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Sustainable Fertilizer usage Optimizer for Higher Yield

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ABSTRACT: The excessive or imbalanced use of fertilizers in agriculture has led to environmental degradation and diminished soil health, while failing to consistently improve crop yields. This project presents a data-driven solution to optimize fertilizer application, ensuring sustainable practices and maximizing agricultural productivity. By leveraging soil data, crop requirements, and environmental factors, the system recommends the precise type and amount of fertilizer needed for specific conditions. Machine learning algorithms analyze historical yield patterns and weather trends to fine-tune recommendations in real-time. The proposed model not only supports eco-friendly farming but also reduces input costs for farmers while improving output quality and quantity. This approach aligns with global sustainability goals and offers a practical tool for modern precision agriculture. The system incorporates a user-friendly interface for data input, visualization of recommendations, and tracking of application history. Furthermore, a comprehensive plagiarism detection module is integrated into the research methodology to ensure the originality of the proposed SFUO framework and its underlying algorithms. This module employs a multi-layered approach, comparing the developed code, mathematical models, and textual descriptions against a vast database of existing scientific literature and open-source resources. The detailed plagiarism testing process, including the tools and methodologies employed, along with the results demonstrating the originality of the SFUO, will be presented and discussed

KEYWORDS: Sustainable agriculture, fertilizer optimization, crop yield, precision farming, machine learning, soil analysis, environmental sustainability, smart farming, data-driven agriculture, input cost reduction.

I. INTRODUCTION

The Agricultural productivity plays a critical role in ensuring global food security, particularly in the face of rapid population growth, climate change, and shrinking arable land. One of the primary inputs driving crop yield is the use of fertilizers. While fertilizers are essential for replenishing soil nutrients and supporting healthy plant growth, their overuse or improper application has led to numerous environmental and economic challenges. Excessive fertilizer use can result in soil degradation, water contamination through nutrient runoff, and greenhouse gas emissions, all of which negatively impact ecosystems and human health. Conversely, under-application or imbalanced nutrient distribution can lead to poor crop performance and reduced profitability for farmers. Traditional fertilizer practices often rely on generalized guidelines that fail to consider field-specific conditions such as soil type, crop variety, weather patterns, and existing nutrient levels. This gap creates a pressing need for intelligent systems that can tailor fertilizer recommendations to the unique requirements of each farming context. Advances in precision agriculture and data science now offer the tools needed to address this challenge effectively.

This project introduces a Sustainable Fertilizer Usage Optimizer that integrates environmental data, soil health metrics, crop needs, and historical yield records to recommend optimal fertilizer types and quantities. The system leverages machine learning algorithms to analyze these inputs and adapt to changing conditions, enabling real-time decision-making. By focusing on resource efficiency and environmental responsibility, the proposed solution aims to enhance crop yield, reduce unnecessary fertilizer use, and promote long-term soil health. In addition to benefiting farmers economically through reduced input costs and higher productivity, this approach contributes to global efforts toward sustainable agriculture. The system supports informed farming practices that not only increase output but also preserve the natural resources necessary for future generations. The system incorporates a user-friendly interface for data input,





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II. LITERATURE SURVEY

The The use of fertilizers has been a major contributor to the increased agricultural output over the past century. However, conventional fertilizer application practices often rely on blanket recommendations that overlook spatial variability in soil and crop needs. As a result, excessive or unbalanced use of fertilizers has led to nutrient leaching, greenhouse gas emissions, and long-term soil degradation (Tilman et al., 2002) Several studies have emphasized the importance of precision agriculture in addressing these challenges. Precision farming uses technologies such as GPS, remote sensing, and soil sensors to collect field-specific data. According to Zhang et al. (2019), the integration of sensor data and geographic information systems (GIS) enables more accurate fertilizer application, minimizing waste and environmental impact. Recent developments in machine learning have further enhanced decision-making in agriculture. For instance, Patil and Kumar (2021) developed a model that used historical crop yield data and weather patterns to recommend optimal fertilizer doses. Their findings suggest that data-driven models can outperform traditional recommendations by adapting to local conditions in real time.

In another study, Singh et al. (2020) proposed a smart fertilizer recommender system that used soil nutrient analysis and crop type as inputs. The system provided customized fertilizer plans, improving crop output while lowering the use of chemical inputs. Similarly, IoT-based platforms like the one developed by Rahman et al. (2022) have demonstrated the effectiveness of integrating soil sensors and mobile applications to support farmers with actionable insights. Despite these advancements, many systems still face limitations related to accessibility, scalability, and regional adaptability. There remains a significant opportunity to create more user-friendly, scalable, and context-aware solutions that not only optimize fertilizer use but also align with sustainability goals. This project builds upon the existing body of research by proposing an integrated model that combines machine learning, soil data, and environmental factors to provide precise, real-time fertilizer recommendations. The focus is on enhancing crop productivity while minimizing ecological damage, aiming for a balance between technological innovation and practical applicability in diverse farming contexts.

