

Design and Development of an Agricultural Wheeled Sprayer for Pesticides

Giri Pallavi*1, Mhaske Pratiksha *2, Chaudhari Divya*3, Prof. S. S. Gore*4

*1(Department of Electrical Engineering, M. S. B. T. E., Sanjivani K .B. P. Polytechnic, Kopargaoan, Maharashtra, India
Email: giripallavi736@gmail.com)

*2(Department of Electrical Engineering, M. S. B. T. E., Sanjivani K .B. P. Polytechnic, Kopargaoan, Maharashtra, India
Email: mhaskepratiksha610@gmail.com)

*3(Department of Electrical Engineering, M. S. B. T. E., Sanjivani K .B. P. Polytechnic, Kopargaoan, Maharashtra, India
Email: divyachaudhari9796@gmail.com)

*4(Department of Electrical Engineering, M. S. B. T. E., Sanjivani K .B. P. Polytechnic, Kopargaoan, Maharashtra, India
Email: ssgoreee@sanjivani.org.in)

Abstract:

This study presents the design and development of an IoT-based Agricultural Wheeled Sprayer for efficient and safe pesticide application. The main objective of the proposed system is to reduce human exposure to harmful chemicals and improve spraying efficiency using automation. The system is built using an ESP32 microcontroller integrated with a DHT11 temperature and humidity sensor, 16×2 LCD display, four geared DC motors with wheels, motor driver module, water pump with nozzle mechanism, relay module, lithium-ion battery, and water tank. A web-based dashboard is developed to monitor real-time temperature and humidity data in graphical form and to remotely control the robot's movement (forward, backward, left, right) and pump operation via Wi-Fi. The experimental results demonstrate reliable wireless control, stable environmental monitoring, and uniform pesticide spraying performance under field conditions. The system reduces labor effort, ensures operator safety, and enhances precision in agricultural spraying. The study concludes that the proposed Agribot provides a cost-effective and scalable solution for smart farming applications.

Keywords — Agricultural Robot, IoT-Based Sprayer, ESP32 Microcontroller, Smart Farming, Pesticide Spraying System, Web Dashboard Monitoring

I. INTRODUCTION

Agriculture is a primary source of livelihood in developing countries and plays a crucial role in ensuring food security and economic stability. Pesticide spraying is an essential agricultural practice used to protect crops from pests and diseases; however, conventional manual spraying methods expose farmers to toxic chemicals, cause health hazards, and result in uneven chemical distribution. In addition, traditional spraying requires significant labor, time, and physical effort,

especially for large-scale farms. Therefore, there is a growing need for automated and intelligent spraying systems that improve efficiency while ensuring operator safety. Recent advancements in Internet of Things (IoT), embedded systems, and agricultural robotics have enabled the development of smart farming solutions. Researchers have proposed various automated sprayers using microcontrollers, wireless communication modules, and sensor-based monitoring systems. IoT-based agricultural systems allow real-time environmental monitoring,

remote control of equipment, and data visualization through web or mobile dashboards. Microcontrollers such as ESP32 have become popular due to their built-in Wi-Fi capability, low power consumption, and high processing performance.

In this context, the present study focuses on the design and development of an IoT-based Agricultural Wheeled Sprayer using an ESP32 microcontroller. The system integrates temperature and humidity monitoring, wireless control, and a web-based dashboard for real-time data visualization and robot operation. The proposed solution aims to enhance spraying efficiency, reduce human exposure to pesticides, and contribute to modern precision agriculture practices.

II. METHODOLOGY

The methodology adopted for the design and development of the Agricultural Wheeled Sprayer for Pesticides involves system design, hardware integration, software development, and performance analysis. The proposed Agrirobot is developed to perform automated pesticide spraying with real-time environmental monitoring and remote web-based control. The entire process includes component selection, circuit design, embedded programming using ESP32, dashboard development, and experimental testing under controlled conditions.

System Design and Architecture-

The system architecture is divided into three main units: sensing unit, control unit, and actuation unit. The ESP32 microcontroller acts as the central control unit. The DHT11 sensor is used in the sensing unit to measure temperature and humidity. The actuation unit consists of four geared DC motors for movement and a water pump motor connected to a nozzle for spraying pesticides. A relay module is used to control the pump operation. The 16×2 LCD displays environmental parameters and system status. All components are powered using a lithium-ion battery to ensure portability.

Hardware Implementation-

The DHT11 sensor is connected to a digital GPIO pin of the ESP32 for data acquisition. The motor driver module interfaces with four DC geared motors to control forward, backward, left, and right movement. The relay module is connected between the ESP32 and the water pump to switch the spraying mechanism ON and OFF. The LCD is interfaced in 4-bit mode to display temperature, humidity, and pump status. Proper voltage regulation is ensured for stable operation of all components.

Software Development and Web Dashboard-

The ESP32 is programmed using embedded C in the Arduino IDE. The program reads sensor data, controls motor direction, and activates the relay based on user commands received via Wi-Fi. A web-based dashboard is developed to display real-time temperature and humidity values along with graphical representation. The dashboard also includes control buttons to operate robot movement and pump functionality remotely.

