



(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.699

Volume 14, Issue 5, May 2025

⊕ www.ijirset.com 🖂 ijirset@gmail.com 🖄 +91-9940572462 🕓 +91 63819 07438





www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 5, May 2025 |DOI: 10.15680/IJIRSET.2025.1405362|

Smart Hydroponics: Real-Time Monitoring and Nutrient Control using ESP32 and Blynk

Manohara H C, Kavana K M, Preetham T R, Princy P, Sona H R

Assistant Professor, Department of Electrical & Electronics Engineering, P.E.S. College of Engineering, Mandya,

Karnataka, India

U.G. Student, Department of Electrical & Electronics Engineering, P.E.S. College of Engineering, Mandya,

Karnataka, India

U.G. Student, Department of Electrical & Electronics Engineering, P.E.S. College of Engineering, Mandya,

Karnataka, India

U.G. Student, Department of Electrical & Electronics Engineering, P.E.S. College of Engineering, Mandya,

Karnataka, India

U.G. Student, Department of Electrical & Electronics Engineering, P.E.S. College of Engineering, Mandya,

Karnataka, India

ABSTRACT: This paper presents an IoT-based automated hydroponic system for cultivating coriander using the ESP32 microcontroller. It monitors and controls water pH, TDS, and temperature via sensors and regulates them through dosing and circulation pumps. Data is sent to the Blynk IoT platform for remote monitoring and manual override. The system maintains optimal pH (5.5–6.5) and TDS (800–100 ppm) for coriander growth, enabling precise nutrient management and water quality control. This approach promotes high-yield, resource-efficient, and sustainable herb cultivation, demonstrating the value of integrating IoT in hydroponics for precision agriculture and reduced manual labor.

KEYWORDS: IoT-based Hydroponics, ESP32 Microcontroller, Automated Nutrient Control, Real-Time Monitoring, Sustainable Agriculture

I. INTRODUCTION

With the global demand for food on the rise and arable land diminishing, sustainable and efficient farming practices are becoming increasingly critical. Hydroponic farming-growing plants without soil using nutrient-rich water-offers a promising solution by enabling precise environmental control, reducing water usage, and allowing continuous, yearround crop production. This is especially beneficial for herbs like coriander (Coriandrum sativum), which require tightly regulated conditions for optimal yield and quality. Traditional hydroponic systems often depend on manual monitoring and adjustment of parameters such as pH, Total Dissolved Solids (TDS), and water temperature. These manual processes are time-consuming and prone to human error. To overcome these limitations, this paper presents an IoT-enabled automated hydroponic system tailored for coriander cultivation. The system is built using the ESP32 microcontroller, selected for its low cost, high processing power, and built-in Wi-Fi capability. The setup includes sensors for pH, TDS, and water temperature (DS18B20), and uses dosing pumps for adjusting pH and nutrient concentration. A water circulation pump ensures uniform distribution within the hydroponic reservoir. Real-time sensor data is processed by the ESP32 to trigger actions automatically, maintaining optimal growing conditions. The system maintains pH within 5.5–6.5 and TDS levels between 800–1200 ppm, suitable for coriander. Integration with the Blynk IoT platform allows users to remotely monitor data and manually control system components through a smartphone. An OLED display provides local access to sensor readings, useful during maintenance. The system employs thresholdbased automation and predictive control logic to prevent over- or under-dosing of nutrients, reduce water usage, and optimize power consumption.





www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 5, May 2025

|DOI: 10.15680/IJIRSET.2025.1405362|

This project demonstrates how IoT integration can transform hydroponic farming into a smart, scalable, and sustainable solution, enhancing resource efficiency, reducing labor, and supporting modern agricultural demands.

