Journal of **N**onlinear **A**nalysis and **O**ptimization
Vol. 16, Issue. 1: 2025
ISSN : **1906-9685**

SMART SOIL MONITORING OPTIMISES CHILLI CULTIVATION WITH IOT

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Abstract: For contemporary agriculture to be efficient, soil quality optimisation is of utmost importance. The goal of this research is to develop a method for evaluating soil quality in the context of growing chilli peppers. Soil analysis makes use of a variety of sensors that monitor things like temperature, humidity, pH balance, nitrogen, phosphorus, and potassium levels. By connecting the sensors to an Internet of Things (IoT) framework with the help of an ESP01 module and an Arduino Nano microcontroller, data can be collected in real-time and sent to the cloud. Important nutrients for chilli plant development may be measured with the help of the NPK sensor, which connects via an RS485 interface.

Effective long-term storage and analysis of soil parameters is made possible by this system's usage of cloud connection, which allows for flexible data management and scalability. By including temperature and humidity sensors, the system becomes even more adept at monitoring environmental factors that impact the growth of crops. By analysing soil data, the Internet of Things (IoT) technology gives farmers useful information that they can use to make better decisions and streamline their chilli production processes.

Keywords: Evaluation of soil quality, NPK sensor, growing chillies, environmental tracking, Internet of Things farming, Arduino Nano, ESP01 module, soil PH values, and cloud data transfer.
Parts: - Arduino Nano, esp 01, NPKSENSOR, PH SENSOR, DHT11, SOIL MOISTURE, i2c module, 7805 regulator, LM1117 regulator, 14007 diode, 16*2 LCD screens, 12v DC power supply, general PCB, and connecting wires..

I. INTRODUCTION

With the incorporation of contemporary technology, agriculture is changing, and the Internet of Things (IoT) is essential to raising production. The productivity and quality of chilli crops are greatly influenced by environmental conditions and soil health. This intelligent IoT system uses real-time sensor data to track vital elements like temperature, humidity, nutrient levels, and soil moisture. This solution not only automates irrigation but also offers data-driven insights to increase crop output, minimise resource waste, and provide ideal conditions for chilli development.

A key spice crop that is cultivated all over the world, chilli is especially important in India for both its culinary and commercial uses. However, there are a number of obstacles to its cultivation, such as insect infestations, erratic weather patterns, inadequate irrigation, and shortages in soil nutrients. Adopting smart agriculture technology is necessary to address these issues. Automation and IoT-based monitoring may make chilli farming more sustainable and productive, which will eventually increase resource management and production.

II. EXISTING SYSTEM

The current research combines a number of components to increase agricultural output, with an emphasis on soil-based crop yield evaluation and toxin activity monitoring. The following functionalities are included in the system:

1. Soil Data Collection: A camera and sensors (such as temperature and moisture sensors) are used to collect data on the state of the soil.

2. Crop Selection and Suitability: Information from Tamil Nadu's Tanjavur region is utilised to determine which crops are most suited for particular soil types and environmental circumstances.

3. Irrigation Control: A GSM module, a controller to maximise irrigation, and water flow indicators help with water management.

4. Mobile Application: Farmers may easily monitor and control their agricultural operations on their cellphones with the help of a specialised application.

5. Using MATLAB for modelling: In order to forecast yield outcomes, MATLAB is used to simulate and analyse data for various crops under various situations.

III. PROPOSED SYSTEM

This project presents a number of improvements and innovations to transform the cultivation of chillies in response to the shortcomings of earlier farming methods. The technology makes it possible to precisely detect and analyse the amounts of soil nitrogen, phosphorus, and potassium—nutrients necessary for strong plant growth—by combining NPK sensors with RS485 communication modules. Furthermore, the use of pH sensors makes it possible to evaluate the acidity or alkalinity of the soil, improving the conditions for growing chillies. Adding temperature and humidity sensors improves monitoring even more and provide information on how the environment affects crop development. The project creates a smooth link to the cloud by utilising ESP01 modules, allowing for remote data transfer and storage for thorough analysis.

