Iot Controlled Automated Multifield Irrigation System

Dr. Kumuda T[1], Amith K R[2], Manasa T P[3], Abhilash N[4], Chiraag A E[5]
[1]*Professor, Electronics and Communication Engineering, Adichunchanagiri Institute of Technology Chikkamagaluru*
[2,3,4,5]*Student, Electronics and Communication Engineering, Adichunchanagiri Institute of Technology Chikkamagaluru*

Abstract— **Agriculture plays a vital role in sustaining human life and economic growth, especially in developing countries where water management is a major challenge. With the growing demand for food and limited water resources, adopting smart irrigation technologies has become essential to improve productivity and efficiency. In this context, automation and IoT-based systems offer reliable solutions for modern farming practices. The design and implementation of an IoT-enabled smart irrigation system using GSM technology for remote control and monitoring in multi-field agriculture. Based on STM32 microcontroller and SIM800L GSM module, the system receives SMS commands via an Android app to activate irrigation for specific fields by indicating the field number and irrigation duration. A relay controls the pump, while solenoid valves direct water flow accordingly. Soil moisture sensors monitor moisture levels and can stop irrigation early to prevent overwatering. A dry run sensor ensures water availability before pump activation, protecting the motor. The system also includes a timer to stop irrigation after the set duration if needed. SMS notifications are sent upon completion or interruption. This solution improves water efficiency, protects crops, reduces manual effort, and offers a scalable, low-cost option for smart farming in resource-limited settings.**

Index Terms— **Multi-Field Agriculture, Automated Irrigation, IoT (Internet of Things), GSM Technology, Smart Irrigation System, STM32 and esp32 Microcontroller, SMS Notifications.**

INTRODUCTION

Agriculture forms the backbone of many economies, especially in developing countries like India. However, traditional irrigation methods result in water wastage, labor dependency, and inefficient resource usage. Automation in agriculture, particularly in irrigation, saves water and enhances crop yield.Water management is one of the most critical aspects of modern agriculture, especially in regions facing water scarcity or unpredictable rainfall. Water distribution in agricultural areas frequently becomes a source of conflict between farmers. Sometimes, farmers time and energy are wasted for coming to the location to provide the supervision. Automatically open and close the irrigation gates according to the water needs for farming using IoT technology.

Additionally, such smart systems can be remotely operated using SMS, mobile apps, or web platforms, making it easier for farmers to manage multiple fields without needing to be physically present. Features like automated dry run protection (to prevent pumps from running when no water is available) and programmable timer-based irrigation cycles further improve efficiency, reduce human error, and conserve water. Sometimes, farmers time and energy are wasted coming to the location to provide the supervision, this will make difficult to handle the field. Lack of education and awareness among people living in the rural areas has resulted in their low access to new devices and technologies. These issues are even more pronounced in rural and remote areas, where farmers typically rely on manual processes and have limited access to modern technology. With advancements in automation and communication technology, smart irrigation systems offer a sustainable solution by ensuring that water is used only when and where it is needed. This project introduces an IoT-enabled smart irrigation system that can be controlled via SMS, making it suitable for areas with low internet availability. The system is designed to manage multiple fields individually, allowing farmers to irrigate different zones based on soil moisture conditions and crop requirements. A key feature of this system is automated dry run protection, which prevents the water pump from operating when there is no water flow thereby avoiding potential damage and energy loss. Another major functionality is timer-based irrigation management, where farmers can set specific watering durations for each field, reducing the risk of over-irrigation and ensuring consistent crop hydration.

II. LITERATURE REVIEW

Abdelmadjid Saadet et al. [8]. Having the ability to monitor water via sensors provides farmers the power to enhance the growth of the crops. The use of these sensors provides accurate and real-time information on different parameters related to water so that farmers can effectively intervene at the right moment. Having the ability to monitor water via sensors provides farmers the power to enhance the growth of the crops. The use of these sensors provides accurate and real-time information on different parameters related to water so that farmers can effectively intervene at the right moment. By this paper we conclude that enabling real-time monitoring through sensors, farmers can make timely and informed decisions, ensuring optimal water usage. This leads to healthier crops, increased yield, and more sustainable agricultural practices. Computer vision to scan crops and detect diseases in real time. This system minimizes the need for manual inspection and supports precision farming practice.

