



IOT BASED HYDROPONICS CULTIVATION USING ESP32 IN BLYNK

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Abstract: The integration of Internet of Things (IoT) technologies has transformed modern agriculture by offering automation, accurate control, and remote monitoring. This work introduces an IoT-enabled hydroponic monitoring and management system that enhances the efficiency and sustainability of soilless cultivation. The system utilizes an ESP32 microcontroller with built-in Wi-Fi to link to the Blynk IoT platform, facilitating live tracking and control through a mobile interface. Core environmental parameters such as moisture and pH are continuously measured using appropriate sensors. The collected data are processed by the ESP32 and transmitted to the Blynk application, where users can view real-time readings and perform necessary adjustments. A relay-based circuit automatically manages water and nutrient pumps to ensure timely and precise delivery to plants. This reduces manual intervention, conserves resources, and maintains stable growth conditions. The proposed system provides a low-cost, scalable, and user-friendly solution suitable for home gardening, academic experiments, and commercial hydroponic farms, contributing to sustainable and productive agriculture.

I. INTRODUCTION

Growing global food requirements, diminishing fertile soil, and the effects of climate change have accelerated the need for sustainable and efficient farming approaches. Hydroponic cultivation—where plants grow in nutrient-enriched water without the use of soil—has emerged as a practical solution. It supports faster growth, uniform yield, and major water savings when compared to traditional agriculture [1][2]. Moreover, hydroponic techniques are adaptable to controlled settings such as rooftop gardens, greenhouses, and indoor environments, making them suitable even in areas with poor soil quality [1][2][5]. By reducing reliance on conventional farmland, hydroponics contributes to modern strategies aimed at achieving food security.

Although hydroponic systems offer numerous benefits, maintaining stable environmental conditions demands precise control of parameters such as nutrient concentration, water level, and pH. Manual observation of these factors is laborious and prone to human error, particularly in large-scale or remote installations where minor deviations can hinder plant growth [3][4]. The inclusion of Internet of Things (IoT) technology in hydroponic systems addresses this challenge by enabling continuous sensing, automated data processing, and remote control [5][6]. IoT-based systems empower growers to monitor and adjust environmental variables in real time, thereby increasing precision, efficiency, and scalability for smart farming applications.

II. LITERATURE REVIEW

Dhakad and Verma [11] developed an IoT-based hydroponic farming model that incorporated multiple interconnected sensors and microcontrollers to monitor environmental parameters in real time. Their setup employed pH, temperature, water level, and nutrient sensors linked to an ESP32 controller, which automatically managed pumps, aerators, and lighting systems. This level of automation reduced manual labor and enhanced the overall productivity and resource efficiency of hydroponic cultivation.

Luo, Xu, and Xu [12] proposed a cloud-connected smart hydroponic monitoring architecture that integrated local sensing with remote supervision and decision-making. Their model captured real-time information on temperature, humidity, and nutrient concentrations and uploaded it to a cloud dashboard for visualization and control. Cloud computing allowed users to access system data remotely through mobile or desktop devices, enabling more effective management and optimal resource use.

Shah and Patel [13] designed an IoT-driven hydroponic management system centered on continuous environmental monitoring and automated control. Utilizing ESP32 microcontrollers and various sensors, their framework adjusted lighting, aeration, and irrigation dynamically to maintain favorable growth conditions. Their research concluded that integrating IoT in hydroponics improves precision, yield, and operational efficiency while minimizing manual effort.



Roy and Bandyopadhyay [14] introduced an intelligent agricultural framework that combined ESP32 and cloud services to automate irrigation and nutrient delivery. Feedback-based control loops adjusted key environmental factors automatically, while users could remotely monitor analytics through the cloud. Their findings highlighted the effectiveness of IoT–cloud integration in achieving consistency and efficiency in hydroponic farming.

Chen and Liu [15] implemented a cost-effective IoT-enabled wireless monitoring network for hydroponic cultivation. Distributed wireless sensors were deployed to measure environmental parameters such as temperature, nutrient concentration, and light intensity. Data were transmitted to a central processing unit, which controlled actuators like pumps and lighting modules. The study demonstrated that affordable IoT-based automation can benefit both small-scale and industrial hydroponic operations.

