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Machine Learning Approaches for Precision Farming, Crop Prediction through Soil Analysis

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Abstract—

Raising agricultural yields to meet the demands of a growing population is a top priority. A number of variables, including soil quality, rainfall, and environmental conditions, affect the agricultural yields of the majority of Indian farmers, who tend to own scattered farmland. About 5.3 billion tons of soil is lost each year in India. Land that is in poor condition can no longer generate enough food. Soil fertility, which is dependent on nutrient levels, is a limiting factor in Indian agriculture; furthermore, soil might be optimal for growing certain crops but disastrous for others. To assess the soil's fertility, plan the cultivation, and forecast the harvest's yield, it is helpful to know the soil's physical, chemical, and biological characteristics.
Topics covered include soil testing, crop recommendations, ML, supervised learning, and categorization.

I. INTRODUCTION

One of the mainstays of the Indian economy is agriculture. In 2011, 60.5% of India's land was used for agriculture, with 52.8% of it going to arable land, 4.2% to permanent crops, and 3.5% to pastures. In 2017–18, agriculture and allied sectors contributed 17.1% to GDP and employed around 42% of the country's total workforce. According to the directorate of economics and statistics (2015), the cultivation areas of key crops in 2013-2014 were 15 million hectars during the Kharif season and 57 million hectars during the Rabi season.
In order to learn what nutrients are present in their soil and in what proportions, many farmers now take soil samples to the nearest Krishi Vigyan Kendra (KVK) center. Soil testing involves analyzing a soil sample to find out what kinds of nutrients it has, how it is made up, and other interesting facts. Typically, tests are conducted to assess fertility and identify areas that require improvement. The data collected by the Soil Health Card (SHC) is useful for keeping track of test results, but it won't tell them exactly which crop to plant for the best harvest. While SHCs are a step in the right direction towards improved soil analysis, most of the decision-making process—including which crops to use and how much fertilizer to apply—is still based on tribal knowledge and experience. This method has been used for a long time and is said to offer some advantages. On the other hand, it's causing more recent and severe issues, such as soil deterioration from using too many fertilizers, poor yields over time, and negative impacts on both humans and the greater environment. The area of data science and computational intelligence has also advanced quickly. Agriculture is only one of several industries seeing an unparalleled surge in digitalization. There is an ever-increasing amount of satellite images and topography at our fingertips, and the land maps have been digitalized. Soil nutrient composition data in vast quantities is at your fingertips. Thanks to cell phones and internet connection, farmers also have access to ubiquitous computing. For instance, they may use mobile applications to register for SHC.

II. LITERATURE REVIEW

Many people have put their hearts and souls into this area. There are essentially two primary ways that soils have been classified, and they are based on:
• Soil biochemistry, including temperatures, pH values, and concentrations of nitrogen, phosphorus, and potassium, among other elements.
• Using satellite photos taken by remote sensing devices and evaluating the resulting photographs of the soil The following studies fall within the first category, which deals with investigating the soil's chemical make-up: "Crop recommendation system for precision agriculture" (S. Pudumalar et al., 2000). [1] makes use of a data mining-based approach that analyzes research data on soil types, soil features, and crop yields to recommend the best crop for farmers