The survey by Srinath M S et al. [7]. Agriculture is the cornerstone of many developing economies, such as India, where a large percentage of the population relies on farming. traditional irrigation methods often result in excessive water consumption, inefficient resource utilization, and high labor dependency. In rural areas, the adoption of efficient water management practices is further hindered by a lack of education, awareness, and access to modern technology. Issues such as continuously running motors, manual supervision of irrigation gates, and poor scheduling contribute to significant water wastage and conflicts over water distribution. Based on the technological paradigms discussed earlier, several existing studies have been reviewed to understand the application of these technologies in agricultural water management. These studies highlight the effectiveness of IoT and automation in addressing key challenges.

Sreekanth Narendran et al. [1] propose a system where a server collects water monitoring data through a gateway, stores it in a database, and visualizes it using a web-based dashboard. The data is organized by timestamp, day, and week, allowing for structured analysis and monitoring. The introduction of IoT in agriculture has enabled intelligent, automated solutions that not only conserve water but also enhance crop productivity, offering a data-driven approach to sustainable farming practices. The server stores water monitoring data from the gateway and displays it on a web-based dashboard with time stamped tracking. IoT integration enables automated, data driven irrigation, improving efficiency and crop productivity. As referred in the paper, the server collects water monitoring data from the gateway, stores it in a database, and displays it through a web-based dashboard with timestamped logs. This IoT-based approach facilitates automated, data-driven irrigation, significantly improving water efficiency and crop productivity.

Thinagaran Perumal et al. \ [2] present an IoT network with supporting infrastructure and protocols for sustainable smart cities. Similarly, Micro Water Distribution Networks address sustainable water systems in Indian villages by considering local factors and challenges. Another study integrates IoT, cloud computing, and GPS for large-scale environmental monitoring with efficient data handling. Together, these works highlight the role of IoT, cloud, and localized design in advancing sustainable water management and environmental monitoring.

Gilroy P. Pereira et al. [6] highlight IoT-based smart irrigation using ESP32, sensors, wireless communication, and cloud dashboards, enabling remote control via apps or SMS. Shereen Ismail et al. [4] demonstrate a drip irrigation system that automates watering based on soil moisture thresholds, conserving water and energy while preventing over-irrigation. Advanced implementations add features like dry run protection, water level monitoring, and turbidity-based purification. Both studies emphasize efficient resource use and call for open agricultural data to support research and innovation. Kurniawan D. Irianto et al. [5] discuss the transition from manual to IoT-based irrigation, highlighting methods like subsurface and drip irrigation for efficient water use. While these systems improve water management in rural areas, challenges such as illiteracy, low digital literacy, and infrastructural gaps hinder adoption. Ritesh Kumar Singh et al. [3] propose a fog- and cloud-enabled irrigation system with SMS alerts, predictive modeling, and real-time monitoring of soil and water parameters. Their work stresses user-friendly design, farmer training, and policy support while integrating IoT, WSNs, and cloud computing to advance precision agriculture, reduce labor, and enhance global food and water security.

III. PROPOSED METHODOLOGY

The proposed irrigation system integrates automation, IoT connectivity, and safety features using STM32 and ESP32 microcontrollers. At initialization, the STM32 configures peripherals including soil moisture sensors, dry run sensor, float sensor, GSM module, and relay drivers. The ESP32 supports wireless communication and interfaces with the IoT-based mobile application. The GSM module registers with the nearest mobile network to enable SMS-based communication. Both controllers coordinate to process sensor inputs and external user commands. Soil moisture sensors continuously monitor field conditions in real time. Readings are compared against predefined thresholds to determine irrigation needs. If soil moisture falls below the limit, irrigation is triggered automatically. Farmers are offered two modes of interaction: SMS-based control and an IoT mobile application. SMS control ensures accessibility in rural regions without internet connectivity. Simple commands such as “PUMP ON” or “STATUS” enable direct SMS operation. The ESP32-based mobile app, built on MIT App Inventor, provides a user-friendly interface. Through the app, farmers can view sensor data, pump status, and activate irrigation remotely. This dual control mechanism balances simplicity with advanced usability. During irrigation, the STM32 activates relays to switch on pumps and control solenoid valves. Safety mechanisms ensure resource protection and equipment reliability. A dry run sensor halts the pump if it operates without water. A float sensor monitors storage tank or borewell levels to prevent dry pumping.