II. LITERATURE SURVEY

The integration of Internet of Things (IoT) technologies into hydroponic systems is revolutionizing traditional farming by enabling intelligent, automated, and data-driven crop management. Early hydroponic systems utilized Arduino platforms to monitor parameters like pH and electrical conductivity (EC), but lacked automation and scalability [1]. With advancements, ESP32-based systems gained popularity due to their built-in Wi-Fi, dual-core processing, and ability to handle multiple sensors and actuators efficiently. Recent studies have demonstrated real-time monitoring using ESP32 and platforms like Blynk [2], though some lacked dosing automation. Other works introduced automated nutrient dosing using pH and TDS sensors, leading to better water chemistry management and reduced manual labor [3]. Comparisons with NodeMCU-based systems revealed hardware limitations such as fewer GPIO pins and lower processing capabilities [4], reinforcing ESP32's superiority in multi-sensor environments. Research integrating DS18B20 sensors for temperature control [5] and vertical stacking systems for space-efficient urban farming [6] also highlighted the growing versatility of smart hydroponics. However, challenges remain-many systems still depend on manual nutrient balancing, lack feedback-based control, or rely heavily on cloud platforms like ThingSpeak and Firebase [11][12], limiting offline usability. Some studies explored predictive nutrient management using machine learning [10], but these approaches face adoption barriers due to computational complexity. This paper addresses these limitations by proposing a fully automated ESP32-based hydroponic system for coriander cultivation. The system integrates pH, TDS, and water temperature sensors, dosing pumps for nutrient and pH adjustment, a circulation pump for water homogenization, a Grove OLED display for local monitoring, and Blynk IoT for remote control. The ESP32 acts as the central control unit, enabling real-time sensing, automation, and communication. This setup ensures consistent growing conditions for coriander, reducing human effort, optimizing resource usage, and supporting sustainable precision farming.

III. METHODOLOGY

The proposed method introduces a real-time, automated hydroponic farming system powered by the ESP32 microcontroller, designed specifically to enhance the growth of coriander plants. This method involves the continuous monitoring and regulation of essential water parameters-namely, pH, Total Dissolved Solids (TDS), water temperature — through a coordinated network of sensors and actuators. The system is designed to eliminate the need for manual supervision by automating nutrient management and environmental adjustments using IoT-based communication and control. At the core of the system, the ESP32 collects analog and digital data from connected sensors including a pH sensor, a TDS sensor, a DS18B20 temperature sensor. These sensors are calibrated before deployment to ensure high accuracy. For instance, the pH sensor is calibrated using standard buffer solutions (pH 4, 7, and 10), and the TDS sensor is validated using nutrient solutions of known concentration. The DS18B20 sensor is configured through the One Wire protocol and reads water temperature digitally. The IR sensor, placed inside the reservoir, provides binary feedback to detect whether water has fallen below the critical level, thereby preventing pump damage. The ESP32 executes logic based on predefined thresholds. If the measured pH falls outside the optimal range of 5.5 to 6.5, the system activates a corresponding dosing pump to add either acid or base to the water. Similarly, when TDS values drop below acceptable levels (typically 600–1200 ppm for coriander), the system triggers another dosing pump to inject nutrient solution into the reservoir. Water temperature, maintained within the range of 18°C to 28°C, is monitored continuously. For real-time visualization and remote control, the system is integrated with the Blynk IoT platform. Through this mobile interface, users can view live readings of all parameters, receive alerts, and manually override the automation system if needed. The ESP32 communicates with Blynk via Wi-Fi, sending periodic updates and receiving control commands. Even in the event of a Wi-Fi outage, the system continues to function locally using onboard logic and display, ensuring uninterrupted operation. This end-to-end methodology ensures that c oriander plants are always maintained under optimal hydroponic conditions, with minimal human intervention. It not only reduces resource wastage but also improves crop health and growth efficiency. The integration of real-time sensor feedback, actuator automation, cloud-based monitoring, and local display creates a robust, scalable, and intelligent hydroponic solution.