Patel and Mehta [16] presented an IoT-powered hydroponic framework that used the Blynk mobile platform for system visualization and control. The mobile interface provided live updates of temperature, pH, and nutrient levels, along with remote actuator access. The system's ability to send automatic alerts allowed timely user responses to abnormal conditions, thus improving efficiency and reliability.

Kumar and Prasad [17] explored the use of IoT in automating greenhouse and hydroponic systems. Their setup utilized ESP32 controllers to dynamically manage irrigation, aeration, and lighting based on sensor feedback. By maintaining balanced environmental parameters through automation, they demonstrated the potential of IoT systems to save resources and promote sustainable, high-yield agriculture.

III. MATERIALS AND METHODS

The proposed IoT-enabled hydroponic farming system is designed to improve crop yield and enable remote supervision through automated control mechanisms. It integrates an ESP32 microcontroller equipped with inbuilt Wi-Fi and Bluetooth modules for reliable connectivity to the Blynk IoT platform [27]. The system continuously monitors key environmental factors such as pH, temperature, humidity, soil moisture, and light intensity to maintain optimal growth conditions. Sensor data are transmitted in real time to the Blynk mobile application, allowing users to control irrigation, lighting, and nutrient delivery with minimal manual input. This approach enhances water efficiency and is suitable for home-based, educational, and commercial farming environments.

Proposed Architecture

The hydroponic system's architecture integrates **sensor networks**, **actuators**, and a **cloud-based control mechanism** to maintain ideal growing conditions. Sensors such as pH, DHT22 (temperature and humidity), soil moisture, and light (LDR) units collect essential data from the cultivation environment. The **ESP32 controller** interprets these sensor inputs and automatically operates actuators like water pumps, lighting units, and cooling fans. Through Wi-Fi, the ESP32 communicates with the **Blynk platform**, ensuring real-time visualization, remote access, and automated operation with minimal human supervision.

a) Sensing Module

Components Used: pH sensor, DHT11/DHT22 temperature and humidity sensor, water level sensor, and Total Dissolved Solids (TDS) sensor.

Description:

This module is responsible for real-time observation of hydroponic conditions, measuring factors such as nutrient concentration, pH balance, and water level. The **pH sensor** stabilizes nutrient solutions, while the **TDS sensor** ensures correct nutrient concentration. The ESP32 collects readings from all sensors and transmits processed information to the **Blynk platform** for real-time display and automated control.

b) Control Module

Components Used: Water pump, air pump, LED grow lights, exhaust fan.

Description:

This module automatically maintains ideal environmental conditions by acting on sensor feedback. When water levels drop, the **ESP32** activates the pump; when temperature exceeds the threshold, the exhaust fan is triggered; and under low light, LED grow lights are turned on. This process optimizes growth conditions, reduces manual involvement, and ensures consistent crop output.

c) Processing and Communication Module

Components Used: ESP32 microcontroller, Wi-Fi connectivity.

**Description:**

The **ESP32** serves as the core processing unit of the system. It executes control logic, processes data from sensors, and makes real-time decisions for automation. Its integrated Wi-Fi module connects to the **Blynk cloud**, facilitating bidirectional communication for sensor updates and remote control of actuators. This guarantees stable and efficient system operation from any connected device.

d) Blynk IoT Module (Cloud and Mobile Application)

Components Used: Blynk Cloud Platform, Blynk Mobile App.

Description:

The **Blynk module** provides a simple and interactive user interface for monitoring and control. Users can view real-time readings of temperature, pH, water level, and nutrient concentration directly from their mobile devices. The interface also supports manual overrides, allowing users to activate or deactivate devices remotely. This cloud integration enables smooth, data-driven management of hydroponic systems, improving precision and efficiency.

