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An Innovative Approach of Economic Smart Aquaponics System

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Abstract: ***Aquaponics is a sustainable method of food production that combines aquaculture and hydroponics to cultivate fish and plants in a symbiotic environment. This paper presents the development of an IoT-based smart aquaponics system aimed at automating and monitoring key environmental parameters to optimize plant and fish health. The system is powered by a NodeMCU microcontroller, which integrates various sensors including a DHT11 sensor for temperature and humidity measurement, and a water level sensor to monitor the plant bed's hydration. A self-operating pump system manages the transfer of nutrient-enriched water from the fish tank to the plant bed, triggered by live data collected from the sensors. The collected data is transmitted via Wi-Fi to the Ubidots IoT platform, enabling live monitoring through a cloud-based dashboard. This approach not only reduces manual intervention but also enhances resource efficiency and promotes sustainable urban farming. The system demonstrates a practical and scalable solution for smart agriculture, making it suitable for both research and real-world applications. This system is designed to reduce the need for manual effort by automating key functions involved in aquaponics management. By streamlining routine tasks such as water circulation and environmental monitoring, the setup helps improve efficiency and reliability. Moreover, it promotes sustainable farming by making use of affordable, easy-to-deploy hardware components. The project illustrates how practical and cost-effective technology can support smarter, greener agricultural methods suitable for both small-scale and larger operations.***

Keywords: IoT, Aquaponics, NodeMCU, Smart Farming, DHT11 Sensor, Water Level Sensor, Automatic Irrigation, Ubidots, Cloud Monitoring, Precision Agriculture.

I. INTRODUCTION

In recent years, the demand for sustainable and efficient agricultural practices has increased significantly due to population growth, urbanization, and limited natural resources. Traditional farming methods often rely heavily on manual labor and water usage, which may not be sustainable in the long run. As a result, innovative solutions such as aquaponics are gaining attention to produce food in a more resource-conscious manner.

Aquaponics is a closed-loop system that combines aquaculture (raising fish) and hydroponics (growing plants without soil), where fish waste provides nutrients for the plants, and the plants help purify the water for the fish.

Although aquaponics is inherently efficient, it still requires regular monitoring and manual control to maintain the balance between plant and fish environments. Parameters such as water levels, temperature, and humidity need to be consistently regulated to ensure the health of the ecosystem. This is where the integration of Internet of Things (IoT) technologies can offer a substantial advantage. By automating the monitoring and control processes, IoT-enabled systems can enhance the reliability and performance of aquaponics setups, while reducing the need for constant human supervision.

This project introduces a smart aquaponics system that uses the NodeMCU microcontroller as the central unit for connecting sensors and handling data. A DHT11 sensor is used to measure ambient temperature and humidity, while a water level sensor keeps track of the moisture condition in the plant bed. Based on the readings from these sensors, an automatic pump is triggered to circulate water from the fish tank to the plants when necessary. This ensures that the plants receive adequate hydration while maintaining a suitable aquatic environment for the fish.

All sensor data is transmitted in real time to the Ubidots cloud platform, where users can monitor environmental conditions through a user-friendly dashboard. This remote access capability not only improves the convenience of system management but also provides useful insights for optimizing system performance. By combining affordable electronics with cloud connectivity, the proposed solution offers a practical and scalable approach to modern agriculture. It demonstrates how smart farming technologies can be adopted even in small-scale or home-based setups to promote sustainability and reduce dependence on manual labor.

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II. LITERATURE SURVEY

Taha et al. (2022)

The authors provide a detailed overview of smart aquaponics systems, highlighting how IoT technologies are revolutionizing traditional farming by enabling real-time monitoring and automation. Their study explores sensor networks, data acquisition methods, and wireless communication technologies used to optimize aquaponic environments.

Mohiuddin et al. (2024)

This paper presents a smart irrigation and monitoring system using NodeMCU and Ubidots. It emphasizes the importance of cloud-based platforms for real-time decision-making and remote access in precision agriculture.

