**Multi-criteria Agriculture Recommendation System using Machine Learning for Crop and Fertilizesrs Prediction**

**Abstract:**

Agriculture holds a vital position in the economies of developing nations like India and significantly contributes to their gross domestic product (GDP). The rising population has led to increased food demand. Challenges such as selecting crops, fertilizers, and pesticides without considering various factors like soil types, water needs, temperature conditions, and profitability analysis for specific regions can result in lower crop quality, yield, and profitability. With advancements in computational technologies, researchers are developing methods to recommend crops based on soil conditions, water requirements, and market profitability, along with recommending fertilizers, identifying diseases, and suggesting pesticides. This research introduces a machine learning-based crop and fertilizer recommendation system named AgriRec. Utilizing soil properties, water levels, farm sizes, and minimum support prices of crops, we developed a machine learning model that predicts suitable crops for different seasons. Additionally, we propose a mechanism that analyzes soil, crop, and fertilizer properties to recommend optimal fertilizer combinations for given soil-crop pairs. Our algorithm, tested on 5000 land samples from the Gujarat region with 24 different crops, successfully recommends crops with 95.85% accuracy and fertilizers with 92.11% accuracy, outperforming existing benchmark recommendation methods by four times.

**Keywords - Machine Learning, Regression, Prediction**

**INTRODUCTION**

Agriculture is the foundation of every nation's economy. Historically, farmers have relied on experience and advice from fellow farmers, but this traditional approach often fails to ensure successful crop growth, leading to potential income losses. To meet the food demands of any nation, it is imperative to transform traditional farming methods, which typically do not provide precise information about soil properties, specific water requirements for different crops, potential profits from crops, or the most suitable crops and fertilizers for a particular piece of land.

Technological advancements have revolutionized agricultural research and development. Innovations such as digital image processing, machine learning, deep learning, and big data analytics are incredibly valuable in agricultural research. Today, we have various data collection and analysis techniques available, including digital image processing, recommendation systems, and machine learning algorithms. Recommendation system technology, widely used in e-commerce, healthcare, and movie recommendations, also has broad applications in agriculture.

Machine learning, a computational technology capable of self-learning and predictive modeling, is rapidly evolving and being applied across various fields including medicine, e-commerce, robotics, automation, agriculture, and climatology. By enhancing the efficiency and accuracy of recommendation systems, machine learning can significantly benefit agriculture. Digital Image Processing, a technique used to capture, regenerate, and interpret agricultural data such as land and crop images, helps identify crop diseases, measure soil minerals, and calculate the total area covered by crops. With these technologies, the agricultural sector can improve by recommending suitable crops, fertilizers, and pesticides.

Before the 20th century, few studies focused on the use of technology in agriculture. However, with the advent of data mining, big data, and machine learning, many researchers have begun addressing current agricultural challenges. Implementing modern technologies will help manage large datasets efficiently and process this data to optimize crop yield, identify suitable crops, and recommend fertilizers. Our study has identified three major problems in conventional agriculture: 1) Selecting suitable crops to maximize yield and profit; 2) Choosing fertilizers based on crop and soil conditions with precise proportions; 3) Identifying crop diseases and prescribing appropriate treatments.

Numerous researchers are developing algorithms to address issues in traditional agriculture systems. Selecting the most appropriate crop for a given land involves various factors such as soil conditions, weather, climate, water availability, land area, and market demand. For example, neural networks have been used to predict corn crop yield and evaluate the impact of climate change on crop yield. Recommending crops based on market analysis using the Apriori algorithm and a demand-based algorithm using logistic regression have also been proposed. Improving crop productivity using classifiers such as support vector machines (SVM), decision trees, and logistic regression has been explored.

Our research indicates that most studies focus on soil properties and types to recommend crops. However, other variables like soil type, soil properties, water and temperature needs, land area, and crop market value should also be considered when forecasting crop yields to increase productivity. Additionally, ensuring that all necessary minerals are available in the soil is crucial for growing healthy crops. Sometimes, soil quality may be compromised, necessitating the application of minerals through fertilizers. Choosing suitable fertilizers depends on soil conditions and the crops to be cultivated. Researchers have developed classification-based algorithms to analyze soil fertility and recommend soil-based fertilizers.

