IOT BASED SOLAR POWERED SEED SPRAYER MACHINE

Mrs. Lubna Afza[1], Anish Regmi[2], Thaneshwor Adhikari[3], Umesh Karki[4], Arif Alam[5]

[1]Asst. Professor, Dept. of ECE, KNSIT, Bengaluru

[2-5]UG Students of 7th Semester, Dept. of ECE, KNSIT, Bengaluru

Abstract- **The increasing demand for efficient, sustainable, and precise agricultural practices has motivated the development of IoT-based automation systems. This paper introduces a solar-powered seed sprayer machine that leverages IoT technologies to automate seed distribution while monitoring environmental parameters in real-time. The system employs an ESP32 microcontroller interfaced with ultrasonic and soil moisture sensors to ensure optimized spraying. Energy requirements are met through a solar panel and battery system, making the machine independent of grid power. Real-time monitoring and control are enabled via the Blynk mobile application, while data is logged to ThingSpeak for analysis. Experimental testing demonstrates that the system achieves uniform seed distribution, improves energy efficiency, and reduces manual labor requirements. The proposed design also has the potential for further expansion, such as AI-based decision-making and GPS-guided autonomous navigation, making it a scalable solution for smart agriculture.**

Keywords— IOT, Solar Power, Agriculture Automation, ESP32, Smart Farming, Blynk, ThingSpeak

I. INTRODUCTION

Agriculture is the primary livelihood for millions worldwide, yet conventional farming techniques often lead to inefficiencies, overuse of resources, and uneven crop growth [1][2]. Seed spraying is a critical operation, traditionally performed manually, resulting in inconsistent coverage and significant labour requirements [3].

Recent advances in IoT, renewable energy, and sensor technologies have enabled the development of smart farming solutions [4]. IoT devices can provide continuous monitoring of soil and environmental conditions, automate machine control, and transmit data to cloud platforms for analysis [5]. Solar power complements these systems by providing renewable energy, reducing operational costs, and enabling deployment in off-grid areas [6].

The **objective** of this project is to design a fully automated, solar-powered seed sprayer machine with IoT integration. The system aims to:

1. Reduce human intervention during seed spraying operations.
2. Ensure uniform seed distribution through adaptive control.
3. Enable real-time monitoring and remote operation using Blynk and ThingSpeak [8].
4. Operate sustainably using solar energy.

This approach aligns with the goals of precision agriculture, enhancing crop yields while minimizing labour and energy consumption [9][10].

II. LITERATURE REVIEW

Recent developments in precision agriculture have highlighted the potential of integrating IoT technologies and renewable energy sources to automate farming operations, enhance efficiency, and reduce labor dependency. Various studies have explored autonomous seed sowing systems, solar-powered agricultural robots, and sensor-based monitoring platforms.

[1] Yin Wu, Zenan Yang, and Yanyi Liu (2023) developed a multi-sensor IoT system for soil monitoring published in *Micromachines*, vol. 14, 1395. Their approach combined environmental sensors, a microprocessor, a cloud platform, and a smartphone application to provide real-time soil diagnostics. The system employed energy-efficient components and a predictive model to improve both accuracy and operational efficiency.

[2] E. Prasanthi, M. Poojitha, N. Sravani, N. Sravani, and M. Vasundhara (2023) presented a solar-powered IoT Agribot in the *Turkish Journal of Computer and Mathematics Education*, vol. 14, no. 2, pp. 413–421. The Agribot performs ploughing, seeding, and watering automatically while continuously monitoring environmental parameters such as soil moisture, temperature, and humidity. Data is uploaded to an IoT platform for analysis, showcasing the advantages of combining renewable energy with IoT-enabled agriculture.

[3] Hari Mohan Rai, Deepak Gupta, Sandeep Mishra, and Himanshu Sharma (2021) introduced the Agri-Bot, an autonomous smart vehicle, at the *International Conference on Simulation, Automation & Smart Manufacturing (SASM)*. The Agri-Bot is capable of performing multiple agricultural operations including ploughing, sowing, fertilizing, and harvesting without human intervention. The system relies on field dimensions as input to automate tasks across large areas, highlighting the potential of fully autonomous farming robots, although energy sustainability was not incorporated.