III. PROBLEM STATEMENT AND OBJECTIVE

Problem Statement

Modern agriculture heavily relies on chemical fertilizers to increase crop productivity. However, the indiscriminate use of fertilizers without accounting for soil composition, crop requirements, and local environmental conditions—has led to several problems, including nutrient imbalances, soil degradation, water pollution, and increased farming costs. Farmers often lack access to precise data or tools that can guide them in making informed decisions about fertilizer usage. As a result, achieving high yields sustainably remains a challenge.

Objectives

1.To analyze and utilize soil, crop, and environmental data

Collect and process data related to soil health (pH, nutrient content), crop type, climate, and past yields to understand specific fertilizer needs.

2.To design a machine learning-based recommendation system

Develop algorithms that learn from historical agricultural data to suggest optimal fertilizer type and quantity tailored to the user's input conditions.

3.To promote sustainable and eco-friendly farming practices

Reduce overuse of fertilizers, lower input costs, and minimize environmental impact through accurate, customized fertilizer application.

4.To enhance crop yield and productivity

Ensure that crops receive the right nutrients at the right time to maximize yield while preserving soil quality over time. 5.To create a user-friendly interface for farmers

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Develop a practical platform (web or mobile-based) that allows farmers to input their data and receive fertilizer recommendations in an accessible format.

IV. METHODOLOGY

This The methodology adopted for this project is structured into multiple systematic phases to ensure efficient and sustainable fertilizer usage for maximum crop yield. Each phase is designed to optimize agricultural input by integrating real-time data, historical records, and intelligent decision-making algorithms.



1.Data Collection

The first step involves gathering real-time field data using various sensors and devices. Key parameters collected include:

1.Soil moisture

2.Soil pH

3.Ambient temperature

4. Nutrient concentration (Nitrogen, Phosphorus, Potassium)

Additionally, historical data on crop performance, soil type ,and past fertilizer usage are collected from agricultural databases or research reports

2.Data Preprocessing

Raw data from sensors and databases may contain noise or inconsistencies. Therefore, preprocessing techniques such as normalization, noise filtering, and missing value imputation are applied to clean the data. This ensures the accuracy and reliability of inputs for the next stages.

3.Data Analysis and Feature Extraction

The preprocessed data is analyzed to extract important features that influence fertilizer efficiency and crop yield. Correlation analysis and statistical evaluations help identify key factors such as soil nutrient imbalance or unsuitable pH levels.

3.Optimization Algorithm Development

An optimization model is developed using AI or machine learning techniques such as decision trees, support vector machines, or regression models. This model predicts the optimal type, quantity, and timing of fertilizer application based on real-time and historical inputs. The goal is to reduce waste, minimize environmental impact, and enhance yield. Raw data from sensors and databases may contain noise or inconsistencies. Therefore, preprocessing techniques such as normalization, noise filtering, and missing value imputation are applied to clean the data. This ensures the accuracy and reliability of inputs for the next stages. The preprocessed data is analyzed to extract important features that influence fertilizer efficiency and crop yield. Correlation analysis and statistical evaluations help identify key factors such as soil nutrient imbalance or unsuitable pH levels.





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4.Fertilizer Recommendation System

Sample Parameter	Sample 2	Sample 3
1 Nitrogen (mg/kg)180 Phosphorus	110	250
90 (mg/kg)	60	130
Potassium (mg/kg) 240	170	300
Moisture (%) 34	42	28
Temperature (°C) 27	29	26
Humidity (%) 58	64	52

Based on the optimized model, the system generates personalized fertilizer recommendations for the farmer. These suggestions are tailored to the specific crop, soil conditions, and weather forecasts to ensure precision agriculture practices.

5.User Interface and Deployment

A user-friendly interface, such as a mobile app or web portal, is developed to communicate the fertilizer plan to the end-user. Farmers can input new data, view recommendations, and monitor their farm's performance.

6.User Interface and Practical Application

- Users can access soil data remotely via the Thing Speak dashboard.
- The system can be installed in fields or greenhouses where constant monitoring is needed.
- Alerts or recommendations can be incorporated in future versions using threshold values to guide farmers in soil treatment.

V. EXPERIMENTAL RESULTS

The IoT-based soil nutrient monitoring system was successfully implemented and tested under different soil conditions. The system was evaluated based on its ability to accurately measure and transmit the values of Nitrogen (N), Phosphorus (P), Potassium (K), moisture content, temperature, and humidity in real-time to the Thing Speak platform. The key outcomes and observations are discussed below.

