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A Project Work on Efficient and Intelligent Decision Making for Eco-Fertilization

Dr. Chethan Chandra S Basavaraddi[1], Prof. Sapna S Basavaraddi[2], Prof. Shashidhara M S[3], BHARATH S (1KI19CS011)[4], MANOJ T ARADHYA (1KI19CS045)[4], PAVAN K M (1KI19CS058)[4], PRANEETH G B(1KI19CS063)[4]

Associate Professor, Department of Computer Science and Engineering, Kalpataru Institute of Technology, Tiptur- 572201[1]

Assistant Professor, Department of Computer Science and Engineering, Kalpataru Institute of Technology, Tiptur- 572201[2]

HOD, Department of Computer Science and Engineering, Kalpataru Institute of Technology, Tiptur- 572201[3]

Student, Department of Computer Science and Engineering, Kalpataru Institute of Technology, Tiptur- 572201[4]

Abstract: Fertilizer use is typically under the limited control of farmers. For the farmers to achieve higher yields and reduce fertilizer loss, competent guidance is required for the best use of these fertilizers. Additionally, there is a connection between rainfall volume and nutrient loss for various fertilizer applications after each rainfall event. Rainfall that is moderate and falls at the right moment can help nutrients penetrate the soil's rooting zone and dissolve dry fertilizer. However, too much rain can increase the possibility of runoff and the pace at which nutrients like nitrogen (N) which is quintessential, phosphorus (P), and potassium (K) which are crucial, manganese (Mn), and boron (B) that are present in the soil. This research presents nutrient recommendations using an updated iteration of the random forest algorithm which is based on time-series data to forecast the required quantity of nutrients for various crops by examining rainfall patterns and crop fertility. The method suggested in this study comes in handy for improving soil fertility by providing nutrients recommendations for optimum conditions for crop growth and reducing leaching and runoff potential.

I. INTRODUCTION

Agriculture plays a very important role in national economic growth. Agriculture contributes 17-18% to India's GDP and ranks second worldwide in farm outputs. Plants need fertilizers and fertilizers replace the nutrients which crops take from the top layer of the soil. The absence of fertilizers can cause a drastic reduction in the volume of crop output. But fertilization requires precise action. Rainfall patterns and the amount of nutrients needed for a certain crop must be considered when using fertilizers. Machine learning is the current technology that can solve this problem by using available data for crop fertility and rainfall. Farmers can greatly benefit from the support of robust information about crops. The proposed model also uses a machine learning algorithm (random forest algorithm with k-fold cross-validation technique) and takes two inputs from the user that are crop and location. After applying the algorithm, the model predicts the amount of nutrients required along with the best time to use fertilizers. The website is built using Flask Python (web framework) to provide access on all platforms and can be shared among users.

Fig. 1: On-Ground Analysis

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1.1 Plant Root Loss

Farmers face a number of challenges every year like, heavy rainfall or unpredictable weather, including high interest rates, an overreliance on traditional crops, and a lack of water. Crops may be submerged in water as a result of flooding, which could cause catastrophic losses. As soon as a plant is submerged, its foliage starts to deteriorate because its leaves are unable to exchange gases with the air above (mainly oxygen & carbon dioxide). Producers face flooding or continuously flooded soil more frequently, which hinders roots' ability to absorb nutrients. If the soil is completely soaked for an extended period of time, root loss may result. Because they can't exchange gases, root cells in waterlogged soils risk dying.

Depending on how long the soil is entirely soaked, different amounts of root loss may occur. Plant mortality and complete crop failure would ensue from total root loss. Lower plant performance and crop output would result from partial root loss. Conditions that are too moist might have other detrimental effects on crop productivity. Unusually excessive rainfall can wash away nutrients from the soil, particularly nitrogen. Granular fertilizer that has been put to the soil as nitrogen is particularly susceptible to leaching. If this happens, farmers would either have to pay more money to reapply fertilizer or see a decrease in crop yield due to nitrogen shortage.

1.2 Soil Leaching

Leaching is the downward transport of pollutants via porous soils, such as water-soluble pesticides or fertilizers. The majority of pesticides, notably clay, adhere to soil particles, become stationary, and do not drain. However, the multiple degradation mechanisms and leaching to groundwater can be seen as competitors in the fate of mobile pesticides. Groundwater does not continuously dilute the pollutants that enter it, in contrast to surface water. It could take many years to remove a contaminated plume from groundwater. Chemical deterioration is slowed by the soil's depth, the freezing temperatures, the limited microbial activity, the lack of sunlight, and the low oxygen levels. As a result, once pesticides enter an aquifer, there is little to no degradation, if any at all. This leads to water pollution.

