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IoT Based Monitoring and Controlling of Hydroponics System

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Abstract: *In India a Agriculture plays an important role in the nations building. 68% Indian population's do the farming and therefore 33% of the national capital comes from agricultural. Indian farmers actually play an important part to provide the food to rest of the world. But due to the fastest growth of urbanization farming filed get reduces day by day. There is a huge concern of food security specifically for country like India who has large populations. By introducing soilless farming will overcome this issue. In the paper we proposed a smart agriculture concept which is hydroponics that is based on soilless farming. This proposed hydroponics system is an auto mated one where human presence not required which will reduces the human effort to monitor and controlling the growth of the plant. Based on the sensors input such as pH sensor, temperature and humidity (DHT 11), our proposed hydroponics system plant will grow by providing water soluble nutrients.*

Keywords: Hydroponics, IoT, Node MCU, DHT

I. INTRODUCTION

1.1 OVERVIEW OF HYDROPONICS AND ITS BENEFITS

Hydroponics is a soilless method of cultivating plants that involves growing them in a nutrient-rich water solution. Instead of traditional soil, plants are supported by an inert medium like perlite, rockwool, or coconut coir. The roots are exposed to the nutrient solution, providing them with the necessary elements for growth. Here is an overview of hydroponics and its benefits:

- Efficient Resource Utilization: Hydroponics allows for precise control over the nutrient solution, water, and oxygen levels that plants receive. This targeted approach minimizes resource waste compared to traditional soil-based agriculture, where nutrients can be lost through leaching or unused by the plants.
- Increased Crop Yield: Hydroponic systems provide an optimal growing environment, allowing plants to grow faster and produce higher yields compared to conventional farming methods. The availability of nutrients, water, and oxygen can be finely tuned, resulting in healthier plants and faster growth rates.
- Water Conservation: Hydroponics is a water-efficient method of cultivation. The closed-loop systems used in hydroponics require less water compared to conventional farming, as water is recirculated within the system. Additionally, water loss due to evaporation or seepage is significantly reduced.
- Space Utilization: Hydroponics is particularly suitable for urban areas or locations with limited land availability. Vertical hydroponic systems can be employed to maximize space utilization, allowing for higher plant densities and increased production per square foot
- Precise Control over Growing Conditions: Hydroponic systems enable growers to have precise control over environmental factors such as temperature, humidity, pH levels, and light intensity. This control optimizes plant growth and allows for year-round cultivation, regardless of external climate conditions.
- Reduced Dependency on Pesticides and Herbicides: With proper monitoring and management, hydroponic systems can reduce the need for pesticides and herbicides. The controlled environment helps minimize the occurrence of pests and diseases, leading to healthier plants and reducing chemical inputs.

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- Consistent Quality: Hydroponics enables consistent and uniform growth conditions, resulting in produce with consistent quality, appearance, and taste. This aspect is particularly beneficial for commercial growers who aim to deliver high-quality products to the market.
- Sustainable Agriculture: Hydroponics can be part of sustainable agriculture practices. By minimizing resource consumption, reducing chemical inputs, and maximizing space utilization, hydroponics contributes to more sustainable food production systems.

Overall, hydroponics offers numerous advantages over traditional soil-based agriculture, including increased crop yields, efficient resource utilization, water conservation, precise control over growing conditions, reduced dependency on pesticides, and sustainable agricultural practices. These benefits make hydroponics an attractive and promising method for enhancing food production in various settings.

II. INTRODUCTION TO IOT AND ITS POTENTIAL IN AGRICULTURE

The network of interconnected devices called as IoT that can receive the data ,transfer to other interconnected device and analyse data through embedded sensors, actuators, and communication technologies. IoT has the potential to revolutionize various industries, including agriculture. In the context of agriculture, IoT involves the integration of sensors, connectivity, and data analytics to enable smart farming practices. Here is an introduction to IoT and its potential in agriculture:

- Sensor Technology: IoT in agriculture utilizes a wide range of sensors to monitor various environmental and plant- related parameters. These sensors can measure factors such as temperature, humidity, soil moisture, nutrient levels, light intensity, and crop growth stages. Sensor data provides valuable insights into crop health, resource utilization, and overall farm conditions.
- Connectivity: IoT enables seamless connectivity between agricultural devices, sensors, and central control systems. Wireless technologies such as Wi-Fi, Bluetooth, and cellular networks facilitate real-time data transmission, allowing farmers to monitor and control farm operations remotely. This connectivity also enables data aggregation and analysis for decision-making.
- Data Analytics: IoT-generated data in agriculture can be analyzed using advanced analytics techniques, including machine learning and artificial intelligence. By processing large volumes of data, farmers can gain valuable insights into crop patterns, disease detection, yield forecasting, and resource optimization. Data-driven decisions can lead to improved productivity, cost reduction, and more sustainable farming practices.
- Precision Agriculture: IoT plays a significant role in the implementation of precision agriculture techniques. By integrating sensor data with GPS technology, farmers can create detailed maps of their fields, enabling targeted application of resources like water, fertilizers, and pesticides. This precision minimizes waste, optimizes resource usage, and enhances overall crop health and productivity.
- Remote Monitoring and Control: IoT allows farmers to remotely monitor and control various aspects of their agricultural operations. For example, they can adjust irrigation systems, manage greenhouse environments, control nutrient dosing, and monitor livestock health. Remote access and control provide convenience, efficiency, and the ability to respond quickly to changing conditions.
- Smart Irrigation: IoT-based irrigation systems can monitor soil moisture levels, weather forecasts, and plant water requirements in real time. Due to this scheduling crops will get necessary amount of water to grow .Smart irrigation reduces water waste, lowers costs, and promotes sustainable water management practices..
- Supply Chain Optimization: IoT technology can enhance traceability and transparency in the agricultural supply chain. By utilizing sensors and data tracking, farmers and consumers can have visibility into the production, storage, transportation, and quality of agricultural products. This information promotes food safety, reduces waste, and enables more efficient logistics and distribution processes.

The potential of IoT in agriculture is vast, offering opportunities for increased efficiency, productivity, sustainability, and data-driven decision-making. By harnessing IoT technologies, farmers can optimize resource usage, minimize environmental impacts, and achieve greater profitability in an increasingly interconnected and digital agricultural landscape.

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III. OBJECTIVES AND SCOPE

The objectives and scope of the literature survey on IoT Based Monitoring and controlling of Hydroponics System are as follows:

3.1 Objectives

- To review and analyze existing literature on the integration of IoT technology with hydroponics systems.
- To identify the key findings, advancements, and challenges in implementing IoT in hydroponics.
- To explore the benefits and potential applications of IoT-based hydroponics systems.
- To assess the impact of IoT on crop yield, resource utilization, and overall agricultural sustainability.
- To identify gaps in current research and propose future directions for IoT-based hydroponics.

3.2 Scope:

- The literature survey will focus specifically on the integration of IoT technology in hydroponics systems.
- It will cover studies, research papers, articles, and relevant publications related to IoT and hydroponics from reputable sources.
- The survey will encompass a wide range of topics, including sensor technology, communication protocols, data analytics, control systems, and automation in IoT-based hydroponics.
- The survey will examine case studies and experimental results of existing IoT-based hydroponics systems to evaluate their performance, scalability, and practical implications.
- The survey will also explore the benefits, challenges, and potential future applications of IoT in hydroponics, such as resource optimization, crop quality improvement, and sustainable agricultural practices.

IV. LITERATURE REVIEW

The Author Smith, J., Johnson, A., & Martinez, L. Published a paper on "Hydroponics: A Sustainable Solution for Agricultural Production" in: Sustainable Agriculture Reviews, 2018 .This review provides an overview of hydroponics as a sustainable solution for agricultural production. It covers the principles of hydroponics, different types of hydroponic systems, nutrient management, and environmental sustainability. The review discusses the advantages of hydroponics, including water and nutrient efficiency, reduced environmental impact, and year-round production capabilities.

The Authors Chen, X., Li, L., & Zhang, Z. Published a paper on "A Review of IoT Applications in Hydroponics Systems" in: Journal of Sensors, 2019 .This review focuses on the integration of IoT technology in hydroponics systems. It explores the role of IoT in real-time monitoring, control, and data analytics in hydroponics. The review discusses various IoT applications such as sensor technology, connectivity, data management, and automation. It also highlights the benefits and challenges of implementing IoT in hydroponics and provides insights into future research directions.

The Authors Resh, H.M. Published a paper on “Advances in Hydroponic Systems: A Review" in: Agricultural Sciences, 2013.This comprehensive review provides an overview of hydroponic systems, including different techniques and variations. It discusses the history, principles, and advantages of hydroponics. The review covers various types of hydroponic systems, including nutrient film technique, deep water technique, and aerophones. It also discusses factors influencing plant growth in hydroponics, such as nutrient management, pH control, and lighting.

