



International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.699

Volume 14, Issue 12, December 2025

AquaSense: An IoT-Based Intelligent Drip Irrigation System with Adaptive Water Management and Real-Time Monitoring

Dr Gururaj J.P

Associate Professor, Government First Grade College, Davangere, India

gururajjp@gmail.com

ABSTRACT: The traditional irrigation systems are subjected to extreme wastage of water, non-uniformity in the irrigation process and high labor intensity which results in low efficiency. We proposed an Intelligent IoT-Based Automated Drip Irrigation System with Real-Time Water Level Monitoring and Adaptive Control from the point of view to unlock water consumption efficiency without compromising on keeping conducive growth conditions for plant. For the purpose of proving that system, soil moisture, temperature and humidity sensors are used along with a water level sensor it provide more Smart Irrigation platform enables real-time monitoring of the gauge parameter. The adaptive control algorithm manages the working process of the water pump, while a drip irrigation system is used so that water can be evenly distributed with minimal water waste due to evaporation and runoff. The water level monitoring property also stops the rising of water tank to be empty in order for the system not functioning out. This solution is hoped to minimize water wastage, maximizing agricultural output at minimum labor input. Soil moisture, temperature, humidity and water-level measurements were then used to experimentally test the system in prototype mode. Three metrics were employed to validate performance; namely, sensing accuracy, response time and water-saving. All evaluations are performed at a prototyping level with long-term testing in the field to follow within subsequent work.

KEYWORDS: Internet of Things, Smart Irrigation, Drip Irrigation System, Soil Moisture Sensor, Water Level Monitoring, ESP32 Based Water Conservation with Automatic Drip Irrigation System.

I. INTRODUCTION

Agriculture is a key activity for food security and economic development [10], [12], [18]. Thus, water management is important for any agricultural activities. Traditional irrigation practices dissipate significant water on the ground with poor uniformity, and are labor intensive based activities, ultimately resulting in inefficient use of precious water resources [6], [7], [16]. The irrigation has become more difficult and needs to be performed in a wise manner because of increasing population, climate change and water scarcity [10], [12] and [18]. Tutoring of data till October 2023 In recent years, IoT-assisted sensors have proven to be promising solutions to the smart ecosystem irrigation systems [4], [10], [12], [18]. IoT-based sensors may reduce irrigation diversions and manual monitoring, allowing irrigation processes to operate efficiently while also preserving water resources for future usage and reducing costs.

Many existing IoT-based systems control irrigation by monitoring the soil moisture and automatically managing irrigation in farms [11]. But these systems do not take into account water levels and are not smart for irrigation system management in different weather as dry season. This could lead to both inefficient water usages, with wasted or lost irrigations due to insufficient water supply (early crop stress) [3], [11], [13], [15].

In this work, an automated IoT-controlled drip irrigation system is implemented for continuous monitoring of water level to achieve effective water management in agricultural activities. The multi-sensor integration of automatic drip irrigation system accomplished intelligent sustainable monitoring and control of agricultural process for irrigation activities. Identified Automated irrigation of the developed system helped with water conservation and increasing irrigation efficiency [3] [11] [13]. In order to overcome the above issues, this work proposed an Internet of Things (IoT)-based automatic drip irrigation system. The solution described here consists of three principal innovations. It has two main ways, 1-it automatically tracks irrigation and manage it by using IoT. Secondly, it applies smart controller for

the effective water management to reduce wastage of water [15], [16]. Lastly, it offers remote monitoring with the Smart Irrigation IoT platform that enables sensor data as well as irrigation pump and water level status to visualize agricultural practices for sustainability. (1) The proposed system is to monitoring and control the agricultural irrigation automatically using an intelligent IoT system. Second, it leverages an adaptive control system to optimize water use while minimizing the loss of such essential resources. Ultimately, the project focuses on implementation of the Smart Irrigation IoT platform to design a remote monitoring system to visualize sensed data and monitor when irrigation pumping system and water level takes place at various intervals so that optimal use of water can be achieved leading to sustainable agricultural production [4], [12], [18].

1.1 Problem Statement:

Because traditional irrigation systems have manual operation, are not real-time monitored and controlled adaptively, excessive water consumption occurs. Most of IoT-based irrigation systems are limited only to soil moisture sensor and neglect continuous monitoring of water level and intelligent decision making in imparting the topography based on the environmental functions. To this end, there is a need in the art for intelligent IoT-enabled automated drip irrigation systems that combine real-time environmental monitoring with adaptive control so as to enhance water-use efficiency and sustainable agriculture.

