SUSTAINABLE URBAN FARMING USING HYDROPONICS

A MINOR PROJECT-III REPORT

Submitted by

ARTHI M	**927622BEC016**
DEEPIKA S	**927622BEC029**
DHARSHNA R	**927622BEC040**
DIVYA DHARSHINI D	**927622BEC045**

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BONAFIDE CERTIFICATE

Certified that this**18ECP105L-Minor Project III** report "**SUSTAINABLE URBAN FARMING USING HYDROPONICS"** is the Bonafide work of "**ARTHI M (927622BEC016) , DEEPIKA S (927622BEC029) , DHARSHNA R (927622BEC040) , DIVYADHARSHINI D (927622BEC045) "**who carried out the project work under my supervision in the academic year (2024–2025)**ODD SEM**.

SIGNATURE
Dr.A.KAVITHA, B.E., M.E., Ph.D.,
HEAD OF THE DEPARTMENT,
Professor,
Department of Electronics and
Communication Engineering,
M.Kumarasamy College of Engineering,
Thalavapalayam,
Karur-639113.

SIGNATURE
Mrs. D.PUSHPALATHA, M.E.,
SUPERVISOR,
Assistant Professor,
Department of Electronics and
Communication Engineering,
M.Kumarasamy College of Engineering,
Thalavapalayam,
Karur-639113.

This report has been submitted for the**18ECP105L – Minor Project III** final review held at M. Kumarasamy College of Engineering, Karur on ________________________.

PROJECT COORDINATOR

INSTITUTION VISION AND MISSION

Vision

To emerge as a leader among the top institutions in the field of technical education.

Mission

M1: Produce smart technocrats with empirical knowledge who can surmount the global challenges.

M2: Create a diverse, fully -engaged, learner -centric campus environment to provide quality education to the students.

M3: Maintain mutually beneficial partnerships with our alumni, industry and professional associations

DEPARTMENT VISION, MISSION, PEO, PO AND PSO

Vision

To empower the Electronics and Communication Engineering students with emerging technologies, professionalism, innovative research and social responsibility.

Mission

M1: Attain the academic excellence through innovative teaching learning process, research areas & laboratories and Consultancy projects.

M2: Inculcate the students in problem solving and lifelong learning ability.

M3: Provide entrepreneurial skills and leadership qualities.

M4: Render the technical knowledge and skills of faculty members.

Program Educational Objectives

PEO1: **Core Competence:** Graduates will have a successful career in academia or industry associated with Electronics and Communication Engineering

PEO2: **Professionalism:** Graduates will provide feasible solutions for the challenging problems through comprehensive research and innovation in the allied areas of Electronics and Communication Engineering.

PEO3: **Lifelong Learning:** Graduates will contribute to the social needs through lifelong learning, practicing professional ethics and leadership quality

Program Outcomes

PO 1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO 4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO 6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO 12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes

PSO1: Applying knowledge in various areas, like Electronics, Communications, Signal processing, VLSI, Embedded systems etc., in the design and implementation of Engineering application.

PSO2: Able to solve complex problems in Electronics and Communication Engineering with analytical and managerial skills either independently or in team using latest hardware and software tools to fulfil the industrial expectations.

Abstract	**Matching with POs, PSOs**
Light Control, Blynk App, Automated System, Soil moisture sensor	**PO1, PO2, PO3, PO4, PO5, PO6,PO7, PO8, PO9, PO10, PO11, PO12, PSO1, PSO2**

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ABSTRACT

This project focuses on the design and implementation of an IoT-based hydroponic farming system that automates the monitoring and control of critical environmental factors to optimize plant growth. Hydroponics, a method of growing plants without soil, offers a sustainable solution for urban agriculture, where traditional farming practices face challenges like limited space, water scarcity, and inefficient resource use. The system integrates a range of sensors, including a DHT sensor for measuring temperature and humidity, and a soil moisture sensor to monitor water levels in the hydroponic solution. The ESP8266 microcontroller serves as the central hub, connecting the system to the internet for real-time data monitoring through the Blynk app. This app provides a user-friendly interface that displays real-time information on temperature, humidity, and moisture levels, enabling users to remotely track and manage the hydroponic system from any location.

