IRO Journal on Sustainable Wireless Systems (ISSN: 2582-3167)
www.irojournals.com/irosws/

IoT-based Smart Agriculture Field Monitoring using Arduino Nano

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Abstract

The rapid developments in the Internet of Things (IoT) have enabled even individuals with limited technical knowledge to access real-time reception of information conveniently at their doorstep. Agriculture, one of the necessities for human livelihood, has been significantly enhanced with technological advancements. The study proposes an IoT-based smart agriculture field monitoring system using Arduino Nano. The device provides real-time data on temperature and soil moisture content for cultivating crops like paddy, tapioca, turmeric, etc. The system also allows farmers to get remote access to the irrigation systems, hence improving the management of the fields along with their resources.

Keywords: IoT, Sensors, ThingSpeak App, Agriculture.

1. Introduction

Farming is one of the significant sectors of the economy of the country, as over 60% of Indians rely on agriculture. One-third of the nation's overall income comes from land-based activities, which are mostly supported by agriculture. Agriculture in India has been primarily conducted using traditional, age-old ways for many generations, even though this provides for a significant percentage of the nation's growth. But, to meet the world's expanding food demand and solve industry issues, agricultural practices must be modernized together with the quickly advancing technologies.

DOI: https://doi.org/10.36548/jsws.2024.3.005
Received: 12.08.2024, received in revised form: 01.09.2024, accepted: 14.09.2024, published: 25-09-2024

The largest barriers to agriculture include limited sources of water, inadequate irrigation systems, and a lack of available real-time monitoring solutions. Such problems result in suboptimal utilization of resources, decrease crop yields, and lead to pollution of the environment. With the use of advanced technologies in all aspects of human life, their introduction into the agricultural field is also required, which will increase productivity and further optimize the utilization of resources.

Possibly, one of the solutions is the introduction of the Internet of Things (IoT) into agriculture. IoT smart agriculture systems can deliver real-time data to farmers over critical parameters such as temperature, humidity, and moisture levels in soil. These help in strategic decisions on irrigation, fertilization, and pest control, thereby enhancing the productivity of the crops. In the long run, these systems will reduce the overuse of resources such as water and fertilizers, leading to reduced costs and lower negative environmental impact.

Such applications, apart from optimizing resource usage, can very importantly be used in detecting and preventing pest and disease outbreaks through crop health and environmental conditions monitoring. Such farming involves precision, which further increases yields and conserves resources.

As agriculture moves towards modern solutions, IoT offers a transformative approach. It connects physical devices and sensors to the internet, allowing seamless communication and data sharing. This enables farmers to access real-time information wirelessly and make more efficient decisions. The potential of IoT in agriculture is vast, and its application can fundamentally change traditional farming methods, driving sustainability and productivity to new heights.

This work focuses on developing an IoT-based smart agriculture field monitoring system using the Arduino Nano, which will provide farmers with real-time data and remote access to control irrigation systems. Such a system can help address many of the challenges Indian farmers face, ensuring better resource management and improving crop outcomes.

2. Related Study

India's agriculture faces challenges like migration and environmental factors. Automation can address these issues by integrating sensors and IoT, saving farmers time, money, and energy. This allows farmers to monitor crops, improve yields, and deliver products timely [1]. The agriculture industry is becoming more data-centric, precise, and smarter due to the emergence of IoT technologies. The study [2] explores the potential of wireless sensors and IoT in agriculture, analyzing their applications, challenges, and benefits. It discusses sensors for soil preparation, crop status, irrigation, insect and pest detection, and their use in crop stages. It also discusses the use of unmanned aerial vehicles for crop surveillance and optimization. The IoT's role in smart agriculture would significantly improve human society by improving food security, optimizing resource usage, reducing human labor, increasing productivity, and enhancing sustainable development [3]. IoT gives simple access to farmers by sending real-time updates on the activities monitored in the field using the wireless sensors employed [4] and reduces the burden of the farmers compared to normal farming [5]. IoT enables farmers to manage the agricultural field smartly and efficiently by employing sensors to gather the soil moisture, temperature, pH level, etc. The microcontrollers are employed as control units to process the data received and actuate the necessary control signal. The existing research has come up with novel ideas to automate the agricultural process using different types of sensors and microcontrollers, such as Node MCU ESP8266, Arduino, ARM Cortex Microcontroller, Arduino Uno, etc. [6–12]. Based on the study, the proposed work aims to devise a low-cost agricultural monitoring system affordable for the farmers of Salem district, Tamil Nadu.