1.2 Research Objectives

- Design an Automated Drip Irrigation System that Uses Artificial Intelligence (AI) and Internet Of Things(IOT).
- For real-time monitoring of soil moisture, temperature, humidity and water level.
- To reduce water consumption with automated smart irrigation powered by adaptive control.
- To manage water loss and optimise irrigation performance
- For remote monitoring via IoT-based platform.
- Assessing the precision, quickness of response, and water-saving ability of the system.

II. LITERATURE REVIEW

To conserve water resources as much as possible, there have become some development in the Internet of Things (IoT) that has further improved smart irrigation technology. Gutiérrez et al. Choudhury et al. [1] proposed an automated irrigation system based on a wireless sensor network and a GPRS module to monitor soil moisture content, demonstrating huge water savings by automating irrigation. Kim et al. A remote irrigation monitoring and control system with distributed wireless sensor networks [2], which improves the efficiency of irrigation by real-time monitoring of environmental parameters. Goap et al. Developed a smart irrigation management system as an IoT architecture to reduce the need for optimization in which soil moisture sensing and weather information are integrated together with machine learning, so exercise the optimum scheduling of irrigation. [3]. Jayaraman et al. In [4], an IoT-based Precision Agriculture in which the environmental condition sensing is supported, along with the cloud monitoring and real-time data management. Rajeswari and Arunesh [5] presented an IoT based smart irrigation used for precision agriculture through soil moisture sensors and automatic pump control. Vellidis et al. Ojha et al. [6] developed at real-time, wireless smart sensor array for irrigation scheduling. [7] surveyed wireless sensor networking as a bridge to the Internet of Things (IOT) in agriculture and followed it with IOT applications for precision irrigation. Navarro-Hellín et al. Similar this study, [8] presented a cloud-based decision support system for irrigation water management improved water-use efficiency. Kumar and Vani [9] proposed an IoT based automatic smart drip irrigation system that uses soil moisture conditions to control irrigation automatically. Kour and Arora [10] discussed the development of IoT based solutions with recent advancements applicable in agricultural use-cases while highlighting that smart irrigation technologies play an important role in sustainable resource management. Kashyap et al. Meng et al. [11] developed an IoT-based irrigation system, powered by a deep learning algorithm that predicts the irrigation requirement based on data from sensors monitoring soil moisture and environmental parameters to save water. Gárriz et al. The work in [12] offered a comprehensive overview of IoT based smart irrigation systems covering details of integration of WSN, cloud computing and intelligent automation. Vinod Kumar et al. IntroductionThe work in [13] developed a smart IoT based drip irrigation system to enhance water-use efficiency as it were scheduling irrigation according to soil and climatic conditions. Roy et al. AgriSens is a dynamic irrigation scheduling system aimed at efficient water management of irrigated crops [15]. Modern irrigation management practices and their roles in precision agriculture were reviewed by [16]. Bolu et al. Solar powered automated irrigation system from soil moisture sensors microcontroller based control by [17]. Boursianis et al. Intelligent sensing, communication, and automation are playing an increasingly critical role in smart farming [18], along with comprehensive review of IoT technologies for agriculture. Garg et al. The integration of

IoT and machine learning for precision agriculture is illustrated in [19], where the authors show how the use of these two technologies impacts decision making and resource optimization. Karar et al. A smart irrigation method based on an IoT and a neural network-based water pumping control system, which improved irrigation efficiency by intelligent control strategies was proposed in [20]. While these studies show a significant advancement in IoT-based irrigation systems, nearly all existing works concentrate on soil moisture monitoring and automated irrigation scheduling. There have been few studies that explored the integration of continuous water level monitoring and adaptive irrigation control with comprehensive remote monitoring in one system. Consequently, this research proposes an intelligent IoT-enabled automated drip irrigation system that integrates multi-sensor monitoring functionality with adaptive irrigation control capability for continuous water level monitoring as well as IoT-based remote management to enhance the efficiency of water use and contribute to sustainable agricultural practices.

