

# IOT based Hydroponic Monitoring and Controlling System

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**Abstract**— Hydroponic is a method where the crops are grown in the absence of soil the nutrients that are acquired from the soil are given to them artificially. This soil less culture of originating crops often involves their roots to be immersed in the nutrient solution along with some gravels or perlite medium. The maximum yield is achieved by the supply of sufficient quantity of nutrients optimum microclimatic conditions. Hydroponic farming, known for its precise environmental control, benefits from IoT's real-time monitoring and automation. The review covers hydroponics basics, IoT's role in agriculture, monitoring parameters (pH, EC, etc.), sensor types, and hardware/software components. It evaluates existing systems, discusses challenges, and outlines future directions. Ultimately, IoT promises to revolutionize hydroponic agriculture, enhancing sustainability and productivity.

**Keywords:** - Hydroponics, IoT, pH sensor, temperature sensor, smart agriculture, real-time monitoring, automation, cloud platform

## I. INTRODUCTION

Hydroponic farming offers a optimistic solution for acceptable agriculture, requiring precise monitoring of environmental factors for perfect plant growth. The integration of Internet of Things (IoT) technology enhances this monitoring capability, enabling real time data collection and automated control in hydroponic systems. This review explores the synergy between hydroponics and IoT, examining their principles, applications, and benefits. Key topics include sensor-based monitoring, existing IoT-enabled systems, challenges, and future directions in IoT driven hydroponic agriculture. With the increasing demand for food and decreasing arable land, **hydroponics** offers a promising solution through soil-less farming. Traditional hydroponic systems require manual monitoring, which is

inefficient and prone to errors. An IoT-based automated system that remotely monitors and controls the environment to optimize plant growth models, The IoT-based hydroponic system demonstrates a practical approach to smart agriculture, enabling sustainable, efficient, and automated plant cultivation. By integrating real-time monitoring and control, the system ensures optimal environmental conditions for plant growth.

## II. LITERATURE SURVEY

(1)Sensor Fusion Based Intelligent Hydroponic Farming and Nursing System; 2022 Yash Vardhan Bhargava, Prithvi Krishna Chittoor, C. Bharatiraja, Senior Member, IEEE. Sensor based hydroponic farming system has been proposed where multiple sensors synchronize and communicate using a common server. Human intervention is reduced to a minimum as the system is operated autonomously using Internet of Things.

(2)Mrs. Chitrapaavai, Akshya R, Devadharshini. Hydroponics Irrigation System using IoT 2022. This paper proposes an IoT system for a hydroponic farm which calculates various parameters, sends data to the consumer, and automatically dispenses water and nutrients based on the parameter readings.

(3)Seema Rathod, Sneha Dhanan, S Sri Harsha, Shivam Choudhary, Dr. Sharmila K P 2021. Hyper focused on LoRa technology, this paper aims to build hydroponic farm monitoring system that collects data that is transferred to the user via LoRa in real time.

Haija and Adebajo (2020) [4] explored the application of transfer learning using Punya Prabha V, Sarala S M, Sharmila Suttur C. Sensor based hydroponic farming is proposed where data is collected and presented to the user. The plant growth is then predicted through the data collected by the sensors using Machine Learning.

(5) Jirabhorn Chaiwongsai Automatic Control and Management System for Tropical Hydroponic Cultivation-2019 This is a system that senses parameters which are essential for plant growth while automating irrigation and nutrient supply.

(6) Laddha (2023) explores the development of an IoT-driven hydroponic cultivations system as a move towards intelligent agriculture Macenko et al. (2009) and Reinhard et al. (2001) for environmental sustainability.

(7) Shrivastava et al. (2023) describe the design and implementation of an hydroponic farming, integrating IoT and big data analysis.

### III. INFORMATION

1.1 Hydroponic Cultivation Techniques Hydroponics, in contrast to conventional farming practices, operates without the necessity of soil. Instead, plants are cultivated on either natural or artificial substrates, allowing their roots to easily access nutrition's from a prepared nutrition solution. Various hydroponic techniques exist, each tailored to specific plants, local climates, and budgetary Considerations in below Figures.