In summary, the use of IoT technology to the production of chillies has enormous potential to transform contemporary agriculture. The project intends to provide farmers with actionable information regarding soil quality through the use of cutting-edge sensors, microcontrollers, and cloud-based platforms, enabling sustainable crop production and optimal resource management. The initiative aims to accelerate the shift to a more effective, resilient, and equitable agricultural system by addressing the shortcomings of earlier farming practices and embracing innovation.

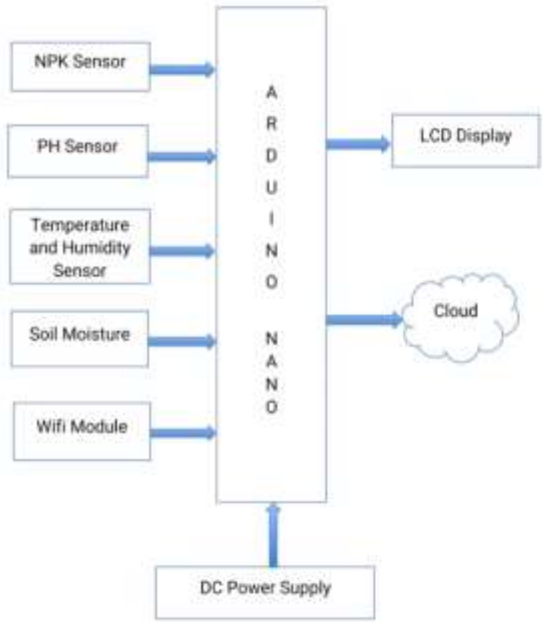

Fig.1. General Block diagram

IV. COMPONENTS USED AND DESCRIPTION

1. ARDUINO NANO CONTROLLER

The Arduino Nano is a small, multipurpose microcontroller board that is used for electrical project development and prototyping. For a multitude of uses in the maker community, education, and professional projects, its compact size, user-friendliness, and extensive feature set make it perfect. The Nano's robust ATmega328P microcontroller has enough memory and processing capacity to run intricate programs and interface with a variety of other devices. Makers may quickly experiment with various circuits and ideas because to its handy form factor, which is readily connected into a breadboard for rapid prototyping. A wide variety of applications can benefit from the Nano's many connectivity choices, which include digital and analogue input/output ports, serial communication capabilities, and compatibility with a large number of sensors and actuators. The Arduino Nano offers a versatile platform for realising your ideas, whether you're creating informative tools, interactive installations, robots, or Internet of Things gadgets. Additionally, the Arduino development environment, which consists of the Arduino Software (IDE), libraries, and online community resources, gives the Arduino Nano good support. For both novice and seasoned developers, this support system makes it simple to begin programming and increase the functionality of their projects. For exploration, education, and creativity in the realm of electronics and embedded systems, the Arduino Nano is an all-around strong and user-friendly instrument. Professionals, educators, and makers all around the world choose it because of its small size, adaptability, and easy-to-use design.

Fig.2. Arduino UNO

2. NPK SENSOR

The soil NPK sensor may be used to measure the amount of nitrogen, phosphorous, and potassium in the soil as well as to determine the soil's fertility by measuring the amounts of N, P, and K. The soil npk sensor's stainless steel probe is long-lasting and resistant to corrosion from alkali, salt, and prolonged electrolysis.

Fig.3. NPK SENSOR

3. LCD Display

One kind of flat panel display that primarily employs liquid crystals for operation is called an LCD (Liquid Crystal Display). Since LEDs are frequently found in computer displays, instrument panels, televisions, and cellphones, they offer a wide range of applications for both consumers and enterprises.

When compared to the technologies they superseded, such as gas-plasma displays and light-emitting diode (LED), LCDs represented a significant advancement. Compared to cathode ray tube (CRT) technology, LCDs made screens significantly thinner. Due to its ability to block light instead of emitting it, LCDs use a lot less electricity than gas-display and LED displays. The liquid crystals in an LCD use a backlight to create a picture where an LED emits light.