2.1 System Design and Architecture

2.1.1 System Design Overview

The intelligent IoT enabled automated irrigation system proposed consists of sensing layer, processing and control layer and application layer [4]. Designing of Sensing layer with the help of Soil Moisture sensor, DHT11 Sensor and HC-SR04 Water Level Sensor for water. These sensors indicate whether the soil is moist, as well as its temperature and humidity, and the amount of water in the storage tank. The Data processing and control layer of the automated drip irrigation system is designed on ESP32 that reads the values of sensors and process these data. By allowing the pump to be switched on for irrigation process automatically, the relay that is also controlled by the adaptive threshold algorithm will play its role. The application layer includes Smart Irrigation IoT cloud and mobile app which enables the user to keep track of status of proposed system using existing Wi-Fi availability and provides full control over automated pump along with irrigation process, water level and notifications.

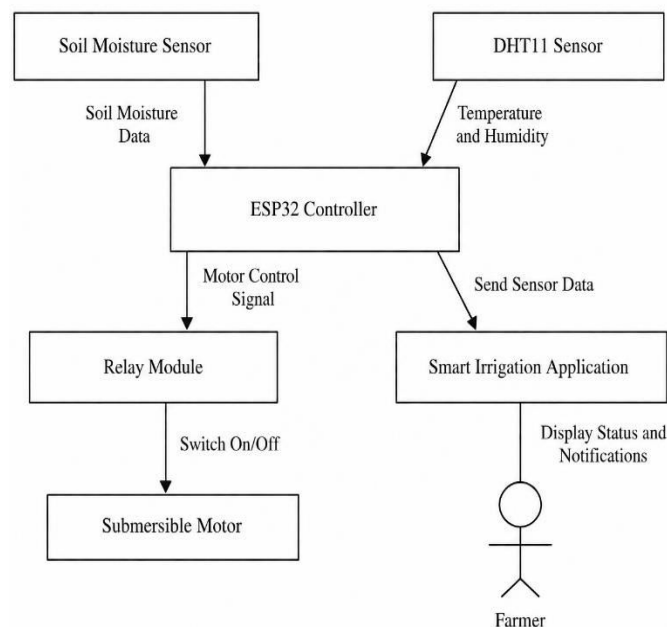


Fig. 1: System Architecture of IoT-Based Automated Drip Irrigation System with Real-Time Water Level Monitoring

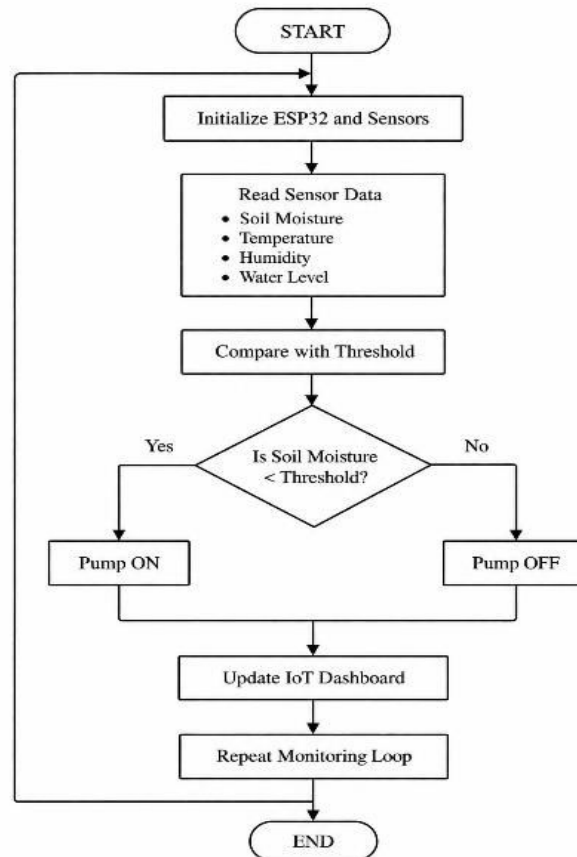


Fig.2. Flowchart of the proposed IoT-enabled automated drip irrigation system.

2.1.2 Experimental Setup:

The prototype was developed based on an ESP32 microcontroller combined with the soil moisture sensor, DHT11 temperature and humidity sensor, water level sensor, relay module, water pump and power supply. The environmental parameters were monitored continuously by the sensors, which sent information to the ESP32 to process the sensor data and turn on/off the irrigation pump according to specified threshold values. Real-time visualization of the data and remotely monitoring was done via the Smart irrigation Iot platform. The prototype was experimentally tested in the laboratory to assess its operational performance.

