Soil Moisture Sensed Auto Irrigation System

Bhumi Jadhav[1], Gayatri Gulbhele[2], Rajnandini Sonone[3], Sanika Pawar[4], Bhavesh Patil[5], Pravin Gawande[6]

1,2,3,4,5 Dept. of Electronics and Telecommunication Vishwakarma Institute of Technology(Kondhwa Campus)Pune, India

6Assistant Professor Dept. of Electronics and Telecommunication Pune, India Vishwakarma Institute of Technology (Kondhwa Campus) Pune, India

Abstract—The effective management of water in agriculture is an urgent and more extreme problem of worldwide water shortages and increasing requirements for food production. The following study gives the process of creating a soil moisture- sensitive auto irrigation system aimed at irrigating farmland based on actual real-time soil moisture dataThe device integrates a soil moisture sensor, a microcontroller, and a custom-made Printed Circuit Board (PCB) that scans soil conditions and controls a water pump in response. When the level of moisture in the soil drops below a predetermined level, the device switches the pump on, and switches it off when adequate moisture has been recovered. This not only minimizes manual intervention but also optimizes the use of water.The custom PCB design provides improved system reliability, wiring simplification, and compact integration appropriate for scale-up agricultural usage. Experimental test validates the utility of the system to ensure evenly controlled soil moisture levels, as well as the potential to promote improved irrigation efficiency in small- and large-scale agricultural uses.

Index Terms—Soil Moisture Sensor , Auto Irrigation System, Printed Circuit Board(PCB), real-Time Monitoring , Water Pump Control, Smart Agriculture,Precision Farming , Water Conservation .

I. INTRODUCTION

Agriculture is the mainstay of the economy of most coun- tries, offering livelihood, food, and development. Conventional irrigation, however, is wasteful, using too much water and man power. Climatic change and population pressure, creating fear of water scarcity, are the right moments to introduce sustainable use of resources in agriculture. Smart technologies, in particular smart irrigation systems based on real-time environmental information, hold the key. They maximize the efficiency of water use, reduce human intervention to a minimum, and promote green farming. Also, irrigation automation can allow farmers to maximize quality of yield, reduce operational cost, and minimize dependence on weather conditions that cannot be predicted. Use of precision farming equipment can also improve decision-making, con- serve natural resources, and improve the long-term sustainabil- ity of agriculture. This research recommends the creation of a Soil Moisture Sensed Auto Irrigation System, which will sense the water content in the soil electronically and regulate an irrigation pump based on predetermined levels. The system in- cludes a soil moisture sensor, a processing microcontroller, and a special PCB for the implementation of compact integration and reliability. The irrigation will be automatically activated when soil moisture falls below a critical level, providing water only when necessary. The modularity of the system increases its scalability, and it will accommodate several agricultural operations from small greenhouses to large open fields. With energy efficiency and with low energy requirements, the sys- tem is optimally suited to accommodate the implementation of renewable forms of energy such as the use of solar panels. With high durability and with low maintenance requirements, the project seeks to provide an energy-efficient and scalable system that accommodates sustainable agricultural systems and promotes the agenda for the implementation of smart agricultural systems.

II. RELATED WORK

Batur Ü retir (2022) suggested an automatic irrigation sys- tem based on a soil moisture sensor to optimize water con- sumption in agriculture. The system operates a water pump by real-time soil moisture data sensed with probes and regu- lated using an Arduino microcontroller. The project focuses on minimizing water wastage, reducing human labor, and assuring plant survival during droughty conditions. It calls for the necessity of smart, autonomous irrigation systems in sustainable agriculture[1].