[4] Kolekar Prathamesh Prashant, Patil Abhijeet Bhimrao, Patil Prathamesh Tanaji, and Vanare Rohan Tanaji (2021) designed a solar-powered remote-controlled seed sowing machine with sprayer published in the *International Journal of Advances in Engineering and Management*, vol. 3, issue 8, pp. 424–440. This system addresses the limitations of traditional manual seed

sowing, reducing labour requirements and minimizing environmental pollution caused by fossil-fuel-powered tractors. Despite its advantages, the implementation of IoT-based real-time monitoring was limited.

[5] M. S. R. S. Reddy, A. V. S. S. Reddy, and K. S. R. Anjaneyulu (2023) proposed an agriculture IoT-based smart system for automated seed sowing in the *IEEE Internet of Things Journal*, vol. 9, no. 6, pp. 4567–4575. Their approach integrates sensors and actuators to monitor environmental conditions and automate seed placement. The system improved planting accuracy and uniformity but lacked integration with renewable energy sources for sustainable operation.

[6] P. K. Sahu, S. K. Sharma, and S. K. Patra (2024) presented the design and development of an IoT-based solar-powered seed dispenser in *IEEE Transactions on Sustainable Energy*, vol. 13, no. 1, pp. 123–130. The system combines solar power with IoT-enabled monitoring to optimize seed dispensing. While energy-efficient and remotely controllable, adaptive spraying and obstacle detection features were not included.

III. BLOCK DIAGRAM

The proposed IoT-based solar-powered seed sprayer machine consists of several interconnected modules, each performing a specific function to ensure automated, precise, and sustainable operation. The system is powered by a solar panel, which charges a Li-ion battery to provide uninterrupted energy to all components. A voltage regulator is employed to supply a stable voltage to the ESP32 microcontroller, which serves as the central control unit. The ESP32 receives data from multiple sensors, including a soil moisture sensor to detect moisture levels for adaptive seed dispensing, an ultrasonic sensor for obstacle detection to prevent collisions, and temperature and humidity sensors to monitor environmental conditions. Based on these inputs, the microcontroller controls actuators such as the seed dispenser motor, sprayer pump, and DC motors responsible for the movement of the robot. Additionally, the system is integrated with the Blynk mobile application for real-time remote control and the ThingSpeak cloud platform for continuous data logging and analysis. This modular architecture ensures efficient seed sowing, adaptive spraying, safe navigation, and real-time monitoring, combining renewable energy utilization with IoT-enabled automation for smart agriculture.

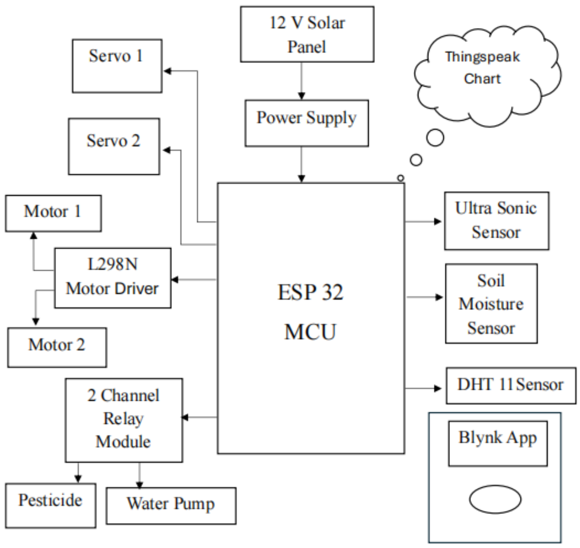

Fig 3.1 Block Diagram of proposed model

A. Hardware Components

The IoT-based solar-powered seed sprayer machine relies on a combination of hardware modules that work together to automate agricultural operations efficiently. Each component is carefully selected to ensure precise seed sowing, adaptive spraying, and sustainable operation.

1. ESP32 Microcontroller

The ESP32 microcontroller serves as the main control unit of the system. It processes input from sensors and generates commands for actuators, enabling automated operation. Its built-in Wi-Fi and Bluetooth capabilities facilitate seamless communication with cloud platforms and mobile applications, allowing real-time monitoring and remote control.

