



IoT Based Smart Indoor Farming using Solar Power and Kitchen Wastewater

Mr.K.Bavisankar, Mr.R.Chandru, Mr.M.Devaraj , Mr.M.Dinesh

B. Tech, Student, Department of Agricultural Engineering, Gnanamani College of Technology, Namakkal,
Tamil Nadu, India

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ABSTRACT: Indoor farming is an innovative approach to agriculture that allows plants to grow in a controlled environment without depending on external weather conditions. With the rapid growth of population and reduction in agricultural land, there is a need for efficient farming methods. This project presents an IoT based indoor farming system that monitors environmental parameters such as temperature, humidity, soil moisture and light intensity using sensors. The collected data is processed through a microcontroller and used to automatically control irrigation and lighting systems to maintain optimal conditions for plant growth. The system provides real time monitoring and reduces manual effort while improving crop productivity and resource efficiency. This smart farming solution helps in sustainable agriculture and efficient food production.

KEYWORDS-IoT, Indoor Farming, Automation, Sensors, Grow Lights, Water Pump, Monitoring, Solar panel.

I. INTRODUCTION

Agriculture is an essential sector that supports food production and economic growth. However, traditional farming methods face many challenges such as climate change, water scarcity, limited agricultural land and lack of

proper monitoring. These issues can affect plant growth and reduce crop yield. To overcome these problems, modern technologies like Internet of Things (IoT) are being used in agriculture. Indoor farming is a technique where plants are grown in a controlled environment without depending on external weather conditions. By controlling factors like temperature, humidity, soil moisture and light, plants can grow more efficiently throughout the year. IoT technology helps in monitoring these environmental parameters using sensors and automating the farming process. This project focuses on developing an IoT based indoor farming system that continuously monitors plant conditions and automatically controls irrigation and lighting. The system reduces human effort, saves water and ensures healthy plant growth. It provides a smart and efficient solution for modern agriculture and supports sustainable farming practices.

II. LITERATURE SURVEY

Several researchers have proposed different IoT based solutions to improve agricultural productivity and reduce manual effort. The following studies provide an overview of existing technologies and methodologies used in smart farming and indoor agriculture.

K. Lakshmi Priya (2018) proposed an IoT based smart agriculture monitoring system that uses sensors to measure soil moisture, temperature and humidity. The system automatically controls irrigation based on real time data collected from the field. This approach helps in reducing water wastage and improves crop productivity by providing continuous monitoring.

R. Kumar (2019) developed a smart greenhouse monitoring system using IoT technology. In this system, environmental parameters such as temperature, humidity and light intensity are monitored continuously to maintain optimal conditions for plant growth. The system also provides alerts when environmental conditions exceed the threshold values, ensuring better crop management.

S. Sharma (2020) introduced an automated indoor farming system using IoT sensors and microcontrollers. The system collects environmental data and automatically controls irrigation and lighting systems. This automation reduces human intervention and ensures plants receive proper care, leading to improved plant health and productivity.



P. Singh (2017) presented an IoT based smart irrigation system that uses soil moisture sensors to monitor water levels in soil. When the moisture level drops below a certain limit, the system automatically turns on the water pump. This method helps in conserving water and improving irrigation efficiency.

M. Patel (2021) proposed a cloud based IoT smart farming system that collects environmental data using sensors and stores it in cloud platforms for analysis. The system allows users to monitor farm conditions remotely through mobile applications. This approach improves decision making and enables efficient farm management by providing real time updates and historical data analysis.

J. Lee (2022) developed an intelligent indoor farming system integrated with artificial intelligence and IoT technology. The system predicts plant growth conditions based on sensor data and automatically adjusts environmental parameters such as light and irrigation. This intelligent approach improves crop yield and ensures optimal plant growth with minimal human intervention.

From the above studies, it is clear that IoT plays a significant role in modern agriculture by enabling real time monitoring, automation and efficient resource utilization. These research works provide a strong foundation for developing an IoT based indoor farming system that ensures optimal plant growth in a controlled environment.

III. PROBLEM IDENTIFICATION

Traditional farming faces major challenges such as water scarcity, climate change, unpredictable weather, and limited land availability. Excessive use of water and chemical fertilizers affects soil health and reduces sustainability. Manual monitoring of crops increases labor cost and reduces efficiency. In urban areas, lack of space makes soil-based farming difficult. Also, many automated systems depend on grid electricity, increasing energy costs. Therefore, there is a need for a solar-powered IoT-based indoor farming system that can monitor temperature and water levels in real-time, automate irrigation and ventilation, reduce resource wastage, and ensure sustainable crop production with minimal human intervention.