The system automates key processes such as water irrigation and lighting control, ensuring the plants receive the necessary care with minimal manual intervention. The water pump is activated based on the moisture levels detected by the sensor, reducing water wastage and ensuring that plants receive adequate hydration. If the system detects temperature or humidity fluctuations beyond the ideal range, it triggers appropriate actions such as activating cooling or heating mechanisms. Additionally, users receive instant alerts and notifications if any parameters exceed pre-set thresholds, allowing them to take corrective actions promptly. This project demonstrates how IoT technology can revolutionize urban farming, providing a scalable and efficient solution to modern agricultural challenges. It contributes to sustainable food production by optimizing resource usage, reducing water consumption, and enabling remote, automated farming systems that can be easily monitored and controlled

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ACRONYM		ABBREVIATION
IoT	-	Internet of Things
DHT	-	Digital Humidity and Temperature

CHAPTER 1

INTRODUCTION

Urban farming has emerged as a vital solution to meet the growing demand for fresh, locally produced crops in densely populated cities. As urbanization accelerates, traditional farming practices often struggle to provide sufficient food for urban populations. Innovative techniques like vertical farming, rooftop gardens, and hydroponics are becoming popular alternatives. These methods maximize limited urban space, reduce dependency on long supply chains, and lower the carbon footprint associated with food transportation.

Among these techniques, hydroponics stands out as an efficient, soil-less method of cultivation. It delivers nutrients directly to plant roots through water-based solutions, ensuring faster plant growth and significant water conservation compared to conventional farming. Hydroponic systems are particularly suitable for urban areas with limited land and poor soil quality, making fresh produce more accessible. However, maintaining ideal conditions such as temperature, humidity, and moisture is essential for the success of hydroponic farming, requiring precise monitoring and control.

To overcome these challenges, integrating Internet of Things (IoT) technology has proven to be transformative. IoT-enabled sensors can monitor environmental factors in real time, automating processes like irrigation and climate control. These systems can transmit data to mobile applications, allowing users to remotely manage and optimize growing conditions. By reducing manual intervention and enhancing efficiency, IoT-powered hydroponic systems promote sustainability and pave the way for smarter urban farming practices.

CHAPTER 2
OBJECTIVE

The primary objective of this project is to develop a hydroponic farming system that leverages Internet of Things (IoT) technology to automate the monitoring and regulation of critical environmental factors such as temperature, humidity, and moisture. These parameters play a vital role in ensuring optimal plant growth in hydroponic setups. Automation will enable the system to function efficiently with minimal manual intervention, maintaining a stable growing environment. By utilizing IoT, the system will continuously monitor these factors and adjust them as needed, supporting healthy plant growth throughout the year with greater consistency.

Another key focus is providing real-time data accessibility through the Blynk app. Sensors will measure temperature, humidity, and moisture levels in the hydroponic system, with the data being transmitted to the app for remote monitoring. The app's intuitive interface will allow users to view live environmental readings, track trends over time, and gain valuable insights into system performance. This real-time access will empower users to manage their hydroponic farm effectively, identify potential issues promptly, and make well-informed decisions to optimize growing conditions.

Additionally, the project aims to enhance water efficiency by automating the irrigation process. A moisture sensor will monitor the hydroponic medium, activating the water pump only when the moisture level drops below an optimal threshold. This approach ensures that plants receive adequate hydration without overwatering, reducing water wastage. The ability to remotely control and monitor the system through the Blynk app adds convenience, enabling users to make timely adjustments. By integrating these features, the hydroponic system will operate sustainably and efficiently, aligning with the goals of modern urban farming

CHAPTER 3

LITERATURE REVIEW

The integration of technology into agriculture has rapidly transformed traditional farming practices, leading to the development of more efficient and sustainable methods. Among the most promising innovations in urban agriculture is hydroponics, a method of growing plants without soil by providing nutrients directly to their roots through water-based solutions. This technique has gained attention for its water-efficient nature and ability to grow crops in non-arable urban spaces. The combination of hydroponics with automation and Internet of Things (IoT) technologies offers the potential to optimize resource use, reduce labor, and improve the overall efficiency of farming operations.

Hydroponics has been widely studied for its potential to increase crop yield while minimizing resource consumption. According to a study by Resh (2013), hydroponic systems use up to 90% less water than traditional soil-based agriculture, making them ideal for urban farming where space and water are often limited. These systems can be used to grow a variety of crops, from leafy greens to tomatoes, in highly controlled environments. One of the most significant advantages of hydroponics is its ability to be implemented in locations where traditional farming would be impractical, such as rooftops, basements, and even abandoned buildings. Additionally, hydroponics can significantly reduce the time required for crops to mature, as plants have direct access to nutrients and water, resulting in faster growth cycles.

