

Internet of Things (IoT) Based Smart Agriculture Irrigation and Monitoring System Using Ubidots Server [†]

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[†] Presented at The 11th International Electronic Conference on Sensors and Applications (ECSA-11), 26–28 November 2024; Available online: <https://sciforum.net/event/ecsa-11>.

Abstract: The growing world population necessitates more efficient food production, particularly in agriculture. The traditional irrigation techniques usually result in overwatering or underwatering, which wastes energy and water and reduces agricultural productivity. Smart agriculture optimizes food production, resource management, and labor. This study introduces an intelligent irrigation and monitoring system that uses the Internet of Things (IoT) to automate water pump management and monitor sunlight, temperature, and humidity levels without human interaction. The system's hardware components include a soil moisture sensor, sunlight sensor, temperature and humidity (DHT11) sensor, ESP32 microcontroller, and pump motor. The sensors are in charge of gathering the information that the ESP32 microcontroller needs in order to properly operate the pump motor. To operate and monitor data from the sensors remotely, the ESP32 is also integrated with the well-known Ubidots server via a wireless sensor network. Initially, sensors such as DHT11, soil moisture, and sunlight level collect data from the field and send it to the ESP32 microcontroller. The microcontroller then compares the received data to the previously stored data. If the values are greater than the threshold, the associated devices turn on and update the sensor value and pump motor condition to the Ubidots server.

Keywords: Internet of Things; Smart agriculture; Sensors; ESP32 Microcontroller.

Citation: Mohiuddin, M.; Islam, M.S.; Shanjida, S. Internet of Things (IoT) Based Smart Agriculture Irrigation and Monitoring System Using Ubidots Server. *Eng. Proc.* **2024**, *6*, x.
<https://doi.org/10.3390/xxxxx>

Academic Editor(s):

Published: 26 November 2024



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1. Introduction

More than 70% of Bangladesh's population and 77% of its workforce reside in rural areas. Agriculture directly employs about half of all Bangladeshi workers, including two-thirds in rural regions, and approximately 87% of rural households rely on agriculture for at least some of their income [1]. According to the report, the world's population is anticipated to reach 10 billion by 2060 [2]. However, due to population growth, the need for food grains has increased suddenly in recent years. Sadly, there is an inverse relationship between population increase and food grains. For this reason, food production should be increased internationally in the upcoming years [3]. People acknowledge agriculture as a crucial pillar of emerging countries' economic frameworks because of its significant economic function. It has been closely linked to the expansion of essential food crops for several decades [4].

The occurrence of a water deficit in both agricultural and non-agricultural areas will have a substantial impact on people's quality of life, especially those who rely on these towns for intermittent food production [7]. Given the significant water consumption in the industrial sector, it is realistic to anticipate a surplus allocation of water resources to agricultural operations. Experts have highlighted insufficient irrigation efficiency as a major source of water waste [8].

Without coordinated planning and unprecedented international cooperation, the next half-century will be plagued by a slew of severe water-related issues, endangering the well-being of many terrestrial ecosystems and severely impairing human health, particularly in the world's poorest regions.

The idea of "smart agriculture" involves using information and communication technologies to coordinate all tasks and operations within the agricultural sector. The Internet of Things (IoT) has the potential to impact many aspects of our lives, including smart cities, connected cars, and sophisticated industries [5,6]. However, IoT has the potential to have a far greater influence on agriculture.

T. Vineela et al. examine different sensor modules for a monitor in the smart agricultural industry. In order to improve agricultural production, the primary goal of this work is to implement a wireless sensor network. This model functions as an interface between the Raspberry Pi and numerous embedded sensors [9]. The irrigation method uses Zigbee protocols [10], an Arduino UNO, and a Raspberry Pi to relay measurement data. The cultivation variable in the appropriate soil will be used to determine the threshold value. Their focus is on minimizing the amount of water lost in the green field [11].