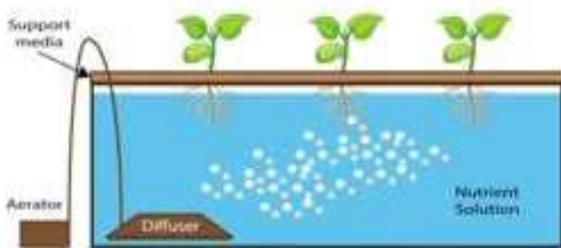


Fig. Different types of Hydroponic System

#### 1.2.1 Floating Root System or Deep Water

**Culture Floating Root System:** Plants grow on Floating platforms with roots extending into nutrition solution via a medium. **Deep Water Culture** Plant roots are suspended directly in nutrition solution, needing active aeration. DWC requires more vertical space, provides direct nutrition access, while Floating Root Systems may offer easier setup and management.

Here's how Floating Root System or DWC works:

1. **Setup:** Plants are suspended above reservoir filled with aerated nutrition solution. Their roots hang freely in the solution.
2. **Aeration:** An air pump continuously oxygenates the nutrition solution in the reservoir, ensuring the roots receive oxygen for proper growth.

3. **Nutrition Absorption:** Plant roots soak up water and nutrition directly from the nutrition solution, allowing for efficient uptake of essential elements necessary for growth.

4. **Support:** The buoyancy of the roots in the solution provides support to the plants, eliminating the need for soil or other growing media.

5. **Recirculation:** Excess nutrition solution may be recirculated through the system to ensure consistent nutrition availability and minimize waste.

6. **Monitoring:** Regular monitoring of nutrition levels, pH, and oxygenation is essential to maintain optimal conditions for plant growth

7. **Aeration:** An air pump continuously oxygenates the nutrition solution in the reservoir, ensuring the roots receive ample oxygen for proper growth.

the need for soil or other growing media.

1.2.2. **Nutrition Film Technique** Nutrition Film Technique is a hydroponic method where plant roots are exposed to a thin stream of nutrition solution flowing through pipes. While it uses less solution than floating root systems, Nutrition Film Technique requires extra energy and components. Excess solution returns to the tank by gravity, and the nutrition flow can be continuous or Here's how it works:

1. **Setup:** Plants are placed in small pots or baskets with their roots exposed. These pots or baskets are positioned in a sloping channel or pipe.

2. **Nutrition Solution Flow:** A pump continuously or periodically pumps nutrition-rich water from a reservoir to the top of the channel or pipe.

3. **Nutrition Film:** The nutrition solution flows down the channel or pipe in a thin film, bathing the roots of the plants as it passes by.

4. **Plant Uptake:** The plant roots soak up the water and nutrition they need from the thin film. Since the roots are not completely submerged, they can also access oxygen from the air.

5. **Excess Solution Return:** Any excess nutrition solution not soak up by the plants drains back into the reservoir by gravity. This excess solution can then be re-circulated through the system.

#### 1.2.3. Ebb and Flow

It sounds like you're describing a simple hydroponic system known as a flood and drain or ebb and flow

system. This method allows for efficient nutrition delivery to the plants while ensuring that excess water is recycled, reducing waste and conserving resources. It's a popular and effective technique for growing a variety of plants hydroponically

Here's how Ebb and Flow works:

1. Setup: Plants are placed in trays or containers filled with a growing medium like perlite or Rockwool. These trays sit above a reservoir containing nutrition solution.

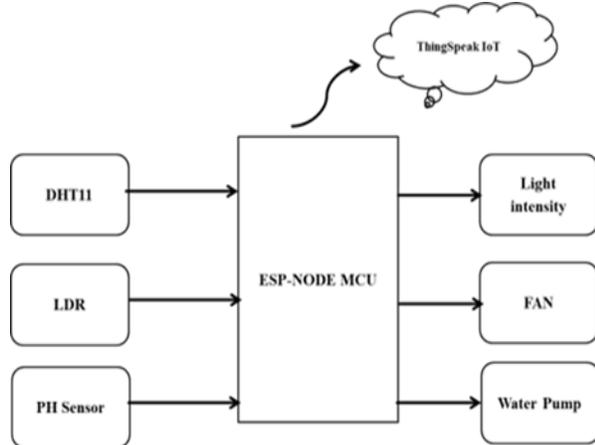


Fig. Block diagram

Inputs consists of Wi-Fi module ESP 8266, DHT11 sensor and water level sensor, and output of the system are fan, LED bulb lamp, and water pump