Dhinakaran et al. (2023)

The authors designed an IoT-enabled system for fish farming that integrates multiple sensors and machine learning algorithms. The system helps in maintaining water quality by automatically adjusting parameters, thus improving fish growth and reducing mortality rates.

Rashid et al. (2022)

This study proposes a biofloc-based aquaculture model where IoT sensors gather water parameters, which are then analyzed using machine learning models to predict future water quality. This proactive approach reduces human intervention while maximizing productivity.

Arduino-Based Aquaponics System (2021)

In this project, a simple aquaponics setup using Arduino Uno was developed. It included temperature and water level sensors to regulate the water pump and ensure stable conditions for plant and fish growth.

Yadav et al. (2023)

This review discusses the recent developments in IoT-based smart aquaculture practices, emphasizing the integration of artificial intelligence and cloud computing for enhanced monitoring and management of aquaponic systems.

Zamnuri et al. (2024)

This systematic review evaluates the integration of IoT in small-scale aquaponics, highlighting how IoT applications optimize water quality and system efficiency, thereby enhancing productivity and profitability.

Gayam et al. (2023)

The authors explore the transformative potential of integrating AI and IoT in aquaponics systems for yield enhancement, focusing on real-time monitoring and decision support mechanisms to improve productivity and sustainability.

Aurasopon et al. (2024)

This study presents an IoT-integrated hydroponic system aimed at enhancing efficiency and productivity in small-scale farming, focusing on real-time monitoring of parameters like electrical conductivity, pH levels, temperature, and humidity.

Dharshana et al. (2023)

The authors developed a cost-effective aquaponics solution incorporating IoT and solar energy to monitor water quality parameters such as pH, temperature, and nitrification processes, aiming to reduce manual intervention and enhance crop yield.

III. PROPOSED SYSTEM

The proposed system is designed to create a fully automated and remotely monitored aquaponics setup by utilizing Internet of Things (IoT) technologies. At the core of the system is the NodeMCU (ESP8266) microcontroller, which enables wireless connectivity and acts as the central processing unit for collecting and transmitting sensor data.

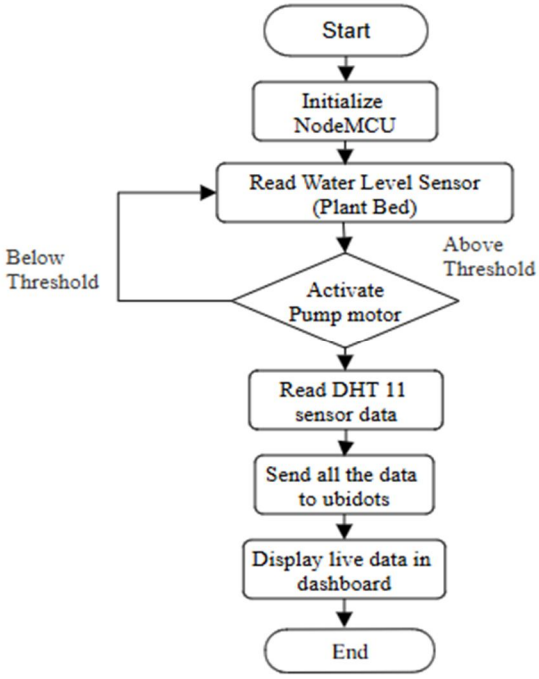
The system consists of a water level sensor in the plant bed which is used to detect the level of water. This water is directed to the plant bed from the fish tank which is the great nutrient source for the plants.When the water level in the plant bed drops below a predefined threshold, the automatic pump motor is triggered to circulate water from the fish tank to the plant bed. This ensures efficient water recycling without manual intervention.

To monitor environmental conditions, a DHT11 sensor is used to track ambient temperature and humidity levels around the plant area. This data is crucial for maintaining optimal conditions for plant growth. All sensor readings are collected in real-time and transmitted to the Ubidots IoT platform, where users can visualize live data through a web or mobile dashboard.

The entire system is designed to operate autonomously, making decisions based on real-time sensor input. If any reading crosses a critical threshold, the system can trigger alerts or adjust the operation of the water pump accordingly. This approach minimizes resource wastage and promotes sustainable agriculture practices by leveraging low-cost electronics and cloud services.