In appropriate soil, the cultivation variable will be used to determine the threshold value. In the green field [12], they focus on minimizing water loss. This is used to ensure that the appropriate amount of fertilizer is applied within the approved limits. This eliminates the cost of extra fertilizer while applying the exact amount required for healthy plant growth, increasing output. Chandan Kumar et al. address the direction of the water and its monitoring methods. Additionally, they are connected to the DHT11 soil moisture sensor to regulate the water's direction. In this model, the motor pump's switch is controlled by a single click within the mobile application. This article describes a cost-effective watering method for the green field. Furthermore, because of this modernized agriculture, it takes energy efficiency into account; nevertheless, access to it is restricted to mobile applications [9,13].

This study proposed an intelligent irrigation and monitoring system that uses the Internet of Things (IoT) to automate water pump management and monitor sunlight, temperature, and humidity levels without human interaction. The sensors are in charge of gathering the information that the ESP32 microcontroller needs in order to properly operate the pump motor. To operate and monitor data from the sensors remotely, the ESP32 is also integrated with the well-known Ubidots server via a wireless sensor network.

2. Proposed System

Traditional irrigation methods typically lead to over- or underwatering, wasting water and energy while decreasing agricultural output. Smart agriculture maximizes labor, resource management, and food output. This study presents an intelligent irrigation and monitoring system that employs the Internet of Things (IoT) to monitor humidity, temperature, and light levels without requiring human intervention. It also automates water pump control. Figure 1 shows the block diagram of the proposed system.

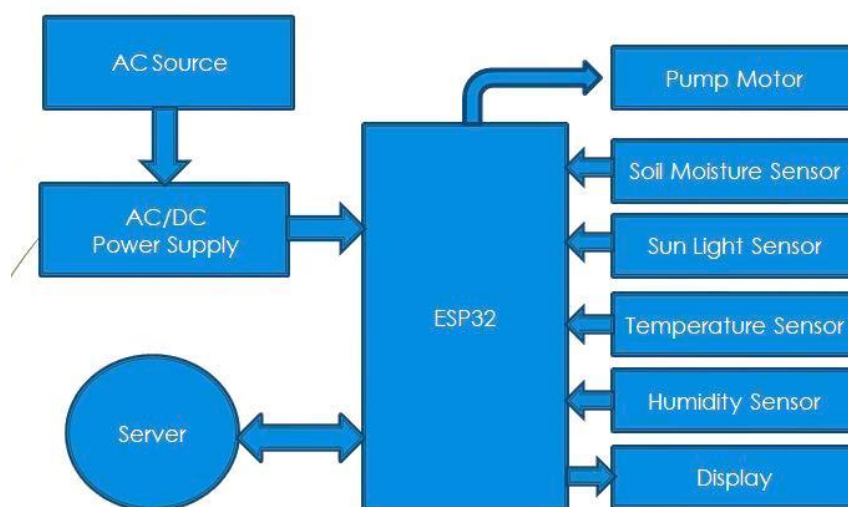


Figure 1. Block diagram of the proposed system.

All of the physical parameters are sensed by sensors, which then convert analog values into digital values. On the field, temperature and humidity are measured using DHT11 sensor that measure these two variables. The soil moisture sensors are used to gauge the amount of moisture in the soil. The sunlight sensor is used to measure the indensity of the sun. This data is then sent to the microcontroller. The microcontroller now compares the received data to the previously stored data, and if the values are greater than the threshold, the associated devices switch on. The microcontroller compares the soil moisture inside the farm to a pre-defined value; if the value is higher than the threshold, alert messages are transmitted in a graphical format to the Ubidots IOT server via the WiFi module. When the target level is reached, these devices switch off automatically. Figure 2 shows the circuit diagram of the proposed system.