The water is pumped from the main tank to the hydroponic system, the water pump stops pumping once the water level is reached. The water is mixed with the nutrient's inappropriate proportions according to selected crop The nutrient filler is also provided with the hardware The completion of this process the user is notified through the sensor The nutrient rich water is then flowed through pH tank with the help of solenoid valve. The pH tank has a pH sensor which monitors the pH of the water. Readings are taken from the water and will track the effective pH. Water Level Sensor, The level of water in the hydroponic system can be noticed by using water level sensor

#### IV.HARWARE IMAGE



Hardware module: It consists of sensor placing and interfacing with the controller Communication module: It consists of sensor data sending to the cloud platform and display over the IoT. Controlling module: It controls the parameters of the hydroponic farm by Fan and water Environment sensing nodes are slave nodes that are responsible for monitoring greenhouse environmental conditions, such as the ambient temperature and humidity. The necessity behind the ESNs is that abnormal temperature and humidity could imply a hazard, Therefore, the temperature is monitored every few minutes, but temperature and humidity readings are permanently stored on an hourly basis in an SD card. The ESN is interrupted by the SCU and then transmits the data to the SCU.

Using Zigbee unless there is an alarm (high temperature), in which case, the ESN does not wait for an interrupt. This allows for effective monitoring of the greenhouse environment while minimizing data transmission and, therefore, power consumption. The number of ESNs present in each greenhouse is dependent on the greenhouse dimensions. Each ESN has its own ID number and Zigbee address. Figure 6 depicts the schematic diagram of the ESN circuit..

The ESN initialization procedure includes initializing the serial and SPI communication (Figure 7) and verifying the connection to all modules. After initialization, the ESN awakes on fixed intervals to collect the ambient temperature and humidity readings and record them on the SD card. If no abnormal readings are present, the ESN remains asleep until interrupted by the SCU when it is time for data collection. On the occurrence of the abnormal readings, the ESN interrupts the SCU with a Zigbee packet payload "Alarm Interrupt\_XX". The "XX" is a code representing either "FIRE" or "Connection" to distinguish whether the alarm is due to high temperature due to a possible fire in the greenhouse

or just a connection problem. The ESN power consumption in sleep mode was approximately 0.4 W compared with approximately 0.55 W during data transmission. However, as mentioned earlier in the SCU subsection (Section 3.1), the transmission only occurs a few times a day, unless there is an alarm. In both modes, the Xbee module stays active as it is an end device to be interrupted by the SCU.

As discussed in Section 2, the GSN was developed as a rudimentary security node and is not essential for the operation of the iPONICS system. It comprises a microcontroller with a motion sensor, camera, SD card and Zigbee transmitter/receiver. The reason such a node may be used is that a greenhouse could be in an isolated area, and we wish to prevent unauthorized entry. It is not meant to be a robust security solution, merely a low-cost warning system. The node spends the majority of time sleeping to conserve energy under normal circumstances. It is woken up by an external interrupt from the motion sensor, in which case, it activates the camera to take pictures and sends an alarm to the SCU through Zigbee. In the case of an authorized user accessing the system, the RFID is used to cancel the alarm. GSNs can also be deactivated and reactivated when receiving a command from the SCU. The microcontroller used for the implementation of the GSN was Arduino UNO, similar to the ESN. Figure 8 depicts the schematic diagram of the node's circuitry the GSN interrupts the SCU and signals a "Security Interrupt" inside the first payload, followed by the images that are data captured by the node. The GSN draws power of about 0.53 W in sleep mode and about 0.68 W during transmission depending on the distance from the SCU..