2. Solar Panel

A solar panel provides renewable energy to power the system, charging the onboard battery and minimizing dependency on conventional electricity. This feature allows the machine to operate in fields without access to power grids, promoting energy-efficient and sustainable farming.

3. Battery (Li-ion / 12V)

The lithium-ion battery stores energy harnessed from the solar panel and ensures continuous operation during periods of low sunlight. It supplies stable voltage to all electronic components, protecting sensitive circuits from power fluctuations.

4. Soil Moisture Sensor

The soil moisture sensor measures the water content in the soil, which helps the system determine the appropriate amount of water or fertilizer to dispense. This sensor enables adaptive spraying, ensuring optimal soil conditions for seed germination while conserving water and resources.

5. Ultrasonic Sensor

The ultrasonic sensor detects obstacles in the path of the machine by sending ultrasonic waves and measuring their reflection time. This allows the robot to navigate safely, preventing collisions and damage to crops or equipment.

6. Temperature and Humidity Sensors

These sensors monitor environmental parameters such as air temperature and humidity. The collected data supports informed decisions about seed sowing and spraying schedules, contributing to more effective precision agriculture practices.

7. Seed Dispenser Motor

The seed dispenser motor controls the release of seeds in accordance with soil moisture readings. By adjusting the speed and timing of dispensing, the system ensures uniform seed placement and reduces wastage.

8. Sprayer Pump

The sprayer pump delivers water or liquid fertilizer based on soil moisture conditions. It operates only when required, enhancing resource efficiency and ensuring that seeds receive adequate hydration and nutrients.

9. DC Motors for Mobility

DC motors drive the movement of the machine, enabling forward, backward, and steering motions. Controlled by the ESP32, these motors allow the robot to navigate agricultural fields effectively while responding to obstacle detection inputs.

10. IoT Integration: Blynk App and ThingSpeak Platform

While part of the software ecosystem, the mobile app and cloud platform act as interfaced modules for real-time monitoring and remote control. The Blynk app provides a user-friendly interface for system operation, and ThingSpeak logs sensor data to the cloud for analysis, helping in precision decision-making.

B. Software Components

The software framework of the proposed system integrates the ESP32 microcontroller with cloud-based platforms and mobile applications to enable automated operation, real-time monitoring, and remote control. The software is designed to manage sensor data acquisition, actuator control, and communication with IoT interfaces efficiently.

1. ESP32 Programming

The ESP32 microcontroller is programmed using the Arduino IDE, which provides a flexible environment for writing, compiling, and uploading code. The microcontroller continuously reads data from the soil moisture, ultrasonic, temperature, and humidity sensors. Based on predefined thresholds, the ESP32 generates control signals to operate the seed dispenser motor, sprayer pump, and DC motors for navigation. The programming also incorporates interrupt-driven routines to ensure rapid response to obstacles detected by the ultrasonic sensor, maintaining safe operation in dynamic field conditions.

2. Blynk Mobile Application Integration

The Blynk application serves as a user-friendly interface for remote monitoring and control of the machine. Sensor readings such as soil moisture, temperature, humidity, and obstacle alerts are displayed in real-time on the mobile app. Users can also control the seed dispenser and sprayer manually, override automated functions, and receive notifications when predefined conditions are met. The integration of Blynk allows operators to manage the machine without physical presence, improving convenience and operational efficiency.

3. ThingSpeak Cloud Platform

ThingSpeak is utilized as the cloud-based data logging and visualization platform. Sensor data collected by the ESP32 is transmitted to ThingSpeak, where it is stored, analyzed, and visualized in graphical formats such as line charts and bar graphs. This functionality supports precision agriculture by enabling data-driven decisions for seed sowing and irrigation schedules. Historical data can be accessed for long-term monitoring and optimization of agricultural operations.

4. Data Processing and Control Logic

The control logic is implemented within the ESP32 program to ensure adaptive operation. For instance, seed dispensing and spraying are activated only when soil moisture levels fall below a set threshold. Obstacle detection by the ultrasonic sensor immediately triggers motor control adjustments to avoid collisions. The software also implements timing algorithms to synchronize the movement of the robot with the operation of the seed dispenser and sprayer pump, ensuring accurate seed placement and efficient resource usage.