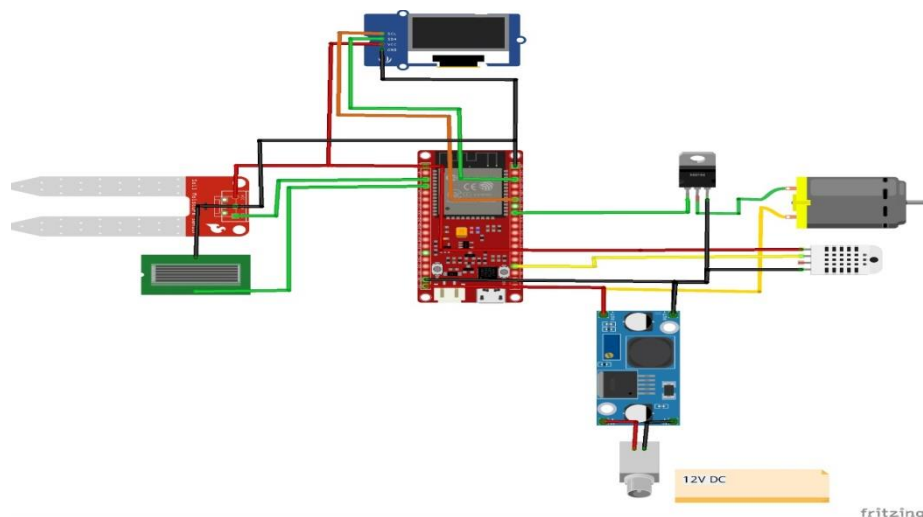


Figure 2. Connection diagram of the proposed system.

Sensor data acquisition: The sensor is connected to the ESP32 microcontroller via a DHT11 Temperature, Humidity, Soil Moisture, and Rain detection sensor.

Wireless data transmission: Sensor data is wirelessly delivered to the Ubidots server (using the Wi-Fi module ESP32).

Data processing and decision making: Data processing is the task of comparing various sensor data received from the field to previously established threshold values. If the soil moisture reading drops below the threshold, the motor will turn on automatically, and

vice versa. The farmer can even activate the motor from his mobile device or laptop via the Ubidots server.

Irrigation system automation: Upon receiving control from a server, the irrigation system becomes automated. Control from a web server is transferred via relays to an Arduino microcontroller, which powers electrical switches. Relays can be used to regulate circuits with low-power signals.

Server application: The server is intended to monitor the field and crops from anywhere via an internet connection. The ESP32 microcontroller is utilized for controlling and communicating with the server.

2.1. Ubidots Server

Data analytics and visualization for the Internet of Things (IoT) is offered by Ubidots [14]. We extract meaningful information from sensor data to support research in education, machine-to-machine communications, business decision-making, and increased resource efficiency worldwide. The IoT may be easily and affordably integrated into your research or business with the help of Ubidots. Ubidots' engineering stack and technology were created to provide our users with a secure, hands-off experience. Real-time data retrieval and transmission to and from our cloud service are made easy and secure by device-friendly APIs (available via HTTP/MQTT/TCP/UDP protocols). Time-series backend services from Ubidots are performance-optimized for IoT data computation, retrieval, and storage. Our platform for enabling applications offers real-time, interactive data visualization in the form of widgets, as well as an IoT that enables developers to add their own HTML/JS code to the platform for private customization as needed. Your data may be empowered from device to visualization with Ubidots [15].

2.2. Cloud Storage

The method of managing, storing, and processing data remotely via the internet via servers rather than on a personal computer is known as cloud computing. The term "cloud computing" is more accurately classified into three distinct categories: Software-as-a-Service, Platform-as-a-Service, and Infrastructure-as-a-Service. IaaS, or utility computing, operates under a classic utility paradigm where customers pay for servers and storage that are made available as needed. PaaS enables the development of applications inside the framework of a provider, such as Google App Engine. SaaS lets users use a browser to access and utilize a program whenever they want. Gmail, which allows you to view your stored data from any computer with internet access, is a popular example of cloud computing [16]. Here, the data storage is done via Gmail.