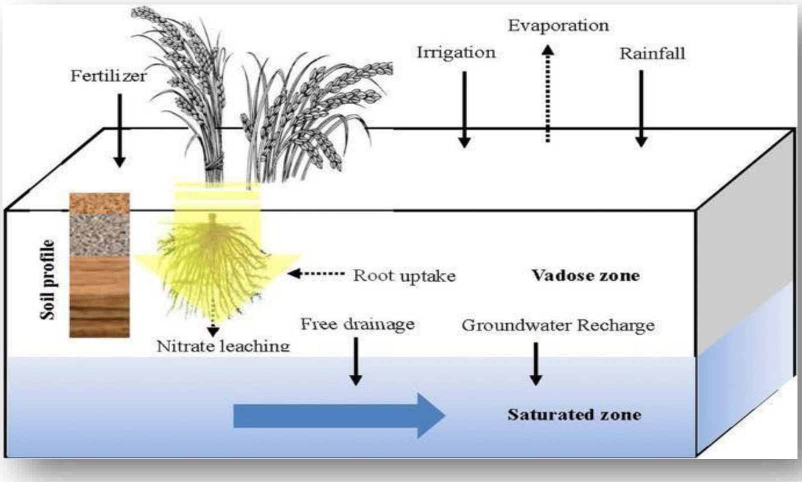

Fig 1.3: Soil Leaching

Soil Features that Influence Leaching:

- *Organic Matter:* The amount of organic matter in a soil is thought to be the single factor that has the greatest impact on how microorganisms break down pesticides. Pesticides are less likely to leach into groundwater because organic matter in the soil improves the surface area available for adsorption, boosts the soil's capacity to retain water and break down pesticides, and nourishes microorganisms. Crop leftovers can be added to the soil, manure can be added, and cover crops can be grown to increase the organic matter in the soil.

- *Soil Texture:* The amounts of sand, silt, and clay in the soil have an impact on how water moves through it. Large pores and high permeability characterize coarse-textured soils with more sand particles, which allow water to pass through quickly. Groundwater is more likely to become contaminated by pesticides delivered by water via soil with a

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coarse texture. Soils with a clay texture have less permeability. More water is retained and more chemicals are absorbed from the water by soil with high clay content. This lessens the likelihood of groundwater pollution, increases the likelihood of chemical breakdown and binding to soil particles, and slows the downward migration of the pollutants.

- *Soil Structure:* Water can travel through the soil quickly because to loosely packed soil particles. Tightly compacted soil acts as a dam, holding water back and preventing its free flow. Openings and channels can be made for water flow in a number of different ways. For instance, animals and earthworms generate openings for water to flow through when they dig burrows. In soil and rock, freezing and thawing causes fissures or splits that dislodge compacted particles. When plant roots decay and die, they pierce the soil and make great water routes. Even through some clay soils, these apertures and channels might allow for a somewhat quick water flow.

- *Soil Water Content:* Rain or irrigation can recharge the groundwater and perhaps cause pesticides to seep into the aquifer, depending on how much water is already present in the soil. Once soil moisture content is getting close to or near saturation, soluble substances are much more likely to enter groundwater. When it rains and there is snowmelt in the spring, saturation is normal. Contrarily, when soils are dry, the additional water simply fills soil pores close to the soil surface, decreasing the likelihood that it will contact the groundwater supply.

1.3 Purpose

The main motive behind Eco-Fertilization is to reduce farmers losses by providing useful insights about the amount and use of fertilizers, and to reduce water pollution by slowing down the process of leaching. It serves as a link between farmers and modern technology and enables them to increase yields while using less inputs. The system is designed as a website to provide platform-independent functionality, so that the user can access it from any device. The user interface has been kept simple with more emphasis on functionality and can be used by any naive user. It takes inputs such as crop, state and city using the drop-down menus provided in the website and applies machine learning algorithms to estimate the correct amount of nitrogen, potassium and phosphorus content required. This system provides a good accuracy in its decision about the nutrients required for the crop.

1.4 Objectives

Crop production is essential to the global food and biofuel economies, and ML is significantly enhancing farmers' contributions on both fronts. To enhance crop productivity and yield, herbicides, insecticides, and fungicides must all be applied at the right time. Even if crop spraying is possible later in the season as soil moisture decreases, crop yields will almost certainly be harmed. Every year, farmers make hundreds of intricate and connected decisions that affect their risk, sustainability, and financial results.

