A Real-Time Monitoring Solution for Water and Electricity Usage in Agriculture

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Abstract. The rising demand for sustainable resource use in agriculture has resulted in a drive to find innovative answers for real-time monitoring and resourceful use of water and electricity. This project develops an overarching tracking application on the concerns of water and electricity, which is designed to help farmers and owners manage their farm resources effectively. Tracking use concerning water consumption, tracking of electricity consumption, and providing much-needed data concerning sustainability while optimizing operations is part of advanced mechanisms used. It monitors the water and communicates to the farmer in real-time current statistics about how much water has been used. It helps prime irrigation decisions and prevents wastage of water [1], [2]. This becomes a major feature of the application—the notification when water has dropped to a user-defined threshold forces the user to cut off the water pumps or motors from over-irrigating the crops and damaging them [4]. In return, this system optimizes the usage of water since it supports crop health as well as sustainable agriculture [6]. On the side of electricity, it monitors energy consumption allied with the water pumps of the farm and other electrical systems. Thus, this ensures that users know the real-time consumption patterns [5]. Users can therefore make efficient energy decisions, keep track of the cost associated with consumption, and predict electricity bills according to real usage [6]. Integrating the monitoring of water and electricity puts an overall view on the resource they consume, which is promoted by improved management and control [7]. This realizes alert systems that enable farm productivity through real-time alerts issued every time specific conditions concerning excess water levels are noticed for timely corrective measures [2]. The application also includes friendly user interfaces on charts and graphical displays about consumption trends that empower a user to render high-performance insights toward saving water and electricity, cutting costs, and sustainable farming [1], [2]. This project could actually help emphasize the possible role of digital tools in aiding resource-efficient agriculture, give a scalable solution, and contribute to environmental conservation on farms.

Keywords. Sustainable agriculture, Resource management, Water tracking, Electricity monitoring, Real-time data, Farm resource optimization, Irrigation management, Energy efficiency

1 INTRODUCTION

In such a global scenario, where growth in population is on the rise at alarming rates, with resultant mounting food demands, agricultural productivity faces the pressure of managing resources like never before. Of those scarce resources on which agricultural productivity largely depends, two of the most crucial are water and electricity [1], [2]. All this pressure for high-yielding growth, however, ends up being overexploitation and wrong use of these vital inputs, increasing operational costs with very serious environmental damage [6]. Unsustainability has led to water scarcity, soil degradation, increased greenhouse gas emissions, jeopardizing the viability of agriculture as well as ecological health [9].Needless to say, innovative solutions to these problems are badly needed .

This research paper introduces a Water and Electricity Tracking Application designed to revolutionize how farmers manage their resource consumption. The application enables real-time monitoring and tracking of water and electricity use, providing farmers with the tools they need for optimal resource allocation. Key features include customizable alerts for over-irrigation and analytic capabilities for usage patterns, helping farmers reduce waste and enhance efficiency while saving costs . The basic characteristic of such applications is that they comprise devices to help out with the activities of the physical infrastructure. It includes sensors and actuators, control units, and physical objects that send messages to physical devices for carrying out computational operations. Thus, CPS fundamentally addresses the interplay of cyber and physical environments. The data acquired and collected there in the real-time network space is stored there, and makes the connection increasingly sophisticated. There are cyber and physical technologies involved at each level, yet it is one of the building blocks of IoT technology that integrates both worlds: physical and digital; however, this integration poses a myriad of security challenges to its very existence and compromises human lives if not left without solution.[8]Integration of the IoT to applications raises concerns about security and privacy when usage is concerned.

Most of the existing security and privacy measures have become ineffective with the increase in cyber attacks. Each user of the Internet may be treated as a commodity by the hackers. Thus, DL techniques are used for robust outputs to be obtained from the large complex databases in which the outputs generated may be utilized for predicting and detecting the vulnerabilities in the IoT systems controlling agricultural resources such as water and electricity.