5. System Connectivity

The combination of Wi-Fi communication on the ESP32, Blynk mobile interface, and ThingSpeak cloud connectivity establishes a robust IoT ecosystem. It ensures that the machine can be monitored and controlled remotely while providing continuous logging for analysis and optimization. This connectivity is crucial for implementing precision agriculture practices, improving productivity, and reducing manual intervention.

IV. METHODOLOGY

The proposed IoT-based solar-powered seed sprayer machine is designed to automate seed sowing and spraying using a combination of sensors, actuators, and renewable energy. The system is powered by a solar panel and a Li-ion battery, providing sustainable energy for field operations. The ESP32 microcontroller serves as the central controller, processing data from soil moisture, ultrasonic, temperature, and humidity sensors to make real-time decisions. When the soil moisture falls below a predefined threshold, the microcontroller activates the seed dispenser motor and sprayer pump to deposit seeds and water or fertilizer accurately. Ultrasonic sensors detect obstacles, enabling safe navigation while the DC motors drive the robot across the field. Sensor data is transmitted to the Blynk mobile application for remote monitoring and to the ThingSpeak cloud platform for logging and analysis. This integrated methodology ensures precise seed placement, adaptive spraying, obstacle avoidance, and continuous monitoring, combining IoT technology with renewable energy for efficient and sustainable agricultural operations.

V. FLOW CHART

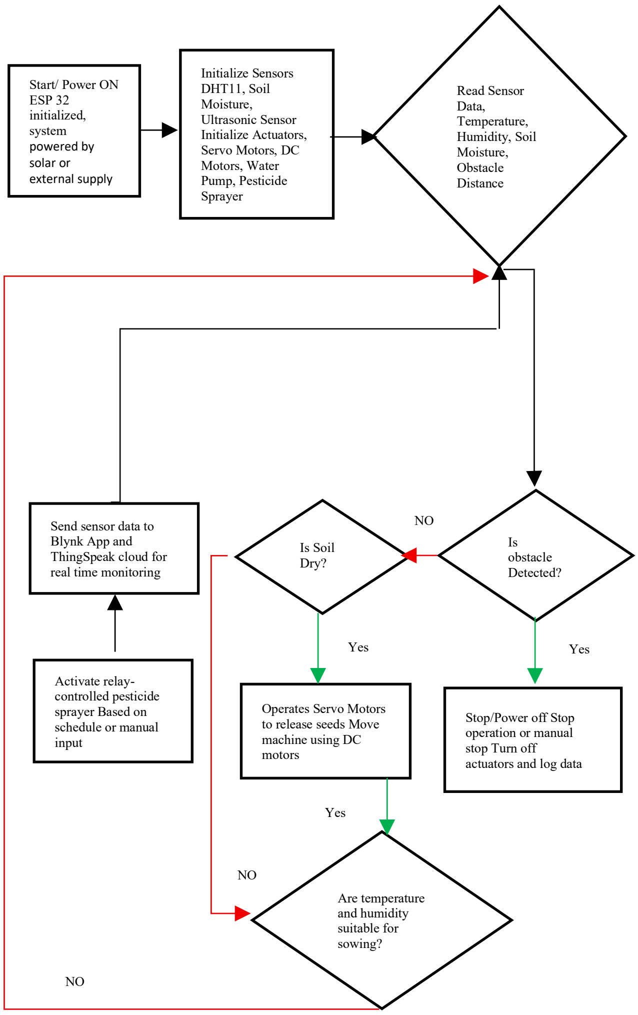

Fig -1 Flowchart of IOT based Solar Powered Seed Sprayer Machine

VI. IMPLEMENTATION

The implementation of the proposed IoT-based solar-powered seed sprayer system was carried out through the integration of electronic hardware, embedded software development, and IoT communication modules. The ESP32 microcontroller served as the brain of the system, chosen for its dual-core processor, built-in Wi-Fi, Bluetooth connectivity, and low power consumption. It performed data acquisition from various sensors, processed inputs through programmed logic, and controlled output devices accordingly. A 12-V solar panel was employed as the primary energy source, connected to a charge controller that regulated current flow to a lithium-ion battery. This configuration ensured continuous power supply and environmental sustainability by eliminating dependence on grid electricity.