A. Disadvantages Of Existing System

- Depends heavily on climate and seasonal conditions.
- High water consumption and wastage.
- Excessive use of chemical fertilizers damages soil quality.
- Requires continuous manual monitoring and labor.
- No real-time monitoring or automated control system.
- High electricity consumption in automated setups.

IV. PROPOSED IDEOLOGY

The proposed system is a solar-powered IoT-based indoor farming system designed to automate plant growth in a controlled environment. Solar panels generate energy and charge a battery to power the system. Water and temperature sensors continuously monitor environmental conditions. The sensor data is sent to a microcontroller with IoT connectivity, which uploads real-time data to a cloud platform for monitoring. Based on sensor readings, relays automatically control irrigation and ventilation systems. This approach ensures efficient water usage, optimal temperature maintenance, reduced human intervention, and sustainable year-round crop production.

A. Proposed Idea Of Problem Statements

To address the challenges faced in traditional agriculture such as water scarcity, unpredictable climate conditions, high labor requirements, and energy consumption, the proposed system aims to develop a smart, sustainable, and automated indoor farming solution. The proposed idea is to design and fabricate a solar-powered IoT-based indoor farming system that operates in a controlled environment without soil. Solar panels are used to generate renewable energy, which charges a battery to power the entire system, reducing dependency on conventional electricity. Water level and temperature sensors continuously monitor essential environmental parameters required for plant growth. These sensors are connected to a microcontroller with IoT capabilities, which transmits real-time data to a cloud platform for remote monitoring and analysis. Based on the sensor readings, a relay module automatically controls irrigation and ventilation systems to maintain optimal growing conditions. This automation minimizes human intervention, reduces water wastage, improves energy efficiency, and ensures consistent crop production throughout the year.



Thus, the proposed system provides an eco-friendly, cost-effective, and smart farming solution suitable for urban and space-limited environments.

B. Advantages of proposed system

- Uses solar energy, reducing electricity cost and carbon footprint.
- Ensures efficient water usage through automated irrigation control.
- Provides real-time monitoring using IoT and cloud connectivity.
- Maintains optimal temperature and environmental conditions.
- Reduces human intervention and labor cost.
- Enables year-round crop production in a controlled indoor environment.
- Suitable for urban areas with limited space.
- Promotes sustainable and eco-friendly agriculture.