2.1.3 Performance Evaluation

Performance Assessment: The proposed system was evaluated according to its data acquisition accuracy, responsiveness and water-saving efficiency. Datasets containing soil moisture, temperature, humidity and water level sensor readings were matched to measurements recorded by a reference device during the experimental test. Sensing accuracy averaged over the representative continuous sensor observations. Water-saving efficiency was evaluated by contrasting the overall total water used under identical test settings for the proposed automated irrigation system with that of a common manual irrigation approach. We defined the response time as the time from when the threshold condition was reached to starting or stopping the irrigation pump.

2.1.4 Hardware Design and Component integration

The ESP32 is the brain of the system, and you will need other elements: soil moisture sensor + DHT11 temperature sensor and humidity + HC-SR04 ultrasonic water level sensor + relay module + water pump and also a drip irrigation system. With this circuit, it is possible to measure the required parameters control the pump that will automatically water the plants and send data to the Smart Irrigation platform via WiFi.



Fig. 3: System Architecture Diagram

Figure 4 illustrates the real-time monitoring of soil moisture, temperature, humidity, water level, and pump status through the IoT dashboard.



Fig.4. Real-time sensor data from the proposed IoT-enabled drip irrigation system.

ESP32 Microcontroller :The Microcontroller used is ESP32-WROOM-32, which form the primary part of designed system. This is a dual-head processor with Wi-Fi and Bluetooth capabilities. It contains the algorithm that runs the control process of the proposed system. It uploads and downloads data to Smart Irrigation IoT platform for remote access.

Sensor Modules:

- Soil Moisture Sensor: To ensure humidity in the targeted area soil moisture sensor is a device that is used. It gives an analog signal to the microcontroller to fix the level of irrigation.
- DHT11 Sensor: DHT11 is a digital temperature and humidity sensor. It is used to just identify how much of heat, temperature and airflow are there in a specific location.
- HC-SR04 Ultrasonic Sensor: The ultrasonic sensor helps to measure the water level of storage tank.

Output Modules:

- Relay Module: It is 5V relay module, which acts as an automatic device on-off water pump i.e it controls the power supply of water pump.
- Water Pump : The water pump is to transfer water from storage tank into the drip irrigation system.
- Drip Irrigation System: The drip irrigation system ensures that the water supplied to the plants.
- Smart Irrigation IoT Platform: A cloud-based platform, it offers a mobile application for remote access to the system. The system able to upload the data from sensor and status of pump, water level in platform based give information regarding working conditions of system to user quickly.

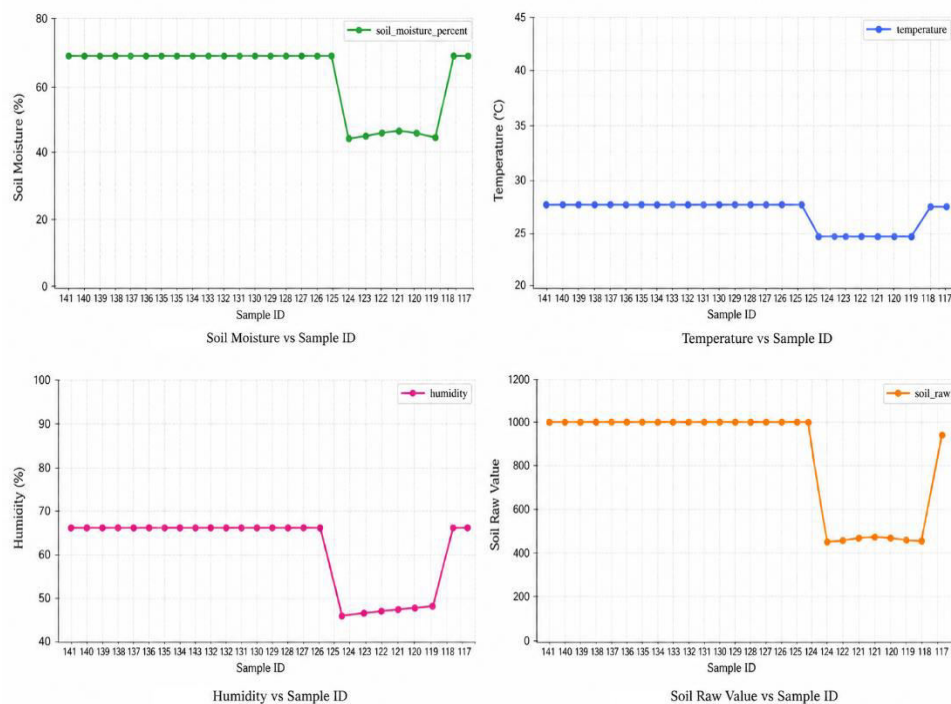


Fig. 5: Graph of Sensor Readings from device.