The goal of employing machine learning in our project is to provide relevant insight for nutrient requirement for crops by taking short-term weather forecasts (specifically for seven days) into account, as well as to prevent water pollution by slowing down the leaching process.

II. IMPLEMENTATION

System implementation builds system pieces that adhere to user requirements of the system requirements founded in the early life cycle stages using the framework generated throughout architectural design and the outcomes of system analysis. These system components are then combined to create intermediate aggregates, which ultimately result in the entire system- ofinterest (SoI). The system hierarchy's lowest-level system components are really produced by the implementation process (system breakdown structure). System components are created, purchased, or recycled. Production includes the forming, removing, connecting, and finishing processes used in hardware fabrication, the coding and testing processes used in software realization, or the processes used to build operating procedures for the duties of operators.

A design method known as "modular design," sometimes known as "modularity in design," separates a system into smaller components known as modules or skids that may be independently produced and then used in multiple systems. Functional division into distinct, scalable, reusable modules; strict usage of very well modular interfaces; and adherence to industry norms for interfaces are characteristics of a modular system.

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III. RANDOM FOREST REGRESSION

A group of several decision trees called a random forest (RF) are trained using different subsets of data and have changeable hyper-parameters. In our project, we are going to take crop and location as input, and based on it, we will predict the value of N, P, and K. First, we will divide our dataset into training and test datasets, where the training dataset is 80% of the original data and the rest 20% is test data. Then we will create three different random forests of size 50 (decision tree) for each N, P, and K and produces the average of the classes as the overall tree projection, shown in Table 3.1.

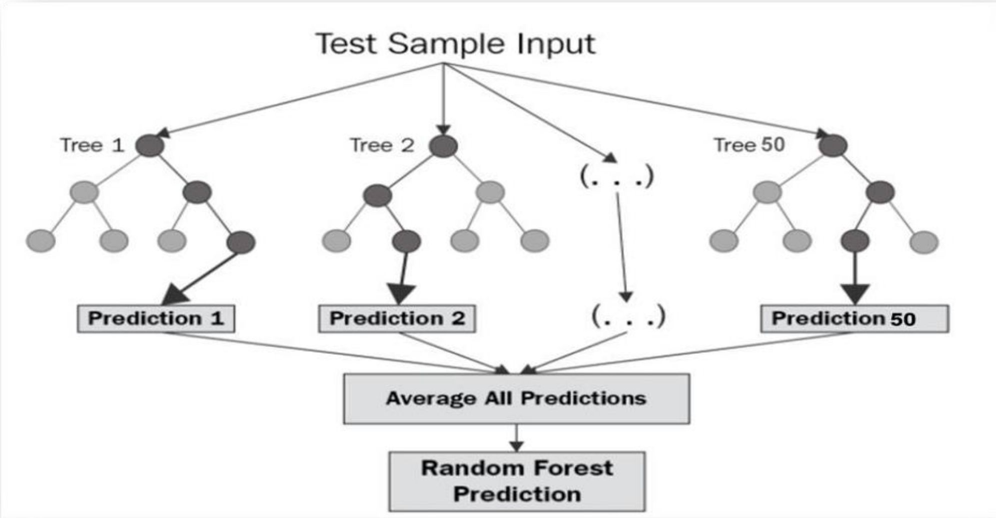

Fig.3.1.1: Random Forest Regression

BEGIN:
Step 1: The dataset of size n = 2200 is divided into training and test dataset (where the raining set is 80% and the test set is 20% that is training set=1,760 and the test set=240).
Step 2: Apply random forest regression to each N, P and K (Nitrogen, Phosphorus & Potassium) value with n estimators=50 (n estimators is the number of decision trees).
Step 3: Train the N Label, P Label and K Label with the training dataset and dependent variable (Where the dependent variable is N for N Label, P for P Label and K for K Label).
Step 4: Each N Label, P Label and K Label generates a 50-decision tree as an output based on the training dataset.
END

Table 3.1: Random Forest Regression Algorithm

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Why we selected 50 decision trees (n_estimator = 50) for each label?

We have tested for different n_estimator values, but the upmost accuracy achieved for *N_Label* is 0.87 for two decimal digit precision. As shown in below figure Fig 3.1.1.