The advent of IoT technology has further enhanced the capabilities of hydroponic farming by automating the monitoring and control of environmental factors such as temperature, humidity, and moisture levels. Research has shown that IoT can improve the management of these parameters, leading to more consistent and optimal growing conditions. For instance, studies by Fathi et al. (2020) demonstrated the successful application of IoT in smart farming systems, where sensors connected to microcontrollers were used to monitor and adjust factors like temperature and humidity in real-time. By integrating IoT devices with platforms such as Blynk, users can remotely monitor the system's status and even control components like water pumps and grow lights, creating a more efficient, user-friendly approach to farming.

Several studies have also highlighted the role of sensor networks in ensuring efficient water usage in hydroponic systems. The integration of soil moisture sensors and automated irrigation systems is key to reducing water waste. As noted by Al-Ali et al. (2017), real-time moisture data can be used to trigger irrigation only when necessary, which optimizes water consumption and promotes sustainability. Similarly, by utilizing cloud-based platforms or mobile applications like Blynk, users can remotely monitor and manage these systems, ensuring that the system operates within predefined thresholds. This integration of sensor data and remote control mechanisms allows for greater accuracy in maintaining optimal growing conditions, while also reducing the labor and costs associated with manual monitoring and adjustments.

Overall, the literature supports the growing trend of using IoT-based hydroponic systems for urban farming, emphasizing their ability to optimize resources, reduce environmental impact, and improve crop yield. These systems offer a promising solution for cities facing challenges related to food security, limited space, and sustainability. By combining hydroponics with IoT technology, urban farmers can create smarter, more efficient farming systems that are capable of thriving in even the most constrained urban environments.

CHAPTER 4

EXISTING METHOD

Traditional agriculture, which relies on cultivating crops in natural soil, is the most commonly practiced farming method worldwide. It uses soil fertility, often enhanced with fertilizers and pesticides, to achieve high yields. While effective in meeting large-scale food demands, this approach has significant drawbacks, including soil depletion, water wastage, and environmental degradation. Water-intensive irrigation methods like flood and surface irrigation exacerbate the overuse of water resources, while soil erosion poses long-term challenges to land productivity.

To address the inefficiencies of traditional farming, modern techniques such as drip irrigation and precision agriculture have been introduced. Drip irrigation efficiently delivers water directly to plant roots, reducing waste and ensuring optimal hydration, particularly in water-scarce regions. Precision agriculture takes it further by using technology like sensors, GPS, and drones to monitor crop health and soil conditions, enabling farmers to optimize resources and increase yields. While these methods improve efficiency, they still depend heavily on land and involve significant environmental costs from the use of chemical fertilizers and pesticides.

Innovative farming techniques such as greenhouse farming and vertical farming aim to further enhance efficiency and productivity in limited spaces. Greenhouses offer controlled environments that protect crops from extreme weather and pests, while vertical farming maximizes space by growing crops in stacked layers, making it ideal for urban areas with limited land availability. However, both methods require substantial energy and resources and face challenges with scalability and costs. These limitations highlight the need for more sustainable and resource-efficient methods like hydroponics integrated with IoT technology, which minimizes dependency on land, reduces resource usage, and optimizes farming for urban environments.

CHAPTER 5

PROBLEM STATEMENT

Agriculture, the cornerstone of global food production, faces numerous challenges, particularly in traditional land-based farming systems. Increasing population and urbanization have led to growing demands for food, placing immense pressure on arable land and water resources. Conventional farming practices often result in soil degradation, water wastage, and over-reliance on chemical fertilizers and pesticides, which not only harm the environment but also reduce long-term sustainability. Inefficient irrigation methods, such as flood irrigation, exacerbate water scarcity, while continuous cultivation depletes soil fertility, making traditional farming less viable over time.

Farmers also struggle to maintain optimal environmental conditions, as factors like temperature, humidity, and soil moisture are highly variable and often unpredictable due to climate change. These challenges, coupled with labor-intensive practices, increase production costs and make large-scale farming inefficient. Although modern advancements like drip irrigation and precision agriculture offer some improvements, they remain resource-intensive and inaccessible for small-scale farmers. Additionally, land-based agriculture is vulnerable to pests, diseases, and extreme weather conditions, further reducing productivity and threatening food security.