Generally, the anomaly detection about security should be part of CPS-based systems. The complexity of attack-cum-Dos and DDOS together with the sophistication of CPSs make traditional methods of anomaly detection inappropriate because they would easily be overpowered by huge quantities of data and also the need for domain knowledge. In the case of CPS, real-time monitoring regarding water and electricity usage can provide farmers with decision-making tools that optimize resource management. Meanwhile, such a system should be secure because of the nature of its data-handling activity; most of the critical infrastructures will share similar vulnerabilities as other implementations of CPS and IoT.[8]

The Water and Electricity Tracking Application in this paper contributes toward the more sustainable agriculture goal via responsible resource management that raises productivity with environmental protection. This project looks to contribute toward the future of agriculture besides developing resiliency and sustainability in the face of growing demands.

2 RESEARCH METHODOLOGY

This paper will demonstrate the design of a system monitoring water and electricity via the simulation of an Arduino setup. The system continuously checks the levels in real time, thereby letting the users know whether to turn off the motor for possible flooding. The succeeding methodology would describe the hardware components, software parts, configuration, and the process followed in the achievement of the objectives.

Hardware and Software Configuration

Mock Arduino Setup: This emulator emulates the activity of Arduino like sensors and actuators. Therefore one can develop and test the application without having to provision for the actual hardware. Simulated data regarding the current water level and electricity consumption are sent in real time to the application by the Arduino code.

Water and Electricity Sensors: Mock sensors were mounted to indicate the percentage of water in levels along with kilowatt-hours (kWh) of electricity consumption. Giving a similarity to real-time real-world conditions, the sensors emitted arbitrary values within the set limit. In one case, the water level reading was between 0 and 100, while for the electricity consumption, a general household's pattern is shown.

Data Transmission: Arduino's information was transmitted to the application using a serial interface that sent data intervals for every 5 seconds. This always ensured constant monitoring and updating of the user.

Software Development

Application Interface: As the application is under development through Flutter, hence it is supporting cross-platform compatibility. The backend is managed through Firebase and from the mock Arduino system, data is stored using Firestore. The application is showing graph representation of water as well as electricity usage through fl_chart library.

Real-Time Monitoring Alert System: This periodically fetches information from Firestore, updates the statistics of how much water and electricity, and when it crosses a predefined threshold value, for example, 75 percent, then it might produce an alert notification within the application asking the user to turn off the motor before the flooding might occur.

Storage and Retrieval of Data: All water and electricity usage data are stored on Firestore. All data points are time-stamped for all historical analyses. The app allows the user to view overview or past usage patterns, hence making them make informed decisions in the area of resource usage.

Mock Testing and Validation: Deep mock testing was done on the system to ensure its accuracy and responsiveness. Simulated sensors were tested for all possible scenarios so that the application behaves perfectly in the case of any change in water levels or electricity consumption. At this testing phase, data consistency as well as accuracy in alert remained first priority.

New and Updates In the methodology, the study uses a mock Arduino technology that simulates a real monitoring setup. The system thus remains potent and ready for the possibility of integration with real sensors in the later phase. Data transmission intervals, alert thresholds, and aspects of data visualization were thus modified to make the app more responsive and user-friendly based on the results of the initial testing. It basically provides a simple framework which can be developed and brought into reality with relevant modifications concerning any specific farming conditions and resource management requirements.

3 THEORY AND CALCULATION

Since smart solutions are significantly enabled by the speed of agricultural technologies, efficiency in resource management has been enhanced through this mini-project, which monitors and controls water and electricity consumption through a mock Arduino system on a farm. The theoretical basis of this project bases it on IoT principles and the real-time acquisition of data with resource optimization for applications in agriculture.

Sensors included in the monitoring system based on Arduino include water level and power consumption sensors. Since the sensor measures continuous real-time measurement, data processed by the system can be viewed as enabling the user with actionable insights. Water level sensors indicate water height in a given range to periodically analyze if it is experiencing overflows or irregular conditions. It immediately alerts the farmer and lets him know that it is time to stop the motor so as not to waste the water and damage some of the crops.