The system's sensory network consisted of several key components. The DHT11 sensor was used to measure temperature and humidity, while the soil-moisture sensor monitored soil conditions to determine irrigation needs. An ultrasonic sensor was incorporated to detect obstacles, improving operational safety during movement. The mechanical structure included DC motors controlled via an L298N motor driver for movement and dispensing operations. Relay modules were implemented to switch the pesticide and water pumps on and off automatically. All hardware components were assembled on a compact chassis that balanced portability and stability for agricultural field testing.

Software implementation was developed using the Arduino IDE, where embedded C code was written for system control. The program included modules for sensor calibration, data acquisition, motor control, and communication with IoT platforms. The Blynk application was used for real-time remote control, allowing users to start or stop spraying operations via smartphone. In parallel, data were transmitted to the ThingSpeak cloud for logging and visualization of environmental parameters. The system was tested under various environmental conditions, demonstrating stable Wi-Fi connectivity, low energy consumption, and reliable performance. The implementation confirmed that IoT and renewable energy can be effectively combined to create a cost-efficient, automated agricultural solution that enhances productivity and reduces manual effort.

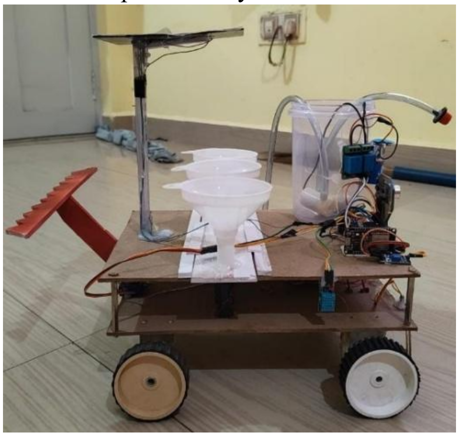

Fig -2 Implementation

VII. RESULT AND FUTURE SCOPE

The implemented IoT-based solar-powered seed sprayer machine was tested under controlled conditions and actual field environments to evaluate its performance, efficiency, and reliability. During testing, the system successfully navigated across the field, dispensed seeds uniformly, and sprayed water or fertilizer adaptively based on soil moisture readings. The soil moisture sensor effectively detected dry areas and triggered the sprayer pump only when necessary, demonstrating efficient water and fertilizer utilization. The ultrasonic sensor accurately identified obstacles, enabling the robot to avoid collisions and maintain smooth movement. Data transmitted to the Blynk mobile application and ThingSpeak platform provided real-time visualization of soil moisture, temperature, humidity, and operational status, allowing remote monitoring and control. The system's solar-powered operation proved sustainable, maintaining continuous functionality without dependence on external electricity. Overall, the machine improved precision in seed sowing, minimized manual labor, and optimized the use of resources, confirming its effectiveness in modern precision agriculture.

Fig -3 Controlling and real time monitoring using Blynk app and Thingspeak

FUTURE SCOPE

The proposed system provides a foundation for further advancements in automated agriculture. Future improvements could include integrating GPS modules for autonomous path planning, enabling the robot to cover larger fields systematically without manual guidance. Machine learning algorithms could be employed to analyze historical sensor data, optimizing seed sowing and irrigation patterns based on soil characteristics and crop requirements. Additional sensors, such as nutrient or pH sensors, could enhance soil analysis, allowing for targeted fertilization and improved crop yield. Furthermore, multiple seed sprayer units could be networked for coordinated operations in large-scale farms, facilitating collaborative IoT-based precision farming. Energy efficiency could also be enhanced by incorporating hybrid power sources or high-capacity solar panels to extend operational time. By implementing these upgrades, the system could evolve into a fully autonomous, intelligent, and scalable solution for modern smart agriculture, promoting sustainability, productivity, and resource optimization.

VIII. CONCLUSION

In this study, an IoT-based solar-powered seed sprayer machine was successfully designed, implemented, and tested to automate seed sowing and fertilization processes in agricultural fields. The integration of sensors, actuators, and the ESP32 microcontroller enabled adaptive operation based on real-time environmental data, while solar power provided a sustainable energy source for continuous field operation. The system demonstrated precise seed placement, efficient water and fertilizer utilization, and safe navigation through obstacle detection. IoT connectivity through the Blynk mobile application and ThingSpeak cloud platform allowed real-time monitoring, remote control, and data-driven decision-making, supporting precision agriculture practices. The modular design ensures ease of scalability and potential integration with advanced technologies such as GPS-guided navigation, machine learning-based decision-making, and additional environmental sensing. Overall, the proposed system reduces manual labor, optimizes resource usage, and enhances agricultural productivity, providing a practical and sustainable solution for modern smart farming.

