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Precision Agriculture: Integrating Machine Learning model using ArcGIS data for crop and fertilizer prediction.

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Abstract: Machine learning and ArcGIS is an emerging research field in crop and fertilizer prediction. Precision agriculture is essential to ensure that site-specific crop management is implemented, which includes soil nutrient remedies per crop requirement. Though fertilization is key in boosting productivity, there is for analysis of the potentials and limitations of soil as a basis for recommending the correct type, quantities, and application time of fertilizers to counter uncertainty in fertilizer use. The complexity of finding the optimal fertilization range greatly contributes to major inefficiencies like productivity losses, resource wastage, and increased environmental pollution caused by farmers' use of intuition, trial and error, guesswork, and estimation. This study proposed the development of a machine learning model that predicts crop and NPK nutrient levels and recommends the best fertilizer remedy and application time based on the various parameters that will be gathered from ArcGIS visualization. This involved the use of machine learning techniques and experimental research design. Historical data of temperature, PH, and NPK from the KAGGLE Library were used to train and validate the model. The developed model achieved by with 75% of the data used for training and 25% used for testing. This is to encourage precise fertilizer production for particular areas of need.

Keywords: NPK, PH, Temperature, humidity, Rainfall and types of Crops, ArcGIS, Random forest etc…

I. Introduction

Modern agriculture faces challenges in maximizing crop yield while minimizing environmental impact. Inefficient use of fertilizers can lead to resource wastage and ecological harm, necessitating a more precise approach to crop and fertilizer recommendations. Instead of using a systematic approach to maximize crop-fertilizer combinations, farmers frequently rely on conventional practices and intuition. machine learning model provides an advanced solution by analyzing large volumes of data to identify complex patterns and relationships. Building on the need to improve agricultural efficiency, this study takes crop requirements, fertilizer composition, and climate variables into account. Precision agriculture has emerged as a result of the modern agriculture sector's integration of cutting-edge technologies, which have transformed conventional farming methods. This novel approach optimizes crop output while reducing resource waste and environmental impact by utilizing state-of-the-art instruments and processes. A novel development in this regard is the combination of Geographic Information Systems (GIS) and machine learning models, as demonstrated by the incorporation of ArcGIS data. Combining ArcGIS data with machine learning has the potential to improve crop output forecast and fertilizer control, which will increase agricultural operations' sustainability and efficiency. Farmers and other agricultural professionals can use ArcGIS's spatial data analysis capabilities in combination with machine learning methods like Random Forest or Artificial Neural Networks.

II. Related Work

The literature has many reported walks in the domain.

[1] **Devdatta A. Bondre, et al. (2019)** The paper refers to related works in the domain, such as a study that focuses on improving crop yield through different steps, including sampling, backpropagation algorithm, and weight updating. Another work analyzes the agriculture analysis of organic and inorganic farming, cultivation time, and profit and loss data, aiming to find information models that achieve high precision and consensus in yield prediction.

[2] **Ersin Elbasi, et al. (2023)** The paper provides a comprehensive review of the use of machine learning algorithms in crop yield prediction methods to improve crop quality and enhance the overall economy. It discusses previous studies on predicting palm oil yield using machine learning algorithms and presents a new architecture for palm oil yield prediction, The paper highlights the development of a web-based application for crop yield prediction, which helps farmers select the best crop to cultivate in the future based on previous crops planted and market demand.

[3] **Prof.B.B. Vikhe, et al. (2023)** The paper discusses the use of machine learning algorithms to predict crop yield and fertilizer requirements in agriculture in India. Various machine learning algorithms such as Linear Regression, ANN, K Nearest Neighbors, Random Forest, and SVM were considered, with SVM being selected for its accuracy of 86%. The paper also mentions the development of a web application that can estimate overall and individual crop yields and provide recommendations on fertilizer application. The authors emphasize the need to address the challenges posed by climate change and other environmental modifications in agriculture.

[4] **Patryk Hara, et al. (2021)** The paper discusses the selection of independent variables for crop yield prediction using artificial neural network models with remote sensing data. It emphasizes the importance of reliable forecasting tools in generating more income from crops and guiding the adoption of appropriate strategies for managing agricultural products.

III. Proposed Work

The proposed system aims to forecast the amount of fertilizer and suitable type of crop in Western Maharashtra using a machine learning model. The topography of the region is examined using ARC GIS Software, and several parameters gathered through the application of spatial analysis techniques are fed into a machine-learning model. The model will be developed in Python to predict crop types suitable for the area and, consequently, the quantity of nitrogen (N), potassium (K), and phosphorus (P) fertilizers needed to achieve this yield. The model will make use of historical farm management and yield data along with farm and field attributes as independent variables.

There are 3 steps in the proposed work.

