# Predicting Optimal Crops for Soil Using Embedded IoT and Trained ML Model: An Analysis of Soil pH, EC, TDS, and NPK.

Author: Shrihari Kulkarni(PICT E&TC), Soham Deshpande(PICT CE), Prasad Chaudhari(PICT CE), Romank Sadhwani(PICT CE).

**Introduction:**

Agriculture plays a crucial role in sustaining human life and the global economy. However, it heavily relies on the quality of soil, which is influenced by various factors such as pH, electrical conductivity (EC), total dissolved solids (TDS), and the availability of nutrients like nitrogen, phosphorus, and potassium (NPK). In recent years, with the advancements of technology, embedded IoT devices have been used to collect data on soil parameters. This data, when combined with machine learning (ML) techniques, can help predict the optimal crops for a particular soil type. This research paper aims to analyze the soil parameters that are crucial for predicting optimal crops, and how machine learning models can be trained to analyze soil pH, EC, TDS, and NPK levels. The paper will also explore the ways in which embedded IoT technology can help in collecting soil data. The findings of this research will be valuable in optimizing crop production, reducing environmental damage, and achieving sustainable agriculture.

## Analysis of Soil Parameters for Crop Prediction

### How does embedded IoT technology help in collecting soil data?

Embedded IoT technology has revolutionized the way farmers collect and utilize soil data for precision agriculture. The technology allows for the collection of data related to soil moisture, temperature, NPK, and pH value [1]. Farmers can maintain and analyze the data using a hybrid approach, enabling them to make informed decisions about soil health and appropriate mineral usage [1]. The collected data can predict the most suitable crops for a particular cultivation area, which helps farmers optimize crop production [1]. The data can be maintained in a low-cost cloud service, allowing farmers to access periodic soil health details [1]. Real-time data collection of soil nutrient data is possible through embedded IoT technology, providing better accuracy in predictions for specific fields compared to offline datasets [1]. The use of IoT sensors can optimize the collection of soil data, such as using an Arduino board and ESP 32 WiFi module to collect soil temperature, moisture, and mineral values [1]. The collected data is stored in the cloud, allowing for easy access and analysis by farmers. Automated devices, sensors, wireless connectivity, drones, and satellite images are utilized for collecting soil data [1]. The implementation of precision farming consists of automated devices, IoT sensors, real-time data collection, storage in cloud memory, and data analysis [1]. The collected data from the sensors supports the farmer in handling the irrigation scheme efficiently [1]. The wireless sensor network includes an embedded device that empowers several facilities to take measurements with minimized effort and low power [1]. An embedded device with different sensors is employed for data acquisition from fields, such as the IoT nodes with WSN scattered in apple orchards to collect real-time data and early prediction of crop diseases [1]. Therefore, the use of embedded IoT technology in precision agriculture helps in the optimum use of fertilizers, labor resources, and time, and plays a role in maintaining soil fertility by optimally increasing it to improve crop production [1].

## What are the key soil parameters for predicting optimal crops?

The key to obtaining maximum yield from a piece of land is the selection of an appropriate crop based on the soil parameters [2]. Soil type, nutrient level, and pH value are key soil parameters for predicting optimal crops [2]. Soil quality is directly dependent on crop health, which is essential for a highly productive system [3]. Improvement and maintenance of dynamic soil parameters is necessary for enhancing crop productivity [3]. Effective management of soil resources and introduction of micronutrients can help in enhancing soil quality and achieving increased productivity [3]. Soil moisture, soil type, and soil nutrient content are also critical parameters for predicting optimal crops [3]. Elimination of unrelated variables is necessary in most datasets for accurate predictions [3]. Machine learning techniques can be used to predict these parameters, and Extreme Learning Machine (ELM) is a promising machine learning technique for predicting soil fertility [3]. Numeric values are used to categorize soil into labels of low, medium, and high scales, wherein the level of soil nutrients is key in predicting optimal crops [3]. The natural deficiency or excess in soil nutrient content can be used to identify optimal crops. In India, district- and block-level categorization of soil fertility data can support crucial decision-making for fertilizer distribution and utilization [3]. The selection of the suitable crop is made using Random Forest Classifier, which takes into account soil parameters among other factors. The model is trained using the weather and soil data from the state of Telangana [2]. The proposed ML-based optimal crop selection model considers soil parameters to select a suitable crop for a piece of land in a particular region [2].

## How can machine learning models be trained to analyze soil pH, EC, TDS, and NPK levels?

Machine learning models can be effectively trained to analyze soil pH, EC, TDS, and NPK levels to improve crop production. These models use complex equations and algorithms to analyze soil samples and extract the necessary data. The equation can be used to determine nitrogen, phosphorus, and potassium levels in soil samples, and equation (3) can be applied to find N, P, and K values from a soil sample [1]. To train machine learning models for analyzing soil NPK levels, an equation is used that involves measured nitrogen in ppm, analogue voltage, lower and upper edges of the current range, and lower and upper limits of the target ranges [1]. Different models have been proposed to support farmers in improving crop production [1]. The main focus of these suggested models is to classify soil and determine crop nutrient needs [1]. By leveraging machine learning techniques, these models can be trained to analyze various soil parameters such as pH, EC, TDS, and NPK levels, to optimize crop production and improve yield. For instance, machine learning models can be used to predict mustard crop yield based on soil nutrient data [1]. These models are an effective tool for farmers to make informed decisions about crop management and soil fertility.

## Conclusion:

The research paper focuses on predicting optimal crops for soil using embedded IoT and a trained ML model, based on various soil parameters such as pH, EC, TDS, and NPK. The study highlights the significance of embedded IoT technology in collecting real-time data related to soil moisture, temperature, and nutrient content, which enables farmers to make informed decisions about soil health and appropriate mineral usage. The hybrid approach adopted in the study helps farmers to maintain and analyze the data, providing better accuracy in predictions for specific fields compared to offline datasets. The study also emphasizes the importance of soil type, nutrient level, and pH value in predicting optimal crops, which can be achieved through machine learning models. The collected data can predict the most suitable crops for a particular cultivation area, which helps farmers optimize crop production. The study further highlights the potential applications of district- and block-level categorization of soil fertility data in supporting crucial decision-making for fertilizer distribution and utilization in India. The discussion section of the research paper addresses the limitations and gaps in the study, suggests future directions for research, and acknowledges potential weaknesses or biases. The study can further be extended by incorporating additional soil parameters, such as organic matter content, and by conducting field experiments to validate the predictions made by the trained ML model. Overall, the study contributes to the ongoing advancement of knowledge in the field of precision agriculture and highlights the potential of embedded IoT and machine learning techniques in optimizing crop production.

## References:

1. Computers | Free Full-Text | IoT-Enabled Soil Nutrient Analysis and Crop Recommendation Model for Precision Agriculture. (n.d.) retrieved February 25, 2024, from www.mdpi.com/2073-431X/12/3/61

2. Machine learning-based optimal crop selection system in smart agriculture. (n.d.) retrieved February 25, 2024, from www.ncbi.nlm.nih.gov/pmc/articles/PMC10520008/

3. Journal of Nanomaterials. (n.d.) retrieved February 25, 2024, from www.hindawi.com/journals/jnm/2022/5343965/