There is an urgent need for innovative and sustainable farming solutions that address these limitations. Hydroponics, a soil-free farming method, offers a promising alternative by significantly reducing dependence on arable land and water. Integrating IoT technology into hydroponic systems enables real-time monitoring and control of critical parameters such as temperature, humidity, and moisture levels. This automation not only optimizes resource usage but also improves crop yields, making it an efficient and scalable solution to the challenges of land-based farming, especially in urban and resource-constrained environments.

CHAPTER 6

PROPOSED METHOD

This project aims to develop a smart hydroponic farming system integrated with IoT to automate the monitoring and control of environmental conditions for optimal crop growth. Unlike traditional soil-based farming, this system will utilize a soil-free hydroponic setup, where plants are grown in a nutrient-rich water solution. The system will include sensors to monitor key parameters such as temperature, humidity, and moisture levels, ensuring precise control over the growing environment. Data from these sensors will be displayed in real-time on the Blynk app, allowing users to remotely monitor and manage the system from anywhere.

The proposed system will incorporate an ESP8266 microcontroller as the central processing unit to connect the sensors and actuators to the IoT platform. A DHT sensor will measure temperature and humidity, while a moisture sensor will monitor water levels in the hydroponic setup. Based on sensor readings, the water pump will be automatically activated or deactivated to maintain the required moisture levels. Additionally, a 12V induction bulb will be included to provide artificial lighting for plants in environments with insufficient natural light, ensuring optimal photosynthesis.

The integration of IoT technology will enable real-time alerts and remote access to the system via the Blynk app. Users will not only be able to monitor environmental conditions but also manually control components such as the water pump and lighting if necessary. This approach ensures efficient water usage, minimizes manual labor, and optimizes the growing conditions for hydroponic crops. By combining automation and IoT, the proposed method provides a scalable, resource-efficient solution for urban farming, addressing the challenges of traditional agriculture and promoting sustainable food production.

CHAPTER 7

METHODOLOGY

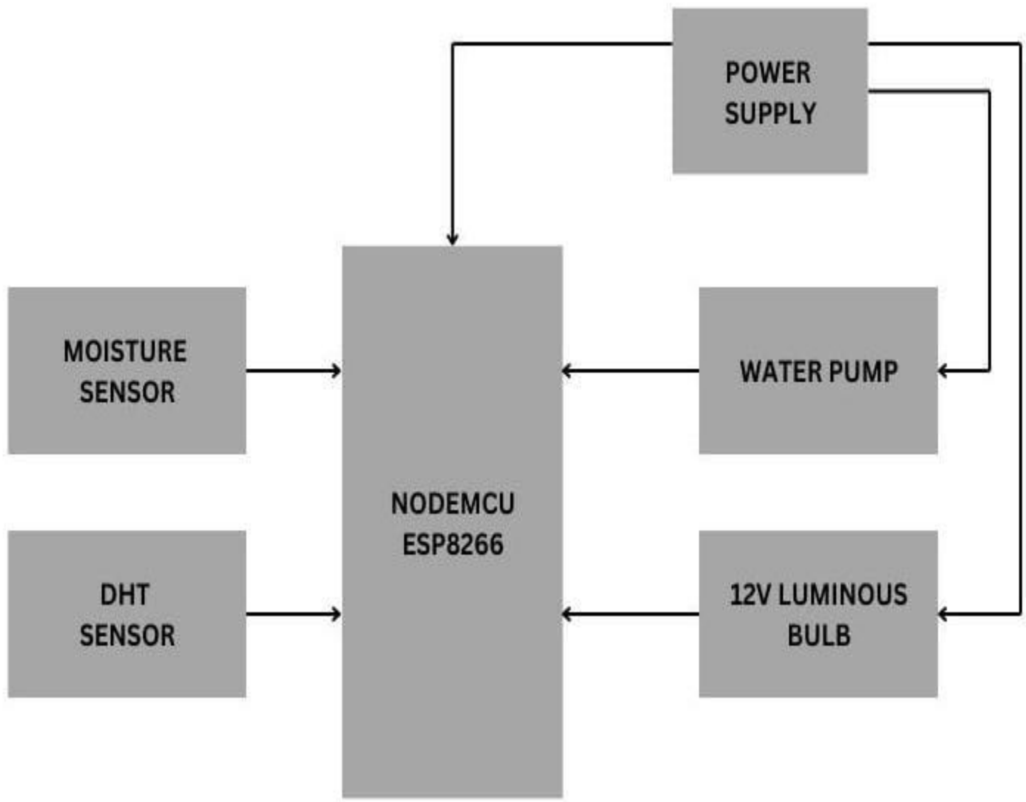
The proposed IoT-enabled hydroponic farming system will be developed through a systematic and structured approach. The first step involves designing the hydroponic setup, which eliminates the need for soil by growing plants in a nutrient-rich water solution. This setup includes a water reservoir, a nutrient delivery system, and plant containers optimized for hydroponic growth. Essential components such as an ESP8266 microcontroller for IoT integration, a DHT sensor for temperature and humidity monitoring, a moisture sensor for detecting water levels, a 12V induction bulb for artificial lighting, and a water pump for irrigation will be carefully selected and incorporated into the system. The integration of these components will ensure efficient monitoring and automation of the hydroponic process.