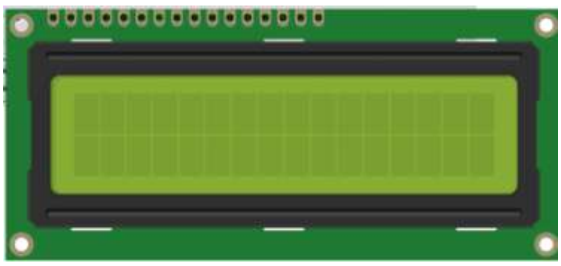

Fig.3. LCD Display

4. Power Supply

Either an external power source or a USB cable can be used to power the Arduino Uno. An AC to DC converter is the most common external power source; batteries are sometimes used. The adapter can be connected to the Arduino Uno by plugging into the power jack of the Arduino board. The Vin and GND pins of the POWER connector can also be used to connect the battery leads. Seven to twelve volts is the recommended voltage range.

5. PH SENSOR

The PH sensor is a device that measures the amount of hydrogen ions present in a solution and transforms that information into a useful output signal. Typically, it consists of a signal transmission component and a chemical component. The digital representation of the measurement range is 0–14. Neutrality is represented by the number 7. Stronger alkalinity is indicated by a greater number, whereas stronger acidity is indicated by a smaller value. The pH sensor is frequently used in industry to test materials like water and solutions.

Fig.4. PH Sensor

6. DHT11 SENSOR

One popular digital temperature and humidity sensor is the DHT11 sensor. For simple temperature and humidity sensor applications, it offers dependable data and is rather easy to use.

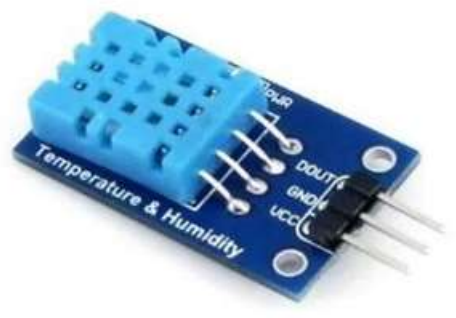

Fig.5. DHT11 Sensor

7. SOIL MOISTURE SENSOR

One tool for determining the amount of moisture in soil is a soil moisture sensor. It is frequently used in gardening, agricultural, and environmental monitoring applications to track soil moisture levels for study or to decide when to water plants.

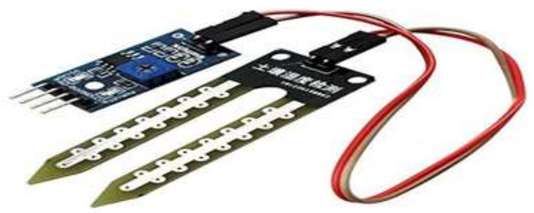

Fig.6. Soil Moisture Sensor

8. ESP01 WIFI MODULE

Based on the ESP8266 Wi-Fi microcontroller chip, the ESP-01 is a popular module. It is well-liked by builders and enthusiasts for a number of reasons.

First of all, because of its inexpensive cost and tiny size, it is perfect for projects with limited funds and space. Wi-Fi connection, GPIO (General Purpose Input/Output) ports for integrating with other components, and support for many communication protocols are just a few of the notable features that the ESP-01 offers despite its small physical footprint.

Fig.7. ESP01 WIFI MODULE

V. WORKING

The proposed system operates based on the following step-by-step process:

1. **Sensor Data Collection**
   - The system begins by collecting real-time data from multiple sensors deployed in the soil.
   - The NPK sensor measures nitrogen, phosphorus, and potassium levels to assess soil fertility.
   - The pH sensor determines soil acidity or alkalinity, which affects nutrient availability.
   - The DHT11 sensor records temperature and humidity, crucial for chilli plant growth.
   - The Soil Moisture sensor detects the water content in the soil to optimize irrigation needs.
2. **Data Processing using Arduino Nano**
   - The Arduino Nano microcontroller processes signals from the sensors.
   - The ESP01 Wi-Fi module enables wireless data transfer to the cloud for real-time monitoring.
3. **Data Display and Transmission**
   - The 16×2 LCD Display shows real-time sensor values locally for farmers' reference.
   - The ESP01 module sends the collected data to a cloud platform, allowing remote access.
4. **Cloud Storage and Analysis**
   - The IoT-based cloud platform stores and analyzes sensor data.