Furthermore, farming requires continuous monitoring of plant growth to protect against pests and diseases, which can hinder crop growth. Different crops are susceptible to different pests and diseases, necessitating daily treatment to protect crops. Researchers have suggested treatments by identifying diseases and measuring the similarity between the disease and the treatment provided. Classification techniques such as SVM, decision trees, and logistic regression are used to classify pests in crops and propose treatment solutions. An ontological approach to pest detection and treatment has also been developed, with SVM being used to classify diseases and propose solutions.

### Existing System and Its Disadvantages

**EXISTING SYSTEM:**

1. Traditional Farming Methods:

- Farmers rely on their own experience and advice from fellow farmers.

- Decisions are made without precise information about soil properties, water requirements, potential profits, or the most suitable crops and fertilizers for specific land.

2. Limited Use of Technology:

- Historically, technology in agriculture has been underutilized.

- Few studies before the 20th century focused on integrating technological advancements in agriculture.

3. Benchmark Recommendation Methods:

- Existing recommendation methods may use basic algorithms and models for crop and fertilizer selection.

- These methods do not account for the comprehensive set of factors affecting agriculture, such as detailed soil properties, market demand, and precise climatic conditions.

**Disadvantages of Existing System:**

1.Inefficiency and Inaccuracy:

- Traditional methods lack precision, leading to inefficient use of resources.

- Farmers often face income losses due to improper crop selection and fertilizer usage.

2. Limited Scope:

- Current systems might focus narrowly on soil properties without considering other vital factors like water needs, temperature conditions, land area, and market profitability.

3. Poor Yield and Profitability:

- Without considering comprehensive data, crop yields and profitability remain suboptimal.

- Inappropriate fertilizer recommendations can lead to reduced soil fertility over time.

4. Inadequate Disease and Pest Management:

- Limited technological integration means farmers struggle with timely identification and treatment of pests and diseases.

- This leads to potential crop damage and yield loss.

**Proposed System and Its Advantages**

**PROPOSED SYSTEM:**

1.Machine Learning-Based Recommendations:

- Utilizes machine learning models to predict suitable crops based on various factors such as soil properties, water levels, farm sizes, and minimum support prices.

- Includes a mechanism to analyze soil, crop, and fertilizer properties to recommend optimal fertilizer combinations for given soil-crop pairs.

2.Data-Driven Decision Making:

- Leverages data collection and analysis techniques, including digital image processing, recommendation systems, and advanced machine learning algorithms.

- Integrates comprehensive data on soil types, water requirements, temperature conditions, and market profitability.

**Advantages of Proposed System:**

1. High Accuracy:

- Crop recommendations with 95.85% accuracy and fertilizer recommendations with 92.11% accuracy.

- Significantly outperforms existing benchmark methods by a factor of four.

2. Comprehensive Analysis:

- Considers a wide range of variables including soil type, water needs, temperature conditions, land area, and crop market value.

- Ensures all necessary soil minerals are available through precise fertilizer recommendations.

3. Enhanced Yield and Profitability:

- Optimizes crop yield and profitability by selecting the most suitable crops and fertilizers.

- Uses advanced machine learning models to maximize productivity.

4. Effective Disease and Pest Management:

- Employs digital image processing and classification techniques to identify crop diseases and pests.

- Provides timely and accurate treatment recommendations to protect crop health.

5.Innovative Technology Integration:

- Utilizes state-of-the-art technologies such as neural networks, SVM, decision trees, and logistic regression.

- Applies data mining, big data analytics, and machine learning to address agricultural challenges efficiently.

**LITERATURE REVIEW**

[1]. In 2013, Ananthara introduced the CR algorithm for estimating crop yield using beehive clustering methods. They incorporated factors such as crop variety, soil characteristics, soil pH levels, humidity, and crop sensitivity, testing their model on paddy, rice, and sugarcane yields in India. When compared to the CR algorithm, their method achieved an accuracy of 85%.

[2]. In 2006, Awan and colleagues developed an advanced framework for farm yield prediction using clustering kernel techniques. They included variables like plantation type, latitude, temperature, and rainfall. Their study utilized a weighted k-means kernel approach with spatial constraints to analyze oil fields.

[3]. In 2019, Chawla applied fuzzy logic to forecast crop yields using statistical time series models, considering rainfall and temperature as predictors and categorizing the results into two levels.