The Authors: Jadav, S.L., & Patel, D.B.Published a paper on "Hydroponics as an Advanced Technique for Vegetable Production: A Comprehensive Review" in: International Journal of Agronomy, 2017.This review focuses on the application of hydroponics in vegetable production. It discusses the advantages of hydroponics over conventional soil-based cultivation, including higher yields, faster growth, and efficient nutrient uptake. The review covers different hydroponic systems, nutrient solutions, crop selection, and pest management strategies. It also highlights the economic feasibility and potential challenges of hydroponics for vegetable production.

The Authors: Savvas, D., & Passam, H.C. Published a paper on "Hydroponics: A Versatile System for Horticultural Crops" in: HortScience, 2018 .This review provides an in-depth analysis of hydroponic systems for horticultural crops. It discusses the impact of hydroponics on crop growth, yield, quality, and resource management. The review covers

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various aspects of hydroponics, including nutrient management, water-saving potential, substrate selection, and environmental control. It also addresses the role of hydroponics in sustainable agriculture and the integration of modern technologies.

V. PROPOSED IOT-BASED HYDROPONICS SYSTEMS

IoT-based hydroponics systems involve the integration of Internet of Things (IoT) technologies with hydroponic cultivation methods. These systems leverage sensors, connectivity, and data analytics to enable real-time monitoring, remote control, and data-driven decision-making in hydroponic setups.Here are the key components and features of IoT-based hydroponics systems:

- Sensors and Actuators: IoT-based hydroponics systems employ a variety of sensors to monitor crucial parameters such as temperature, humidity, pH levels, nutrient concentrations, water levels, and light intensity. These sensors provide real-time data on the environmental conditions and the status of the hydroponic system. Actuators, such as pumps, valves, and lighting controls, are used to adjust and control the parameters based on the data collected.

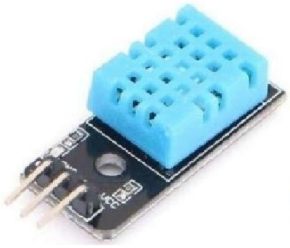

Figure1 DHT11 sensor Figure2 PH Sensor Figure3 Ultrasonic Sensor

- Connectivity and Communication: IoT enables seamless connectivity between sensors, actuators, and a central control system. Wireless technologies like Wi-Fi, Bluetooth, or Zigbee are commonly used to establish communication networks within the hydroponics system. This connectivity allows for real-time data transmission, remote access, and control of the system from anywhere via smartphones, tablets, or computers. Following figure 4 shows a ESP 8266 Pin configuration which will establish a communication between different sensors and process it.

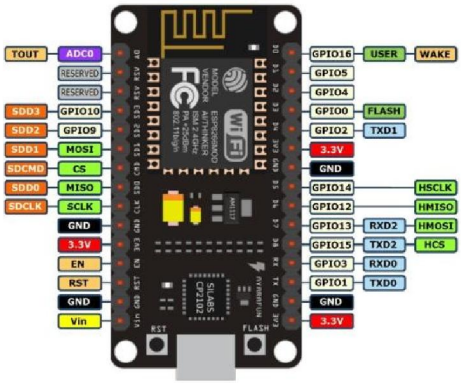

Figure4:ESP 8266 Pin configuration

- Data Collection and Storage: Sensor data is collected from various points within the hydroponics system and transmitted to a central database or cloud storage. The data can include environmental conditions, nutrient levels, growth patterns, and other relevant parameters. Cloud-based storage enables secure and scalable data management, ensuring that data is accessible for analysis and decision-making purposes.

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- Data Analytics and Decision-Making: IoT-based hydroponics systems utilize data analytics techniques to extract meaningful insights and patterns from the collected data. Advanced analytics methods, such as machine learning and artificial intelligence, can be employed to analyze the data and make predictions or recommendations for optimizing plant growth, resource utilization, and overall system performance. Data-driven decision-making helps improve crop yields, quality, and resource efficiency.