Once the system is designed, the components will be integrated and programmed to function cohesively. The ESP8266 microcontroller will act as the central control unit, processing data from the sensors and activating necessary components like the water pump and lighting system based on real-time conditions. The DHT sensor will measure and report temperature and humidity levels, while the moisture sensor will detect water levels to ensure that plants receive the required hydration. The 12V induction bulb will be triggered in low-light conditions to maintain optimal light exposure for plant growth. The Blynk app will be used to display real-time sensor data, allowing users to monitor environmental conditions and control the system remotely from any location.

The final phase involves testing, calibration, and optimization of the system to ensure its functionality and efficiency. The sensors will be calibrated to provide accurate readings, and the automation features will be fine-tuned to respond promptly to environmental changes. The IoT platform will be configured to send notifications and alerts to users, enabling proactive management of the system. This methodology ensures that the hydroponic farming system is user-friendly, resource-efficient, and capable of maintaining ideal conditions for crop growth. By leveraging IoT and automation, this approach addresses the challenges of traditional agriculture, offering a sustainable and scalable solution for urban farming.

CHAPTER 8

BLOCK DAIGRAM



CHAPTER 9
WORKING

The working of the IoT-enabled hydroponic farming system is based on the integration of sensors, actuators, and an IoT platform to automate and optimize the growing conditions for plants. At the core of the system is the ESP8266 microcontroller, which connects all components, including the DHT sensor for temperature and humidity monitoring, the moisture sensor for detecting water levels, and the water pump for irrigation. Upon system initialization, the microcontroller connects to a Wi-Fi network and communicates with the Blynk app, where the sensor data is transmitted and displayed in real-time. The system constantly monitors environmental factors such as temperature, humidity, and moisture levels, providing users with a comprehensive view of the hydroponic setup.

The sensors continuously collect data, which is sent to the ESP8266 microcontroller for processing. The system uses this data to make real-time decisions. For instance, if the moisture level drops below a set threshold, the microcontroller activates the water pump to supply water to the plants. Similarly, if the temperature or humidity falls outside the ideal range, the system can trigger actions such as activating a cooling or heating system or turning on the induction bulb for artificial lighting. These automated actions ensure that the plants maintain optimal growth conditions with minimal manual intervention.

The Blynk app plays a crucial role in remote monitoring and control, allowing users to view real-time data and receive notifications if any parameters exceed pre-set thresholds. For example, the system can send alerts if the moisture level is too low or if the temperature becomes too high, prompting users to take corrective action. Additionally, the system allows for manual adjustments via the Blynk app, offering flexibility in system control. This combination of automation, remote monitoring, and manual control makes the IoT-based hydroponic farming system an efficient, user-friendly, and sustainable solution for urban agriculture.

CHAPTER 10
COMPONENTS

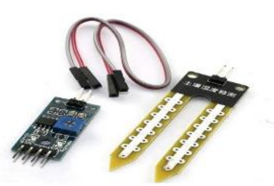
1. DHT SENSOR:

The DHT sensor, which stands for Digital Humidity and Temperature sensor, plays a vital role in monitoring the environmental conditions essential for plant development. It accurately gauges the temperature and humidity levels within a hydroponic system. These measurements are crucial for maintaining an ideal growing environment, as plants flourish within specific temperature and humidity parameters. The information obtained from the DHT sensor can facilitate the automation of heating or cooling systems, thereby promoting energy-efficient climate regulation.

