

# AGRI-BOT: Irrigation Control Based on Water Quality Monitoring and Pest Detection with Automated Pesticide Sprayer

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**Abstract**— Inefficient irrigation and manual pest control in agriculture lead to water wastage, crop losses, and increased costs for farmers. This study presents the design, development, and evaluation of AGRI-BOT, a Raspberry Pi-based system for irrigation control based on water quality monitoring and pest detection with an automated pesticide sprayer. Sensors monitor water parameters like flow meter and turbidity while a camera enables real-time pest identification, with the Raspberry Pi processing data to activate pumps and sprayers autonomously. Evaluation results from field tests and expert reviews yielded an overall mean score of 4.31, interpreted as Acceptable, with strong performance in automation accuracy and cost-effectiveness. Findings indicate that AGRI-BOT significantly improves resource utilization and crop protection for sustainable farming.

**Keywords**— Water Quality Monitoring, Integrated Sensor Network, Eco-friendly farming, Turbidity, Flow Meter.

## I. INTRODUCTION

Agriculture, a pivotal sector of the global economy, confronts various challenges in contemporary times. Due to population growth, climate variability, resource scarcity, and the need for sustainable agriculture, food demand is rising. Traditional agricultural practices employ manual labor and indiscriminate irrigation and pesticide usage, resulting in poor resource allocation, environmental damage, and lower crop output. The use of advanced agricultural technologies has become essential for productivity, sustainability, and environmental protection. Intelligent agricultural systems that use automation, AI, and sensors to improve farming are a major invention. Precision irrigation and pest control are crucial to these systems.

To address these challenges in modern agriculture, this study proposes AGRI-BOT: Irrigation Control Based on Water Quality Monitoring and Pest Detection with Automated Pesticide Sprayer, powered by Raspberry Pi. The system is designed for water quality monitoring pest management by integrating sensors for real-time water quality analysis (water flow, turbidity) and computer vision for pest identification, eliminating manual monitoring and overuse of resources.

The proposed AGRI-BOT system supports Android, iOS, and Windows platforms, enabling farmers, agronomists, and farm managers to access real-time agricultural monitoring through dedicated mobile and desktop applications. Once connected, users receive live updates on water quality metrics, pest detection alerts, and irrigation status directly on their devices. On the operational side, farm supervisors gain a centralized website app to oversee the kinds of pests detected and spraying status.

The system, powered by Raspberry Pi, enhances overall farm efficiency by minimizing manual monitoring and optimizing resource utilization through automated irrigation and targeted pest control. Real-time data from water quality

sensors and pest detection cameras allows farmers to plan interventions effectively, while supervisors benefit from streamlined oversight and precise resource allocation. Furthermore, the system prioritizes usability and accessibility via an intuitive website app compatible with Android, iOS, and Windows devices, accommodating users with diverse technical skills.

## II. SYSTEM DESIGN AND METHODOLOGY

### A. Development Framework

To ensure wide accessibility of this system, the hardware used for water quality monitoring, pest detection and spraying and software mobile application is designed for iOS, Android and Windows. This framework was made by Python and uses computer vision-based pest identification.

### B. Conceptual Framework

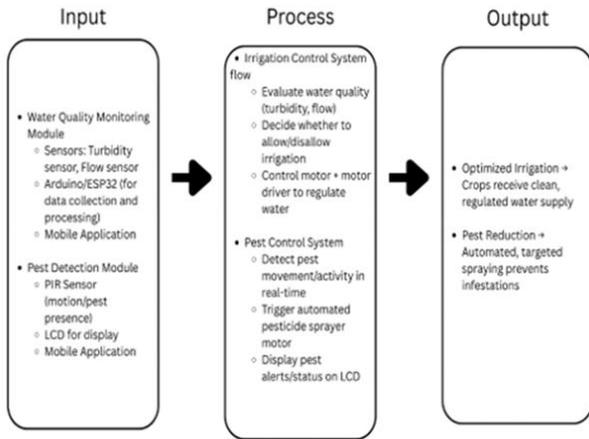
The study adopts the Input-Process-Output (IPO) model to provide a structured approach to the development of the system. This framework ensures that all user requirements are systematically converted into functional system features

1) *Input*: The Input phase captures real-time environmental data through water quality monitoring sensors (pH, turbidity, flow via turbidity sensors) and processing for irrigation decisions, alongside a mobile application module for water monitoring and web app for pest detection. The pest detection module uses webcam and Raspberry Pi for image recognition of insects on crops.