These safeguards reduce maintenance costs and extend pump lifespan. The system provides continuous feedback via SMS and IoT dashboards. Notifications include soil moisture data, water levels, and pump status. Once the required moisture level or timer cycle is achieved, irrigation stops automatically. The STM32 and ESP32 deactivate pumps and valves to prevent water and power loss.

Together, real-time sensing, remote communication, and automation enhance efficiency.

IV. HARDWARE AND SOFTWARE REQUIREMENTS

A. Electronic Parts

This setup includes: 1. STM 32 and ESP 32 – Captures real- time images of crops for disease detection. 2. Relays (×4) – Control switching operations for pumps and other peripherals. 3. GSM Module – Used for movement and navigation of the system.4. Water Pumps – Enable the water to flow through the irrigation

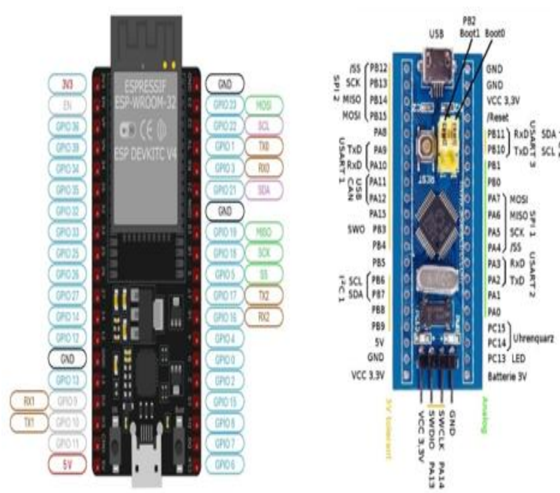

Fig. 1: Specifications of both STM32 and ESP32 board

land. 5. Dry run sensor Provides regulated voltage supplytcomponents. 6.Solenoid valve Control switching operations for pumps and other peripherals. 7. LCD display Distributes power to different circuit modules.8. Soil Moisture sensor Controls the DC motors for forward, backward, and directional movement.

B. Software

1. STM32 and ESP32 with Arduino IDE. 2. VS Code Editor – Used for writing and debugging the Python code for the system. 3. Flask Framework – Provides a lightweight web server to host the control panel. 4. Web Browser Interface – On running the program, a link is generated; opening it in a browser displays the control panel for monitoring and control.

V. DESIGN AND IMPLEMENTATION OF SYSTEM

A. Block Diagram

The block diagram of the IoT-Controlled Automated Multi-Field Irrigation System illustrates the integration of sensors, controllers, and communication modules for efficient irrigation management. At the core, the STM32 ARM Cortex-M3 microcontroller processes inputs from soil moisture, dry run, and DHT11 temperature-humidity sensors, while the GSM module enables two-way SMS communication, allowing farmers to operate the system even without internet access. In parallel, the ESP32 microcontroller provides Wi-Fi connectivity and links the system to an IoT-based mobile application, enabling farmers to monitor field conditions and ↔control irrigation through a graphical interface. Based on sensor data and farmer inputs, the STM32 controls the motor driver circuit to operate the pump and activates solenoid valves to distribute water to selected fields. Safety is ensured through the dry run sensor, which protects the pump from damage in the absence of water, and the soil moisture sensor, which prevents over-irrigation by triggering watering only when necessary. The DHT11 sensor supplies additional environmental data useful for crop management, while a regulated power supply ensures stable operation of all modules. Together, the STM32, ESP32, GSM, and sensor network form an automated, SMS- and IoT-controlled irrigation system that is water-efficient, reliable, and well-suited for multi-field farming applications.