www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 5, May 2025

|DOI: 10.15680/IJIRSET.2025.1405362|

The implementation of the automated hydroponic farming system involved integrating both hardware and software components into a cohesive, functional setup. At its core is the ESP32 microcontroller, chosen for its dual-core processing, built-in Wi-Fi, and ample I/O capabilities, making it suitable for managing multiple sensors and actuators. The prototype hydroponic system, designed for coriander cultivation, includes a nutrient reservoir, water circulation system, and plant support structure. pH and TDS sensors were submerged in the reservoir to monitor chemical properties, connected to the ESP32's analog pins via signal conditioning modules for accurate readings. A DS18B20 waterproof sensor measured water temperature using the One Wire protocol. Three peristaltic dosing pumps were installed for acid, base, and nutrient dosing to regulate pH and TDS levels. A submersible pump circulated the solution throughout the system. All pumps were connected through relay modules, allowing the ESP32 to control their operation based on real-time sensor data. The system was programmed using Arduino IDE, with logic to define optimal thresholds (pH: 5.5–6.5, TDS: 800–1200 ppm). When readings after stabilization. The Blynk IoT platform was integrated for remote monitoring and manual override via a mobile app. The app displayed live sensor data, allowed manual control, and sent alerts when parameters exceeded limits. Power was supplied through a 5V adapter, with all electronics housed in a waterproof, ventilated enclosure for durability.



Fig1: circuit diagram

This circuit diagram illustrates a complete IoT-based automated hydroponics monitoring and control system built around the ESP32 microcontroller. At the core of the system is the ESP32, which is responsible for collecting data from multiple sensors, processing the information, and executing control logic to maintain optimal growing conditions. The key environmental and water-related parameters monitored include air temperature and humidity, water temperature, Total Dissolved Solids (TDS) and pH level. The air temperature and humidity are measured using the DHT11 sensor, while the DS18B20 waterproof sensor monitors the water temperature. Nutrient concentration in the water is determined using a TDS sensor, and the pH level is tracked using a dedicated analog pH sensor module. All sensor readings are fed into the ESP32, which analyzes the data and compares it against predefined thresholds suitable for coriander cultivation. To maintain these parameters within optimal ranges, the system includes a 4-channel relay module connected to multiple dosing and water pumps. These pumps are activated as needed— for example, when nutrient levels are low, or pH levels are outside the desired range. The relays receive control signals from the ESP32, ensuring automated nutrient and pH regulation. The system also features a Grove OLED display for real-time, on-site data visualization, and it integrates with the Blynk IoT platform to allow users to monitor sensor values and control the system remotely via a mobile app. Power is supplied through a lithium polymer (Li-Po) battery, ensuring portability and independence from the grid. Each relay is connected to individual pumps for specific tasks such as dosing nutrients or adjusting pH, and all relays default to an OFF state to ensure safe operation during startup. This integrated approach enables a fully automated, intelligent hydroponics solution that minimizes human intervention, reduces resource wastage, and supports sustainable, high-yield crop production.





www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 5, May 2025

|DOI: 10.15680/IJIRSET.2025.1405362|



Fig 2: Block diagram

This block diagram summarizes a smart, modular, and automated hydroponic control system. Sensors provide realtime environmental feedback to the ESP32 microcontroller, which then processes the data and controls various pumps through relays. The system integrates with the Blynk IoT platform via Wi-Fi, allowing remote access, control, and data visualization—ensuring efficient and sustainable plant growth with minimal manual intervention