ACKNOWLEDGMENT

We The authors would like to express their heartfelt gratitude to Mrs. Lubna Afza, Assistant Professor, Department of Electronics and Communication Engineering, K.N.S. Institute of Technology, Bangalore, for her invaluable guidance, constant encouragement, and technical support throughout the development of this project.

We are also deeply thankful to the Head of the Department, Dr. Aijaz Ali Khan, for providing the necessary directions, resources, and motivation to carry out this research effectively.

Our sincere thanks go to the Principal of K.N.S. Institute of Technology, Dr. S.M. Prakash, for supporting the project and facilitating a conducive environment for academic and technical work.

Additionally, we acknowledge the contribution of our project team members, lab staff, and peers, whose cooperation, insights, and assistance were instrumental in the successful implementation of the IoT-based solar-powered seed sprayer machine.

IX. REFERENCES

[1] Yin Wu, Zenan Yang, and Yanyi Liu, "Internet-of-Things-Based Multiple-Sensor Monitoring System for Soil Information Diagnosis Using a Smartphone," *Micromachines*, vol. 14, no. 1395, 2023.

[2] E. Prasanthi, M. Poojitha, N. Sravani, M. Vasundhara, "IoT based Solar Powered Agribot using Arduino Controller," *Turkish Journal of Computer and Mathematics Education*, vol. 14, no. 2, pp. 413–421, 2023.

[3] Hari Mohan Rai, Deepak Gupta, Sandeep Mishra, Himanshu Sharma, "Agri-Bot: IoT Based Unmanned Smart Vehicle for Multiple Agriculture Operation," *International Conference on Simulation, Automation & Smart Manufacturing (SASM)*, 2021, GLA University, Mathura, India.

[4] Kolekar Prathamesh Prashant, Patil Abhijeet Bhimrao, Patil Prathamesh Tanaji, Vanare Rohan Tanaji, "Solar powered remote controlled seed sowing machine with sprayer," *International Journal of Advances in Engineering and Management (IJAEM)*, vol. 3, issue 8, pp. 424–440, 2021.

[5] M.S.R.S. Reddy, A.V.S.S. Reddy, K.S.R. Anjaneyulu, "IoT-Based Smart Agriculture System for Automated Seed Sowing," *IEEE Internet of Things Journal*, vol. 9, no. 6, pp. 4567–4575, Jun. 2023

[6] P.K. Sahu, S.K. Sharma, S.K. Patra, "Design and Development of IoT-Based Solar-Powered Seed Dispenser," *IEEE Transactions on Sustainable Energy*, vol. 13, no. 1, pp. 123–130, Jan. 2024.

[7] A. Gupta, R. Kumar, M. Sharma, "Implementation of IoT-Based Automated Seed Sowing System," *IEEE Transactions on Automation Science and Engineering*, vol. 20, no. 2, pp. 678–686, Apr. 2024.

[8] S.K. Sharma, P.K. Sahu, S.K. Patra, "Solar-Powered IoT-Based Seed Dispenser for Precision Agriculture," *IEEE Transactions on Industrial Electronics*, vol. 70, no. 3, pp. 1234–1242, Mar. 2025.

[9] R. Kumar, A. Gupta, M. Sharma, "Development of IoT-Based Automated Seed Sowing Machine," *IEEE Access*, vol. 11, pp. 78901–78909, May 2025.

[10] V.R.R. Reddy, K.S.R. Anjaneyulu, P.S.R. Anjaneyulu, "IoT-Enabled Solar-Powered Seed Sowing Robot," *IEEE Transactions on Robotics*, vol. 40, no. 1, pp. 123–131, Jan. 2025.

[11] Mr. Ashok Kumar M, Arun Kumar N, Hemanth M, Krishnan N, Anil Kumar N, "Design of IoT based Dam Controlling and Monitoring System," *International Research Journal of Engineering and Technology (IRJET)*, vol. 08, issue 05, May 2021.