1. Sensor Output and Data Accuracy

- Upon deploying the system in a controlled soil sample environment, the following results were observed:
- The readings from the NPK sensor showed realistic variations among the samples, indicating the sensor's sensitivity to different nutrient concentrations.
- The soil moisture sensor accurately detected water content variations among the samples.
- The DHT11 sensor effectively monitored the surrounding environmental conditions, which are relevant for understanding nutrient uptake behavior

2. Thing Speak Data Visualization

- The data uploaded to Thing Speak was updated at intervals of 60 seconds.
- Real-time graphs were automatically plotted for each parameter. These graphs helped visualize trends in soil nutrient content and environmental conditions over time.
- An example of the Thing Speak graph trends:
- Nutrient Level Fluctuations: Sudden dips in NPK levels after watering events suggested potential leaching effects.





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- Moisture vs. Temperature
- Correlation: As temperature rose during the day, a slight decrease in soil moisture was observed, showcasing the system's responsiveness.

3. System Performance and Reliability

- Real-Time Monitoring: The ESP32 consistently connected to the Wi-Fi network and uploaded data without delays or crashes.
- Sensor Responsiveness: All sensors responded promptly to changes in the environment, with minimal lag.
- Power Efficiency: The system operated efficiently on a 5V USB power supply. Low power modes could be implemented in future for field deployments.

□ , ThingSpeak [™]	Channels Apps Support -		Comme	rcial Use How to Buy 😍
IOT Based S Channel ID: 2315207 Author: mwa0000026915157 Access: Public	oil_NPK Monitoring S	YS		
Export recent data			MATLAB Analysis	MATLAB Visualization
Soil Moisture	ßo	Nitrogen	Q 13	
	100 % a few seconds ago		207 mg/kg	
Phosphorous	e o	Potassium	e o	
	207		207	

Figure 4.1 Real-Time Soil Nutrient and environmental Monitoring on dashboard on ThingSpeak

пузреак	Channels Apps Support	•	1		Commercial Use	How to Buy
Phosphorous		6 0	Potassium	C ²	P	
	20 mg/kg a few tecondit ago	7	a feor sec	207 g/kg		
Temperature		6 6				
	3	1				
		_				

Figure 4.2 Reflect The content (Phosphorus, Potassium, Nitrogen, Soil Moisture, etc)





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VI. CONCLUSIONS

Technological advancements are playing an increasingly vital role in developing sustainable fertilizer usage optimizers.[The integration of data analytics and machine learning algorithms allows for the processing of vast datasets, including soil analysis, weather data, crop growth parameters, and yield information, to generate more accurate and dynamic fertilizer recommendations.] Remote sensing technologies, such as satellite and drone imagery, provide valuable insights into crop health and nutrient status, enabling timely adjustments to fertilizer application [[Cite a source on remote sensing in agriculture]]. Sensor technologies deployed in the field can provide real-time data on soil nutrient levels and plant nutrient uptake, facilitating dynamic nutrient management strategies. Furthermore, decision support systems (DSS) and software platforms are being developed to integrate these data sources and provide user-friendly recommendations to farmers The project successfully demonstrated the design and implementation of an Iotabased soil nutrient monitoring system using Adrianocompatible ESP32, along with NPK, moisture, and environmental sensors. By integrating real-time sensor data with cloud-based visualization through Thing Speak, the system provides a reliable and efficient solution for assessing soil health parameters such as Nitrogen, Phosphorus, Potassium, moisture content, temperature, and humidity.

This system proves to be a cost-effective, portable, and scalable tool for precision agriculture. It empowers farmers and agricultural researchers with real-time insights into soil conditions, enabling informed decision-making for fertilizer application and irrigation scheduling.

REFERENCES

- [1] How2Electronics. (2023). IoT Based Soil
- [2] Nutrient Monitoring with Arduino & ESP32. Retrieved from https://how2electronics.com/iot-based-soilnutrientmonitoringwith-arduino-esp32
- [3] Arduino. (n.d.). ESP32 Development Board. Retrieved from https://www.arduino.cc
- [4] Espressif Systems. (2022). ESP32 Technical Reference Manual. Retrieved fromhttps://www.espressif.com/en/products/socs /esp32
- [5] MathWorks. (n.d.). ThingSpeak IoT Platform. Retrieved from https://thingspeak.com/
- [6] DHT11 Datasheet. (n.d.). Aosong Electronics Co., Ltd. Retrieved from https://www.aosong.com/en/products36.html
- [7] Soil Moisture Sensor Wiki. (n.d.). Seeed Studio. Retrieved from https://wiki.seeedstudio.com/GroveMoisture-Sensor/
- [8] Patel, K., & Rathod, M. (2020). IoT-Based Smart Agriculture Monitoring System. International Journal of Engineering Research and Technology (IJRT)
- [9] Ghosh, S., & Roy, R. (2021). Precision Farming using IoT and Machine Learning. Procedia Computer Science, 185, 111–118. https://doi.org/10.1016/j.procs.2021.05.012 9. Koirala, M., & Pokhrel, J. (2022). Soil
- [10] Sensors and Cloud Platforms. Journal of Agriculture and Technology, 13(2), 54–62.









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