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The setup is compact, energy-efficient, and suitable for small to medium-scale farming applications. By integrating automation and live monitoring, the proposed system not only reduces manual workload but also supports healthier crop production and improved water management.



IV. SYSTEM ARCHITECTURE

The architecture of the proposed system includes both hardware and cloud-based components that work together seamlessly. The NodeMCU microcontroller acts as the communication hub, receiving data from connected sensors and controlling the motorized pump. The water level sensor is installed in the plant bed, while the DHT11 sensor monitors environmental factors such as temperature and humidity in the surrounding environment.

The system is powered through a stable DC source, and the pump is controlled via a relay module based on water level readings. Once the sensor data is collected, the NodeMCU sends the information to Ubidots via Wi-Fi. The cloud platform not only logs the data but also visualizes it in real-time for the user to monitor remotely. This setup provides timely alerts and status updates, enabling users to respond quickly to any abnormal conditions.

V. DESIGN AND IMPLEMENTATION

The design of the system starts with connecting the controller unit with water level senor, relay module, and water pump. These are connected using standard electronic wiring practices, and the firmware is uploaded to the NodeMCU using the Arduino IDE. The code includes logic to read the sensors periodically and decide whether to activate the pump. It also contains the API credentials required to push the data to Ubidots.

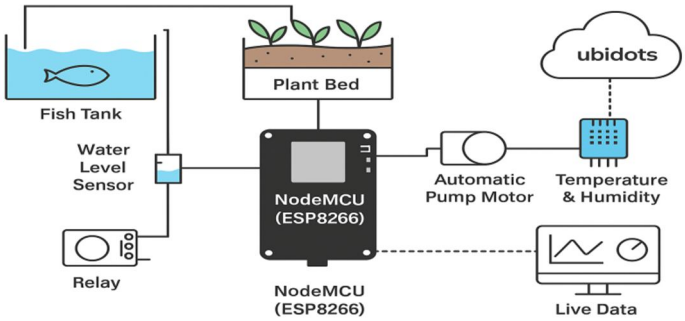


Fig.1 Design Structure of the Proposed system

Once the circuit is assembled and tested, the system is placed within an actual aquaponics setup. The water pump is placed inside the fish tank, and the plant bed is positioned in such a way that it receives the circulating water. This allows nutrient-rich water from the fish tank to be supplied directly to the plants, promoting healthy growth. The Ubidots dashboard is configured with gauges and graphs to visualize live sensor data, allowing the user to oversee the entire operation from any location.

VI. RESULTS AND DISCUSSION

The implemented IoT-based aquaponics system was tested in a controlled environment to evaluate its performance in terms of automation, reliability, and real-time monitoring. The system successfully managed the flow of water between the fish tank and the plant bed using real-time feedback from the water level sensor. The pump motor was activated only when the water level dropped below the predefined threshold, ensuring efficient water usage and consistent plant irrigation.

Environmental parameters such as temperature and humidity were accurately captured by the DHT11 sensor and transmitted to the Ubidots cloud platform. The dashboard provided a user-friendly interface, allowing live data to be visualized in the form of graphs and widgets. The update frequency was stable, and users were able to access this data remotely without delays, confirming the system's capability for continuous real-time monitoring.

During multiple test runs, the system responded reliably to changes in environmental conditions and executed control actions without manual input. The automation of the pump system helped avoid overwatering, and the overall setup ensured that the nutrient-rich water from the fish tank was recycled effectively. This minimized water wastage and created a sustainable loop between fish and plant ecosystems.

The use of low-cost components like NodeMCU and basic sensors proved that such systems can be built affordably while still maintaining functionality. Although the current version of the system does not include parameters like pH or ammonia levels, the results demonstrate a solid foundation for small-scale smart farming. With minor enhancements, this system can be scaled or integrated into more advanced smart agriculture frameworks.