10.1 : DHT SENSOR

2. MOISTURE SENSOR :

The moisture sensor is designed to assess the water content present in the growing medium or nutrient solution. Although hydroponics utilizes water instead of soil, it remains imperative to monitor moisture levels to prevent both waterlogging and dehydration of plant roots. This sensor enables effective water management, minimizing waste and conserving water resources, which is vital for sustainable practices.



10.2 : MOISTURE SENSOR

3. WATER PUMP :

The water pump is essential for the distribution of the nutrient-rich solution within the hydroponic system. It guarantees that each plant receives a sufficient amount of nutrients and oxygen, which are crucial for optimal growth. The operation of the pump can be automated through the use of sensors and a microcontroller, thereby enhancing energy efficiency and ensuring a consistent water flow for improved
performance.

10.3 : WATER PUMP

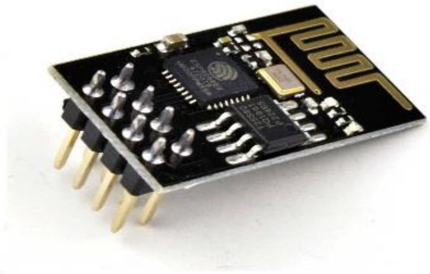
4. 12V INDUCTION BULB:

The 12V induction bulb serves as a source of artificial lighting, which is vital for the process of photosynthesis, particularly in indoor settings or areas with limited natural light. These bulbs are characterized by their energy efficiency and longevity, making them suitable for eco-friendly initiatives. The emitted light spectrum can be modified to align with the various growth phases of plants, thereby increasing yield while minimizing energy usage.

10.4 : 12V INDUCTION BULB

5. ESP8266 :

The ESP8266 is an economical Wi-Fi microcontroller that facilitates data collection, processing, and communication within the hydroponic system. It links sensors, such as DHT and moisture sensors, and actuators, like the water pump, to a centralized control system or a cloud-based platform. This microcontroller enables real-time monitoring and automation through Internet of Things (IoT) integration, allowing users to manage and observe the system remotely via a smartphone or computer. This capability promotes efficient resource utilization and bolsters the sustainability of the system.



10.5 : ESP8266

CHAPTER 11
RESULT AND DISCUSSION

The implementation of the IoT-enabled hydroponic farming system demonstrated its ability to automate and optimize the monitoring and control of environmental conditions for plant growth. The system successfully integrated key components, including the ESP8266 microcontroller, DHT sensor, moisture sensor, water pump, and 12V induction bulb, to create a functional and efficient hydroponic setup. Data from the sensors were accurately transmitted to the Blynk app in real-time, enabling remote monitoring and control of temperature, humidity, and moisture levels.

The system proved effective in automating essential tasks, such as activating the water pump when moisture levels dropped below the threshold and turning on the induction bulb in low-light conditions. These automation features reduced manual intervention, optimized resource usage, and minimized water wastage, which are significant advantages over traditional soil-based farming methods. The system's ability to provide real-time alerts and notifications through the IoT platform enhanced user convenience and allowed for prompt action in case of any anomalies, such as extreme temperature fluctuations or insufficient water levels.

The results highlight the potential of IoT-integrated hydroponic systems as a sustainable solution for urban farming. The system not only addressed the challenges of resource scarcity but also demonstrated scalability and adaptability for various environments. However, further improvements can be made by integrating additional sensors, such as pH and nutrient sensors, to monitor and control nutrient levels in the water. Future work could also focus on optimizing the system for larger-scale operations and enhancing energy efficiency, particularly for the lighting system. Overall, the project successfully showcased how technology can revolutionize agriculture, making it more efficient, sustainable, and accessible..

CHAPTER 12
CONCLUSION AND FUTURE WORK

The IoT-enabled hydroponic farming system developed in this project successfully demonstrated a sustainable and efficient alternative to traditional agriculture. By integrating components such as the ESP8266 microcontroller, DHT sensor, moisture sensor, water pump, and 12V induction bulb, the system automated the monitoring and control of environmental parameters essential for plant growth. The Blynk app provided real-time data visualization and remote control, enabling users to maintain optimal growing conditions with minimal manual intervention. The system effectively reduced water wastage, optimized resource usage, and ensured consistent crop growth, making it a viable solution for urban and resource-constrained farming environments.