- Historical data helps in monitoring soil conditions over time and predicting necessary adjustments.

5. **Automated Decision-Making & Irrigation Control**
   - Based on soil moisture data, the system can automate irrigation using relays connected to water pumps.
   - Farmers receive alerts if any parameter (moisture, pH, NPK levels, temperature, etc.) is outside optimal ranges.
6. **User Access via Mobile or Web Interface**
   - Farmers can monitor real-time soil conditions and recommendations through a mobile or web application.
   - The data-driven insights help in optimizing fertilizer use, irrigation, and overall chilli cultivation efficiency.

VI. RESULTS

The implementation of the smart soil monitoring system for chilli cultivation demonstrated significant improvements in soil quality management and crop yield. By integrating IoT sensors, real-time data on temperature, humidity, soil moisture, pH, and nutrient levels was collected and analyzed. This allowed farmers to make informed decisions regarding fertilization, irrigation, and environmental control, leading to optimized resource utilization and reduced wastage.

The ESP01 module and Arduino Nano-based system enabled seamless data transmission to the cloud, providing farmers with remote access to soil health insights. The integration of NPK and pH sensors helped in maintaining optimal nutrient levels, reducing the risk of deficiencies that affect plant growth. Additionally, the automated irrigation system ensured that water was supplied efficiently based on soil moisture readings, leading to better water conservation and healthier crop development.

Through continuous monitoring and data-driven recommendations, the system enhanced chilli production efficiency, minimized human intervention, and improved overall farm productivity. The ability to track long-term soil conditions also provided valuable insights for future crop planning and soil management strategies, making the system a sustainable solution for smart agriculture.

Fig.8. project kit

Fig.9. output kit

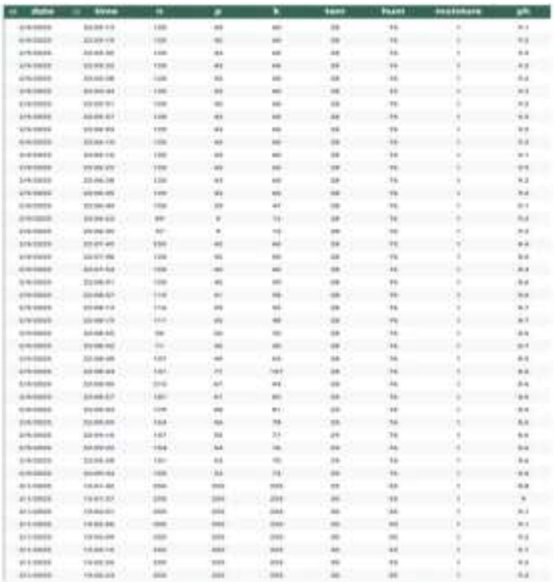

Fig.10. cloud data storage

VII. CONCLUSION

Using IoT to optimise chilli farming through the installation of a Smart Soil Monitoring System provides a data-driven method for raising crop output, quality, and resource efficiency. Farmers may minimise water waste and maximise fertiliser use by using real-time soil moisture, temperature, and nutrient monitoring to drive their decisions. By encouraging sustainable agricultural methods, the use of IoT technology reduces environmental effect while simultaneously increasing output.

This smart technology equips chilli producers with automated insights, saving human work and assuring greater crop health. For even more accurate agricultural advice, future developments can integrate automation and AI-based predictive analytics. In the end, IoT-driven smart agriculture opens the door to high-yield, economical, and effective chilli production, resolving the difficulties of contemporary farming while boosting farmer profits.

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