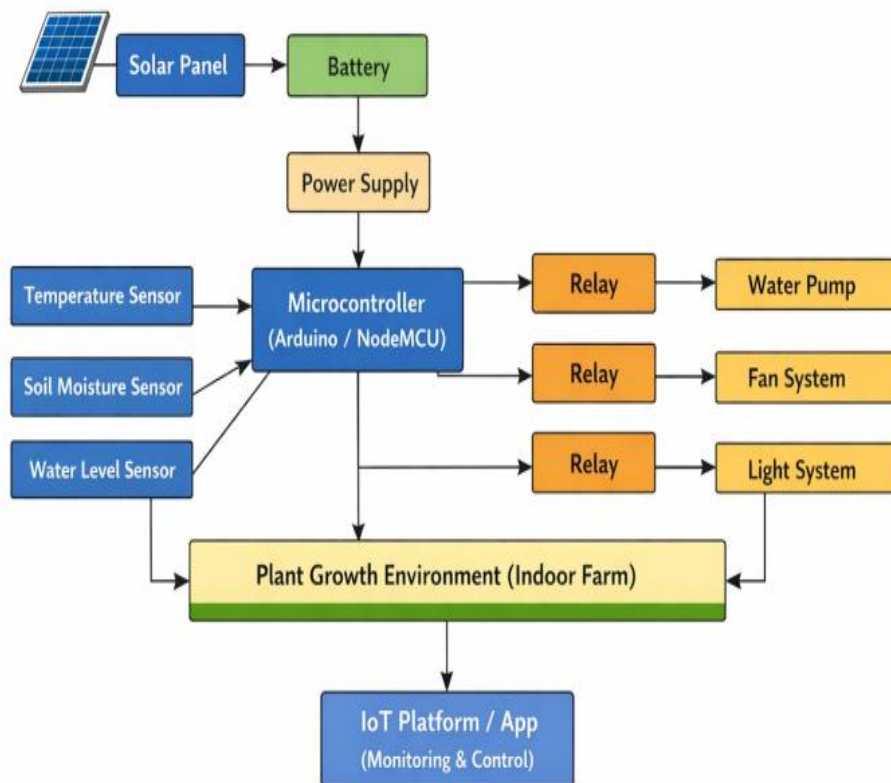
V. WORKING METHODOLOGY

The proposed IoT-based solar indoor farming system operates by integrating renewable energy, environmental sensors, automation, and cloud connectivity to maintain optimal plant growth conditions. Initially, solar panels capture sunlight and convert it into electrical energy. This energy is stored in a rechargeable battery, which supplies power to the entire system including the microcontroller, sensors, IoT module, and relay circuits. This ensures uninterrupted operation even during low sunlight conditions. Water level sensors and temperature sensors are installed inside the indoor farming chamber to continuously monitor essential parameters. These sensors collect real-time data and transmit it to the microcontroller (such as Arduino/ESP module). The microcontroller processes the sensor data and compares it with predefined threshold values. If the temperature exceeds the set limit, the microcontroller activates the relay to turn on the ventilation fan or cooling system. Similarly, if the water level or soil moisture level drops below the required level, the relay automatically switches on the water pump to irrigate the plants. Once the desired conditions are achieved, the system automatically turns off the respective devices to conserve energy and water. The IoT-enabled microcontroller sends real-time environmental data to a cloud platform. This allows users to monitor system performance remotely through a smartphone or web dashboard. Alerts and updates can also be provided if abnormal conditions are detected. Through continuous monitoring, automated control, and renewable energy utilization, the system ensures efficient resource management, reduced manual effort, and sustainable year-round crop production in a controlled indoor environment.

A. Architecture of working module

The working module of the IoT-based indoor farming system is designed to automate plant growth by monitoring environmental conditions and controlling devices accordingly. The system starts with the sensing unit, which includes temperature sensor, soil moisture sensor, and water level sensor. These sensors continuously collect real-time data from the indoor environment and send it to the microcontroller.

IoT-Based Indoor Farming System



The microcontroller (Arduino/NodeMCU) acts as the processing unit. It analyzes the sensor data and compares it with predefined threshold values.

Based on the analysis:

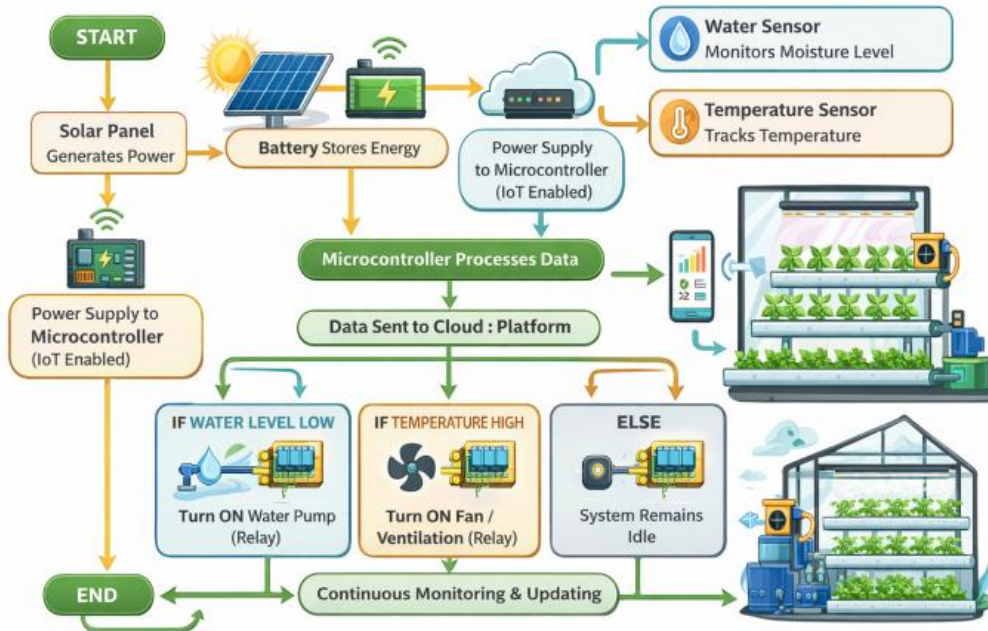
- If the soil moisture level is low, the microcontroller activates the water pump through a relay
- If required, the light system is turned ON to support plant growth

The relay module works as a switching device to control the water pump and light system. The system is powered using a solar panel and battery, ensuring energy efficiency and continuous operation. Finally, the system is connected to an IoT platform, which allows users to monitor data and control the system remotely.