The proposed study is designed using the Arduino Nano, temperature and soil moisture sensors, and ThingSpeak to collect the information in real-time and send notifications to the farmers.

3. Proposed work

3.1 Block Diagram Description

The proposed work aims to provide farmers with easy access to their agricultural fields at an affordable cost. Figure 1 shows the block diagram of the proposed system. The proposed system includes a DHT11 sensor to measure the temperature and humidity, and a YL-69 to measure soil moisture in the farmland. The system uses Arduino Nano as the central control unit to monitor the environmental conditions of the field by reading the sensor data, processing it, performing control operations, and communicating the observed data to an LCD and

ThingSpeak. Additionally, the system also includes a motor driver (L298N), water pump, and 16x2 LCD.

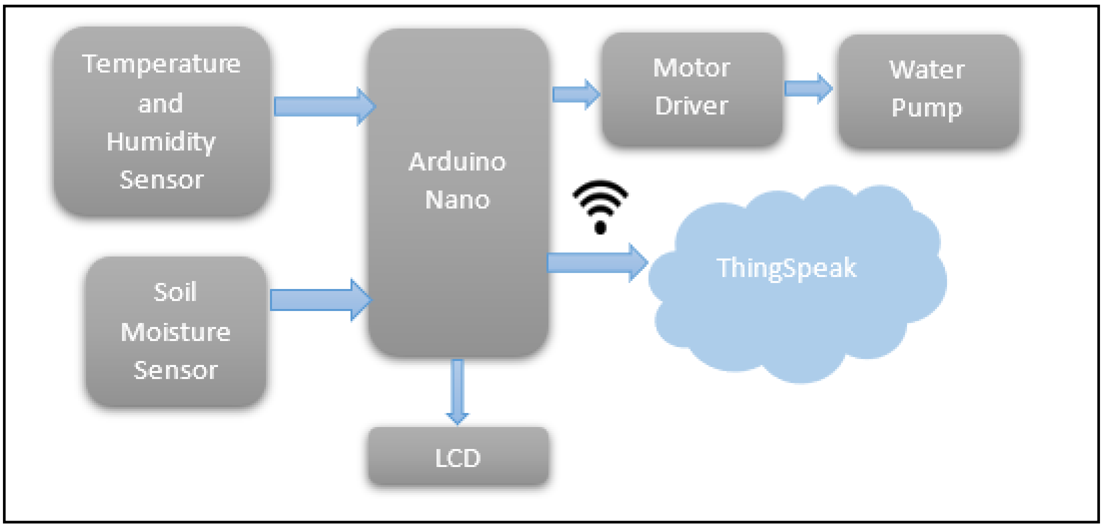


Figure 1. Block Diagram of the Agriculture Field Monitor

3.2 Working Description

The Arduino Nano acts as the central hub and monitors environmental conditions such as temperature, humidity, and soil moisture using the DHT11 and YL-69. The data gathered are processed by the Arduino Nano. Based on the temperature and the soil moisture level data received from the sensors, the Arduino Nano compares these readings with predefined threshold levels and actuates the water pump through the motor driver. The moisture level of the soil, as well as the temperature and humidity of the environment, are continuously updated every second. Once the soil moisture reaches the optimum moisture level the Arduino Nano sends an instruction to the motor driver to switch off the water pump. Thus, ensuring that sufficient water is supplied to the plant. The proposed system closely watches the moisture level of the soil and prevents the soil from becoming too dry. The flowchart in Figure 2 illustrates the working of the proposed framework.