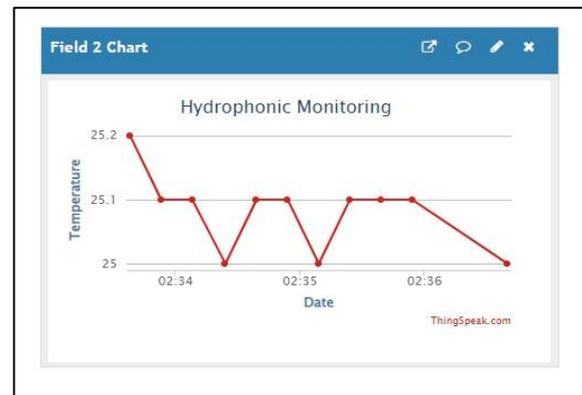
V.DISCUSSION

Since the above components are meant to operate continuously in greenhouse conditions for long periods in order to grow crops, we aimed to analyze their reliability at as early a stage as possible. We performed preliminary reliability analysis based on the errors and failures observed since they were operational, both in laboratory and greenhouse conditions. Reliability analysis was important in the iPONICS system because electronic failures could lead to crop failure, as well as a waste of energy and water. We performed the analysis on the SCU and ESN nodes since the GSN nodes operated infrequently and were aimed at outside threats, which are irrelevant to the plant growth process. The central role of

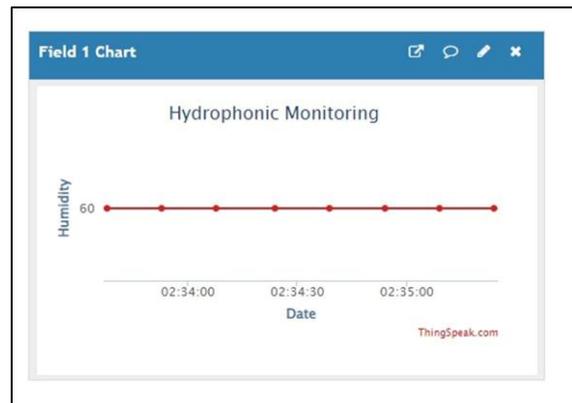
the SCU makes it the most critical unit in the subsystem. The ESN nodes have redundancy that allows fault tolerance, while there is a single SCU in each GHU. We had two SCUs and four ESNs operate continuously for close to 1000 h. Using that continuous operation as a basis, we observed errors and measured the mean time between them (MTBF)..

Sensor errors—Generally, sensor errors can be divided into two main categories: hard failure (complete failure) and soft failure, such as bias, drift and outliers. We observed no hard failures, but we observed both drift and outline transmission errors—We noticed occasional GPRS transmission failures. Some were corrected by retransmission and we added automatic retries that generally solved the problem, but there was one occasion that required manual intervention by communicating with the internet service provider in order to be resolved.

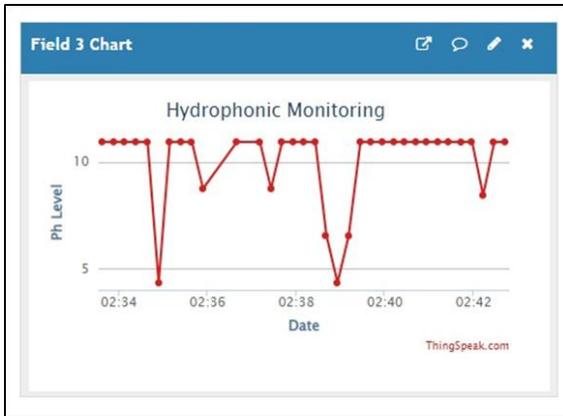
VI.RESULT



Temperature Sensor



Humidity Sensor



PH sensor

## VII.CONCLUSION

The integration of IoT into hydroponic systems promises enhanced efficiency and sustainability. Through real-time monitoring and control, growers can optimize environmental and nutrition delivery for maximum yield and quality. Predictive analytics enable proactive decision-making, preventing crop issues before they occur. Remote management capabilities offer flexibility and convenience, allowing growers to monitor operations from anywhere. Precision nutrition dosing minimizes waste and reduces

Environmental impact. Future advancements may include block chain integration for supply chain transparency and expansion into vertical farming for urban agriculture initiatives. Overall, IoT-driven hydroponic systems hold immense potential to revolutionize modern agriculture, addressing food security challenges while promoting sustainability and productivity. Has further enhanced diagnostic accuracy and sensitivity.

Despite these advancements, challenges such as data imbalance, high computational costs, and limited interpretability of DL models continue to hinder their clinical adoption. Addressing these limitations through improved data preprocessing, standardized evaluation metrics, and explainable AI frameworks will be critical for future developments.

The ongoing research in this domain promises to make breast cancer diagnosis more accurate, efficient, and accessible, ultimately contributing to early detection and better patient outcomes. Continued collaboration between researchers, clinicians, and technologists will be essential to fully harness the potential of these transformative technologies.

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