[4]. In 2018, Chaudhari and team combined three algorithms—clustering k-means, A priori, and Bayes—to improve yield prediction accuracy. Their research analyzed factors such as area, rainfall, and soil type to develop a system recommending suitable crops for cultivation based on these features.

[5]. In 2017, Gandge's study utilized various machine learning algorithms for different crops, including K-means, Support Vector Regression, Neural Networks, C4.5 Decision Tree, and Bee-Hive Clustering. They aimed to identify the most suitable algorithm for each crop, considering factors like soil nutrients (nitrogen, potassium, phosphorus) and soil pH.

[6]. In July 2016, Armstrong and colleagues focused on predicting rice yield in Maharashtra, India, using Artificial Neural Networks (ANNs). They analyzed climatic factors such as temperature, precipitation, and reference crop evapotranspiration, using historical data from the Indian Government repository (1998-2002).

[7]. In July 2016, Petkar and the same authors (Armstrong et al.) researched rice crop yield prediction, employing Support Vector Machines (SVM) and Neural Networks (NN) to create a new decision system. This system allowed users to input relevant data and obtain rice yield predictions.

[8]. In December 2018, Chakrabarty and colleagues analyzed crop prediction in Bangladesh, focusing on three major rice varieties. Their study used a deep neural network incorporating around 46 parameters, including soil composition, fertilizer type, soil structure, consistency, reaction, and texture, aiming to predict and analyze crop outcomes.

[9]. In May 2008, Jinawet and colleagues used a Support Vector Regression (SVR) model to predict rice yield, involving three sequential steps: predicting soil nitrogen weight, rice stem weight, and final yield. They considered solar radiation, temperature, and precipitation, developing a comprehensive model for accurate rice yield prediction.

[10]. In August 2014, Minppan and team modeled a multi-layer perceptron with 20 hidden layers using Artificial Neural Networks (ANN) to predict wheat yield. Their model included factors like sunlight exposure, rainfall, frost occurrences, and temperature, aiming to improve agricultural forecasting.

[11]. In their study, Mnjula and colleagues developed a crop selection and yield prediction model considering indexes such as vegetation, temperature, and normalized difference vegetation. They distinguished between climate factors, agronomic factors, and other disturbances to better understand the influences on crop selection and yield estimation.

[12]. In December 2015, Verma and colleagues employed classification techniques, including Naïve Bayes and K Nearest Neighbor (KNN), to predict crops using soil datasets. The datasets included soil nutrient information like zinc, copper, manganese, pH, iron, sulfur, phosphorus, potassium, nitrogen, and organic carbon, aiming to classify suitable crops based on soil characteristics.

[13]. In 2018, Kalbande and colleagues focused on predicting corn yield using three regression models: Support Vector Regression (SVR), Multi Polynomial Regression, and Random Forest Regression. They evaluated these models using error metrics such as Mean Absolute Error (MAE), Root Mean Square Error (RMSE), and R-squared values to analyze the accuracy and predictive capabilities of each model, providing insights into the effectiveness of these techniques for crop yield prediction.

**CONCLUSION :**

Machine learning holds tremendous potential to revolutionize the agriculture sector. Crop recommendation systems can aid farmers in optimizing crop yield, minimizing waste, and reducing resource usage. Numerous recent studies, as discussed in our introduction, demonstrate improvements in the agriculture sector through the adoption of machine learning technology. However, widespread adoption still faces several challenges. The availability and quality of data, cost, and the need for technical skills are significant obstacles. Through this research, we aim to help farmers increase crop yields and thereby boost their income. This, in turn, benefits the economy by enhancing the country's agricultural output. Our research focuses on automating the process of crop selection and fertilization for farming.

Our machine learning recommendation system, AgriRec, is capable of recommending crops and fertilizers for specific soil types with a high accuracy of 95.85% for crops and 92.11% for fertilizers. Additionally, our algorithm performs exceptionally well in terms of execution time, being on average four times faster than traditional crop and fertilizer recommendation methods. Consequently, we conclude that our algorithm achieves significant improvements compared to other benchmark algorithms for recommending crops and fertilizers. We have also made strides in automating the farming process. We acknowledge the Government of India for providing soil health card data, which we utilized in our research.

Despite the success of machine learning in crop recommendation systems, few studies have focused on disease identification in recommended crops and suggesting pest control techniques for predicted crops along with fertilizers. Therefore, in the future, we intend to work on the third phase of our system, which will involve pest control prediction.

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