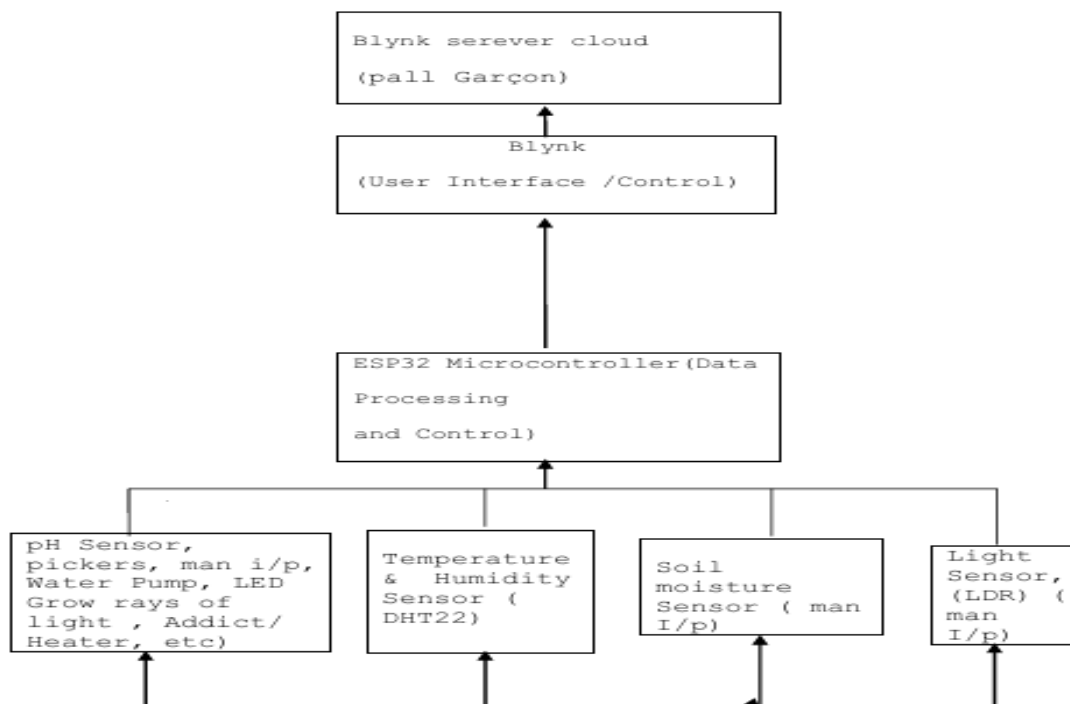
**IV. EXPERIMENTAL RESULTS**

Table .1 Performance Metrics

Metric Value (on Test Set)	
Accuracy $\pm 5\%$	
Response Time 1–2 seconds	User Interaction delay of 2–3 seconds
IoT Connectivity 98%	System Stability 24 hours



Table .2 Comparative Analysis with Other Models

Model	Accuracy	Model Size	Inference Time	Deployment Suitability
Monitoring (Traditional Hydroponics)	Low (depends on human observation)	None	Slow (hours to days)	Suitable only for very small setups; prone to errors.
Arduino-based Automation (Non-IoT)	~80-85%	Small	<1s	Good for local automation but lacks remote monitoring.
Raspberry Pi-based Smart Hydroponics	~90-92%	Large (requires storage & OS)	(2-5s)	Suitable for research and advanced farms, but costly and power-hungry.



E-Mail

Password

Log In

or

 Log In With Google Log In With Apple Log In With QRDon't have an account? [Sign Up](#)

