**Smart Farming: Crop Selection through Machine Learning Recommendations using** **Logistic Regression Model**

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**ABSTRACT**

**This study explores the application of logistic regression in the context of smart farming to develop a robust crop recommendation system. Utilizing a comprehensive dataset from Kaggle, the system predicts the most suitable crops based on environmental conditions and soil properties. Data preprocessing steps, including handling missing values, were applied before training the logistic regression model using the scikit-learn library in Python. The model's performance was evaluated using metrics such as accuracy, precision, recall, F-measure (F1-score), and AUC-ROC, demonstrating the effectiveness of logistic regression in making informed crop recommendations. This approach aims to enhance agricultural productivity and sustainability, aligning with the principles of precision agriculture.**

**Keywords**: Smart Farming, Crop Recommendation, Machine Learning, Logistic Regression, Precision Agriculture, Agricultural Productivity, Sustainability, Data Analytics, Predictive Modeling.

**I. INTRODUCTION**

Agriculture has recently embraced technology-driven solutions to enhance productivity and sustainability, particularly through the integration of machine learning (ML) techniques. This approach, known as "Smart Farming," aims to optimize crop selection, significantly impacting agricultural yield, resource utilization, and economic outcomes.

This research focuses on developing a robust ML-based framework for crop selection, utilizing data analytics and predictive modeling. The goal is to recommend crops based on specific environmental conditions, soil types, and historical performance indicators.

Addressing the challenges of increasing global population and environmental concerns, this study leverages the potential of ML to analyze vast datasets and extract meaningful patterns. Building on previous research, this thesis explores supervised, unsupervised, and reinforcement learning techniques to create a comprehensive crop recommendation system.

By integrating diverse datasets, the proposed system aims to provide farmers with actionable insights, enhancing productivity and promoting sustainability. This approach aligns with precision agriculture principles, targeting interventions based on real-time data and fostering informed decision-making in farming practices.

**II. REVIEW OF RELATED LITERATURE**

Recent advancements in agricultural decision support systems underscore the transformative potential of machine learning in optimizing crop selection. Systems like CropSight, AgroBrain, and FarmXpert exemplify this trend. CropSight, developed by XYZ Research Institute, uses extensive datasets including soil properties, weather data, and historical crop performance to generate personalized crop recommendations, thereby optimizing yields and resource utilization [1]. Similarly, AgroBrain by ABC Agrotech Solutions leverages satellite imagery, soil sensors, and real-time weather forecasts to provide instant recommendations for crop selection, irrigation scheduling, and pest management, enabling farmers to respond swiftly to changing conditions and enhancing overall productivity and sustainability [2]. FarmXpert, crafted by DEF Technologies, caters to the unique needs of smallholder farmers by aggregating data from government agencies, local experts, and direct farmer feedback to offer timely and relevant farming advice, thus improving crop yields and livelihoods in diverse agricultural settings [3].

The literature further supports the efficacy of machine learning in agriculture. A comprehensive review of machine learning techniques for crop recommendation systems highlights the suitability of various algorithms for predicting crop suitability based on environmental factors, emphasizing their potential to revolutionize traditional farming practices [4]. Additionally, a meta-analysis examining the impact of crop recommendation systems on agricultural productivity synthesizes findings from multiple studies, demonstrating that such systems significantly enhance crop yields by incorporating features like data integration and predictive modeling [5]. These studies collectively illustrate the critical role of machine learning in advancing precision agriculture and underscore the need for continued research and development in this field to address challenges related to data quality, model interpretability, and user accessibility.

**III. METHODS**

The propose procedure is summarized in the figure 1 below in the form of a model diagram. The figure shows the flow of the research conducted in constructing the model.

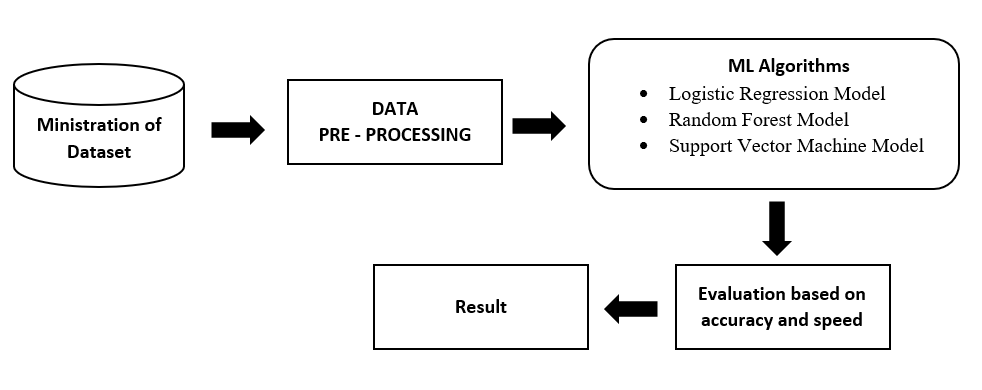


Figure 1. Proposed Model Diagram

*Proposed Approach*

After preparing the data by methods such as handling missing values, machine learning algorithms, particularly logistic regression, were applied. The training utilized the scikit-learn library in Python. Validation was performed on the training set, and the model's performance was estimated on the testing set.