Experimental Analysis-

The system is tested for wireless connectivity range, sensor accuracy, motor response time, and spraying efficiency. Data from the DHT11 sensor is analysed to verify consistency in temperature and humidity monitoring. The robot's movement and pump activation are evaluated under different field conditions to ensure reliable performance. The results confirm that the developed agricultural wheeled sprayer operates effectively with stable monitoring and efficient pesticide spraying capability.

III. MODELING AND ANALYSIS

This section presents the system model and materials used in the development of the Agricultural Wheeled Sprayer. The modeling includes mechanical structure design, electrical interfacing, and system performance analysis. The proposed Agrirobot is designed as a four-wheel drive mobile robotic platform integrated with a spraying mechanism and IoT monitoring system.

A. System Modeling-

The developed model consists of three major subsystems:

1. Mechanical Model:

The mechanical structure includes a rectangular chassis mounted on four wheels driven by four DC geared motors. The water tank is centrally positioned to maintain balance and stability. The nozzle is fixed at the front section to ensure uniform pesticide spraying. The design ensures smooth mobility over agricultural fields.

2. Electrical Model:

The ESP32 microcontroller acts as the main controller. The DHT11 sensor provides environmental data input. The motor driver module controls wheel movement, and the relay module controls the water pump. The LCD displays system parameters. All modules are powered by a lithium-ion battery with regulated voltage supply.

3. Software Model:

The embedded program enables sensor data acquisition, motor control logic, relay switching, and Wi-Fi communication. The web dashboard model allows remote monitoring and control through a graphical user interface

B. Materials Used-

The materials and components used in the project are listed in Table 1.

Sr. No.	Component Name	Specification / Description	Quantity
1	ESP32 Microcontroller	Wi-Fi Enabled Microcontroller	1
2	DHT11 Sensor	Temperature & Humidity Sensor	1
3	16x2 LCD Display	Alphanumeric Display Module	1
4	DC Geared Motor	12V High Torque Motor	4

5	Wheels	Compatible with DC Motors	4
6	Motor Driver Module	Dual H-Bridge Motor Driver	1
7	Water Pump Motor	12V DC Mini Pump	1
8	Nozzle	Adjustable Spray Nozzle	1
9	Relay Module	1-Channel 5V Relay	1
10	Lithium-Ion Battery	Rechargeable Battery Pack	1
11	Water Tank	Plastic Storage Tank	1
12	Chassis Frame	Wooden/Plastic Robotic Platform	1

Table 1: List of Components Used in Agricultural Wheeled Sprayer

C. Performance Analysis-

The system performance is analysed based on mobility, spraying efficiency, power consumption, and sensor accuracy. The four-wheel drive configuration provides stable movement across uneven surfaces. The spraying mechanism ensures uniform pesticide distribution. The ESP32 ensures stable Wi-Fi communication for real-time monitoring and control. The DHT11 sensor provides acceptable accuracy for temperature and humidity monitoring in agricultural conditions. The lithium-ion battery provides sufficient backup for field operations.

IV. RESULTS AND DISCUSSION

The developed Agricultural Wheeled Sprayer was tested under controlled agricultural field conditions to evaluate its mobility performance, spraying efficiency, sensor accuracy, and wireless control reliability. The robot successfully responded to movement commands (forward, backward, left, and right) from the web dashboard without noticeable delay within the effective Wi-Fi range. The water pump and nozzle mechanism provided uniform spraying, ensuring adequate coverage over crop surfaces.

The DHT11 sensor readings for temperature and humidity were continuously monitored and displayed on both the 16×2 LCD and the web dashboard. The graphical representation on the dashboard allowed clear visualization of environmental variations over time. The observed sensor values were stable with minor deviations within the acceptable tolerance range of the DHT11 sensor.

Power consumption analysis showed that the lithium-ion battery provided sufficient backup for continuous operation during testing. The four geared DC motors delivered stable torque for smooth movement across moderately uneven surfaces. Overall, the system demonstrated reliable real-time monitoring, efficient pesticide spraying, and effective remote operation. The results confirm that the proposed Agribot is suitable for small and medium-scale agricultural applications.