B. Analysis of work flow

The workflow of the IoT-based indoor farming system represents a continuous and automated process designed to maintain optimal plant growth conditions with minimal human intervention. Initially, solar panels generate electrical energy, which is stored in a battery to ensure uninterrupted power supply. This energy is used to operate a microcontroller with IoT capabilities, which acts as the central unit of the system. Water and temperature sensors continuously monitor environmental conditions and send real-time data to the microcontroller.

IoT Indoor Farming System Workflow



The collected data is then processed and transmitted to a cloud platform for remote monitoring. Based on predefined threshold values, the system makes decisions automatically: if the water level is low, the relay activates the water pump, and if the temperature is high, it turns on the fan or ventilation system. If conditions are normal, the system remains idle. This cycle repeats continuously, forming a closed-loop system that ensures efficient resource utilization, reduces manual effort, and supports sustainable indoor farming.

VI. RESULT AND ANALYSIS

The IoT-based indoor farming system was successfully designed and implemented, and its performance was analyzed under different environmental conditions. The system effectively monitored key parameters such as water level and temperature using appropriate sensors. Based on the real-time data collected, the microcontroller processed the information and made accurate decisions according to predefined threshold values. Whenever the soil moisture level dropped below the required limit, the system automatically activated the water pump through the relay module, ensuring that plants received sufficient water. Similarly, when the temperature exceeded the optimal range, the fan or ventilation system was turned on to maintain a suitable environment for plant growth.

The integration of IoT technology allowed continuous data transmission to the cloud, enabling remote monitoring and control of the system. This feature improves user convenience and provides better insights into environmental conditions over time. Additionally, the use of solar energy as the primary power source ensured uninterrupted operation while promoting sustainability and reducing electricity costs.

From the analysis, it is evident that the system significantly reduces manual intervention and optimizes resource utilization, particularly water usage. The automated control mechanism ensures that plants are maintained under ideal conditions, which can lead to improved growth and productivity. However, the system's efficiency depends on the accuracy of sensors and stable internet connectivity for IoT communication. Overall, the proposed system proves to be a reliable, cost-effective, and eco-friendly solution for modern indoor farming and smart agriculture applications.



VII. CONCLUSION

The IoT-based indoor farming system was successfully developed to provide an automated and efficient solution for plant cultivation in a controlled environment. By integrating sensors, a microcontroller, relay modules, and IoT technology, the system continuously monitors and maintains optimal conditions such as water level and temperature. The use of solar energy further enhances the system by making it sustainable and energy-efficient. The automated decision-making process reduces human effort, minimizes water wastage, and ensures healthy plant growth. Overall, this system demonstrates a reliable, eco-friendly, and smart approach to modern agriculture, making it suitable for year-round indoor farming with improved productivity and resource management.

VIII. FUTURE ENHANCEMENT

The IoT-based indoor farming system can be further improved by integrating advanced technologies to increase efficiency and scalability. Future enhancements may include the use of additional sensors such as humidity, light intensity, and pH sensors to provide more precise control over plant growth conditions. The system can be upgraded with Artificial Intelligence (AI) and Machine Learning (ML) algorithms to predict plant needs and optimize watering and temperature automatically. A mobile application can be developed for better user interaction, real-time alerts, and remote control. Integration with automated nutrient delivery systems (hydroponics) can further improve plant health and yield. Additionally, improving battery storage and energy management can enhance reliability during low sunlight conditions. These enhancements will make the system more intelligent, user-friendly, and suitable for large-scale smart agriculture applications.

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Explanation: Provides detailed knowledge about IoT architecture, communication models, and real-world applications including smart agriculture.
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Explanation: Provides technical guidance for programming and interfacing microcontrollers with sensors and relay modules used in the system.
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Explanation: Explains WiFi-enabled microcontrollers that support IoT communication for real-time monitoring
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Explanation: A cloud platform used for collecting, visualizing, and analyzing sensor data in real-time.
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