3. Experimental Results & Analysis

The hardware and software of the proposed system are made to provide water uniformly and directly to the plant root zone, keeping soil moisture levels within ranges that support healthy plant growth and preventing excessive water loss, erosion, deterioration of the water's quality, or salt buildup. Figures 3–5 show the physical view of the proposed system.

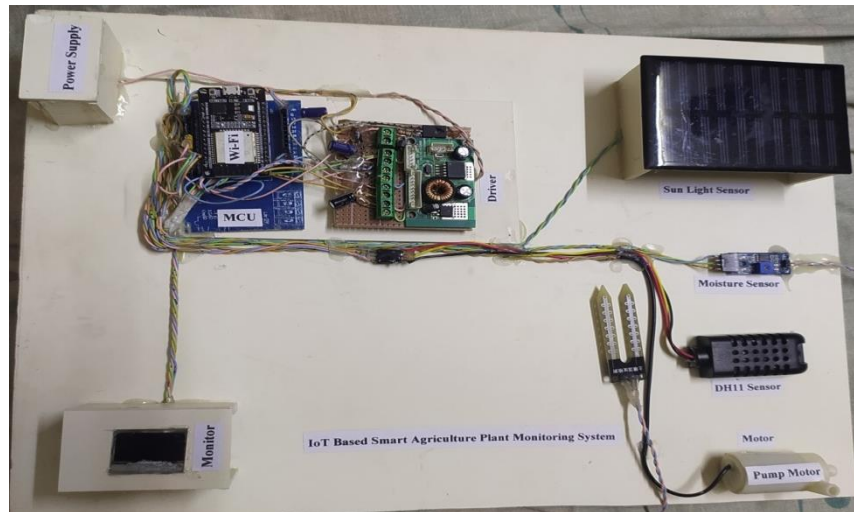


Figure 3. Physical view of the proposed system (Top View).

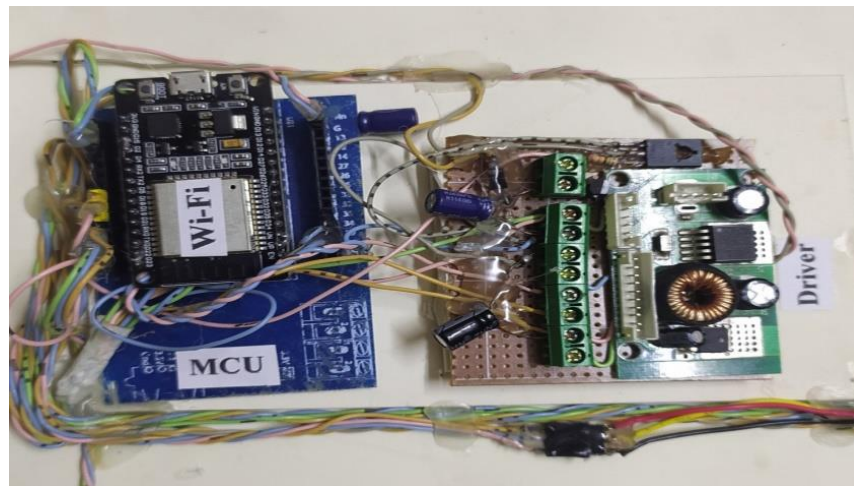


Figure 4. Physical view of the proposed system (Controlling Part).

