-based platform to provide an accessible and user-friendly advisory tool. Through this system, users can easily enter soil parameters and receive fertilizer recommendations that help improve soil productivity and crop growth.

The implementation results demonstrate that the system can effectively analyze soil nutrient conditions and generate useful fertilizer advisory information. The web-based design allows users to access the system easily from different locations using standard internet-enabled devices.

In the future, the system can be enhanced by integrating additional features such as crop recommendation, weather data integration, and advanced machine learning models for more accurate agricultural decision support. These improvements can further strengthen the system's ability to support sustainable farming practices and efficient soil management.

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