2) *Process*: The process phase involves the actual hardware and software. First in hardware it consists two prototypes the water quality monitoring is to evaluate the (water flow, turbidity) while the second hardware is used for pest detection and sprayer. For software it has a web app that can see the real-time status of data of water monitoring and pest identification.

3) *Output*: The Output module of the system delivers optimized irrigation and crop water supply, ensuring precise delivery

based on real-time water quality data to promote healthy growth and conserve resources. It also provides pest reduction through targeted, automated pesticide spraying, minimizing chemical overuse while displaying the I.P address on LCD for immediate operator awareness. These outcomes enhance farm efficiency and to reduce waste.



### C. Core Features and User Interface

The system integrates real-time monitoring on water quality and it see the status of turbidity and water flow while on the web app for pest the kinds of pests be identified and trained by machine learning (YOLO) and shows the status of the sprayer once it is trigger.

### D. Testing and Security

The implementation follows a phased testing protocol, beginning with initial prototyping followed by beta testing to incorporate beneficiary feedback. Furthermore, data privacy and security are prioritized through the implementation of end-to-end encryption and secure payment gateways throughout the application architecture.

### E. Evaluation Instrument

The primary instrument used for data collection was a highly structured evaluation survey based on the ISO/IEC 25010 Software Quality Model. This international standard was selected to ensure a multidimensional assessment of the system's performance and reliability.

1) *Survey Structure*: The instrument was divided into five key domains: Functional Suitability, Performance Efficiency, Usability, Reliability, and Maintainability. Each domain contained specific criteria that respondents rated based on their direct interaction with the mobile application.

2) *Scaling and Quantification*: To quantify the qualitative feedback from students, administrative staff, and IT experts, a five-point Likert Scale was employed. This allowed for the calculation of the weighted mean, which served as the basis for the final system assessment. The scale and its corresponding verbal interpretations are detailed in Table I.

3) *Instrument Validation*: Before the formal conduct of the study, the instruments underwent a validation process by a panel of three IT and agricultural technology experts. This ensured that the sensors for water quality monitoring

(flowmeter and turbidity), pest detection, and automated pesticide sprayer components were technically sound, calibrated accurately, and aligned with the objectives of the system for irrigation control and pest management.

TABLE I. Likert Scale and Verbal Interpretation

Scale	Range	Verbal Interpretation
5	4.51 – 5.00	Highly Acceptable
4	3.51 – 4.50	Acceptable
3	2.51 – 3.50	Moderately Acceptable
2	1.51 – 2.50	Slightly Acceptable
1	1.00 – 1.50	Not Acceptable

### G. System Requirement

The successful implementation and operation of the queuing system depend on specific hardware and software configurations. These requirements ensure that the real-time synchronization between the student's mobile device and the administrative dashboard remains stable.

Category	Specification / Requirement
Mobile Operating System	Android and iOS
Desktop Operating System	Windows 10 or 11
Programming Language	Python
Development Framework	UI, Raspberry Pi 4
IDE / Code Editor	Visual Studio Code / MIT Inventor App

1) *Hardware Requirements*: The system architecture involves two primary hardware interfaces: the water monitoring and the pest detection with pesticide sprayer.

Mobile Device: To ensure compatibility with the hybrid framework, the device must have at least 8GB of RAM and an active internet connection (LTE/5G or Wi-Fi).

- **Administrative Workstation**: A computer with at least an Intel Core i3 processor (or equivalent) and 8GB of RAM is required to manage the pest identification and pump status
- **Network**: A stable local area network or cloud-based server connection for real-time updates.