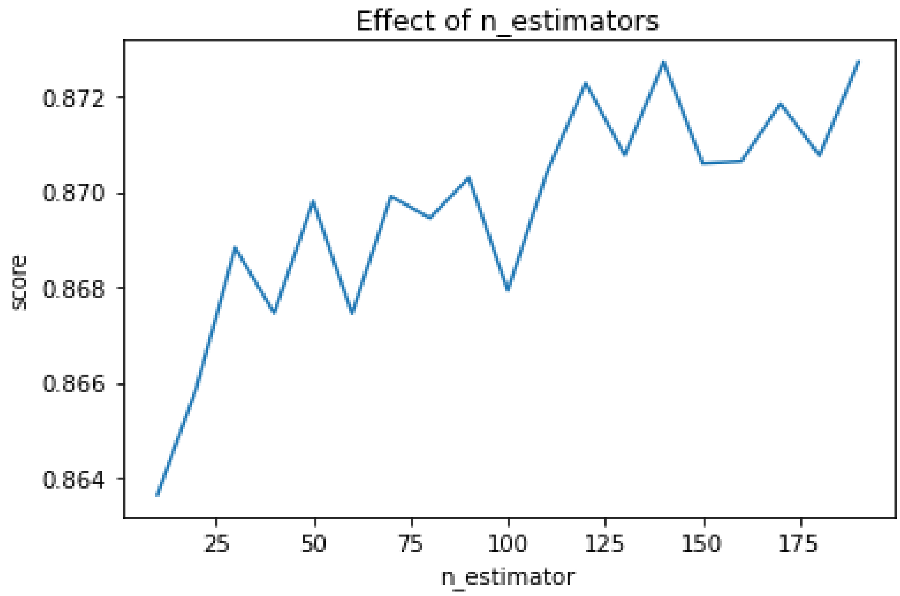
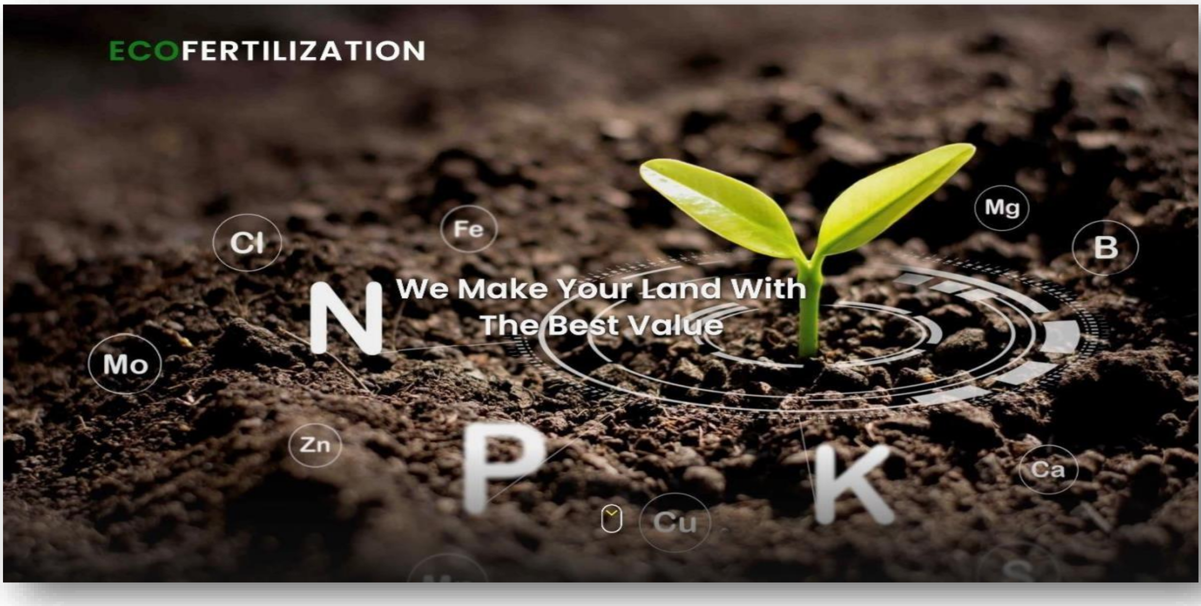


Fig 3.1.2: Effect of n_estimator.

IV. RESULTS

Eco-Fertilization, a user-friendly system, has been implemented in the form of a website to Fig 7.1: Homepage of Eco-Fertilization



provide cross-platform functionality and suggest appropriate timings and amount of nutrients required for an inputted crop with alert system for heavy rainfall (as shown in Fig 7.1-7.5).