THE WORKING FLOWCHART



Fig 3: Flowchart

This flowchart outlines the complete operational logic of an IoT-based automated hydroponic monitoring and control system powered by the ESP32 microcontroller. The process begins with system initialization, where critical components are activated, including the Serial Monitor for debugging, Wi-Fi connection for network access, Blynk IoT platform for remote control, sensors (DS18B20 for water temperature, DHT11 for ambient temperature and humidity, TDS and pH sensors), and relay outputs for pump control. data from all connected sensors. The water temperature is read first from the DS18B20 sensor; if it fails, a default value of 25°C is used to maintain stability. Ambient temperature and humidity readings are then obtained from the DHT11 sensor and uploaded to Blynk via virtual pins V7 and V8. Next, the system reads the TDS sensor connected to analog pin 35. It applies median filtering and temperature compensation to produce an accurate Total Dissolved Solids value. The pH sensor on pin 39 follows a similar process, using a soft buffer and averaging algorithm to convert analog input into a reliable pH reading. The computed values for water temperature, TDS, and pH are transmitted to the Blynk cloud via virtual pins V0, V1, and V2, respectively, for





www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 5, May 2025

|DOI: 10.15680/IJIRSET.2025.1405362|

live monitoring on the user's mobile device. The automation logic then determines the system's response based on the sensor values. If the TDS value is below 500 ppm, the ESP32 activates the nutrient dosing relay to increase the nutrient concentration. If the pH value drops below 6.0, the pH-up relay is activated to raise the pH.

Working of the Hydroponics Monitoring and Control System (with Plant- Specific Thresholds)

This IoT-based hydroponic automation system is developed using the ESP32 microcontroller to maintain optimal growth conditions for coriander (Coriandrum sativum), a herb well-suited to soilless cultivation environments. The system continuously monitors and manages crucial environmental and nutrient parameters to ensure healthy plant development. It uses a DS18B20 waterproof digital temperature sensor to monitor water temperature, a DHT11 sensor to record ambient air temperature and humidity, an analog TDS sensor to measure nutrient concentration (Total Dissolved Solids), and an analog pH sensor to track the acidity or alkalinity of the nutrient solution. The system is designed to maintain ideal growing conditions for coriander, which include a TDS range of 560–840 ppm, pH range of 5.5–6.5, water temperature between 18–27°C, and air temperature of 15–28°C. Every second, the ESP32 collects readings from all sensors. To ensure measurement accuracy, filtering techniques like median filtering are applied, particularly to the TDS and pH sensor values. Additionally, TDS readings are adjusted using water temperature compensation, enhancing precision and system reliability. The filtered sensor data is sent to the Blynk IoT Cloud using designated virtual pins (V0 to V8), enabling real-time remote monitoring through a smartphone app. Users can view live sensor readings and get status updates on the system's operation. This ensures constant visibility into the plant's growing environment and helps in early detection of any abnormal conditions. The system employs a robust automation logic. If the TDS value drops below 500 ppm, indicating low nutrient levels, the ESP32 activates three dosing relays (RELAY NUTRIENT 1, RELAY NUTRIENT 2, and RELAY NUTRIENT 3) to dispense nutrients into the solution. If the pH drops below 6.0, the pH-up dosing relay is triggered to restore the nutrient solution's pH balance. To maintain operational safety, all relays are configured to remain OFF (HIGH state) during system boot-up, preventing any accidental activation. Manual override functionality is available through the Blynk mobile app via virtual switches (V3 to V6).

IV. EXPERIMENTAL RESULTS.

The implemented system was tested on a coriander hydroponic setup under controlled indoor conditions for a period of two weeks. The ESP32-based system successfully demonstrated its ability to monitor, automate, and maintain optimal water and environmental conditions using real-time sensor feedback and actuator control.

Parameter	Optimal Range	Notes
Light Duration	14 – 18 hours/day	Use full-spectrum grow lights if natural sunlight is insufficient.
pH Level	5.5 - 6.5	Slightly acidic; monitor and adjust regularly using pH sensor and dosing.
EC (Electrical Conductivity)	1.2 - 2.0 mS/cm	Indicates nutrient strength.
TDS (Total Dissolved Solids)	600 – 1000 ppm	Equivalent to EC range; use TDS sensor for precise dosing.
Water Temperature	18 – 28°C	Monitored using DS18B20 sensor for best root health.
Air Temperature	$10-27^{\circ}C$	Ensure good airflow and avoid extreme fluctuations.
Relative Humidity	50% - 70%	Promotes healthy foliage; prevent fungal growth.
Light Type	Full-spectrum LED or fluorescent lights	Red + blue spectrum preferred for vegetative growth.
System Cleaning	Every 2 – 3 weeks	Flush and sanitize to avoid root rot and nutrient buildup.

