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Smart Urban Farming Pods

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***Abstract* - The Smart Urban Farming Pods Project integrates aeroponic vertical farming with automation of IoT controls to enable efficient, floorless cultivation in urban rooms. Used the ESP32 W-room 32 Microcontroller to collect real time data from moisture, temperature, light and raindrop sensors, store them in Firebase and process them through node.js and Express.js backends. React native apps allow users to monitor sensor data and automatically analyze and control trends. With cloud services that ensure remote access, the system optimizes resource use, improves urban agriculture efficiency, and promotes the sustainability of modern cities.**

Keywords: Urban Farming, IoT, Aeroponics, ESP32, Firebase, Node.js, React Native, Google Assistant, Smart Irrigation, Cloud Computing.

I. INTRODUCTION

With rapid urbanization and population growth, traditional agriculture is a challenge such as spatial restrictions, water shortages and environmental degradation. Due to limited land availability and inefficient food supply chains, urban residents often have difficulty accessing fresh, pesticide-free products. To address these issues, the Smart Urban Farming Pods Project uses Aeroponic vertical farming in conjunction with automation of IoT controls to enable sustainable floorless cultivation in urban rooms.

This innovative system integrates environmental monitoring, automated irrigation, and data-controlled knowledge to optimize plant growth and at the same time minimize resource consumption. In the core, the system uses the ESP32-WROOM-32 microcontroller to collect data from a variety of sensors, including moisture, temperature, light, and raindrop sensors. This data is stored in the real Firebase database and processed through the node.js and Express.js backends to provide meaningful knowledge to the user.

The project has a native mobile application that is user friendly and allows for seamless interaction with the system. Users can monitor real-time sensor data, analyze historical trends, and control remote irrigation systems. Automated pump controls adapt water supply using custom threshold values to ensure optimal system health.

To improve accessibility and scalability, cloud services such as Google Cloud and AWS make IoT integration easier and remote monitoring easier. A combination of intelligent automation, real-time monitoring and user-friendly analytics will significantly improve the efficiency of the urban stage, reduce water consumption, and allow fresh products to grow even in tightly-held rooms.

The Smart Urban Farming Pod Project presents a modern, scalable and sustainable solution for urban agriculture that takes into account concerns about nutrition security and promotes environmentally friendly practices. Through the integration of advanced technology in efficient agricultural technology, this project will allow urban residents to control food production and promote self-sufficiency and sustainability in urban environments.

II. RESEARCH METHEDOLOGY

The research method for the Smart Urban Farming Pod Project is embedded in several phases, ensuring a systematic and efficient approach to the development of sustainable and technologically advanced urban farming systems. Methodologies include problem identification, system design, hardware and software integration, data collection, testing and evaluation.

2.1 Identifying Problems and Literature Summary

The early stages include identifying issues related to urban agriculture. B. Space limitations, inefficient resource use, environmental issues. A comprehensive literature overview is carried out to analyze existing smart agriculture technologies, IoT-based automation, and aeroponic agriculture systems. This will help you understand current trends, limitations and potential solutions for integrating intelligent agriculture into urban environments.

2.2 System Design and Architecture

System architecture is designed based on the results of a literature overview that includes both hardware and software components. The system consists of the esp32-wroom-32 microcontroller, which collects data from sensors such as moisture, temperature, light, raindrops, and more. The collected data is stored in the Fire Base Real -Time database.

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This allows for real access and analysis. The backend was developed with node.js and express.js, and the frontend was created with react native and expo, providing an interactive mobile interface.

2.3 Hardware and Software Integration

Hardware components such as microcontrollers, sensors and actuators are integrated to ensure seamless communication. IoT-based automated systems are programmed to control defined moisture thresholds based on predefined definitions. Software development follows an agile approach focused on modular programming, scalability and security.

2.4 Data Collection and Processing

Actual data is collected by sensors to monitor environmental conditions. Data are processed and analyzed to release meaningful knowledge such as historical trends in plant growth and resource consumption. * Cloud services such as Google Cloud and AWS * improve data processing capabilities to ensure remote accessibility and scalability.