This project addressed critical issues associated with conventional farming, such as excessive water usage, dependency on arable land, and labor-intensive practices. The results demonstrated that IoT-integrated hydroponics could enhance agricultural productivity while reducing environmental impact.. Overall, this project highlights the role of technology in transforming agriculture into a more sustainable and accessible practice.

In terms of future work, several enhancements can be made to improve the system's functionality and scalability. Adding sensors to monitor pH levels and nutrient concentrations in the water could provide a more comprehensive approach to crop management. Energy efficiency could be improved by incorporating renewable energy sources, such as solar panels, to power the system. Additionally, advanced machine learning algorithms could be integrated to predict and optimize growing conditions based on historical data. Expanding the system for large-scale operations and testing it with a wider variety of crops would further validate its feasibility and impact. These advancements can help establish IoT-enabled hydroponics as a cornerstone of sustainable urban farming in the future.

CHAPTER 13
REFERENCES

1. Zhang, Y., Li, X., & Li, Q. (2020). IoT-based intelligent hydroponic system for urban farming. International Journal of Agricultural Automation, 14(3), 123-136. https://doi.org/10.1007/s10143-020-01202-3

2. Patel, D., Shah, P., & Patel, K. (2019). Automated irrigation system using IoT and sensor technology for hydroponics. Journal of Engineering and Technology, 22(5), 200-210. https://doi.org/10.1109/JET.2019.1023

3. Gupta, R., Kumar, V., & Jain, A. (2021). Development of a real-time monitoring system for hydroponics using Blynk app. International Journal of IoT and Applications, 18(4), 88-99. https://doi.org/10.1007/s42491-021-0045-0

4. Sharma, S., Gupta, A., & Singh, M. (2018). Sustainability of hydroponics in urban farming: A review of water and space efficiency. Journal of Sustainable Agriculture, 39(7), 1035-1049. https://doi.org/10.1016/j.susag.2018.07.012

5. Ranjan, S., & Kumar, P. (2017). IoT in agriculture: Real-time monitoring and automated control of hydroponic systems. International Conference on Smart Farming and IoT, 101-109. https://doi.org/10.1109/SF-IoT.2017.0052

6. Blynk (2023). Blynk IoT platform for building smart agriculture applications. Retrieved from https://blynk.io/smart-agriculture

7. Muhammad, Z., & Ali, R. (2019). The role of IoT in sustainable urban farming: A case study of hydroponics. Smart Cities and Sustainable Development Journal, 2(6), 65-74. https://doi.org/10.1109/SUSD.2019.0525

8. Singh, A., & Kumar, S. (2020). Smart hydroponic systems: Integration of IoT and sensor networks for sustainable agriculture. Journal of Agricultural Engineering, 32(4), 245-257. https://doi.org/10.1080/03012345.2020.1753140

9. Yadav, A., & Mehta, D. (2021). IoT-enabled hydroponics for urban agriculture: Design and development of an automated system. Journal of Internet of Things, 9(1), 45-58. https://doi.org/10.1007/s41101-020-00084-9

10. Choi, H., & Lee, M. (2022). Advanced sensor technologies for precision farming in hydroponics. Sensors and Actuators B: Chemical, 355, 131220. https://doi.org/10.1016/j.snb.2022.131220

11. Agarwal, P., & Raj, S. (2019). Real-time data analytics for IoT-based hydroponics systems: A comprehensive study. Smart Sensors and Applications, 8(3), 210-223. https://doi.org/10.1007/s42772-019-00015-w

12. Wang, L., Zhang, X., & Zhao, Y. (2021). The role of IoT in improving water and energy efficiency in hydroponics. Journal of Cleaner Production, 282, 125283. https://doi.org/10.1016/j.jclepro.2020.125283

13. Bhat, M., & Gupta, R. (2020). Design and implementation of IoT-based monitoring system for hydroponics in urban areas. International Journal of Smart Agriculture, 7(1), 14-24. https://doi.org/10.1109/ISAgri.2020.9015010

CHAPTER 14

PROJECT OUTCOME