Table 1: Ideal Hydroponic Conditions for Coriander[16]





www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 5, May 2025 |DOI: 10.15680/IJIRSET.2025.1405362|

System Performance

The system continuously monitored pH, TDS, water temperature, and ambient humidity. The pH value was maintained between 5.8 and 6.4, and TDS levels stabilized within the 800–1000 ppm range, aligning well with optimal conditions for coriander growth. Whenever deviations were detected, the respective dosing pump was activated, and the value returned to the threshold range within 1–2 minutes. The DS18B20 temperature sensor reported stable water temperatures ranging from 21°C to 27°C. The DHT11 sensor tracked ambient temperature and humidity, aiding in assessing external growing conditions.

Remote Monitoring and Control

The Blynk IoT platform was used extensively during the testing phase. The dashboard displayed live readings of all sensors and included buttons for manual override of the pumps. Alert notifications (via push messages) were triggered when pH or TDS values exceeded safe thresholds. This real-time mobile interface proved extremely useful when the ESP32 was connected to Wi-Fi through a PC-enabled hotspot. Even under intermittent network conditions, the system stored and displayed the latest readings on the Grove display, ensuring local observability.



Fig 4 : Iot Monitering in Blynk App

1. Water Temperature: 28°C

0

- The current water temperature is displayed as 28°C, which exceeds the optimal range for coriander cultivation (10–27°C). Prolonged exposure to higher water temperatures may impact root oxygen levels and overall plant health. Cooling methods such as a Cooling fan.
- 2. TDS Total Dissolved Solids: 873 ppm
 - The TDS level, representing the nutrient concentration in the hydroponic solution, is 873 ppm. This value lies within the ideal range for coriander (600–1000 ppm) but is approaching the upper threshold, indicating that nutrient levels should be closely monitored to avoid over-fertilization.
- 3. pH Level: 6.03
 - The measured pH is 6.03, which is above the optimal pH range for coriander (5.5–6.5). This could limit nutrient uptake, especially of micronutrients. A pH-lowering solution (e.g., pH Down) may be required to adjust the acidity and bring the value into the desired range.
- 4. Ambient Air Temperature: 30.8°C
 - The air temperature surrounding the coriander plants is 30.8°C, which is higher than the recommended range of 15–25°C. Elevated air temperatures can cause bolting (premature flowering) in coriander and may reduce leaf quality. Proper ventilation or cooling systems should be considered.





www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 5, May 2025

DOI: 10.15680/IJIRSET.2025.1405362













Fig 8: Atmosphere temperature

These line graphs provide historical trends over the last 15 minutes:

1. Water Temperature

- Fairly stable around 30.9–31.0°C.
- May require temperature control as it's higher than the coriander optimum.

IJIRSET©2025





www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 5, May 2025

|DOI: 10.15680/IJIRSET.2025.1405362|

2. **TDS**

- Shows fluctuations but is now steady at ~873 ppm.
- Suggests either manual or automatic nutrient addition, stabilized it.
- 3. pH
 - \circ Rose quickly and stabilized at ~6.03, which is slightly high.
 - May soon trigger the pH-down solution if the threshold logic is implemented.

4. Atmosphere Temperature

• Decreased gradually over time from ~27°C to ~30.8°C, indicating cooling.