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Fig7.2: Input Form

Fig 7.3: Details filled using the drop-down menu

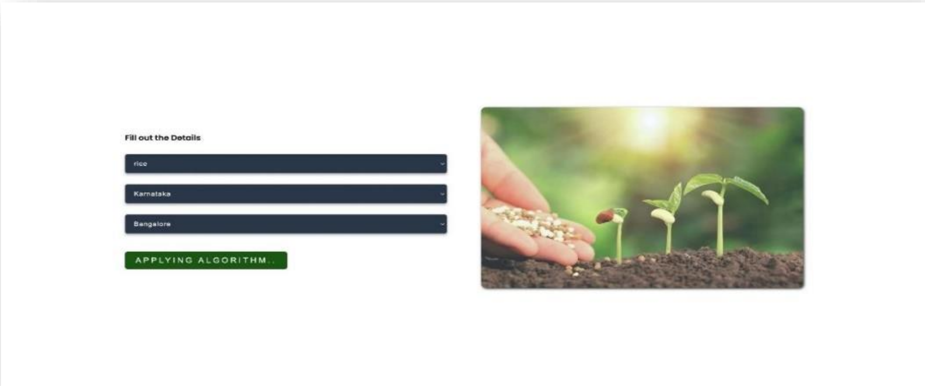

Fig 7.4: Applying Algorithm to inputted details

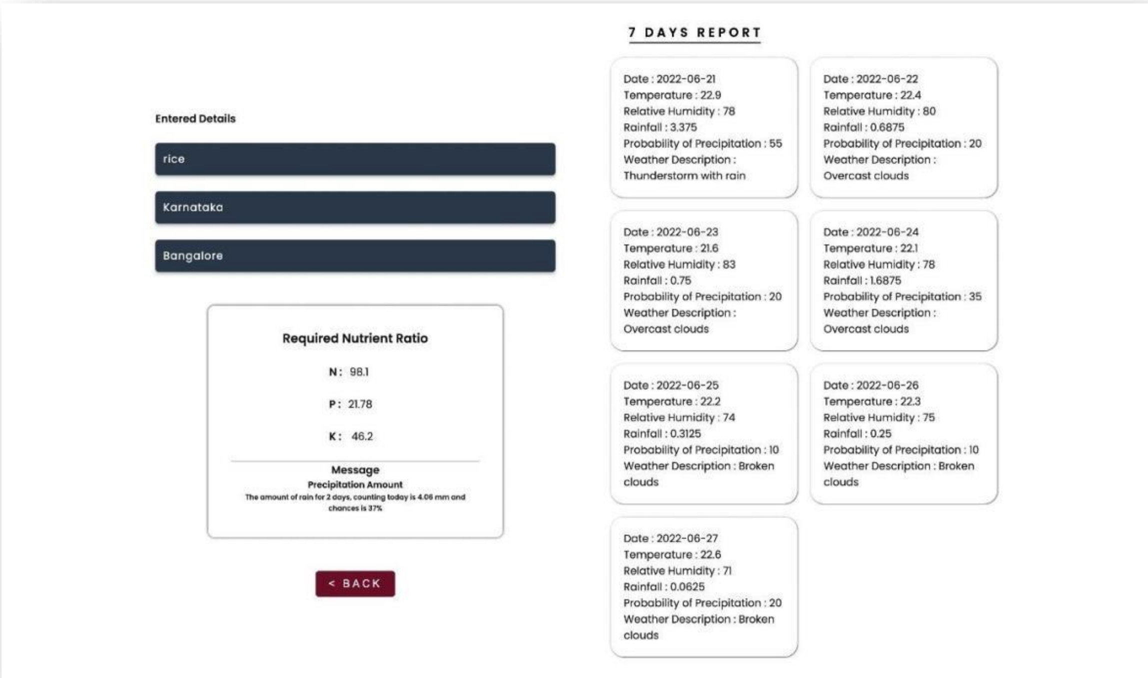

Fig 7.5: Output with seven days of weather forecasts & alerts/messages

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CONCLUSION

The proposed system is able to achieve 92% of accuracy, which is quite good for any predictive model. It provides information about the use and the amount of nutrients required by the crops for satisfactory crop growth and production with respect to weather conditions. It provides weather alerts and messages. Alerts are displayed in the output of this application in case of bad weather conditions. The accuracy can be improved further with development in technologies.

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