1) **Data Collection:**

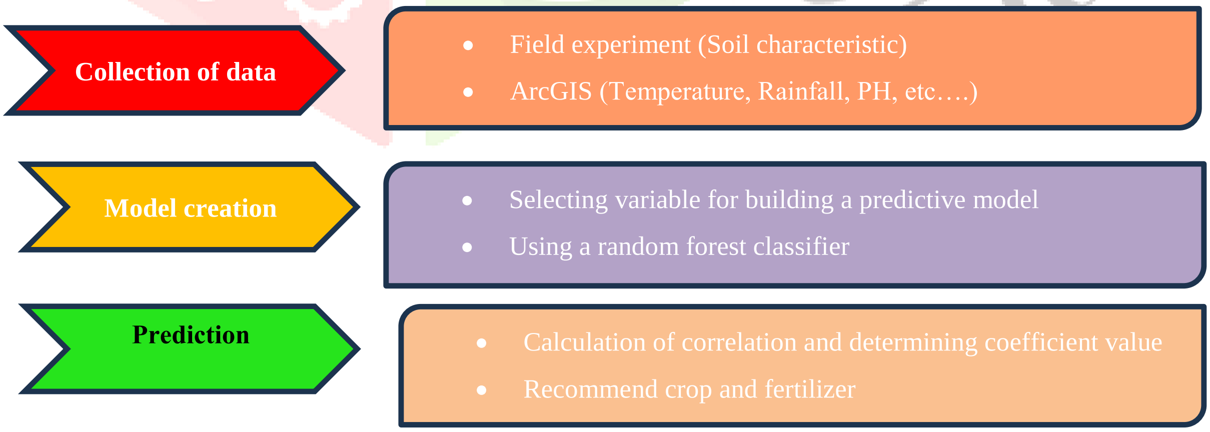
Numerous parameters, including pH, temperature, and rainfall, are gathered through ArcGIS (spatial analysis), while soil characteristics, including nitrogen, phosphorus, and potassium, are obtained by physical testing of the soil. These parameters are needed to feed the machine-learning algorithm.

2) **Crop Prediction:**

Crop Prediction can be done using previous crop data, nutrient content, and location data (western region). These inputs are passed to Random Forest Machine algorithms. These algorithms will predict crops based on present inputs.

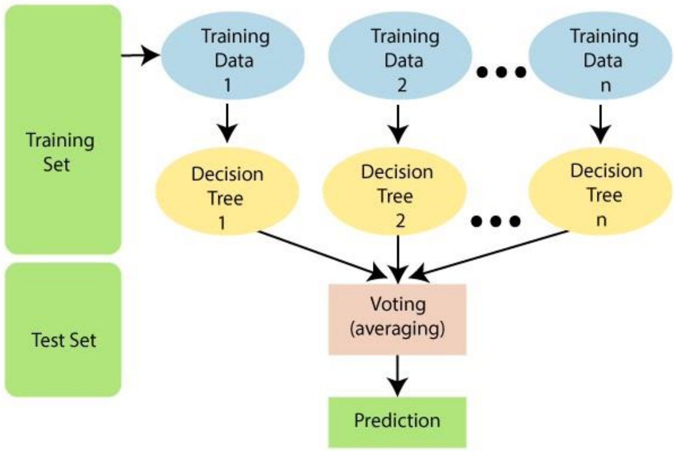
3) **Fertilizer Recommendation:**

Fertilizer Recommendation can be done using fertilizer (NPK ratio) data, crop, location data, and Soil type. This part recommends appropriate crops and the necessary fertilizer for each crop.



Random Forest:

Random Forest is a popular machine learning algorithm that belongs to the supervised learning technique. It can be used for both Classification and Regression problems in ML. It is based on the concept of ensemble learning, which is a process of combining multiple classifiers to solve a complex problem and improve the performance of the model.
As the name suggests, "Random Forest is a classifier that contains several decision trees on various subsets of the given dataset and takes the average to improve the predictive accuracy of that dataset." Instead of relying on one decision tree, the random forest takes the prediction from each tree and based on the majority votes of predictions, it predicts the final output.
The greater number of trees in the forest leads to higher accuracy and prevents the problem of overfitting.



Advantages of Random Forest

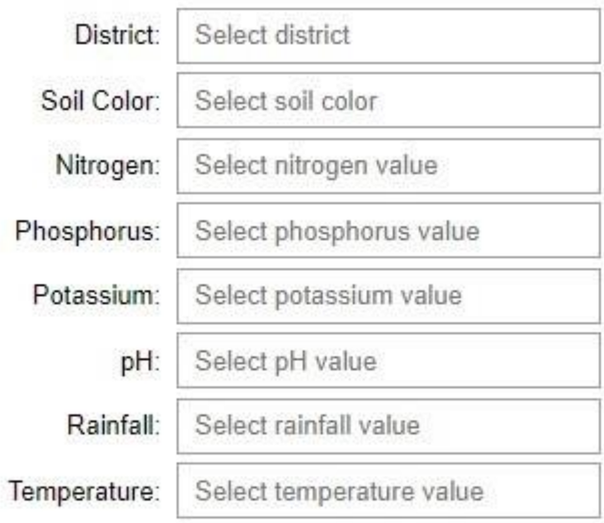
- Random Forest is capable of performing both Classification and Regression tasks.
- It is capable of handling large datasets with high dimensionality.
- It enhances the accuracy of the model and prevents the overfitting issue.

Disadvantages of Random Forest

- Although random forest can be used for both classification and regression tasks, it is not more suitable for Regression tasks.

IV. Expected Result

Our experimental results consistently demonstrate a strong correlation between the quality of input data and the suitability of outcomes. When the widgets box was filled with relevant, accurate, and comprehensive data, the resultant outcomes were deemed more suitable and aligned with expectations. Conversely, inadequate or erroneous input data led to suboptimal outcomes, often deviating from desired goals.



V. Conclusion and Future Scope

Higher crop yields can be attained, as demonstrated by location-based crop forecasts, appropriate fertilizer ratios, and effective algorithmic application. We test 20% of the data and train 80%. Based on the work above, I have determined that Random Forest, with an accuracy rate of 84.12%, is a solid method for classifying soil. The following features can be added by expanding the work further. We can design an application and deploy the code to assist farmers in increasing agricultural yield. Use a smart irrigation system to increase farm yields.

VI. Acknowledgment

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