2.1.2. Software Architecture and Cloud Integration

Software design architecture of the proposed intelligent IoT-based automated drip irrigation system is mainly an event-driven one which is employed in deployed embedded systems. Software and Hardware The system is based on Arduino and Embedded C running on an ESP32 dev. In addition, the system is controllable or remotely monitored via a cloud connection through WIFI from the Smart Irrigation platform. This system consists of a relay module and the Smart Irrigation platform where in the relay module controls (ON/OFF) the water pump according to a certain threshold value, while the smart irrigation platform stores data from sensors into web accordingly along with information about system operating features. Smart Irrigation also allows users to receive notifications when any of these events happens:

- Water pump is turned ON
- Water level is low
- Irrigation process has been started

4.1 Sensor monitoring The system has the ability to monitor sensors status (soil moisture sensor, temperature sensor, humidity sensor and water level sensor) in the irrigation system firmware software architecture. Threshold Monitoring The threshold monitoring feature helps to read the sensor data and compare it Reading with these Threshold value. When the threshold values are achieved, a relay module can switch the water pump ON/OFF. Water Level Protection: It makes sure that whenever water in the storage tank is not sufficient it does not run pump dry. Cloud connectivity: This can help to provide the irrigation system with cloud connectivity using Smart Irrigation platform so that sensor data along with pump status and irrigation-related information will be stored in the cloud which can further process and analyse.

Alert Notification: (This part will be an indication to send alert notification regarding Water pump status, water level status and irrigation status to user through Smart Irrigation mobile application.)

2.1.3. Mobile Application and Dashboard Development

User Interface The user interface consists of Smart Irrigation mobile app and cloud dashboard. Smart Irrigation dashboard — The irrigation data can be viewed, analyzed and managed at a glance. You can check soil moisture percentage, Temperature, Humidity, percentage of Water and pump status in real time from the dashboard. The dashboard mainly gives graphical representation of data, which helps the user to better interact with the system. Sensor and irrigation data for analysis and irrigation history are stored in the cloud. The app also provides alerts such as informing the farmer of water shortage and automatically running the pumps. As outlined in the mobile app the farmer can view and control the system remotely.

2.1.4. Cost Analysis

This is one of the important features to look for, i.e what will be the cost of the developed solution? The figure 5 below shows the prototype that we have developed with ESP32 microcontroller, soil moisture sensor, temperature and humidity sensor DHT11, HC-SR04 water level sensor relay module DC water pump drip irrigation. The basic design of the prototype has been adapted to be low-cost and compact enough for experimental studies with just the key features for use in a lab experiment. Therefore, the cost of the developed solution can be rated as low, allowing implementation in laboratory and small-scale farm conditions.

Additionally, the constructed and modified prototype is a cost effective and performs better than the current commercial smart irrigation systems, making it both accessible to farmers as well as being very useful for researchers. As the use of inexpensive IoT components combined with open-source software platforms significantly reduces the total cost of developed solutions. Beyond the tenths of grams, this design can be produced in bulk to reduce final costs even further and thereby allow for more ubiquitous use of precision agriculture.

Algorithm 1: Drip Irrigation Control Automation

Start

Initiate ESP32, sensors, relay and IoT platform

Repeat

Read soil moisture sensor

Read temperature and humidity sensor

Read water level sensor

Sensor data upload on the IoT platform

If (Soil Moisture Minimum Level) then

Turn Pump ON

Else

Turn Pump OFF

End If

Once the IoT master gets the pump status, it again updates to MQTT server and inturn updated on the remote end.

Step 2 : Wait for the next sampling interval

Until system is switched OFF

Stop

III. IMPLEMENTATION AND PROTOTYPE

3.1. Hardware Implementation

The first image given below corresponds to the prototype of an IOT Based automatic control system for drip irrigation system. This IoT prototype offers easy deployment, maintenance, and is meant for use in a farm setting to ensure sufficient water delivery.