Mishra Pratiksha S., Jadhav Kiran S., et al. (2021) suggested an automated irrigation system on the basis of soil moisture sensing, implemented through Arduino microcontrollers. Their system senses soil moisture in real time and automatically switches on a water pump to irrigate the land only when needed, thereby conserving water. The system incorporates low-cost sensors and electronic devices, hence cost-effective and adaptable for small and medium-scale farmers. They also emphasized the way automation in irrigation can lessen human labor, conserve energy, and enhance sustainable agriculture. Further research has demonstrated that incorporation of soil sensors into IoT-based systems further improves monitoring and remote control of irrigation operations.[2]

Sakshi Singh (2018) designed an automated irrigation system with Arduino, soil moisture sensors, and GSM modules to make the process of watering automatic based on real- time soil moisture levels. The system reduces water wastage and labor effort while optimizing the amount of water given to crops. It operates with solar energy powering the system and GSM technology to send notifications to farmers, making it incredibly efficient and sustainable for far-off agricultural lands.[3]

Harishankar et al. (2014) developed a smart solar-powered irrigation system employing solar panels to power water pumps and soil moisture sensors for the automatic irrigation of farms. The proposed design minimizes grid electricity consumption and water waste by controlling the supply of water according to soil moisture in real time. Stepper motors drive valves, thereby minimizing water usage and making the process eco-friendly and cost-efficient for farmers, especially for power-scarce regions.[4]

Muvva et al. (2022) created an automated irrigation system based on soil moisture to improve the efficiency of irrigation in agriculture. They have used a soil moisture sensor interfaced with an Arduino Uno microcontroller for operating a relay- based mini water pump to automate irrigation solely in low real-time soil moisture conditions. The system incorporates a 16×2 LCD display for monitoring the state of soil for proper irrigation on demand. Their findings showed a halfof decrease in water use from conventional systems, cost-efficient and scalable towards sustainable agriculture. Future technologies

such as home-scale water management and incorporation of soil health sensing are also indicated by the authors.[5]

In Vinay Kumar et al.(2022) work on a micro-irrigation system driven by automatic controls was envisioned making use of soil moisture sensors to maximize the use of water. The system was continuously monitoring soil condition and irrigating only when required, minimizing wastage of water significantly. Their model was energy-aware and used sig- nificant real-time feedback, hence most appropriate for arid regions. Wireless data transfer must be achieved, as maintained by the authors, in remotely monitoring. The research verified that automation of irrigation not only saved water but also enhanced yield and decreased labor.[6]

In the research of Sandeep Kumar and Kiran R.[2024],an irrigation automation system was devised to effectively control the water supply intelligently through the moisture level of the soil. Moisture sensors integrated with a microcontroller were used in their system for automation of watering in order to minimize human involvement. The system was predicted to deliver maximum efficiency in water use and lower operating expenses for farmers. Real-time monitoring and automatic pump control were key aspects of their design. The authors stated that such automation can go a long way toward sustain- able agriculture.[7]

Seyfi Akman et al.(2018) have created an Arduino Mega 2560, SIM900 GSM module, YL69 soil moisture sensor, LM35 temperature sensor, and L293D motor driver-based smart irrigation system. The system facilitates remote manage- ment of irrigation via smartphone application and a dedicated website. It regulates irrigation automatically based on feedback from soil moisture and temperature sensors, ensuring water efficiency and agricultural productivity. Real-time monitor- ing and manual operation using GSM technology provide increased flexibility and control to the user.[8]

Ragab et al.(2022) designed an intelligent irrigation system based on IoT using center pivot irrigation technology. The system combines real-time monitoring and control systems to automate irrigation activities depending on environmental conditions. Using IoT applications, the system improves the efficacy of water management, saving

labor costs, and provides data-driven information for farmers to make informed deci- sions. This method is consistent with sustainable agricultural practices through the optimization of resource use.[9]

In their research, Mothilal Tendulkar et al.(2017) developed an intelligent irrigation system to solve problems that farmers encounter, including water shortages and excessive electricity usage. The system employs solar power to reduce energy usage and a microcontroller to automate irrigation. Through the use of sensors and automation, the system will save water and reduce the use of grid power. This is a sustainable method of efficient water utilization in agriculture.[10]

Gandhimathi (2023) proposed an IoT-enabled smart irri- gation system where Arduino controllers and soil moisture sensors are used to make irrigation automatic. Soil moisture, temperature, and humidity are sensed real-time by the system, and it is routed to a cloud server for decision-making and control. It is proposed to cut down water waste, minimize human labor, and improve agricultural efficiency by making irrigation automatic based on sensor readings.[11]

Dr. Geetha S,(2022) in the article titled "Automatic Water- ing System using Soil Moisture Sensor and RTC Timer with Arduino," designed an automated watering system utilizing a soil moisture sensor and an RTC timer to detect soil moisture levels and plan for watering. The system is based on an Arduino microcontroller to read the data and operate a water pump, with the aim of achieving maximum plant hydration and minimizing wastage of water and labor in farming and gardening practices.[12].