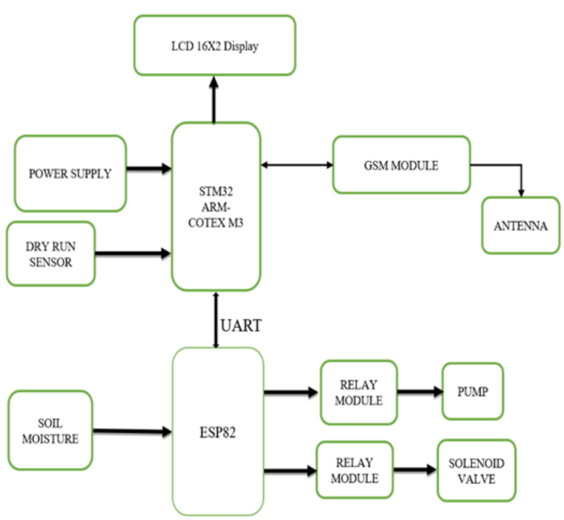

Fig. 2: Block Diagram of Model

B. Flow of the System

The flowchart of the Automated Irrigation System shows the sequence of decisions and actions that the system follows during operation. The process begins with system initialization, where the STM32 microcontroller activates all sensors and prepares the GSM module for communication. The farmer can then send an SMS command or use the mobile application to select a particular field and set the irrigation duration. Once a command is received, the first step is to check the dry run sensor to ensure that water is available. If the sensor detects that there is no water flow, the system immediately halts irrigation and sends an SMS alert to the farmer (e.g., "Irrigation failed: No water supply detected"), thus protecting the pump from damage.

If water is available, the system next verifies the soil moisture level of the selected field. If the soil is already moist enough, irrigation is skipped, and the farmer is notified (e.g., "Field 1 already has sufficient moisture, irrigation not required"). On the other hand, if the soil is dry, the system proceeds to activate the pump via the motor driver and opens the solenoid valve corresponding to the chosen field.

Suppose a farmer sends the SMS "Field 3, 20 minutes". The system initializes and checks the dry run sensor. If water is available, it checks the soil moisture in Field 3. Let's assume the soil is dry. The system then switches on the pump and opens the

solenoid valve for Field 3. Irrigation begins, and water flows to the field. After 12 minutes, the soil moisture sensor detects that the soil has already reached the optimal moisture level. In this case, the system automatically stops irrigation before the 20-minute timer completes, saving 8 minutes' worth of water. The farmer then receives an SMS stating "Field 3 irrigation stopped after 12 minutes moisture level adequate."