This project fits into the theoretical model of precision agriculture. Precision agriculture is that program that refers to the targeted application of interventions differentiated using data in real time. The system tracks water levels and electricity usage as it tries to optimize resource utilization, minimize wastage, and maximize efficient operation on the farm. Relevant to this proposition is the integrated alert system since it ensures that the user takes immediate action, which is required to avoid adverse impacts over-irrigation has on crop health.

The part calculating electricity monitoring is done in terms of electrical energy, which calculates the consumption of power for the whole period of utilization by farm equipment. The result of tracking electricity usage also gives light to patterns in consumption. In addition, as it is correlated with electricity consumption, it assists in holistic resource management through this method that is foundational to sustainable agriculture.

Calculation

Calculation part carries out both the water level detection and electricity usage analysis.

Water Level Detection

The water height is measured by a sensor that gives an analog or digital output that represents the water level in the tank. In this case, the sensor has been set to produce a certain reading when the water reaches a specific level in the tank.

Equation 1:- This measurement is used to obtain the volume of water therein. For a tank, whose shape is cylindrical, the volume V
V can be calculated using the formula

Equation 1:- □ = □□2*h*

where

- **r** is the radius of the tank,
- **h** is the height of the water level detected by the sensor.

Electricity Consumption Computation

Equation 2:- Electricity will be calculated as current and the voltage supplied to the motor, directly following its computation of power usage through

Equation 2:- $\square = \square \times \square$

where

- **P** is the power in watts (W),
- **V** is the voltage in volts (V),
- **I** is the current in amperes (A).

Equation 3 :- The total energy consumption E over a period t is then calculated as:

Equation 3 :-$\square = \square \times \square$

In the process giving the farmer real-time information on the utilization of water and the amount of electricity used, therefore helping the farmers make the right decisions on the need to stop irrigating, thus conserving water and conserving energy. Application, therefore, presents an application of models for optimizing resources in practice fields of agriculture.

4 RESULTS AND DISCUSSION

Hence, this project with the aim to develop an application to track water and electricity usage by crops for agricultural purposes, and an Arduino mock system, has excellent opportunities for improving these resources' management in the farm environment. Below, one can also discuss the results of the project concerning their applicability in sustainable agriculture, comparing them with the latest findings in the field.

Water Monitoring and Alarm System

The water tracking component efficiently tracks how much water is used and gives real-time feedback in consumption levels. An important feature is the installation of a notification system; it will send out a signal to turn off the motor before getting over-irrigation when the water level exceeds a threshold. This function directly addresses a significant problem for agricultural purposes-that is, manage irrigation well not to let crops get overwatered and be damaged.

There is a new kind of solution which has recently been applied to smart farming systems, namely real-time alerts. However, there are very few solutions so targeted when giving notifications that would prompt action directly.

This the working model of our application where we need to set the desired water level for the crops it maybe wheat, rice, barley etc