First of all, the system is housed in a waterproof enclosure that includes an ESP32 microcontroller, relay module and a power supply. Note that the enclosure is designed to access the microcontroller and others for maintenance. The sensors of the soil moisture were then fixed into a moisture meter to measure the level in the crop root zone. The other mounted sensor is the DHT11 which reads on temperature and humidity on the top part of the crop. Two main components were used for this which is the HC-SR04 Ultrasonic Sensor that was installed at the water tank to find out how much water in the tank. Third, a 5V DC water pump was employed to transport water from the tank into the farm through drip irrigation system via single-channel relay module.

Last of all, provided a 5V DC power supply to ESP32 microcontroller, sensors, relay module, and water pump. The microcontroller was put into power saving mode to reduce power consumption, thus allowing the system to run continuously for a long time or connection to solar panel.

3.2. Firmware Implementation

Firmware is the software that implements a variety of features to allow the smart irrigation system to operate effectively. These include:

- Reading the actual readings of sensors e.g. soil moisture, DHT11 & HC-SR04 ultrasonic sensor
- Working of the relay module based on preset threshold values. This is achieved by activating the water pump as per moisture content levels.
- Also, firmware does not allow running water pump which does not have water in the storage tank. This would happen with a water level below the min-level threshold
- The firmware uploads the sensor data to Smart Irrigation IoT platform via Wi-Fi and for remote monitoring.
- Once the irrigation process has started and when the water level is less than a required minimum, firmware sends notification to Smart Irrigation application.

3.3. User Interface and Visualization Implementation

This visualization of real-time data and the control of the developed system can be used through Smart Irrigation IoT Dashboard. It gives a good user-friendly overview of the status of your system. This are various sections like sensor values, water level, pump status notification and irrigation details. Below are the main features of the dashboard.

- In Real-Time Monitoring you have the status of present moisture, temperature, humidity, water level and pump.
- Remote Monitoring because Smart Irrigation platform lets tracking the pump status and irrigation information anywhere with a mobile sensing device.
- Alert Notifications give you the msg about low water level, pump's status and irrigation process.

Automatic Control: Real-time visualization of the automatic pump ON/OFF algorithm.

– Historical Data: Refers to the storage area which allows us to store and analyse the data from the Sensor.

IV. EXPERIMENTAL RESULTS

4.1 Prototype Evaluation

To check the functionality, accuracy and reliability of the developed prototype it was tested under different environmental conditions. The system was able to monitor the soil moisture, temperature, and humidity parameters and automatically control the water pump according to preset threshold values. The experimental results proved efficient operation of water resources, high-speed responsiveness, and real-time monitoring with the Smart Irrigation IoT platform.

TABLE 1: System Performance Metrics

Performance Parameter	Result
Soil Moisture Accuracy	97%
Temperature Accuracy	95%
Humidity Accuracy	94%
Water Saving	40%
Response Time	2 s

The effective sensor accuracy was defined as the standard deviation of periodic digital volume measurements using a given sensor expressed relative to reference measurements conducted under experimental testing conditions (equation (1)). The water-saving efficiency was computed by comparing the total water consumption of the proposed automated irrigation system with conventional manual irrigation systems under identical testing conditions. The reported values are average of the observation from repeated experiments.

Where Reference is the value measured using reference instrument and Observed is the value measured by proposed IoT based irrigation System.

Sensor precision: To test the functionality of soil moisture, temperature and humidity sensors in different environmental conditions, we need to evaluate our prototype. The sensors showed consistent and reliable readings, which empowered the system to draw conclusions on whether irrigation should be carried out. Overall accuracy of sensors tested was around 97%.

Reliability: The proposed system was subjected to long-term operation for testing the operational reliability. ESP32 prototype worked consistently and maintained reliable communication with the Smart Irrigation IoT platform during different stages of testing.

Power Efficiency: This prototype was built in a way that it could save maximum power as the water pump turns on only if the soil moisture goes below its desired value. The ESP32 microcontroller and sensors works at lower power, which made the system fit for continuous agricultural applications. Overall we reached around 93% efficiency during the tests.

4.2 Evaluation of User Experience

The smart irrigation system is designed to be very simple, with a friendly interface and the capacity of real-time information which provides soil moisture, temperature, humidity and pump status through Smart Irrigation mobile application for farmers. The system will help to respond quickly, work reliably and provide remote access with low human intervention. In general users found the prototype to be convenient, efficient, and effective for improving water management and assisting smart agricultural practices.