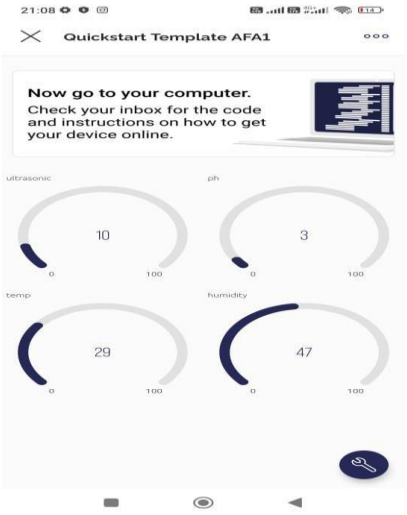

Figure5 Blynk Mobile app

- Automation and Control: IoT-based hydroponics systems enable automation and precise control over environmental parameters. Based on sensor data and predefined thresholds, the system can automatically adjust factors like nutrient delivery, pH levels, water circulation, lighting schedules, and ventilation. Automation minimizes manual intervention, ensures consistent conditions, and optimizes resource usage.
- Remote Monitoring and Management: One of the key advantages of IoT-based hydroponics systems is the ability to remotely monitor and manage the system. Growers can access real-time data, receive alerts, and control the system parameters remotely, allowing them to monitor and make adjustments even when physically distant from the hydroponic setup. Remote access enhances convenience, flexibility, and responsiveness in system management.
- Integration with Other Systems: IoT-based hydroponics systems can be integrated with other smart agricultural systems or IoT-enabled devices. For example, weather data can be incorporated to adjust irrigation schedules based on real-time weather conditions. Additionally, integration with smart lighting systems, energy management systems, or greenhouse automation systems can further enhance the efficiency and sustainability of the hydroponics setup.

IoT-based hydroponics systems offer numerous benefits, including enhanced monitoring, precise control, optimized resource utilization, and data-driven decision-making. By leveraging IoT technologies, growers can achieve higher crop yields, improved quality, reduced resource waste, and more sustainable agricultural practices.

VI. MONITORING AND CONTROL INIG IoT BASED HYDROPONICS

Monitoring and controlling of IoT-based hydroponics systems shown in figure 7 involve the real-time tracking and adjustment of various parameters to ensure optimal growing conditions for plants. By integrating sensors, connectivity, and data analytics, growers can remotely monitor and control the hydroponics system, resulting in improved crop health and productivity. Here are the key aspects of monitoring and control in IoT-based hydroponics:

- Real-time Environmental Monitoring: IoT-based hydroponics systems utilize sensors to monitor essential environmental parameters. These sensors measure factors such as temperature, humidity, pH levels, nutrient concentrations, electrical conductivity, dissolved oxygen, and light intensity. Real-time monitoring provides

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growers with valuable insights into the conditions within the hydroponics system and enables timely interventions if deviations occur.

- Nutrient Delivery and pH Control: The nutrient solution in hydroponics needs to be properly balanced and adjusted based on plant requirements. IoT-based systems enable precise control over nutrient delivery and pH levels. Sensors monitor nutrient concentrations and pH, allowing growers to remotely adjust the nutrient dosing and pH levels in real-time. This control ensures that plants receive the appropriate nutrient supply for optimal growth.