VII.FUTURE ENHANCEMENT

There's plenty of room to build on this system in the future. One useful improvement would be adding sensors to check pH levels and nutrients in the water, which could help maintain an even better environment for the fish and plants. Including an automatic fish feeder could also cut down on daily maintenance and ensure feeding happens on time. Over time, collecting system data and using it to train simple predictive models could make the system smarter—automatically adjusting settings based on patterns it learns. Using solar panels to power the setup could also make it eco-friendlier and more cost-effective. Finally, creating a simple mobile app that lets users get alerts or control the system remotely would make it even easier to use, especially for those managing it from a distance.

VIII. CONCLUSION

The proposed IoT-based aquaponics system successfully integrates smart technology to support sustainable farming practices. By using a water level sensor in the plant bed, the system ensures timely water delivery from the fish tank through an automatically controlled pump, maintaining optimal conditions for plant growth. Additionally, the DHT11 sensor effectively monitors ambient temperature and humidity, providing critical environmental data. The real-time monitoring capability via Ubidots enhances system reliability and allows users to track and manage conditions remotely. Overall, this automated and data-driven approach simplifies aquaponics management, improves resource efficiency, and promotes a more sustainable and productive method of cultivation.

This system not only reduces the need for constant manual supervision but also minimizes water waste and energy usage through intelligent automation. The seamless integration of sensors and IoT platforms creates a scalable solution that can be adapted for both small-scale urban farming and larger agricultural setups. By combining aquaculture and hydroponics with modern IoT tools, this project demonstrates how technology can be leveraged to support eco-friendly food production systems. With further enhancements, such as nutrient monitoring or automated feeding, this model holds great potential for future development in smart agriculture.

REFERENCES

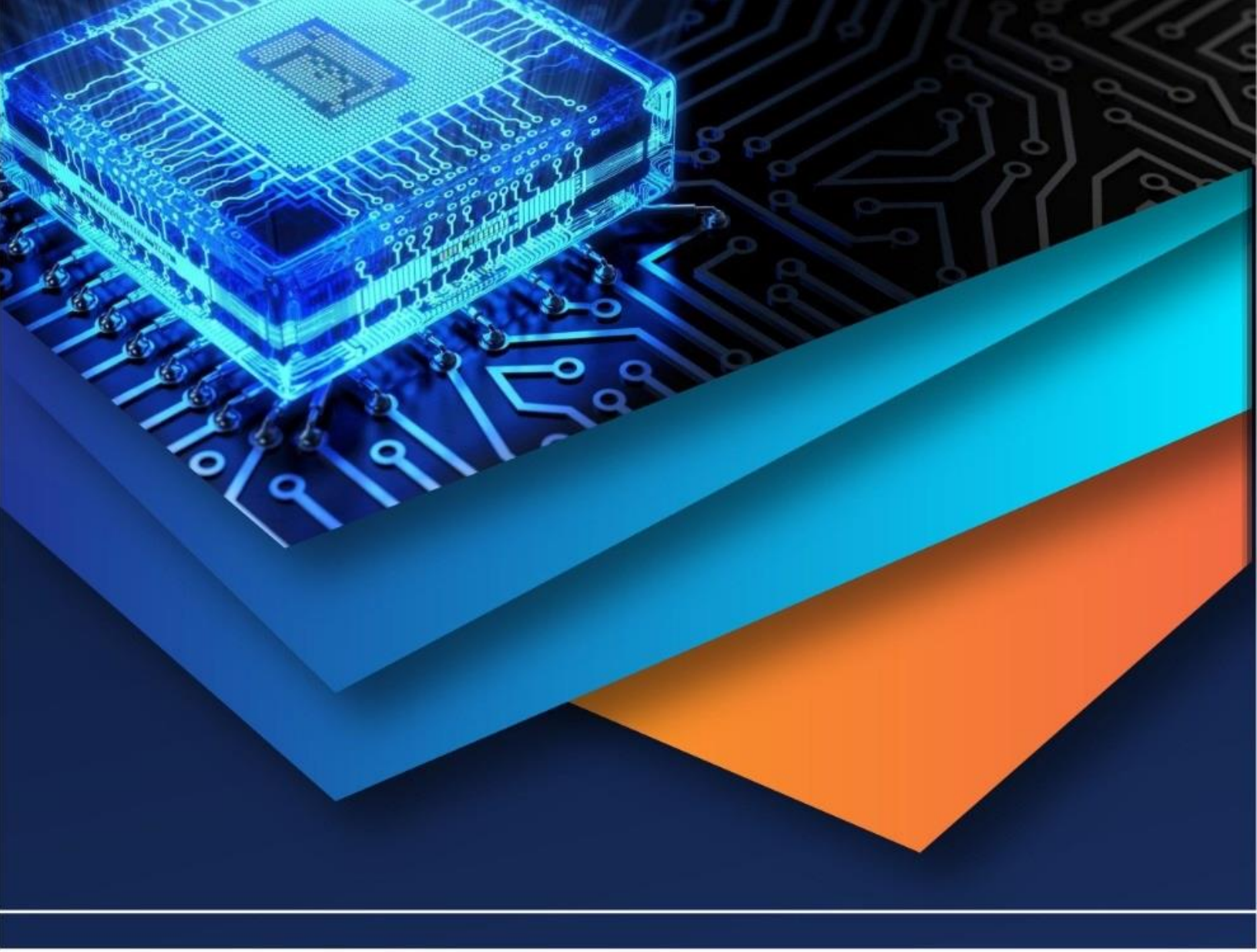
[1] Taha, M. F., ElMasry, G., Gouda, M., Zhou, L., Liang, N., Abdalla, A., Rousseau, D., & Qiu, Z. (2022). Recent Advances of Smart Systems and Internet of Things (IoT) for Aquaponics Automation: A Comprehensive Overview. Chemosensors, 10(8), 303