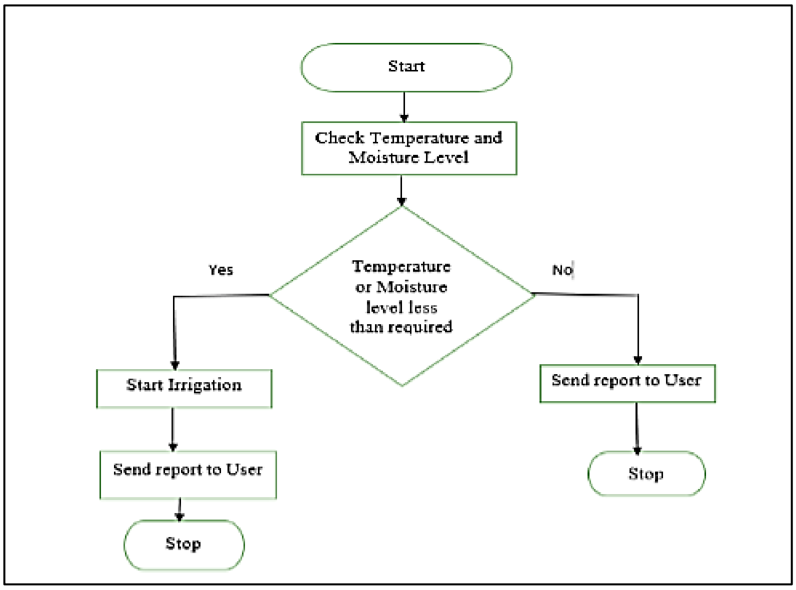


Figure 2. Flowchart of Agriculture Field Monitor

4. Results

The hardware prototype of the proposed system is shown in Figure .3 below. The Arduino IDE is used to develop and upload the necessary code to the Arduino Nano. The basic operations (monitoring, processing, controlling, and communicating) of the Arduino Nano and its programmed in C++ and uploaded to the Arduino Nano. The sensors and the other devices are integrated with the Arduino by including their respective libraries in the code. The components are connected using the wires and jumpers, as shown in the figure below.