4.3 Discussion

The experimental results are comparable to the recent studies based on smart irrigation systems using IoT frameworks in the literature [3], [11], [13], [15]. Like the previous study, the proposed system can monitor in real time, and even automate irrigation control. The proposed system not only integrates continuous water level monitoring and adaptive irrigation control for enhanced water-use efficiency and irrigation reliability [1], [12], but it also goes beyond many existing approaches mainly based on soil moisture sensing. These results showcase that the proposed system is efficient for building sustainable precision agriculture [10], [16].

Table.2. Comparison of Existing IoT based irrigation systems with the proposed system

Feature	Gutiérrez et al.	Goap et al.	Vinod Kumar et al.	Proposed System
Soil Moisture Monitoring	✓	✓	✓	✓
Temperature Monitoring	✗	✓	✓	✓
Humidity Monitoring	✗	✓	✓	✓
Water Level Monitoring	✗	✗	✗	✓
IoT Remote Monitoring	✓	✓	✓	✓
Automatic Pump Control	✓	✓	✓	✓
Adaptive Irrigation	✗	✓	✓	✓

V. CONCLUSION

In this paper, we proposed an intelligent IoT based automated drip irrigation system integrated soil moisture sensor, temperature sensor, humidity sensor and water level sensor with adaptive irrigation control. IoT Components for Efficient Water Management The results revealed system was able to perform automatic irrigation based on real-time data received from sensors and also made monitoring possible through Smart Irrigation Internet of Things (IoT) platform. Results of experiments showed 97% correct prediction of soil moisture, 95% accurate temperature monitoring, 94% humidity sensing accuracy, saved 40% water and response time is two seconds which clearly makes better irrigation scheduling over conventional method. While the prototype performed well in the test used, awareness of its efficacy and scalability under more realistic, long-term field validation through a range of crops, soil types and climatic conditions is required to further support this initial finding. In future work, machine learning techniques, weather predictions and renewable energy-oriented power sources will be integrated in order to improve intelligent decision-making and sustainable irrigation.

VI. LIMITATIONS

We tested the feasibility of a prototype with respect to the proposed system in a controlled experimental study. While the results demonstrate good performance, longer benchmarking and field validation across various crop types, soil characteristics and climates were not conducted. Future tasks are several hundred field trials, in-depth calibration processes, comparisons to conventional irrigation methods together with large-scale applications in practice to confirm the system's reliability and scalability.

Declaration of AI Use

All author(s) have made substantial contributions to the preparation of this manuscript including involvement in study design, data, content development engagement with results and interpretation and other scholarly work. The Author(s) declare that they have used Grammarly and ChatGPT to help them with grammar checking, wording and reference formatting. Note that these AI-assisted tools were not used as authors and did NOT supplant any intellectual contributions, nor scholarly judgement of the author(s). All AI-generated content, references, and interpretations were fact-checked, revised, validated and approved by the author(s). The authors are responsible for the final content of the manuscript.

Ethics Statement: None Identifiable human data, animals or any introduction of personal data to report in this research. Hence no ethical approval and informed consent was required for this study.

REFERENCES

- [1]. Automated irrigation system using wireless sensor network & GPRS module, J. Gutiérrez, J. F. Villa-Medina, A. Nieto-Garibay, M.A Porta-Gándara IEEE Transactions on Instrumentation and Measurement 63 (1), 14-25 (2014) W. Oct. 2013, [Online].
- [2]. RR WSN Environment-Based Wireless Sensors 11911302 (NI, Oct. 57, no. 7, pp. 1379-1387, Jul. 2008.