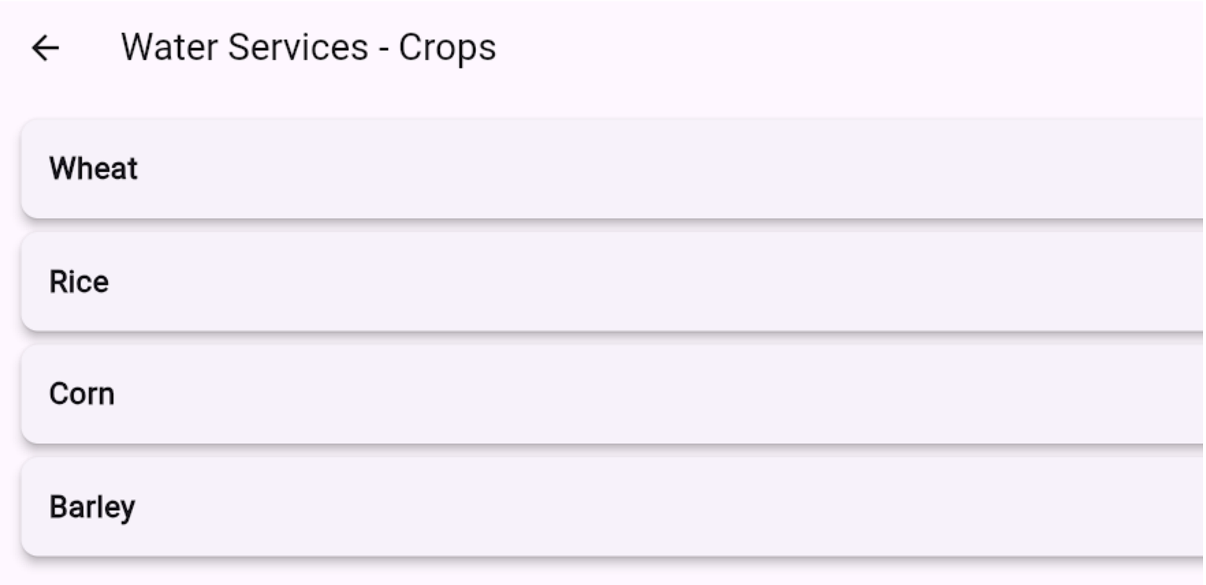

Figure 1. Water Tracking for Multiple Crops

After selecting the crop we need to set the desired water level from this window:

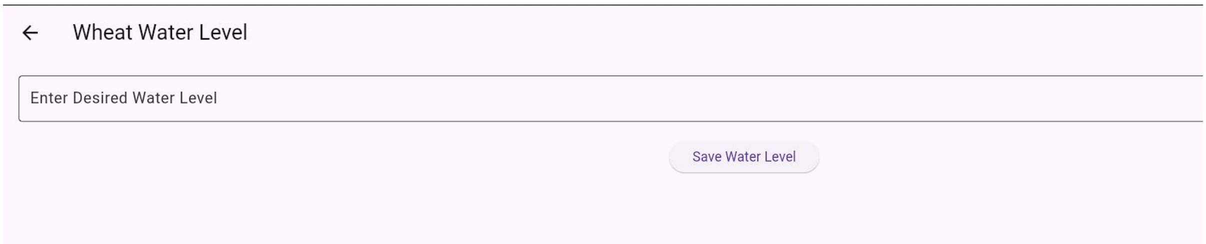

Figure 2. Desired Water Level Selection for Crop

If the Desired water level crosses the water level in the field then it triggers the warning to turn off the motor which may look like

