

IoT based NPK monitoring & Crop recommendation system

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ABSTRACT

Our project aims to enhance agricultural productivity and optimize resource management through a smart farming system that integrates IoT technology, NPK sensors, Wi-Fi based data collection and processing through ESP32 and firebase cloud-based platforms. The project performs better than conventional techniques in finding soil NPK and other nutrient content under varied conditions. Multisite real-time data confirm its utility for precision agriculture. The continuous monitoring capability offers farmers valuable insights into soil health, enabling precise and timely fertilization practices, optimizing crop yield and minimizing environmental impact through nutrient management. Future work will incorporate deep learning and edge computing to scale up and improve real-time response

Keywords : - Soil NPK sensor, ESP32, Agricultural productivity, Internet of Things (IoT), Real-time monitoring

1. INTRODUCTION

Soil contains both macronutrients, such as Nitrogen (N), Phosphorus (P), and Potassium (K) collectively known as NPK and micronutrients like iron, zinc, manganese, and copper. Among these, Nitrogen, Phosphorus, and Potassium (NPK) are the primary macronutrients that significantly affect plant growth [2]. Each of these macronutrients has a distinct function in soil fertility and plant physiology, and balanced growth depends on the soil's ideal concentration of each. As a crucial building block of proteins, amino acids, and chlorophyll, nitrogen (N) is necessary for photosynthesis, leaf development, and vegetative growth. For the best plant growth, soil should contain between 20 and 50 mg/kg (parts per million, or ppm) of nitrogen, while the exact amount needed depends on the type of crop. While too much nitrogen can create an imbalance and encourage too much foliage at the expense of fruit or grain production, too little nitrogen causes stunted development and yellowing of the leaves. Phosphorus (P): A key component of ATP (adenosine triphosphate), phosphorus is essential for energy transfer in plants. It encourages the growth of roots, flowers, and seeds. For the majority of crops, the optimal soil phosphorus concentration is between 10 and 20 mg/kg (ppm).

Potassium (K): Potassium is essential for water homeostasis, enzyme activity, and disease. Depending on the needs of the particular crop, the necessary potassium content in soil is typically between 100 and 200 mg/kg (ppm).

Maintaining the ratio of all these nutrients is much needed for maximizing crop yield. However, real-time monitoring is required because traditional soil testing techniques are frequently labor-intensive and time-consuming. Accurate measurement and monitoring of NPK levels are critical for improving soil fertility and ensuring that crops receive the required nutrients for optimal growth. Traditional soil testing methods are often time-consuming and costly, involving laboratory analysis that can take weeks to provide results. To overcome these limitations, advanced sensor technologies have been developed to provide real-time data on soil nutrient levels. These sensors, such as the NPK sensor, are essential tools for on-site monitoring, enabling farmers to make data-driven decisions on fertilization and crop selection. NPK sensors, which provide on-the-go detection of soil nutrients, offering a faster alternative to conventional laboratory testing. The growing demand for enhanced agricultural production and the integration of the Internet of Things (IoT) has created a significant need for compact, low-power, and affordable sensors for real-time soil monitoring.

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2. SYSTEM DESIGN AND ARCHITECTURE

The Internet of Things has effectively led to real-time monitoring and control of various agricultural processes in recent years [3]. IoT technology is used in measuring soil nutrient values with accurate data requirements for crop selection and application of fertilizer [4]. The work outlines an IoT-based system that measures the soil's NPK values using a 7-in-1 NPK sensor interfaced with an ESP8266 microcontroller. The NPK sensor data is transmitted to a firebase and then to the application that gives exact value of NPK in the soil and recommendations for the best crop suited for this soil and the precise amount of NPK fertilizer required for optimal growth [5].fig[1]shows the block diagram of our system.

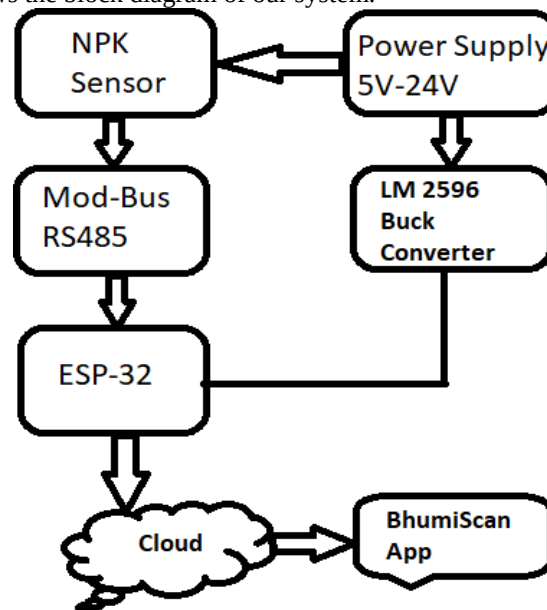


Fig -1: Block diagram of IoT based NPK monitoring & Crop recommendation system

Traditional soil testing methods are time-consuming, often taking weeks for laboratory results, and typically only provide nutrient levels without offering specific crop recommendations. To address this issue, we have designed a real- time crop prediction system. The working principle of this gadget is quite simple. The entire design, excluding the sensors, is enclosed in a single case [fig.2]. This device is designed to assist farmers by providing real-time data on soil nutrient content, helping to optimize crop fertility and productivity. The sensor, inserted into the soil, features a probe that detects nutrient levels.

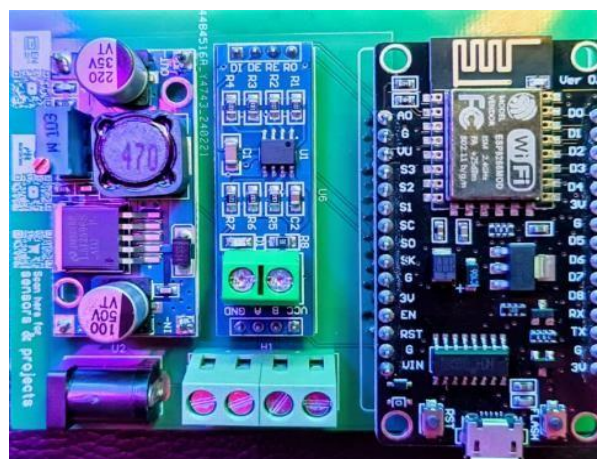


Fig.2- On board device excluding NPK sensor

3. CONCLUSIONS

The integration of ESP32 microcontrollers, RS485 communication, and cloud-based data analytics ensures a robust, scalable, and user-friendly solution that can assist farmers in optimizing crop yield while minimizing environmental impacts. This research demonstrates that the application of IoT technologies can significantly enhance the decision making process in agriculture by providing data-driven insights. The system's ability to

dynamically analyze soil nutrient levels and adjust recommendations in real time helps farmers make informed decisions, which can lead to increased agricultural productivity and sustainable farming practices.

4. REFERENCES

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