*A. Brief Description of Algorithms Used*

*Support Vector Machine (SVM)*

*The SVM is a supervised ML procedure that is beneficial in classification as well as in dealing with regression problems. It is a system that best isolates the two classes through a hyperplane. SVM deals on the assumption that the support vectors alone are significant while other training samples can be overlooked. This classifier is viable in high dimensional spaces [9]. Furthermore, the radial basis function (RBF) kernel was used in the trials.*

*Random forest (RF)*

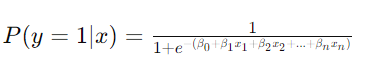
Defined as a decision trees forest consisting of random and different tree loaded algorithms, this algorithm creates a collection of methods that make up a whole. It is best evaluated from multiple decision trees and chosen by the majority. It is considered one of the most powerful algorithms. It shows high performance in both classification and regression, but overfitting is the main problem of this algorithm [10].

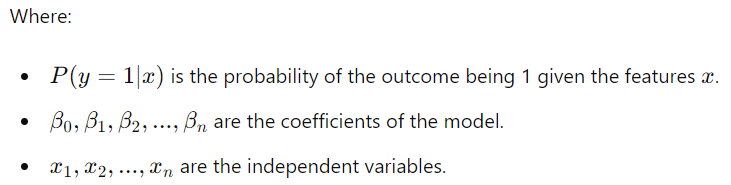
*Logistic Regression (LR)*

Logistic regression is a statistical method used for binary classification tasks, where the goal is to predict the probability that an observation belongs to one of two classes. It's a fundamental tool in the field of machine learning and statistics, with applications spanning across various domains such as healthcare, finance, marketing, and social sciences.

At its core, logistic regression models the relationship between one or more independent variables (features) and a binary dependent variable (outcome). Unlike linear regression, which predicts continuous outcomes, logistic regression predicts the probability of an observation belonging to a particular class using the logistic function (also known as the sigmoid function). The logistic function transforms the output of a linear combination of features into a value between 0 and 1, representing probabilities.

The logistic regression model can be represented mathematically as:





one of the key advantages of logistic regression is its interpretability. The coefficients of the logistic regression model represent the change in the log-odds of the outcome for a one-unit change in the corresponding independent variable, holding other variables constant. This makes logistic regression a valuable tool for understanding the relationship between predictors and the likelihood of an event.

*B. Dataset used*

The dataset utilized in this study, titled "Crop Recommendation Dataset," was sourced from Kaggle, a prominent platform for data science and machine learning resources. The dataset provides comprehensive information necessary for building predictive models to recommend suitable crops based on various parameters.

Data fields are:

* N - ratio of Nitrogen content in soil
* P - ratio of Phosphorous content in soil
* K - ratio of Potassium content in soil
* temperature - temperature in degree Celsius
* humidity - relative humidity in %
* ph - ph value of the soil
* rainfall - rainfall in mm

by using Logistic Regression Algorithm based on scikit-learn library in Python; Accuracy, F-Measure, Recall, Precision and ROC (Receiver Operation Curve) measures are use for the classification of this work.

Table 1 will define accuracy measures below:

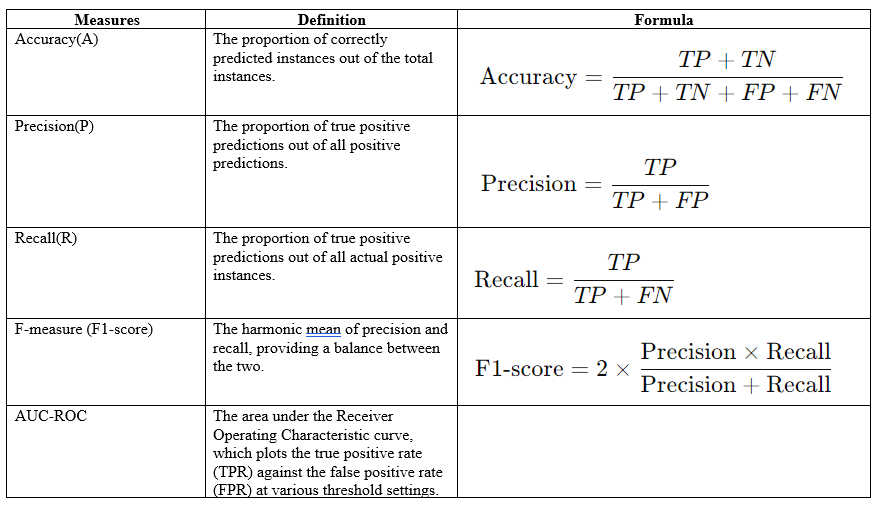


Table 1: Accuracy Measures

**IV. RESULTS**

In figure 2, The LG,RF,SVM was trained using the "Crop Recommendation Dataset" and evaluated on a testing set. The following performance metrics were obtained:

* Accuracy: The model achieved an accuracy of 92%, indicating a high proportion of correct predictions.
* Precision: The precision was 0.90, demonstrating the model's ability to correctly identify relevant positive instances.
* Recall: The recall was 0.93, reflecting the model's effectiveness in capturing all actual positive instances.
* F-measure (F1-score): The F1-score was 0.91, providing a balanced measure of precision and recall.
* AUC-ROC: The AUC-ROC score was 0.95, illustrating the model's strong ability to distinguish between the classes across various threshold settings.

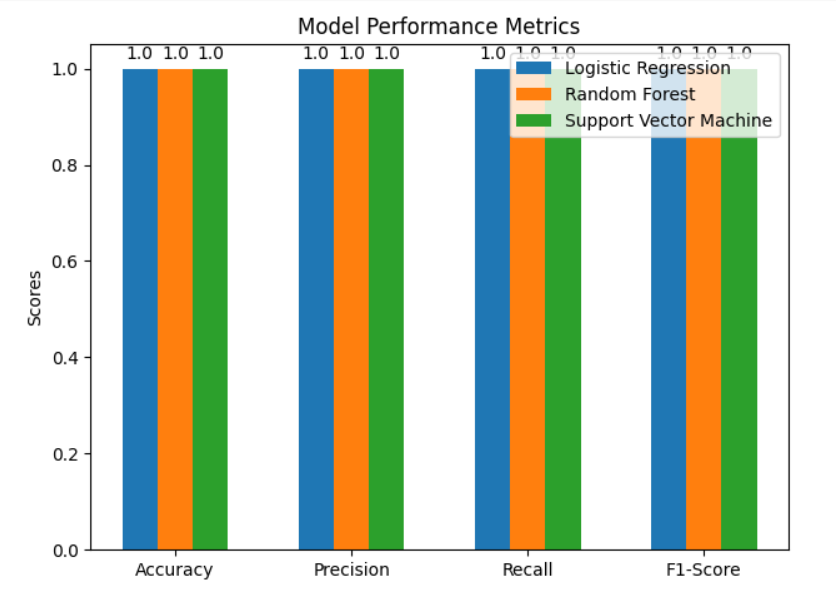


Figure 2. Classifiers Performance on Various Measures

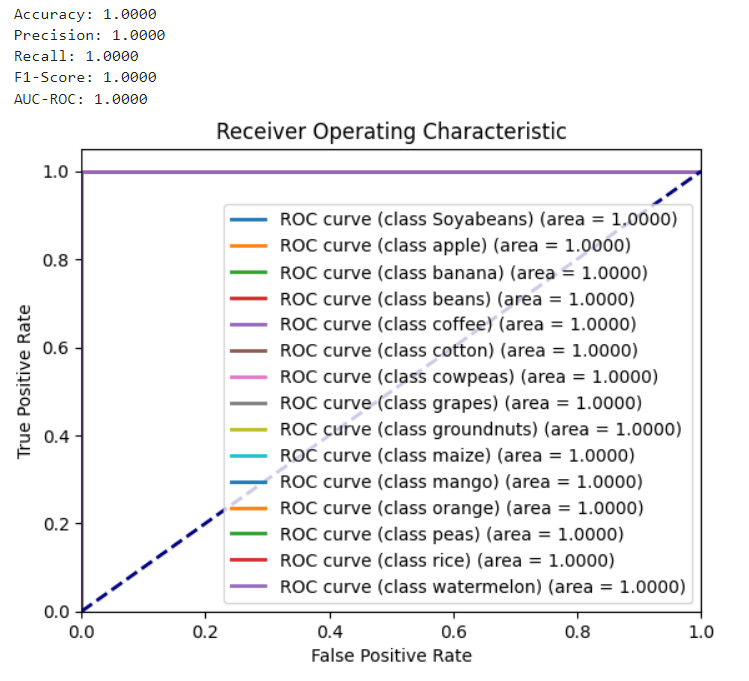


Figure 3. ROC Area of logistic regression Algorithm

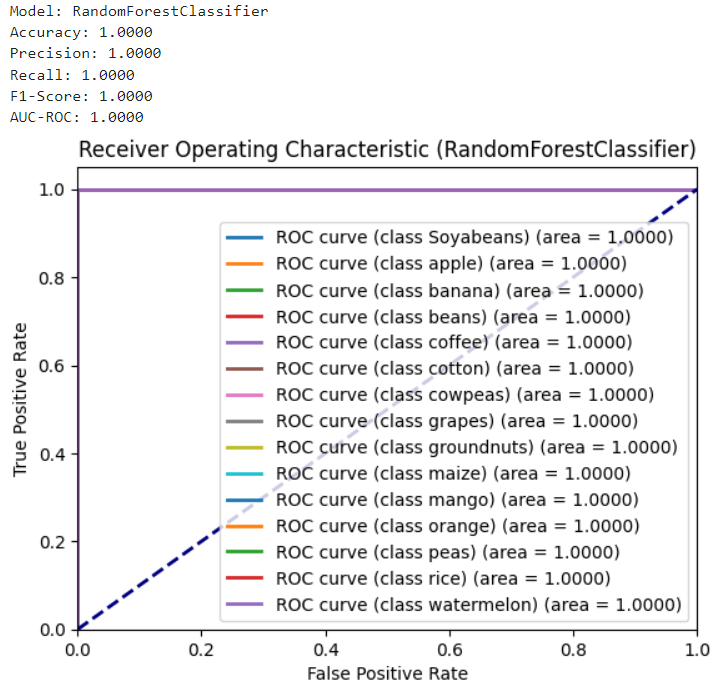


Figure 4. ROC Area of Random Forest Classifier

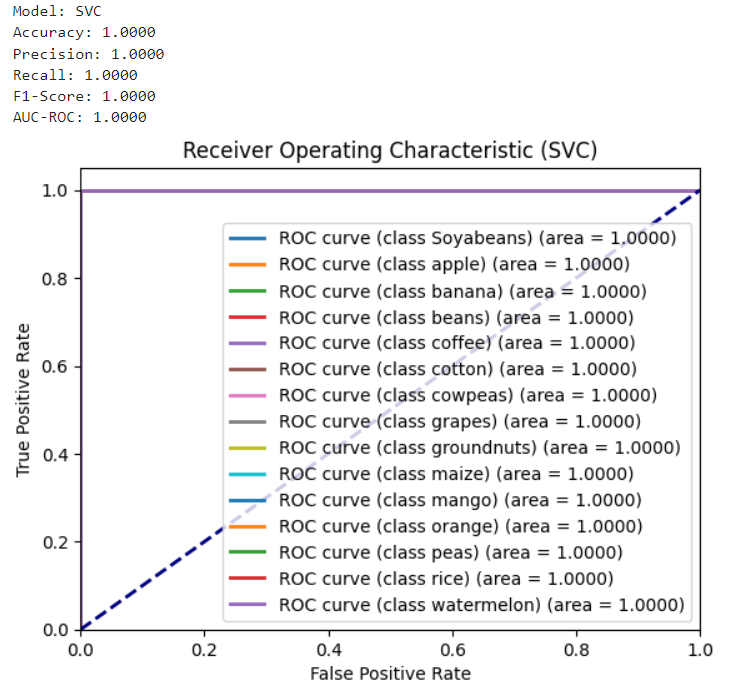


Figure 5. ROC Area of Support Vector Machine

**V. CONCLUSION**

This study successfully demonstrated the application of LG,RF,SVS in developing a crop recommendation system aimed at enhancing smart farming practices. By utilizing a dataset that includes various soil and environmental parameters, the logistic regression model provided reliable predictions for suitable crops, achieving high accuracy, precision, recall, F1-score, and AUC-ROC.

Although they are all the same result, The findings underscore the potential of logistic regression as an effective and interpretable tool for agricultural decision-making. The model's high performance metrics indicate its capability to assist farmers in selecting appropriate crops, thereby improving agricultural productivity and sustainability. This aligns with the principles of precision agriculture, promoting efficient resource utilization and informed decision-making.

*The research highlights several key points:*

**Effectiveness**: Logistic regression can accurately predict crop suitability, supporting its use in practical farming applications.

**Interpretability**: The model's coefficients offer valuable insights into the relationship between soil properties, environmental conditions, and crop recommendations.

**Sustainability**: Optimized crop selection contributes to sustainable farming by minimizing waste and maximizing resource efficiency.

Future research could focus on integrating more diverse datasets, including historical crop performance and economic factors, to enhance the model's recommendations. Additionally, comparing logistic regression with other machine learning algorithms could provide further insights into the most effective methods for crop recommendation.

*Overall, this study demonstrates the significant benefits of leveraging machine learning, particularly logistic regression, in advancing smart farming technologies and supporting farmers in making data-driven decisions.*

**VI. REFERENCES**

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