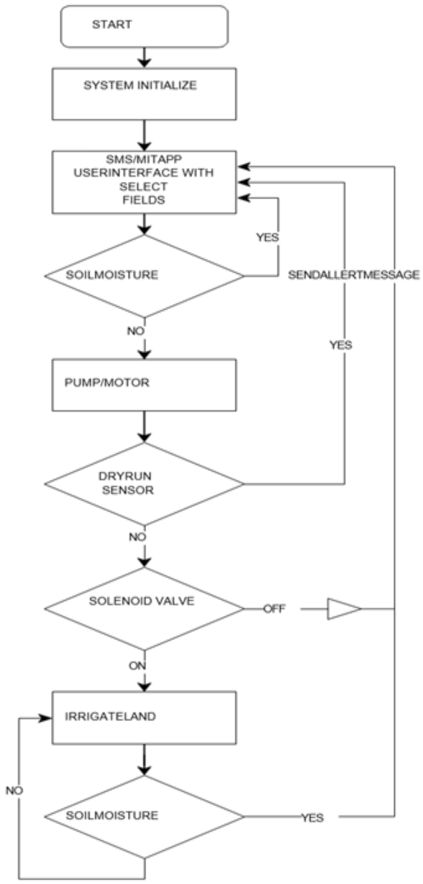

Fig. 3: Flowchart of the Model

The operation of the proposed irrigation system begins with the initialization of the STM32 microcontroller, ESP32 module, GSM unit, sensors, and associated peripherals. Once activated, the system awaits a command either through SMS sent by the farmer or through the IoT-based Android application. SMS commands are received via the GSM module over USART, while the ESP32 enables Wi-Fi-based connectivity to the mobile app, providing real-time monitoring of soil moisture, pump status, and water levels. Before irrigation starts, the system checks water availability using the dry run sensor; if no water is detected, the process is halted, an alert message ("Dry run detected, irrigation stopped") is sent to the farmer, and the system returns to idle. If water is available, the soil moisture sensor of the selected field is read. When moisture is sufficient, irrigation is skipped, and the farmer is notified via SMS and app update. Otherwise, irrigation begins with the STM32 activating the pump through the relay module and opening the solenoid valve of the chosen field. The system continuously monitors the process until either the preset timer expires or the soil moisture sensor detects adequate levels. Irrigation is then stopped automatically, with the pump and solenoid valve switched off, followed by a confirmation message ("Irrigation completed successfully") sent via both reverts to idle mode SMS and the mobile app. Finally, the system, awaiting the next SMS or app-based instruction.

VI. RESULTS

The implemented GSM and IoT-based automation system successfully demonstrated remote and manual control of electrical loads. The microcontroller efficiently communicated with both the GSM and Wi-Fi modules, responding accurately to SMS commands and web-based inputs. When a control message was sent through the GSM network, the respective relay was activated or deactivated as per the instruction, and the updated status was displayed on the LCD screen. Similarly, through the IoT interface, devices could be monitored and controlled in real-time using a web or mobile application.The system performed reliably in both Manual and Remote modes, with fast response time and stable communication between modules. The LCD provided clear operational feedback, and the 5V DC regulated power supply ensured consistent performance without fluctuations.Overall, the results confirmed that the designed system effectively integrates GSM and Wi-Fi technologies for smart device control and monitoring, offering a flexible, efficient, and user-friendly solution for home or agricultural automation.

VII. HARDWARE IMPLEMENTATION

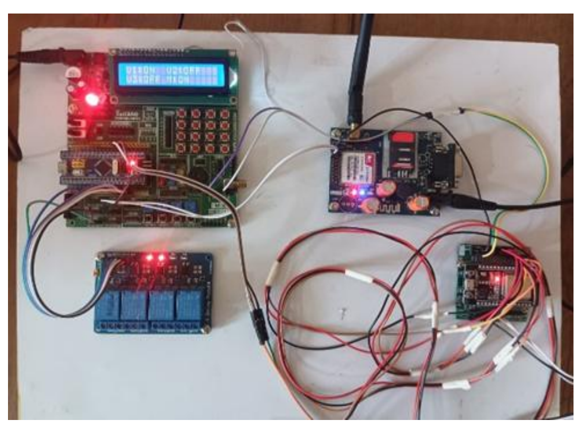

Fig.4: Hardware Components

This image shows the hardware implementation of the system consists of a various communication and control modules, including a SIM800L GSM module, an ESP32 Wi-Fi module, a 4-channel relay board, and a 16x2 LCD display. The central STM32/Arduino-compatible microcontroller serves as the main control unit that coordinates all modules and processes user commands.

The GSM module enables device control through SMS commands, allowing users to switch devices ON or OFF remotely using a mobile phone. Simultaneously, the Wi-Fi module connects the system to the Internet, enabling remote access via a web-based IoT interface or a mobile application. The relay module is responsible for controlling external electrical loads, such as home appliances or agricultural equipment, based on received instructions.

The LCD display provides real-time feedback of system operations, including device status (ON/OFF) and communication activity. This image shows the hardware implementation of the GSM and IoT-based automation system, where all modules are interconnected on a single platform. The system can operate in two modes: Manual and Remote, allowing control either through physical switches or wireless commands. Communication between modules is handled through serial and digital I/O interfaces, ensuring reliable data exchange and response. The setup demonstrates effective integration of embedded hardware and wireless technologies for smart device automation and monitoring application.