H. Y. Truneh,(2021) in "Moisture Based Automatic Irrigation System," created an automatic irrigation system employ- ing soil moisture sensors and an Arduino Uno microcontroller to sense soil moisture. The system turns on a relay to turn on a water pump when the soil is dry and turns off the pump when the target moisture level is achieved. It is a water-saving system that minimizes manual labor and is cost-effective and flexible to implement by small-scale farmers in Ethiopia.[13]

K. G. M. R.(2020) , in "Automatic Irrigation System Using Soil Moisture Sensor," designed an automatic irrigation system utilizing a soil moisture sensor to monitor soil moisture content and regulate irrigation

using real-time data. The system employs an Arduino microcontroller to energize a submersible pump in case the soil moisture level drops below a predeter- mined level, with the objective of maximizing water usage and minimizing wastage in agricultural use by automatically carrying out the irrigation.[14]

Rhuanito Soranz Ferrarezi, Sue K. Dove, and Marc W. van Iersel(2015)designed a low-cost, open-source automated irrigation system for use on container-grown plants. They used soil moisture sensors to measure the substrate water content and programmed low-cost microcontrollers to regulate irrigation valves as a function of real-time moisture content. Their irrigation scheduler is automated to optimize water use, reduce labor, and provide optimal growing conditions for plants, showing how inexpensive technology can improve precision farming.[15]

Srilikhitha, M. Manoj Saikumar, Nannu Rajan, M. L. Neha, and M. Ganesan (2017)constructed an autonomous irrigation system using soil moisture and temperature sensors that are regulated by the AT89S52 microcontroller. The system senses environmental conditions and checks them against pre-defined values to switch a relay that provides power to a water pump and hence automate the irrigation process. Real-time data is provided to the user in the form of an LCD display, and an SMS message for the motor status is sent through a GSM module. This strategy seeks to reduce wastage of water and manual handling with a cost-saving mechanism especially in water-scarce areas. [16]

J.Gutie´rrez,(2014) implemented an automated irrigation sys- tem using a wireless sensor network (WSN) and GPRS mod- ule. The microcontroller receives input from the soil moisture and temperature sensors and controls the irrigation valves. Solar panels provide power supply with remote monitoring using web application and water savings up to 90 percent in field tests.[17]

Apoorva Joshi and Layak Ali (2017) have developed an in- telligent irrigation system using soil moisture and temperature sensors and an Arduino microcontroller. The system measures environmental conditions and controls a water pump according to threshold values defined in advance, optimizing water use effectively. The system also provides a GSM module to send real-time

notifications to users, enhancing remote monitoring capabilities. This technique aims to limit the degree of human input and water wastage and offers an economic solution to precision agriculture.[18]

A.N Samanta(2017) designed an automated irrigation system using Arduino Uno regulator board, soil humidity detector, DHT11 temperature and moisture detector, relay module, and water pump. The external terrain and soil humidity position are tasted and controlled continuously, wherein the water pump is automatically turned on whenever the soil humidity position falls below a certain value. The stoner is given detector input feedback and system operating status via an TV display for interactive stoner input. The process is made to save water and minimize labor in agrarian processes.[19]

Mahir Dursun and Semih Ozden(2011) created a wire- less drip irrigation system using soil humidity detectors to automate irrigation processes. It consists of three units base station unit(BSU), stopcock unit(VU), and detector unit(SU). Solar- powered wireless accession stations are employed for data accession in a way that enables real- time monitoring and control of the irrigation faucets. It not only suppresses humidity stress in crops but also promotes effective use of brackish coffers and decreases labor application in irrigational operation.[20]

III. COMPONENTS REQUIRED

This is the List of Electronics Components we have used for the Prototype :
1) Atmega328p
2) Soil Moisture Sensor
3) Relay Module
4) Motor
5) OLED Display
6) Power Supply (5v)
7) PCB (Kicad)
8) crystal Oscillator
9) Connecting Wires and Resistors