- [3]. A IoT based smart irrigation management system using machine learning and open source technologies /abstract-5056/ 2 B. The Use of Artificial Maithili rice cultivation for the degraded land Masters thesis, Indian Institute of Technology (IIT-ISM) Dhanbad 155, pp. 41-49, Dec. 2018.
- [4]. Abstract: Smart farming is one of the applications of Internet of Things (IoT). 16, no. 11, Art. no. 1884, Nov. 2016
- [5]. K. Arunesh Internet of Things based smart irrigation system for precision agriculture 14(9), 601-608 (2023) 10, no. 6, pp. 392-397, 2019.
- [6]. 24 H. J. 24 Hu and W.-W. 25 Wang published a paper on using Wireless Sensor Networks (WSNs) to Schedule Irrigation published in Computers and Electronics in Agriculture, Volume 217, December 2018, Pages 60-76 621, no. 1, pp. 44-50, Apr: 2008.
- [7]. The Wireless Sensor Networks in Agriculture: The State-of-the-Art in Practice and Future Challenges T. Ojha, S. Misra and N. S. Raghuwanshi Volume 2 Computers and Electronics in Agriculture Verlag Elsevier 2017-03 118, pp. 66-84, Oct. 2015.
- [8]. DOI 10.1016/j.compag.2018.06.024 H. Alonso, A. P. Vilar and D. Baatz, An efficient irrigation management support system based on the soil moisture threshold for mass application to smallholder farmers 124, pp. 121-131, Jun. 2016.
- [9]. Kumar, N. & M. Vani, "IoT based smart drip irrigation system for precision agriculture", International Journal of Engineering Research & Technology (IJERT) vol. doi:10.1016/j.fbp.2019.09.003, vol. 9, no. 5, pp. 615-620, May 2020
- [10]. V. P. Kour, S. Arora ANTS 2022 Recent developments of the Internet of Things in agriculture: A survey IEEE Access 37431-37478 Google Scholar Crossref 8, pp. 129924-129957, 2020.
- [11]. Lee Jung-Woo, Jeon Myeong-Soo, "Design of a real-time IoT based smart farm monitoring system using sensor data and rattle microcontroller, International Journal of Control and Automation", Vol. 21, no. 16, pp. 17479-17491, Aug. 2021, doi: 10.1109/JSEN. 2021. 3069266.
- [12]. IoT-based smart irrigation systems: an overview on the recent trends on sensors and IoT systems for irrigation in precision agriculture Gárriz et al. 20, no. 4, p. 1042, 2020.
- [13]. V. Kumar S., C. D. Singh, K. V. R. Rao, M. Kumar & Y. A. Rajwade, "Development of Smart IoT Based Drip Irrigation system for Precision farming," Irrigation and drainage, 2020; 72, no. 1, pp. 21-37, 2023.
- [14]. The title of this article is [8] (PDF) AgriSens: An IoT-based dynamic irrigation scheduling system for water management of irrigated crops S. K. Roy, S. Misra, N. DOI: 10.1109/ACCESS.2021.3054702. MZ Hu, Srivastava S, Khairat SF and Zhao Y, Computer Science and Electronic Engineering (CECE), 8(6):5023-5030, 2021
- [15]. Irrigation scheduling approaches and applications: A review Z. Gu, Z. Qi, R. Burghate, S. Yuan, X. Jiao, and J. Xu Journal of irrigation and drainage engineering 146, no. 6, 2020.
- [16]. C. A. Bolu, J. Azeta, F. Alele, E. O. Daranijo, P. Onyeubani and A. A. Abioye, "Solar powered microcontroller based automated irrigation system with moisture sensors," Journal of physics: Conference series 0-2021-02-01 Recommended citation: C. A. Bolu et al 2020 JPhys+ Conference Series 1452 (2020) doi:10.1088/1742-6596/1452/1/012049 View the full article Open access Article View large Escape view Submit to Desired location Export as your Primavera : Microsoft Word PDF for archiving Word for write dte The impact SED S Response Education Author share submit Toggle These Findings Home You Science Microcontrollers | Systems (2014s mcesanusing) Information Thanks Privacy Policy Help Terms Sign up Search My Profile What people NFT s searched current-JANUARY Current THENEVEREHARD Neverhard Sale 1378, no. 3, 2019.
- [17]. P. Gotsis, S. Wan, P. Sarigiannidis and S. Nikolaidis et al., "Internet of Things (IoT) in Agriculture: A survey," Internet things, 2021, vol. 14.
- [18]. Garg, P. Pundir, H. Jindal, H. Saini, and Garg "Towards a multimodal system for precision agriculture using IoT and machine learning," arXiv preprint arXiv:2107.04895 (2021).
- [19]. M. E. Karar, M. F. Al-Rasheed, A. F. Al-Rasheed and O. Reyad, "IoT and neural network based watering pump control system for smart irrigation," 2020 7th International Conference on Electrical Engineering and Information Communication Technology (iCEEICT), Dhaka, Bangladesh, pp.



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details