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according to their unique site conditions. This improves output while decreasing the likelihood of picking the incorrect crop. In order to provide a crop for the site-specific parameters with high accuracy and efficiency, this work proposes an ensemble model with majority voting approach. The model uses Random tree, CHAID, K-Nearest Neighbor, and Naive Bayes as learners. This solves the issue. The article "A Machine Learning Approach to Assess Crop Specific Suitability for Small/Marginal Scale Croplands" was written by Bhimanpallewar R et al. [2] suggests a machine learning approach that takes into account the crop in question, environmental factors, and the current availability of soil components as inputs, and returns a suitability level for that crop as an output. Decisions like how to make the soil more suitable or how to maintain the area undeveloped for a certain amount of time may be aided by this approach, despite its limitations. 'Predicting if land is suitable for agricultural production using a parallel random forest classifier.' The authors of the study by Senagi K et al. [3] used an improved ML algorithm to forecast whether a piece of land would be good for growing sorghum crops based on data about the soil. Parallel Random Forest (PRF), Linear Regression (LR), Linear Discriminant Analysis (LDA), KNN, Gaussian Naïve Bayesian (GNB), and Support Vector Machine (SVM) are the experimental setting up methods used. Classifying soils according to their composition is an area that has received very little attention. Among these is "An Analysis of Agricultural Soils by using Data Mining Techniques" (Ramesh Babu and Rajesh Reddy, 2018). referenced in [4], [5] by Supriya D., "Analysis of Soil Behaviour and Prediction of Crop Yield using Data Mining Approach," [6] by Sirsat M. et al., and "Crop Recommendation System Using Neural Networks," [7], "Classifying Land Suitability with Machine Learning" [8]. Some examples of research that has made use of soil and remote sensing satellite images are: • "Deep Learning Classification of Land Cover and Crop Types Using Remote Sensing Data" [9] by Kussul N et al. employs a multi-level DL architecture to classify land cover and crop types from multi-temporal, multi-source satellite images. The foundation of the design is a collection of supervised neural networks (NNs), plus an unsupervised NN for optical image segmentation and missing data restoration from clouds and shadows. It compares convolutional neural networks (CNNs) with classical fully-connected multilayer perceptrons (MLPs) and random forests, the two most popular methods in the remote sensing (RS) field. • In their study titled "Improving crop classification with landscape stratification based on MODIS-time series," Driessen B et al. [10] investigate the feasibility of using MODIS images with a moderate resolution for stratification purposes instead of using detailed soil and elevation maps. For more effective monitoring, it employs the principle of land stratification, which entails dividing a target region into smaller pieces. A training set has been used to do classification using many methods, including k-NN, multinomial logistic regression, RF, SVM, and ML. • A approach that automatically classifies crops from spatio-temporal remote sensing is described in '3D Convolutional Neural Networks for Crop Classification with Multi-Temporal Remote Sensing Images' [11] by Ji S et al. • Rose M. Rustowicz's "Crop Classification with Multi-Temporal Satellite Images" The use of machine learning to crop categorization using time series satellite images is discussed in [12]. Research into a broader agricultural industry has been attempted and encouraged by the government. A massive quantity of data is being made accessible for study as part of the SHC's broad program. 'Detection & Prediction of Pests/Diseases Using Deep Learning' [13] and similar initiatives follow a similar trajectory.

III. PROPOSED SYSTEM

We may now do the soil analysis, sort the soil into different types, and then further divide them into cultivation categories based on which crops they are most suited to. Machine learning, big data analysis, and the ever-increasing computing capacity of cloud-based GPU farms will all be used by the suggested system. There will be two stages to the implementation of this in the proposed system: • In the first stage, there is a system that sorts the soil by its fertility levels, nutrients, and other characteristics. • In Phase 2, you'll discover the connection between the soil classification groups discovered in Phase 1 and the crop nutrient requirements. This may be achieved by grouping crops that have comparable fertility and soil nutrient needs into labels. Soil analysis is the intended use of the following data by the proposed system: • The soil's biochemical make-up • Images of the soil • Remote sensing data and satellite images of the land (when accessible) Crop nutrient needs (both macro and micro), soil pH, water retention capacity, and electrical conductivity are some of the characteristics that may be used to assign crops to certain soil types. The suggested system is going to employ a mix of the following methods: Using decision trees, neural networks, support vector machines, and other deep learning techniques for classification, etc. • Bayes

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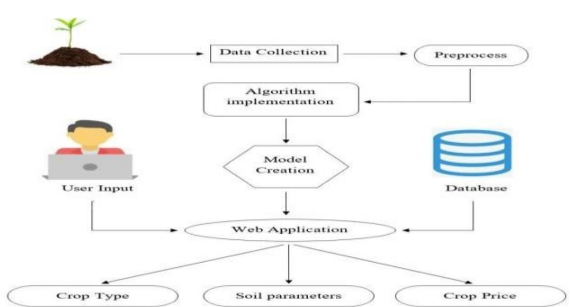
distribution, regressions, and other statistical techniques