IV. METHODOLOGY

The design of the Soil Moisture Sensed Auto irrigation System follows A systematic process that includes hardware integration, software programming, and system testing.The approach can be broken down into a number of major stages:

A. Requirement Analysis:
the first step involves identifying the essential components required the system . This Includes :
1) *Soil Moisture Sensor:* - It detects the moisture in the soil .
2) *Atmega328p:* - It process sensor data and control the pump .
3) *relay Module:* - it act as a switch for Controlling the water pump.
4) *Printed Circute Board:* - it is used to integrate all components in a compact and efficient layout .
5) *Power Supply:* - for stable operation of all components.

B. System Design:
A block illustration was created to define the control signal and information inflow between factors. The PCB was created using PCB design software(KiCad) similar that there was correct signal routing and power force connections to every module.
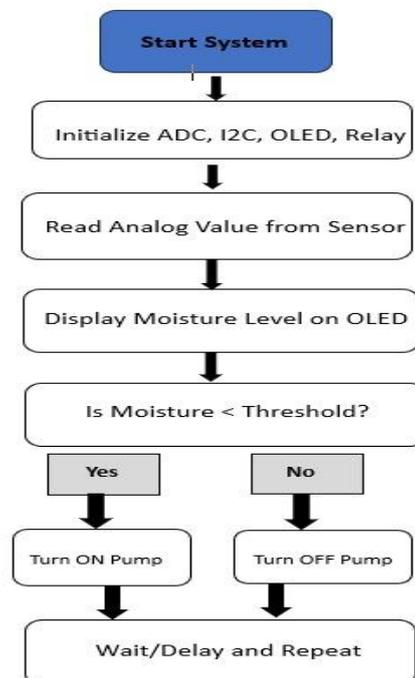
C. Hardware Implementation:
The entire tackle was erected on a breadboard to first test it. After testing the circuit, the entire design was erected on a especially designed PCB. The soil humidity detector was fitted into the soil sample, and the water pump was connected through the relay to use it with electrical insulation and safe operation.
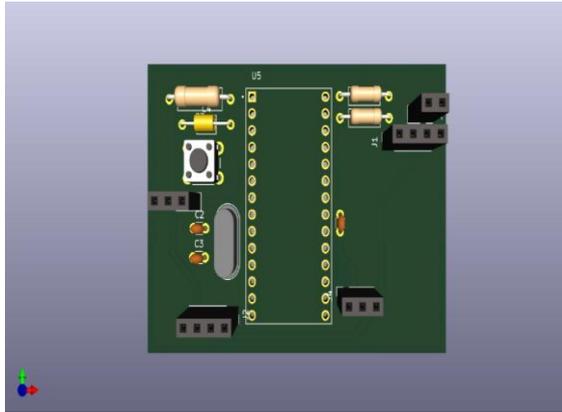
D. Software Development:

The ATmega328p microcontroller was programmed with Arduino IDE. The law continuously reads the humidity sit- uations and compares them with a set threshold. When the humidity position goes below the threshold, the microcon- troller turns off the relay to spark the pump. Once the asked humidity position has been attained, the pump is switched off automatically.

E. System Calibration and Testing:

The system was later tested for trial several times on different soils after installation to test its delicacy and response time. The soil humidity detector was calibrated so that its digital affair nearly approached the factual soil humidity content.Based on the results of tests, the activation time of the water pump along with the humidity threshold values situations were optimized for best performance..

F. Performance Testing and Optimization:

A complete analysis was done to test the system's efficiency, power operation, and long- term lifetime. It was optimized for minimizing hindrance from detectors, solidifying the tackle for increased ruggedness, and maintaining regular performance under nonstop operation..