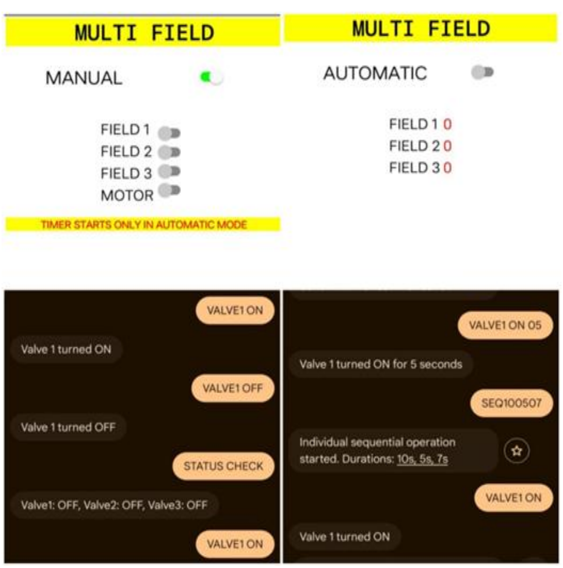

Fig. 5: Web Interface

VIII. CONCLUSION

Irrigation has been backbone of human civilization since man has started agriculture. The successful in building an IOT-enabled smart drip irrigation system. IoT platforms are real-time monitoring It provides an enhanced automatic feature, where if the soil is dry, the temperature is in the ideal range for maximum water absorption and with the safety features to prevent the over irrigation. This system is cheaper and efficient when compared to the other type of automation system. In large scale application, high sensitivity sensors can be implemented for large areas of agricultural lands. The system has an incorporated Bluetooth for remote monitoring which reduces the problem of range with GSM network and saves SMS costs for the farmer. The sensors used to send emergency information to user in case of fire in field or burning of motor. The design is low power, low costs, small size, robust and high versatile. It describes a general architecture of smart water monitoring systems, followed by a breakdown of the different applications associated with IoT-based water management systems by classifying those systems into residential, industrial, and agricultural. This work surveys state-of-the-art research proposed for IoT-based water management systems design. These directions have been investigated by the research community wand monitoring techniques relying on advanced technologies such as the Internet of Things (IoT), Wireless Sensor Network (WSN) and cloud computing. In the future, the ultra-sonic sensor could be replaced by precise water level sensor, so that the system can perform more reliably and gives higher accuracy of water level detection reading. Further improvisation would developing a custom dashboard using mobile app would be ideal for such application in consumer networks.

REFERENCES

[1] An Internet of Things (IoT) based Sustainable Water Management: Sreekanth Narendran, Preeja Pradeep, Maneesha Vinodini Ramesh IEEE 2017.

[2] Internet of Things (IoT) Enabled Water Monitoring System: Thinagaran Perumal 1, 1 Md Nasir Sulaiman, 2 Leong. Y 1 University Putra Malaysia, 2 Catrino, Malaysia, IEEE, pp

86-86, 2015.

[3] Agri Fusion: An Architecture for IoT and Emerging Technologies Based on a Precision Agriculture Survey: RITESH KUMAR SINGH, (Graduate Student Member, IEEE), RAFAEL BERKVENS, (Member, IEEE), AND MAARTEN WEYN, IEEE, pp 136253-136283,2021.

[4] IoT-Based Water Management Systems: Survey and Future Research Direction: SHEREENISMAIL (Graduate Student Member, IEEE), DIANA W. DAWOUD2, (Member, IEEE), NADHEM ISMAIL, RONALD MARSH1, AND ALI S. ALSHAMI, IEEE, vol 10, pp 35942 35952,2022.

[5] Design of Smart Farm Irrigation Monitoring System Using IoT and LoRa: Kurniawan D. Irianto Jurnal RESTI (Rekayasa Sistem dan Teknolog iInformasi) Vol. 6 No.1, pp 47-55, (2022)

[6] IoT-Enabled Smart Drip Irrigation System Using ESP32: Gilroy P. Pereira, Mohamed Zachary, Fawwad Daroge MDPI, pp 221-243 ,2023.

[7] GSM based Automatic Irrigation Control System for Efficient Use of Resource and Crop Planning by Using an Android Mobile: Pavithra D.S, M, S. Srinath IOSR –JMCE, pp 49-55, 2014.

[8] Water Management in Agriculture: A Survey on Current Challenges and Technological Solutions ABDELMADJID SAAD, ABOU EL HASSAN BENYAMINA1, AND ABDOULAYE GAMATIE, IEEE, Vol 8, pp 38082-38097, 2020.