2) *Software Requirements*: The software stack was chosen based on its ability to support cross-platform deployment and low-latency data handling.

- **Operating System**: The mobile application is compatible with Android and iOS
- **Development Framework**: Python programming language was used to deployed the codes.
- **Development Environment**: Visual Studio Code, MIT Inventor App, Raspberry Pi OS and Arduino served as the primary Integrated Development Environments (IDEs).

## III. RESULTS AND DISCUSSION

This section presents the data gathered during the testing phases and evaluates the system's performance based on the established metrics.

### A. System Evaluation

The system underwent rigorous evaluation by farmers. The assessment focused on key ISO/IEC 25010 quality characteristics, including Functionality, Usability, and Maintainability.

### B. Data Analysis

The overall mean score for the system was 4.31, which translates to an interpretation of "Acceptable". High ratings were specifically noted in:

- **Functionality:** Respondents indicated that the real-time monitoring and status of the water quality and pest identification.
- **Maintainability:** Software employs containerized Python microservices via Docker on Raspberry Pi OS, enabling OTA updates for AI models and ROS2 navigation without full redeployment, alongside comprehensive logging for diagnostics.

To determine the overall acceptability of the Mobile-Based Queueing System, the weighted mean was utilized. The calculation is based on the following formula:

$$\bar{x} = \frac{\sum fx}{N}$$

Where:

$\bar{x}$  = Weighted Mean

$f$  = Frequency of responses

$x$  = Weight assigned to each response based on the Likert scale

$N$  = Total number of respondents

The results of the evaluation based on the ISO/IEC 25010 quality standards are summarized in Table II

TABLE II. Overall System Evaluation Summary

Criteria	Weighted Mean	Interpretation
Functionality	4.40	Very Acceptable
Efficiency	4.07	Very Acceptable
Usability	4.50	Highly Acceptable
Reliability	4.35	Very Acceptable
Maintainability	4.40	Very Acceptable
Portability	4.10	Very Acceptable
Safety	4.40	Very Acceptable
<b>General Weighted Mean</b>	<b>4.31</b>	<b>Very Acceptable</b>

As indicated in Table II, the "Agri-Bot System" achieved an overall mean score of 4.31, which is interpreted as Acceptable. This statistical result confirms that the hardware and software application successfully meet the requirements for farming process

### C. Project Description

The system enhances crop management through precise irrigation and pest control. It monitors water quality parameters like flow rate and turbidity to optimize water usage, preventing over-irrigation and wastage via flow meters and turbidity sensors. The pest detection module uses image processing to identify insects, triggering targeted pesticide spraying to minimize chemical use and environmental impact. The mobile

website application was designed for the farmers to have the access on it.

## IV. CONCLUSION

The results of the study lead to the conclusion that AGRI-BOT: Irrigation Control Based on Water Quality Monitoring and Pest Detection with Automated Pesticide Sprayer is an effective and practical tool for modernizing farm operations. By continuously sensing key water quality parameters and automatically regulating irrigation, the system helps ensure that crops receive sufficient water at the right time while minimizing wastage and dependence on manual supervision. This capability supports more consistent growing conditions, reduces labor requirements, and contributes to more efficient use of important farm inputs such as water, electricity, and manpower, making day-to-day field management easier for farmers.

## V. RECOMMENDATIONS AND FUTURE WORK

To further enhance the capabilities of the current system and reach the highest level of hardware/software quality ("Highly Acceptable"), the following recommendations are proposed:

- Integrate soil moisture and nutrient sensors to create a holistic precision agriculture system, enabling crop-specific irrigation adjustments for diverse Philippine field crops like rice and vegetables.
- Deploy edge-cloud hybrid AI with federated learning, allowing continuous pest detection model improvement from farmer-contributed images while maintaining data privacy.
- Add autonomous navigation with RTK-GPS and obstacle avoidance, expanding AGRI-BOT from stationary spraying to full field patrolling across small-medium farm areas

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