[2] Mohiuddin, M., Islam, M. S., & Uddin, M. J. (2024). Internet of Things (IoT)-Based Smart Agriculture Irrigation and Monitoring System Using Ubidots Server. Engineering Proceedings, 82(1), 99.

[3] Dhinakaran, D., Gopalakrishnan, S., Manigandan, M. D., & Anish, T. P. (2023). IoT-Based Environmental Control System for Fish Farms. IJRITCC, 11(10), 8482.

[4] Rashid, M. M., Nayan, A., Rahman, M. O., Simi, S. A., Saha, J., & Kibria, M. G. (2022). IoT based Smart Water Quality Prediction for Biofloc Aquaculture. arXiv preprint.
[5] Mpho P. Ntulo, Pius A Owolawi, Temitope Mapayi, Vusi Malele, Gbolahan Aiyetoro, Joseph S. (2021). IoT-Based Smart Aquaponics System Using Arduino Uno. International Conference on Electrical, Computer, Communications and Mechatronics Engineering (ICECCME).
[6] Yadav, A., Noori, M. T., Biswas, A., & Min, B. (2023). A Concise Review on the Recent Developments in the Internet of Things (IoT)-Based Smart Aquaculture Practices. Reviews in Fisheries Science & Aquaculture, 31(1), 103–118.
[7] Zamnuri, M. A. H. b., Qiu, S., Rizalmy, M. A. A. b., He, W., Yusoff, S., Roeroe, K. A., Du, J., & Loh, K.-H. (2024). Integration of IoT in Small-Scale Aquaponics to Enhance Efficiency and Profitability: A Systematic Review. Animals, 14(17), 2555.
[8] Gayam, K. K., Jain, A., Singh, R., Gehlot, A., & Akram, S. V. (2023). Smart Aquaponics with Integration of AI and IoT for Yield Enhancement through Real-Time Monitoring and Decision Support. International Journal on Recent and Innovation Trends in Computing and Communication, 11(10), 2039–2049.
[9] Aurasopon, A., et al. (2024). Integration of IoT Technology in Hydroponic Systems for Enhanced Efficiency and Productivity in Small-Scale Farming. Acta Technologica Agriculturae, 27(4), 203–211.
[10] Dharshana, S., Elanchezhiyan, B., Veshun, D., & Prakash, R. S. (2023). Determination of Water Quality in Aquaponics Using IoT. International Journal of Recent Advances in Multidisciplinary Topics, 4(3), 124–129.

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