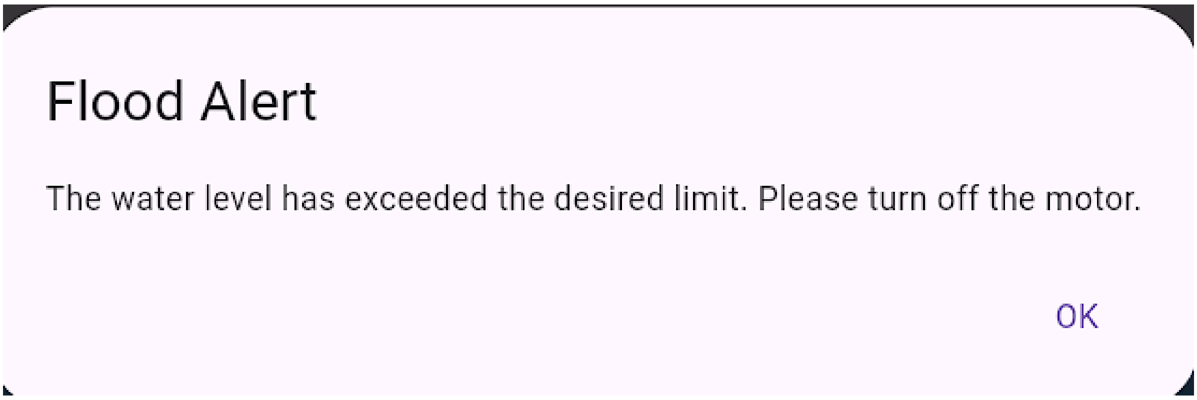

Figure 3. Flood Alert when Desired Water limit Exceeded

Also, this system may provide an instant alarm whereas traditional water monitoring systems involve batch data acquisition and processing which therefore make a latent response. Mock Arduino demonstrates the simulation of real overflow of excessive water levels proving that the practicability of this system comes through hardware, hence the solution for farmers to be easily accessible and scalable.

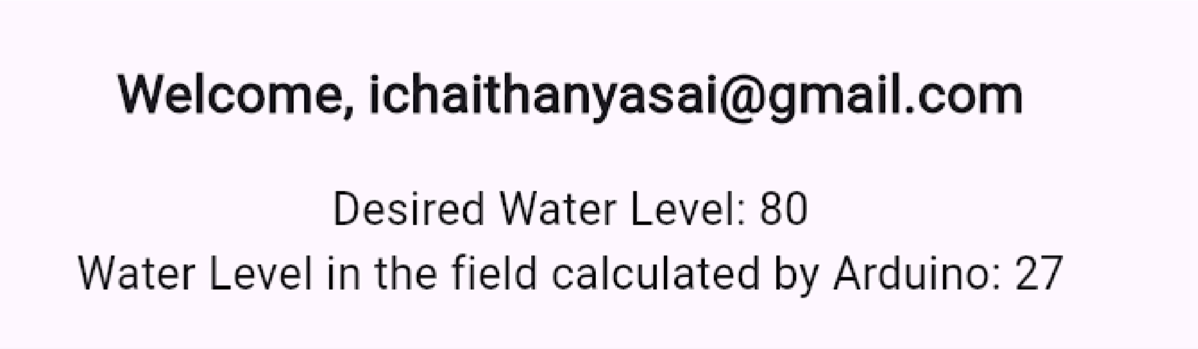

Figure 4 : Real Time Water Tracking Progress

Table 1. Water Usage Monitoring and Pump Status Control

Time	**Water Level (liters)**	**Pump Status**	**Notification**
08:00 AM	150	On	Water level normal
09:00 AM	200	On	Water level normal
10:00 AM	300	On	Alert: Turn off motor!