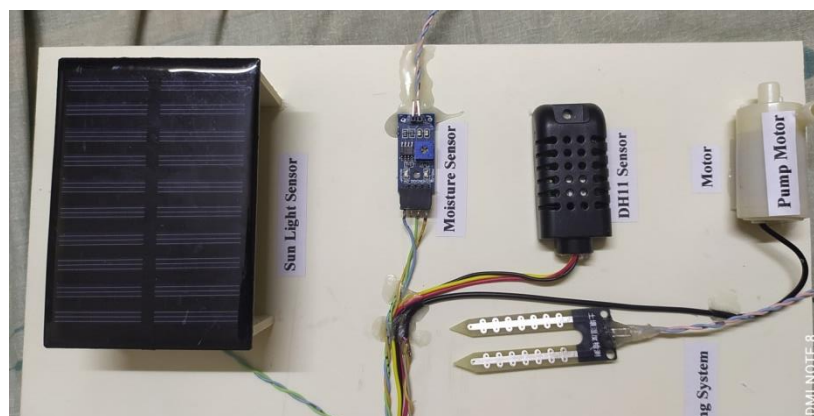


Figure 5. Physical view of the proposed system (Sensors Part).

The controllers demonstrated efficacy in preserving the plant’s soil water content within the established parameters. The drip irrigation system has undergone successful testing in the optimal scenario of carefully regulated plant irrigation to keep soil moisture levels within the parameters of a model-based system. The system is functioning well, and the soil’s water need is maintained well above the wilting point. Irrigation begins and the

soil moisture is continuously sensed and shown on the LCD when it falls below the minimal value. The moisture sensor under development provides an analog value for various moisture levels between 5 and 0 volts. A unique sensor with variable resistance to changes in soil moisture has been designed specifically for soil moisture sensors. Ten meters separated the locations of the sensor units. Figure 6 shows the server visualization of the proposed system. Once the valve is turned on, variations in the soil's moisture content indicate changes in the voltage output of the sensor over time.

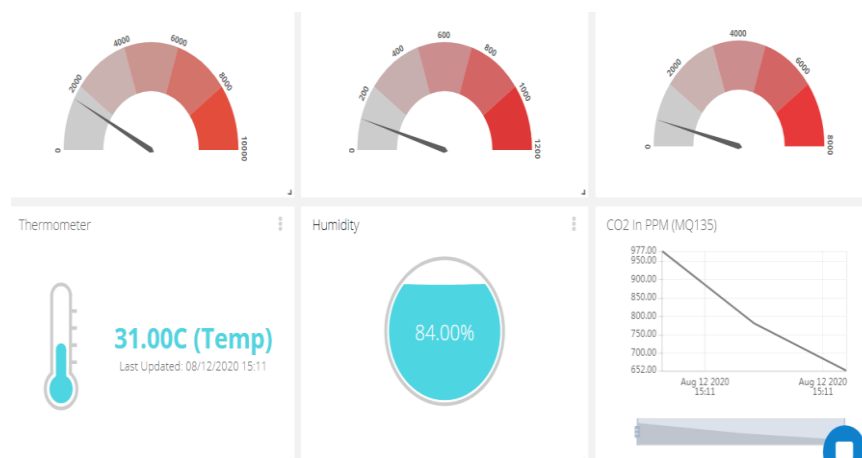


Figure 6. Server visualization of the proposed system.

4. Conclusions

The most crucial resource for raising crop yields in our nation is water, which can also be stored for other crops. This study describes an IOT-based automated watering system. Together, cloud computing and the Internet of Things (IoT) create a system that efficiently manages the agriculture industry. All environmental characteristics will be sensed by this system, and data will be sent to the user via cloud computing. The actuator will be used to accomplish the controlling action that the user takes. With this asset, the farmer can enhance cultivation in a way that best suits the needs of the plant. Increased crop yield, longer production time, improved quality, and reduced usage of protective pesticides are the results. Flood alarm information can be shown on LED display boards for road users and placed strategically for safety. Such data should be collected in real-time and delivered wirelessly from the measured site. Solar cells could serve as a power source for sensors and the centralized control unit. The flood monitoring system will be simple to construct and maintain if powered by solar cells. The usage of solar energy will also provide a cheaper source of power for the entire system.

Author Contributions: Conceptualization, M.M.; software, writing—original draft preparation, M.S.I.; review, editing, and supervision. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

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