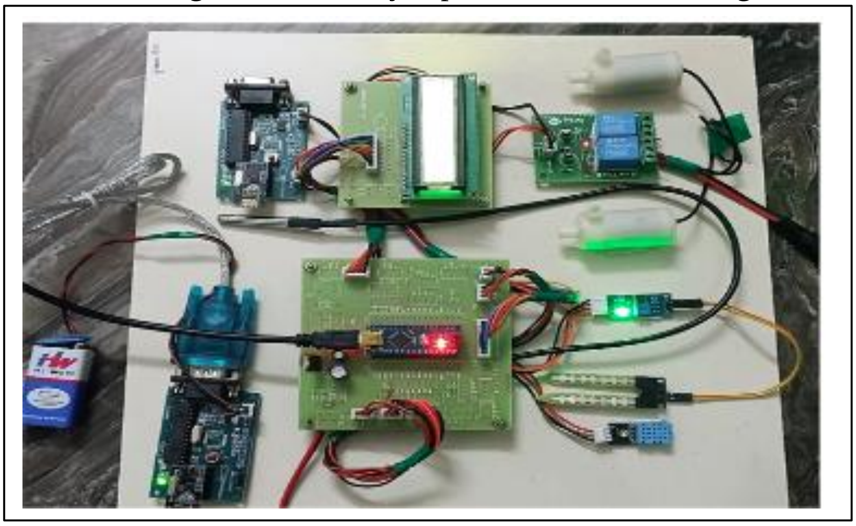


Figure 3. Hardware Prototype of Agriculture Field Monitor

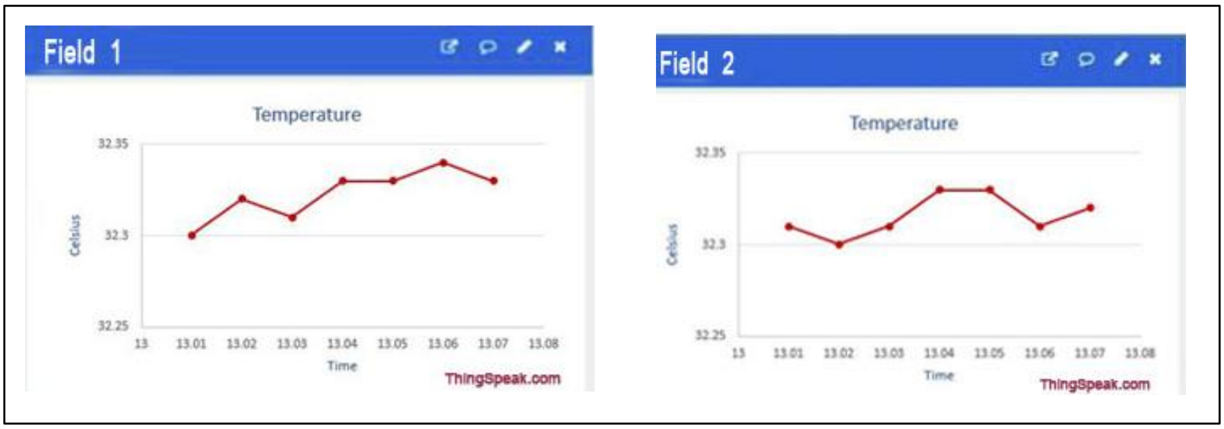
The proposed field monitor was implemented for practical use in tapioca and a paddy field in the Salem district, each managed by different farmers. The readings in Table 1 below show the soil moisture, temperature, and humidity levels measured in both fields at the same time of the day. The soil moisture thresholds for each field were customized based on the specific needs of the crops. The implementation was carried out to ensure the effective operation of the proposed system.

Table 1. Field 1 and Field 2 Temperature, Soil Moisture, Humidity Measurement

S.No	Time (Minutes)	Field 1 (Paddy , Threshold – 90%)			Field 2 (Tapioca, Threshold – 55%)		
		Temperature (0C)	Soil Moisture (V)	Humidity (%)	Temperature (0C)	Soil Moisture (V)	Humidity (%)
	13:01	32.30	1.3	20.01	32.31	1.3	21.01
	13:02	32.33	1.4	20.02	32.30	1.4	20.09
	13:03	32.31	1.7	20.03	32.31	1.6	22.03
	13:04	32.33	2	20.00	32.33	1.5	20.00
	13:05	32. 33	2.2	20.00	32.33	1.5	21.02
	13:06	32.32	2.5	20.00	32.32	1.5	20.03
	13:07	32.32	2.5	20.00	32.31	1.5	21.01

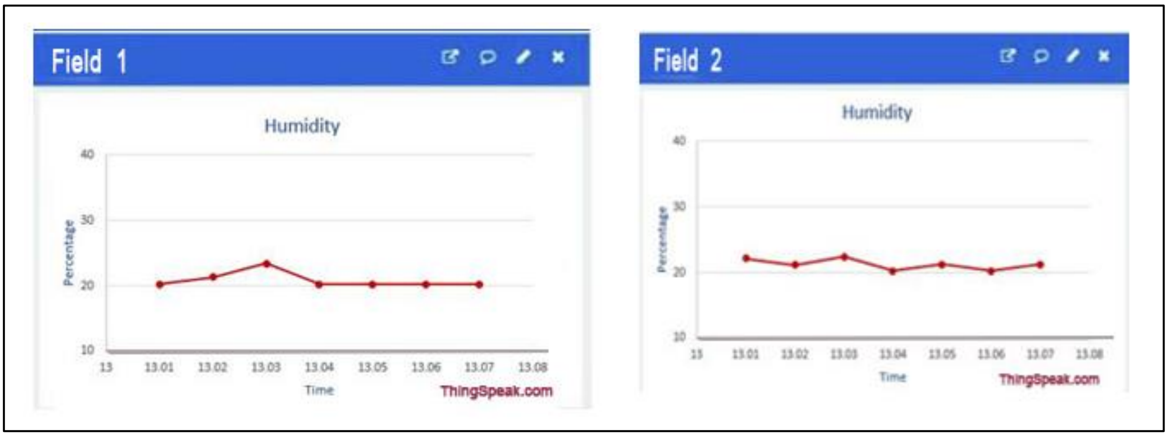
The threshold for paddy was set as 90% as paddy requires very moist soil, and the threshold for tapioca was set as 55%, as it can tolerate moderate moisture. The analog readings gathered were mapped to percentages using the ADC (analog to digital converter) in Arduino Nano and the map ( ) function.