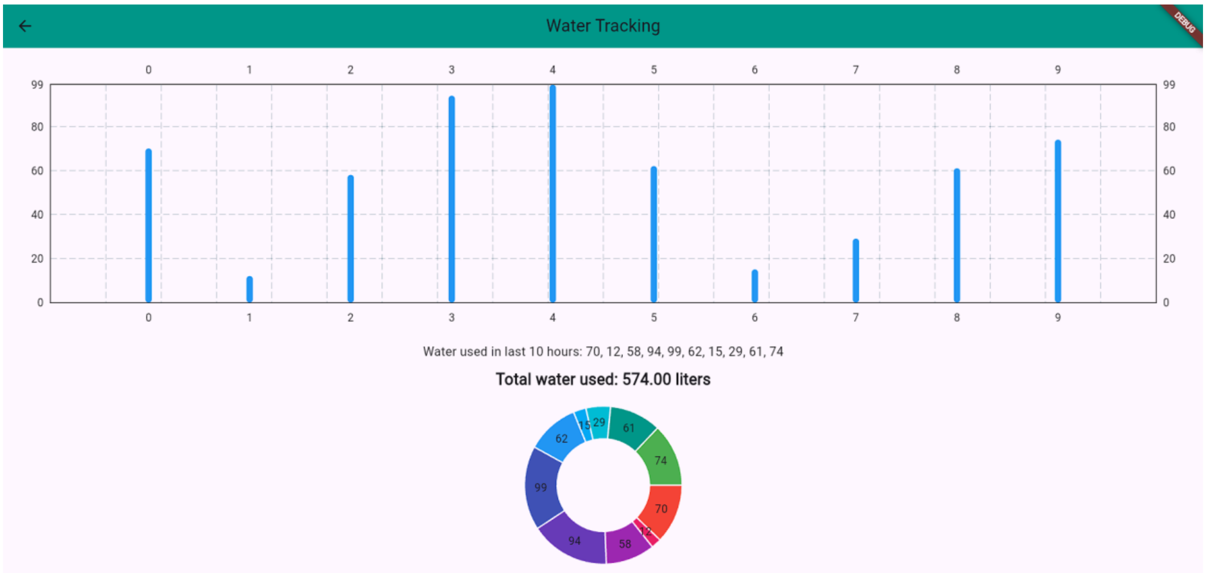

Figure 5. Real Time Water Tracking For Last 10 Hours

Electricity Consumption and Economic Data

This feature of electricity monitoring will easily reveal to the farming operator what amount of energy their water pumps and all other electrical equipment consume. Farming operators will, therefore, have direct access to consumption data in real time and trace patterns for better decision-making on how to use and manage energy.[5] It is at a time when costs of energy are rising, and coupled with the need to adopt more energy-efficient methods of farming.

It can calculate how much energy cost has been consumed additionally. This makes it possible for the users to calculate the monetary implications of their consumption.[7] This functionality already exists in some smart energy systems through updates that were recently introduced and included information above and beyond mere consumption data. Unlike most other commercially available energy management tools that demand extremely high setup and investment, this proposed tool is seemingly easy and cost-efficient to be applied for any small to medium-sized farms.[3]

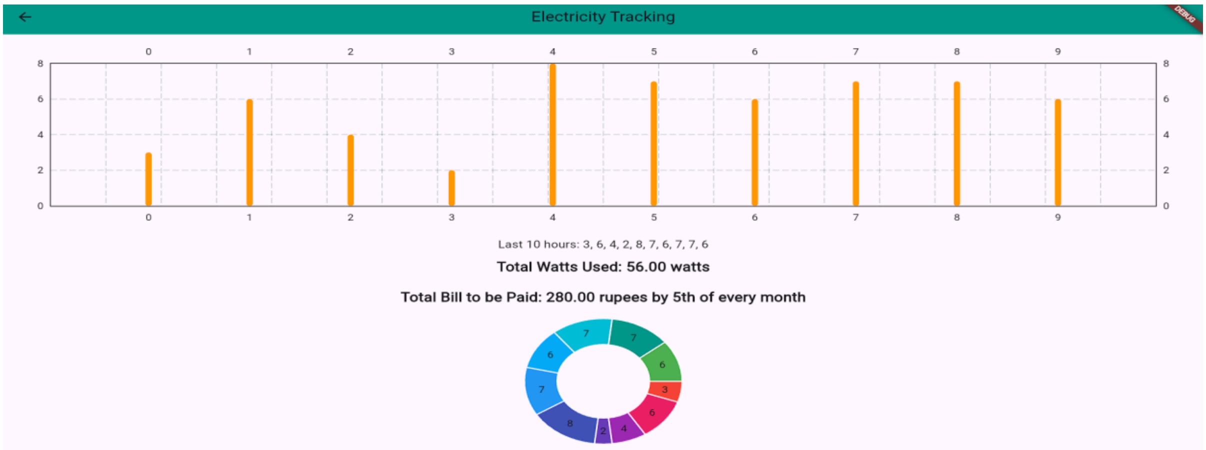

Figure 6. Real Time Electricity Tracking For Last 10 Hours

New Contributions and Recent Literature Comparison

The smart agriculture-based literature, at present, very clearly enunciates a requirement for a more cost-effective and scalable solution that could deliver real-time monitoring and control. The classic systems are generally derived from complex infrastructures that prevent the likes of small-scale agricultural operations from such systems. The project, however, demonstrates a minimalist approach yet effectively required by using a mock Arduino in simulation and critical areas of water and electricity.[4]

This approach fills an identified gap in the literature; solutions often target only one of the aspects of resource management or even incur high upfront costs.[8] Additionally, while there are several current applications that do offer data visualization, what makes this project novel is integrating water level alerts designed specifically for irrigation management. This application serves to fill a gap in recent innovations because most of the recent developments focus on soil moisture monitoring and general weather data, yet less attention has been given to real-time action-able notifications appropriate for situations involving flooding by water.