Fig 2: Registration User Interface

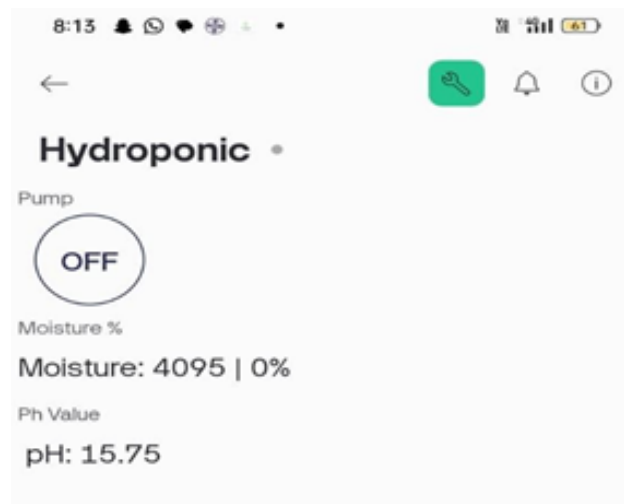


Fig 3: User Reference Screen

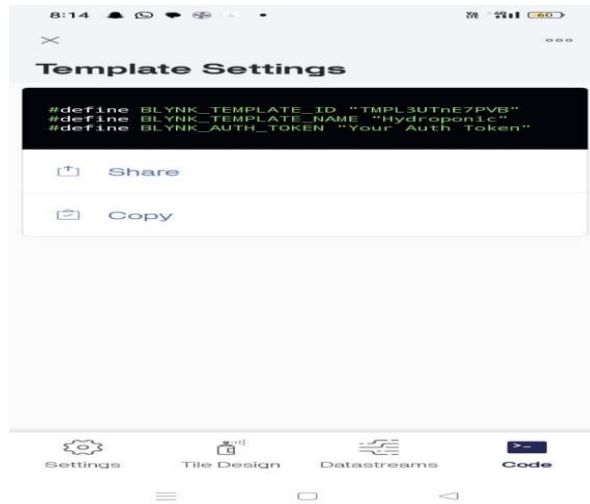


Fig 4: Template Screen

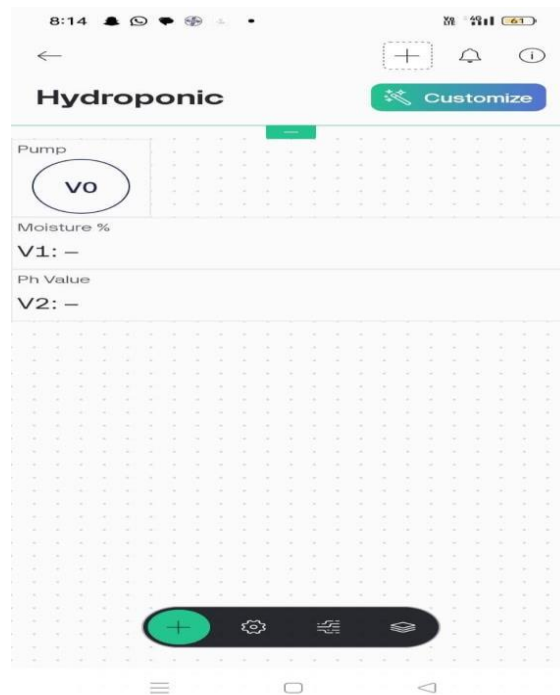


Fig 5: Home Screen

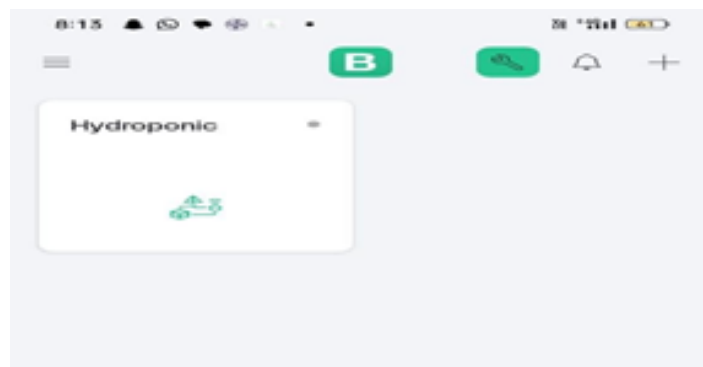


Fig 6: Code Uploading page



Fig 7: Output Screen



Fig 8: Output Screen

V. CONCLUSION

This project highlights the strong potential of **Internet of Things (IoT)** technology in advancing hydroponic farming by improving productivity, sustainability, and operational convenience. By integrating an **ESP32 microcontroller** with multiple sensors and the **Blynk IoT platform**, the system enables precise and continuous monitoring of critical parameters such as **pH, temperature, and moisture levels**. Through remote access and automatic control of pumps and actuators, the design minimizes manual work, optimizes water and nutrient distribution, and maintains ideal environmental conditions for plant growth.