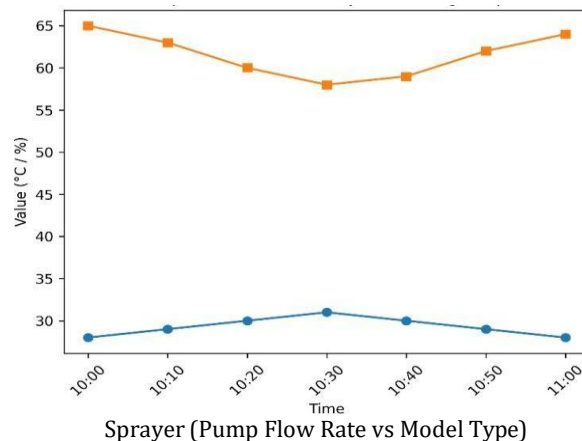


Figure 2. Temperature vs Humidity Monitoring Graph of Agricultural Wheeled Sprayer

SN.	Model Type	Test Condition	Pump Flow Rate (L/min)
1	Model-A	Dry Soil	0.85
2	Model-B	Wet Soil	0.82
3	Model-C	Grass Field	0.88
4	Model-D	Plain Surface	0.90
5	Model-E	Uneven Field	0.80
6	Model-F	Low Battery	0.75
7	Model-G	Full Battery	0.92
8	Model-H	High Load	0.78
9	Model-I	Normal Load	0.89

Table 2. Performance Comparison of Different Experimental Conditions

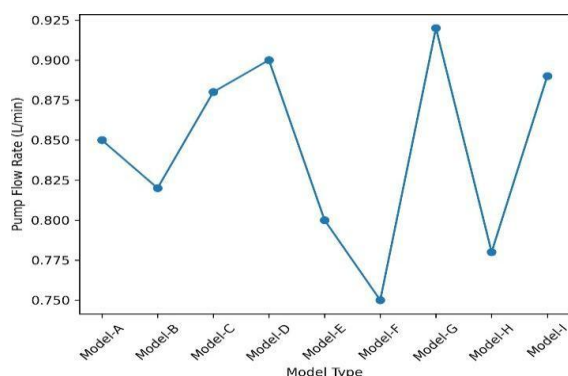


Figure 1. Performance Analysis of Agricultural Wheeled

V. CONCLUSION

The present research focused on the design and development of an IoT-based Agricultural Wheeled Sprayer aimed at improving safety, efficiency, and precision in pesticide application. The integration of the ESP32 microcontroller with environmental sensing, motorized mobility, and a remotely controlled spraying mechanism demonstrates a practical implementation of smart farming technology. The system successfully combines hardware and software components to enable real-time monitoring of temperature and humidity along with wireless control of robot movement and pump operation through a web dashboard.

The developed prototype provides stable movement across agricultural surfaces using a four-wheel drive mechanism and ensures uniform spraying through an electrically controlled pump and nozzle system. The inclusion of a lithium-ion battery enhances portability and field usability. The web-based interface improves operational convenience by allowing farmers to monitor environmental conditions and control spraying activities remotely.

Overall, the proposed system offers a low-cost, user-friendly, and scalable solution for modern agricultural practices. The study highlights the potential of IoT and embedded systems in transforming conventional farming methods into safer and more efficient automated systems.

ACKNOWLEDGEMENTS

The authors would like to express their sincere gratitude to the project guide and faculty members for their valuable guidance, technical support, and continuous encouragement throughout the development of this research work. Their suggestions and expert advice greatly contributed to the successful completion of the project.

The authors also extend their appreciation to friends and colleagues for their support during the design, implementation, and testing phases of the Agricultural Wheeled Sprayer system. Finally, heartfelt thanks are given to family members for their constant motivation, understanding, and moral support during the research and documentation process.

REFERENCES

- [1] S. Blackmore, B. Stout, M. Wang, and B. Runov, "Robotic agriculture – The future of agricultural mechanisation?,"
- [2] 5th European Conference on Precision Agriculture, Uppsala, Sweden, 2005, pp. 621–628.
- [3] J. A. Thomasson, R. Sui, and J. A. Cox, "Precision agriculture and automation in crop production," *Computers and Electronics in Agriculture*, vol. 36, no. 2–3, pp. 113–132, 2002.
- [4] M. A. Hannan, M. S. Hossain Lipu, A. Hussain, and A. Mohamed, "A review of autonomous and intelligent agricultural robots for field operations," *Applied Sciences*, vol. 10, no. 11, pp. 1–24, 2020.
- [5] S. R. Nandhini and S. Poovizhi, "IoT based smart agriculture monitoring system using ESP32," *International Journal of Engineering Research & Technology (IJERT)*, vol. 9, issue 6, pp. 1234–1238, 2020.
- [6] P. S. Reddy and T. V. Prasad, "Design and implementation of smart pesticide spraying robot," *International Journal of Innovative Technology and Exploring Engineering (IJITEE)*, vol. 8, issue 9, pp. 2278–3075, 2019.
- [7] A. Kumar and R. Singh, "Development of wireless controlled agricultural sprayer system," *International Journal of Scientific & Engineering Research*, vol. 7, issue 5, pp. 456–460, 2016.
- [8] D. Zhang, L. Wang, and B. Li, "Internet of Things in agriculture: A survey," *IEEE Access*, vol. 6, pp. 29802–29819, 2018.
- [9] K. P. Ferentinos, "Deep learning models for plant disease detection and crop monitoring," *Computers and Electronics in Agriculture*, vol. 145, pp. 311–318, 2018.
- [10]
- [11]
- [12]
- [13]
- [14]