IV. GAPS AND SUGGESTED SOLUTION

So far, every method and endeavor has relied on one of two main pillars: (a) analysis and classification of soil composition or (b) analysis and classification using remote sensing satellite photos or soil pictures. 2. We need to address the issue comprehensively so that we may mix and utilize the best of both methods. It can save a lot of time and money by automatically classifying soil pictures based on previous soil composition categorization. Thirdly, previous research and solutions have only focused on soil classification or crop recommendation; what we really need is a streamlined, end-to-end solution that can suggest crops based on the soil classification and labeling that has already been done. 4. Soil classification and crop suitability suggestion are handled by the solution using Supervised Machine Learning (ML) methods. Trained models may be used to identify and categorize fresh soil samples, as well as determine the appropriateness of crops for those samples. 5. In the end, the proposed method would lead to better agricultural yields and more money in the farmers' pockets.

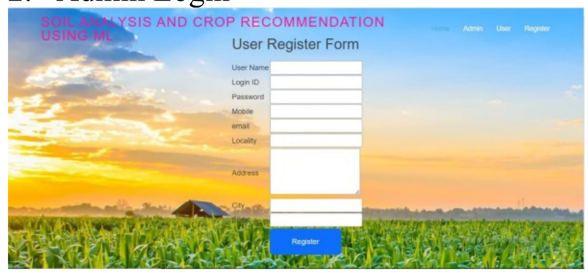
SYSTEM ARCHTECTURE:



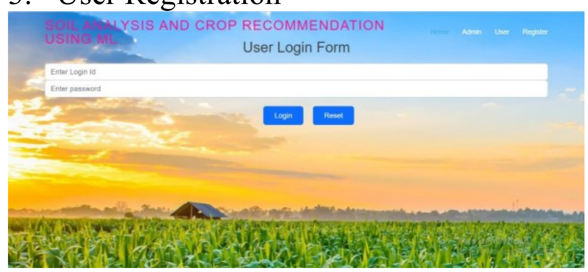
SYSTEMIMPLEMENTATION:

1. Home Page

2. Admin Login



3. User Registration



4. User Login

5. Module Prediction

V. OBJECTIVES

Our goal is to accurately classify the soil using its biochemical makeup and/or the given digital picture. There should be a method to determine the crop's compatibility and achieve the maximum crop production based on the soil labeling. The procedure will be made more precise with the use of modern computing methods such as data science and machine learning. up addition to preventing soil erosion and loss, this practice will deter farmers from focusing too much on a single crop and fill up nutritional gaps. In an ideal world, the following goals would be achieved by the suggested system: Conduct a soil analysis using biochemical and environmental parameters as well as digital imaging. Soil fertility,

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nutrient content, water holding capacity, and other characteristics should be used to categorize the soil. • Suggest which crops might do best in certain types of soil. • Assist in halting soil erosion and preventing soil loss. • Assist in the adoption of soil-appropriate crops; dissuade monoculture, which depletes soil fertility. • Maximize return on investment while enhancing agricultural productivity.

VI. CONCULUSION AND FUTURE SCOPE

The project demonstrates the significance of using modern computational techniques like machine learning for soil analysis and crop suitability recommendation. By accurately classifying soil based on biochemical and environmental factors, the proposed system enables farmers to choose suitable crops, thereby maximizing yield and reducing soil degradation. This innovative approach bridges the gap between traditional agricultural practices and data-driven precision farming, contributing to sustainable agriculture. The Future expansion may be done in different areas like 1). Integration of Advanced Technologies: Incorporate real-time data collection using IoT sensors for continuous monitoring of soil health and environmental conditions. 2). Enhanced Models: Develop more sophisticated machine learning algorithms to improve classification accuracy and crop recommendations. 3). Global Applicability: Expand the system's application to include varied geographic regions by integrating region-specific soil and crop data. 4). Farmer-Friendly Tools: Design mobile apps or platforms for farmers to easily access soil analysis results and crop suggestions in their native language.

Collaboration with Government Programs: Align with government initiatives like Soil Health Cards to offer comprehensive, streamlined solutions to farmers.

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