The affordability and simplicity of the hardware components make this setup suitable for **home gardens, educational demonstrations, and commercial hydroponic operations**. Furthermore, the modular structure of the system allows future expansion, such as incorporating **artificial intelligence** for automated decision-making or adding **advanced sensors** for improved accuracy. Overall, the proposed system offers a **cost-effective, scalable, and smart solution** that contributes to modern, sustainable agricultural practices powered by IoT.

REFERENCES

- [1]. Resh, H. M. (2015). *Hydroponic food production*. CRC Press.
- [2]. Jones, J. B. (2016). *Hydroponics: A practical guide for the soilless grower*. CRC Press.
- [3]. Kumar, V., & Patel, H. (2021). Design and development of ESP32-based smart hydroponics system. *International Journal of Computer Applications*, 183(35), 15–21.
- [4]. Singh, A., & Sharma, R. (2020). IoT-based hydroponics system for sustainable agriculture. *International Journal of Engineering Research & Technology (IJERT)*, 9(6), 225–229.
- [5]. Lee, S., & Lee, J. (2015). An overview of smart farming using IoT in hydroponics systems. *International Journal of Agriculture & Biology*, 17(5), 103–110.
- [6]. Kim, J., Park, H., & Kang, S. (2019). Cloud-based monitoring system for smart hydroponics using IoT. *Journal of Sensor and Actuator Networks*, 8(4), 55–63.
- [7]. Espressif Systems. (2022). *ESP32 technical reference manual*. Retrieved from <https://www.espressif.com>
- [8]. Blynk IoT Platform. (2022). *Blynk documentation*. Retrieved from <https://docs.blynk.io>
- [9]. Pandey, A., & Gupta, S. (2020). Automation of hydroponics using IoT and ESP32. *International Research Journal of Engineering and Technology (IRJET)*, 7(5), 5501–5506.
- [10]. Ramya, P., & Raj, R. (2020). IoT-enabled smart farming using ESP32. *Journal of Emerging Technologies and Innovative Research*, 7(6), 234–240.



- [11]. Dhakad, S., & Verma, M. (2021). Design of IoT based smart hydroponics farming system. *International Journal of Engineering and Advanced Technology*, 11(1), 111–116.
- [12]. Luo, H., Xu, G., & Xu, J. (2020). A smart IoT system for hydroponics monitoring. *IEEE Access*, 8, 155512–155520.
- [13]. Shah, R., & Patel, D. (2021). IoT-based monitoring of soilless cultivation. *International Conference on Advances in Computing and Communication Engineering*, 1–5.
- [14]. Roy, A., & Bandyopadhyay, S. (2020). Smart agriculture using ESP32 and cloud computing. *International*
- [15]. Chen, Y., & Liu, Q. (2019). Wireless hydroponic monitoring system using IoT. *Procedia Computer Science*, 155, 600–607.
- [16]. Patel, H., & Mehta, K. (2020). IoT enabled smart hydroponics with Blynk integration. *International Journal of Future Generation Communication and Networking*, 13(3), 789–797.
- [17]. Kumar, R., & Prasad, A. (2019). IoT-based greenhouse and hydroponics monitoring. *International Conference on Smart Technologies for Smart Nation (SmartTechCon)*, 431–436.
- [18]. Sharma, P., & Jain, S. (2020). Automated irrigation and nutrient monitoring using ESP32. *International Journal of Engineering Research in Computer Science and Engineering*, 7(2), 21–26.
- [19]. Khan, S., & Rahman, M. (2019). Low-cost IoT hydroponics solution using ESP32. *International Journal of Recent Technology and Engineering*, 8(4), 953–959.
- [20]. Qureshi, M., & Raza, H. (2020). Real-time hydroponics monitoring using ESP32 and Blynk app. *International Conference on IoT and Smart Systems*, 245–251.