2.5 Testing and Evaluation

The system undergoes rigorous testing to verify performance. Functional testing ensures that all components function as expected, and usability testing assesses the efficiency and intuition of the user interface. Performance metrics such as water consumption efficiency of sensor data, system response, and accuracy are analyzed.

2.6 Conclusions and Future Improvements

The final phase includes documenting results, identifying issues and suggesting future improvements. This research method ensures that the Smart Urban Farming Pods project is developed in a structured manner, providing a scalable and efficient solution for modern urban agriculture issues.

III. LITERATURE REVIEW

Further developments in smart farming and Internet of Things (IoT) technologies have changed agricultural practices, allowing farmers to optimize operations through automation and practical monitoring. This change is particularly important in urban agriculture. Innovative systems such as hydro cultivation and aeroponics are popular in this agriculture. These bottomless cultivation methods provide a sustainable solution for compact urban food cultivation that addresses the challenges arising from urbanization and limitedarable land.

Hydroponic Cultivation Systems include cultivation of plants in nutrient-rich water solutions that eliminate the need for soil. Research shows that these systems can reduce water consumption by up to 90% compared to traditional agricultural methods. This water efficiency is extremely important, especially in urban areas, where water shortages represent an increasing problem. Furthermore, regardless of seasonal changes, hydrocarbons allow the production of older plants, allowing city residents to continuously cultivate fresh products. Research shows that hydrogen-grown plants often have fast growth rates and increase nutrient content because they have direct access to nutrients in the water.

The aeroponic system goes a step further by using plants in fog environments. This method increases the growth rate of the system by up to 25%, mainly because nutrients and oxygen deliver oxygen directly to the roots. Studies show that aeroponics produce healthier and more resistant plants, as exposed roots absorb oxygen more efficiently. The mist system used in aeroponics significantly reduces water consumption and maximizes nutritional efficiency. Additionally, aeroponic systems can be easily integrated into smart technology to monitor environmental conditions, optimize growth conditions and improve overall returns. Research shows that IoT adoption could increase revenue by 30-50%. Actual monitoring of soil moisture, temperature, air humidity and nutrient levels allows data to be controlled decisions, irrigation, nutrition collection and optimization of pest control. Sensors alert farmers to environmental changes, prevent harvest losses, reduce costs, and allow for quick adjustments that minimize human error.

By integrating hydroponic and aeroponic agriculture into automation of IoT control, urban agriculture is more efficient, sustainable and accessible, providing innovative solutions to the challenges of modern agriculture.

IV. RESULTS AND DISCUSSION

The Smart Urban Farming Pod Project demonstrated improved water efficiency, plant growth and automation. The microcontrollers activated real-time monitoring, while the native React app provided seamless control. The automated pump system provided optimal levels of moisture and reduced manual effort.

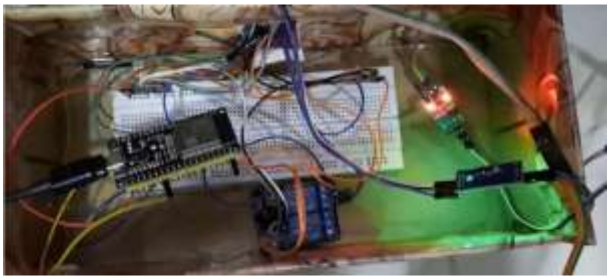

Figure 1: Circuit of IoT Connections

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Urban Adaptability: Vertical crops use small urban areas efficiently and promote sustainability and nutritional safety. The cost of initial furniture can be high, but long-term savings in water, workers and ongoing crop yields are a practical solution. Future improvements include AI control analysis, better sensor calibration, and various plant expansions.

Figure 2: Screenshot of Software Application developed

Figure 3: Image of Vertical Aeroponics Structure

V. CONCLUSION

In summary, this project has successfully achieved urban agriculture challenges by providing a compact, efficient and user-friendly solution. By using technology to automate critical agricultural processes, it promotes sustainability and accessibility and paves the way for the widespread adoption of urban agricultural practices. The results highlight the potential of systems to revolutionize how food is grown in urban areas, making it a valuable contribution to sustainable agriculture.

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