The environmental data collected were communicated through ThingSpeak to the farmers over Wi-Fi. Figures 4-6 show the output of the temperature, humidity, and soil moisture readings observed from the Field 1 and 2. The current system supports remote access for monitoring. Future work will be on enabling remote control of devices as well as incorporating pesticide recommendations.



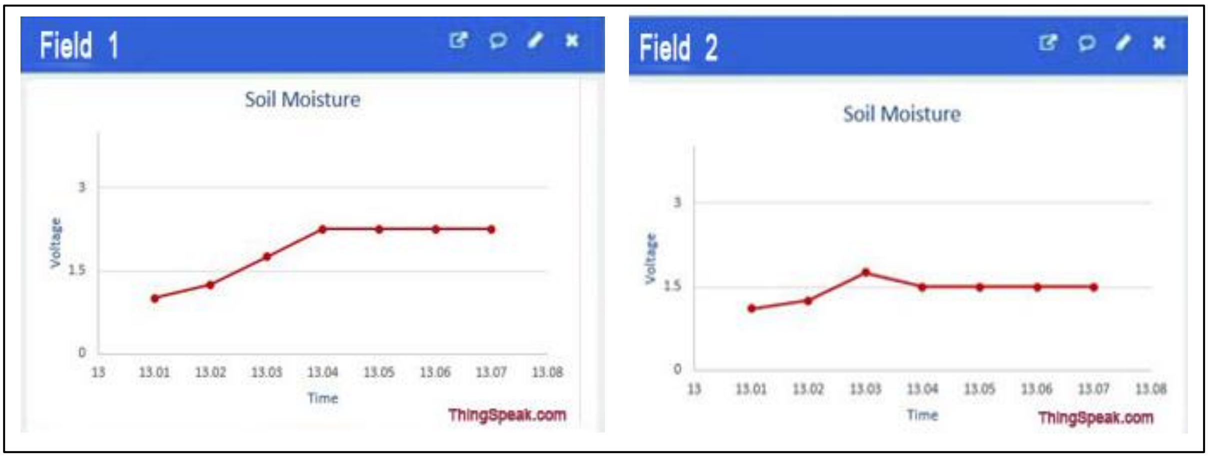
(a) (b)

Figure 4. (a) Field 1 and (b) Field 2 Temperature Readings



(a) (b)

Figure 5. (a) Field 1 and (b) Field 2 Humidity Readings



(a) (b)

Figure 6. (a) Field 1 and (b) Field 2 Soil Moisture Readings

The readings presented by ThingSpeak were observed to be 90% accurate for Field 1. However, slight discrepancies were observed in the readings from Field 2, which were likely due to Wi-Fi connectivity issues. The prototype's performance was found satisfactory by the farmers, as the proposed system successfully automated the watering of crops without human intervention. To have a more precise prediction the integration of the machine learning models would be preferred in further development.

5. Conclusion

The proposed system for smart field monitoring is an efficient and inexpensive IoT solution for real-time agricultural field monitoring. The system was designed using Arduino Nano and integrated with sensors and other devices, such as a motor, and LCD to monitor, process, control, and communicate the environmental conditions in the field. The web-based application (ThingSpeak) is used to monitor the parameters, such as soil moisture, temperature, and humidity. Thus, enabling a real-time access. Future work will be on enabling remote control of devices as well as incorporating pesticide recommendations along with the integration of machine learning models to make a precise prediction.

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