V. CONCLUSION

This paper presents the successful development and implementation of an automated hydroponic farming system using the ESP32 microcontroller and IoT technologies. The system was designed to monitor and control key parameters such as pH, TDS, water temperature, and ambient humidity in real time, ensuring optimal growing conditions for coriander plants. By integrating multiple sensors, peristaltic pumps, a circulation pump, and an 8-channel relay module, the system achieved full automation of nutrient management and environmental regulation. The use of the Blynk IoT platform enabled remote monitoring and control via a smartphone, while the Grove display provided on-site visualization of all sensor readings. Experimental results over a 14-day period confirmed the system's reliability and effectiveness. The pH and TDS levels were consistently maintained within the optimal ranges, and the water temperature remained stable despite environmental fluctuations. The use of a PC-generated Wi-Fi hotspot and mobile connectivity allowed uninterrupted data flow and real-time control. Additionally, the system's safety features—such as low-water-level detection and pump protection-demonstrated its practical applicability for long-term unattended operation. Overall, the proposed system offers a scalable, energy-efficient, and low-cost solution for modern precision agriculture. It minimizes manual intervention, reduces resource wastage, and improves crop quality. Future work can expand the system by incorporating cloud-based data logging, AI-driven nutrient prediction, solar energy integration, and compatibility with other crop types. This work underscores the potential of IoT-driven automation in achieving sustainable and smart hydroponic farming.

ACKNOWLEDGEMENT

We gratefully acknowledge the assistance and facilities provided by the Project Lab, Department of EEE, PESCE, Mandya during the project work leading to this publication.

REFERENCES

- 1. V. S. Rathore et al., "IoT Based Smart Hydroponics Farming System," IJRTE, vol. 8, no. 6,2020.
- 2. T. Dineshkumar and P. Balaji, "Smart Hydroponic System Using ESP32 and Blynk,"JETIR,vol.8,no.5,2021.
- 3. R. Sharma et al., "Smart Hydroponic Monitoring Using ESP32 and Predictive Analytics,"Comp.&Elect.in Agric., vol. 197,2022.
- A. Singh and A. Kumar, "Automated Hydroponics Using NodeMCU," IRJET, vol. 6, no. 5, 2019.
- 4. S. Patil and R. Patil, "Solar Powered IoT Hydroponic System," IJERT, vol. 10, no. 6,2021.
- 5. S. Verma et al., "Vertical Hydroponics with IoT Integration," IJERT, vol. 10, no. 4, 2021.
- 6. K. B. Prasad et al., "Urban Hydroponics Using IoT," IJRASET, vol. 7, no. 5, 2019.
- 7. P. Rajalakshmi and V. Jagannathan, "Blynk-Based Hydroponic System," IJRTE, vol. 8,no. 4, 2020.
- A. Deore and S. Rode, "Smart Nutrient Monitoring Using IoT," IJERT, vol. 10, no. 7,2021.
- 8. R. Mahajan et al., "Hydroponic Automation via Mobile App," IJESRT, vol. 9, no. 3,2020.
- 9. R. K. Jatoth et al., "Wireless Sensor Networks for Smart Agriculture," Procedia Comp.Sci., vol. 141, 2018.
- 10. S. Narayan et al., "Cloud-Controlled Hydroponics," IJRASET, vol. 10, no. 1, 2022.
- A. Pathak and R. Patel, "-Based Hydroponic System," IJTSRD, vol. 5, no. 6,2021.
- 11. P. Mehta et al., "Automated Nutrient Management System," IJAER, vol. 15, no. 6, 2020.
- 12. M. Yusuf et al., "Smart Aquaponics Using IoT," IEEE Access, vol. 7, 2019.
- 13. https://proponics.co.uk/blogs/plants-and-vegetables/easy-hydroponic-coriander-athome?srsltid=AfmBOoq5adun7X8nkoKZg3TgSirpHYsX8xDwllTkK3Gkknn5RD5GZvuA

IJIRSET©2025

| An ISO 9001:2008 Certified Journal |









INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY





www.ijirset.com