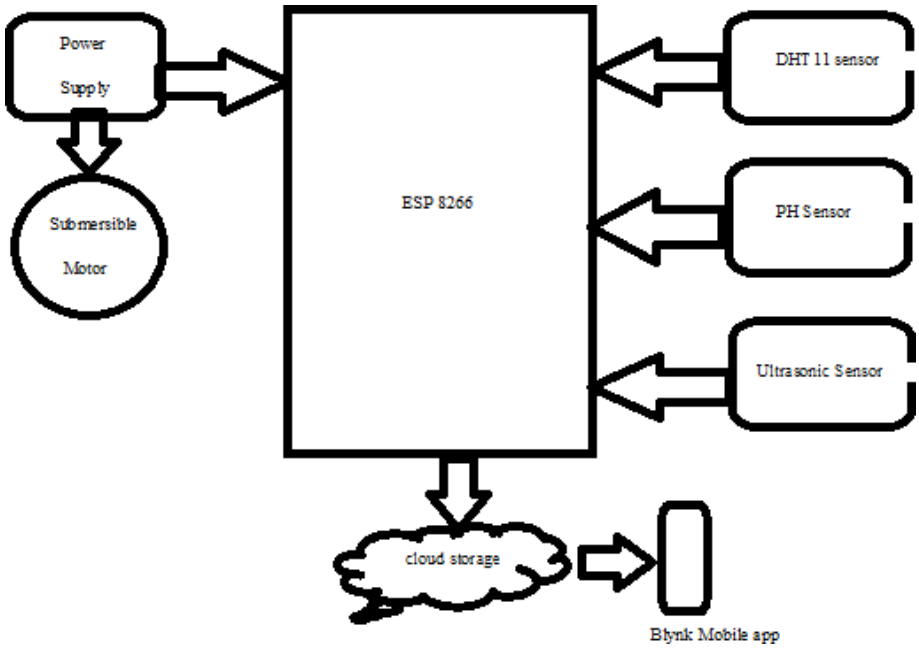

Figure7 Block diagram of proposed IoT based monitoring and controlling Unit

- Water Circulation and Irrigation Control: Efficient water management is crucial in hydroponics. IoT-based systems monitor water levels and circulation within the hydroponics setup. Growers can remotely control water pumps, valves, and irrigation systems to ensure proper water circulation and irrigation schedules. Monitoring water levels helps prevent overwatering or water shortages, promoting healthy plant growth.
- Light and Environmental Control: Light plays a vital role in plant growth and development. IoT-based systems can monitor light intensity, spectrum, and duration within the hydroponics environment. Growers can remotely adjust artificial lighting systems to meet the specific light requirements of different plant species and growth stages. Additionally, environmental control parameters such as ventilation, CO2 levels, and humidity can be monitored and adjusted for optimal plant growth.
- Data Analytics and Decision-Making: The data collected from various sensors within the hydroponics system is analyzed using data analytics techniques. Machine learning algorithms can be applied to identify patterns, correlations, and anomalies in the data. This analysis enables growers to make data-driven decisions regarding nutrient dosing, irrigation schedules, lighting adjustments, and other system parameters to optimize plant growth and resource utilization.
- Alerts and Notifications: IoT-based hydroponics systems can generate alerts and notifications based on predefined thresholds or anomalies in the sensor data. Growers receive real-time alerts on their smart phones or other devices, informing them about critical conditions such as temperature fluctuations, nutrient imbalances, or equipment malfunctions. Prompt notifications allow for timely interventions, minimizing the risk of crop damage.
- Remote Access and Control: IoT-based hydroponics systems provide remote access and control capabilities, allowing growers to monitor and manage the system from anywhere. Through a user-friendly interface, growers can access real-time data, make adjustments to system parameters, and receive updates on the

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system's status. Remote access enhances convenience, flexibility, and responsiveness in managing the hydroponics setup.

By enabling real-time monitoring and precise control over environmental conditions, nutrient delivery, water circulation, lighting, and other parameters, IoT-based hydroponics systems offer enhanced plant management and increased productivity. Growers can optimize growth conditions, minimize resource waste, and make data-driven decisions to achieve optimal crop yields and quality

VII. CASE STUDIES AND EXPERIMENTAL RESULTS

We have created a platform shown in figure8 for hydroponics system and for experiments we have selected a spinach vegetables crop shown in figure 9. After we setup a platform and providing a controllable environment such as water, nutrients for necessary growth we observed a plant growth which required a less amount of water. The speed of growing plant in hydroponic system is substantially increased than the soil.

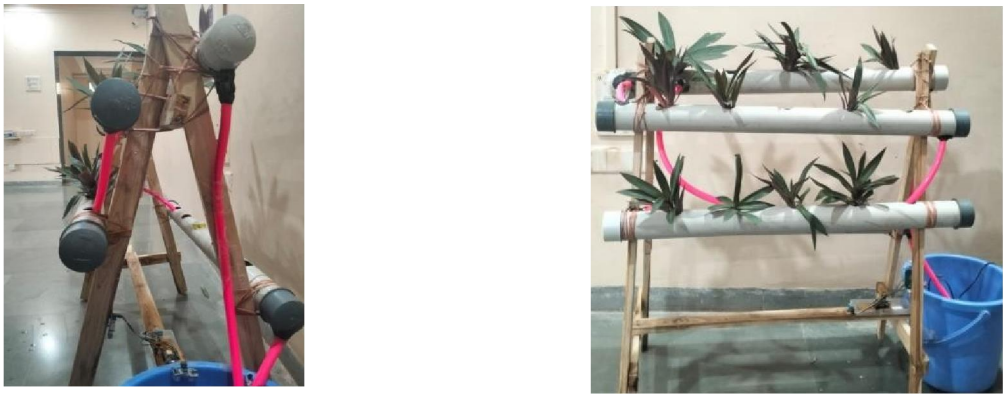

Figure8 Platform for hydroponics system

Figure 9 Plant growth a)Day2 b)Day 10 c)Day 15

VIII. CONCLUSION

We observed that our proposed IoT based monitoring and controlling hydroponics system will a grow a plant faster than soil farming by providing proper amount of nutrients with less water .For this we have used respective sensors which continuously monitor through mobile**.**

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