Implications and Further Development This project is therefore important as it avails real time data and actionable insights without necessarily demanding very complex settings and huge investment for the farmers. In the development stage, a mock Arduino was used but the setting might open the possibility of a very low-cost implementation of the hard-ware. It might actually include some actual sensors for field testing that would provide more realistic data to further refine the thresholds of the alerts.

5 CONCLUSIONS

The paper presents a mock Arduino-based system to realize real-time monitoring of water and electricity usage in agriculture. This project addresses the challenge of the ever-increasing demand for sustainable resource management by providing a solution through which farmers can observe water consumption and electricity usage effectively. It combines sensors and alerting mechanisms that advise farmers when water levels exceed a threshold, enabling them to take emergency measures, such as switching off the motor, to prevent flooding and crop loss. The ability to access real-time information about water levels and electricity consumption would be essential for optimized resource usage, waste minimization, and more sustainable farming practices. This application empowers farmers with decision-making capabilities, helping them achieve better crop health, increased yields, and lower operational costs.

Additionally, the user-friendly interface, with graphical representations and notifications, simplifies the process of tracking and managing resources.

However, there are limitations.

As the system is based on a mock Arduino set-up, it may not fully capture the complexities and nuances present in live farm environments. Realization in the field will require further validation through field-testing and calibration to ensure accurate reliability under varying conditions. Moreover, where the system currently informs the user to switch off the motor manually, future advancements could incorporate automated motor control, reducing human dependency and improving system efficiency.

Despite these limitations, the project has successfully demonstrated how IoT and mobile application technologies can be leveraged to address resource management challenges in agriculture. Its potential extends beyond small-scale farming, with applications in larger agricultural operations and industries for effective conservation of water and energy. Future versions may focus on expanding monitoring capabilities to include other critical parameters, such as soil moisture and temperature, for a more holistic view of on-farm conditions.

It can integrate data analytics with predictive modeling to make more informative decisions. The farmers can predict resource usage and be better prepared for its implementation. Further, it should develop the system by using renewable energy to reduce the environmental footprint of the system and integrating connectivity features that allow it to connect with other broader farm management systems. More importantly, having in mind the high level of accuracy achieved by methods based on improvements in the CPS security world, namely Bi-GRU and CNN-based models with Self-Improved Blue Monkey Optimization (SI-BMO), such strategies might improve the resilience of agriculture IoT-based systems. Indeed, improving the security and robustness of real-time monitoring systems in agriculture may be obtained by similar methods.[10] [11]

In conclusion, this project is a meaningful step toward more sustainable and efficient agricultural practices, offering a model that can be adapted or expanded to meet various farming needs while ensuring responsible resource management.

6 DECLARATIONS

This project on a mock Arduino demonstrates in real-time how farms use water and electricity resources. Whenever the water level crosses safe thresholds in order to prevent flooding, it switches off the motor and sends alerts to users on time so that resource management can be sustainable in agriculture.

Study Limitations

1. **Simulation Environment:** As the project is a simulation-based Arduino, it can't be used in real-time environments. Accordingly, it might not offer the same kind of performance when it is implemented in real time scenarios.

2. **Data Accuracy**: Simulated sensor data is probably not of the accuracy that actual sensors would deploy within an actual farm environment; therefore, resource tracking and potentially alerts may be affected.

3. **Sensor Scope:** All scopes of sensors and actuators that could be involved in a full-scale farm monitoring system cannot be reflected by this mock Arduino setup thus making the implementation of the system decrease.

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