V. RESULT

A. System Functionality

The pump could be driven or stopped effectively in real time using the sensor to measure soil moisture levels accurately and react to them accordingly by switching the pump on or off. When soil moisture fell below the pre-selected upper threshold level the pump was activated automatically. The pump was turned off when the moisture level climbed above the established upper limit value with no over-irrigation taking place.
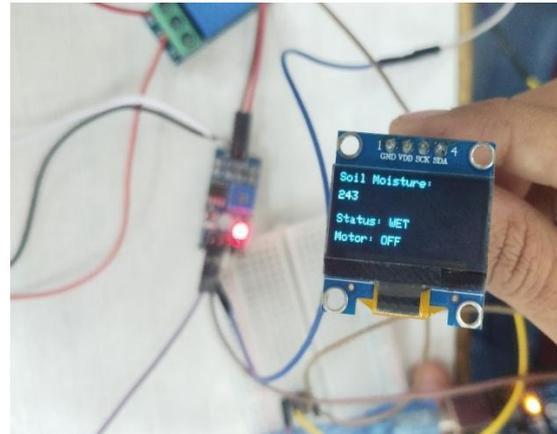
B. Water Conservation

Experimental trials proved that the system reduced water consumption by significantly larger amounts compared to traditional manual watering systems. An average of around 25–35 percent of water was saved on a regular basis, indicating the ability of the system to enable sustainable agriculture.

C. System Stability and Accuracy

Repeated testing across several days reflected steady perfor- mance with no malfunctioning or spurious triggering. Read- ings from the sensor were reliable, with the detection of moisture varying by as little as ± 2 percent when in constant conditions. This reinforces the accuracy of the sensor control logic and calibration.

D. User Interaction

As the system is completely automated, human intervention was never required in testing stages. The users simply had to fill the water reservoir and provide power to the system, which is reflective of ease of operation and minimal maintenance needs.

VI. CONCLUSION

The Soil Moisture Sensed Auto Irrigation System proposed in this work effectively meets the urgent requirement of effec- tive and automatic water management in agriculture. Utilizing a soil moisture sensor, ATmega328p and a specially designed PCB, the system provides real-time observation of the soil and automatic irrigation according to real moisture content. This method not only saves water but also lessens manual effort, making it an economical option for farmers, gardeners, and agriculture experts who want efficient irrigation. Results from experimental testing prove that the system is well-functioning under different conditions, saving water

and ensuring the ideal soil moisture for plant growth. Despite limitations in the existing model, it is a strong base for future developments like IoT integration, solar panels. Overall, the project is a valuable addition to the developing area of smart agriculture and presents a low-cost, scalable, and eco-friendly solution for the irrigation challenges of the modern age.

VII. ADVANTAGES

1) *Efficient Water Use:* -The system provides water only when necessary, minimizing water waste and enabling sus- tainable management of resources.

2) *Automation and Manpower Reduction:* - Through the automation of irrigation, the system avoids unnecessary man- ual monitoring and control, conserving time and manpower for farmers and gardeners.

A. PCB Integration
The custom-designed PCB minimizes wiring clutter, en- hances system stability, and allows for compact and reliable operation, making it ideal for long-term deployment.

B. Energy Efficiency
The system only runs when needed, saving energy by not continuously running the pump.

C. Cost Effective
With the use of easily available components and an opti- mized circuit design, the system as a whole is cost-effective and within reach for small farmers.

D. real-time monitoring
Ongoing real-time monitoring of soil conditions ensures optimal moisture levels, supporting healthier plant growth and increased crop yields

VIII. FUTURE SCOPE

To enhance the system's capability and applicability, several improvements and extensions can be considered in future development:

A. IoT Integration
Integrating IoT modules (Wi-Fi, GSM, or LoRa) for remote monitoring, data logging, and mobile application notifications.

B. Weather Forecasting Integration
-Utilizing APIs or sensors to retrieve weather information to smartly delay or trigger irrigation depending on forecasted rainfall.

C. Machine Learning Algorithms

Utilizing AI models to learn the best irrigation patterns in relation to crop, soil, and environmental conditions.

D. Solar Power Support
Utilizing solar energy as a secondary power source to make the system self-sustaining and environmentally friendly.

IX. ACKNOWLEDGMENT

REFERENCES

[1] B. Üretir, "Automatic Irrigation System using Soil Moisture Sensor," Thesis, Muğla Sıtkı Koçman University, Aug. 2022, DOI: 10.13140/RG.2.2.19913.62564.

[2] Pratiksha S. Mishra, Kiran S. Jadhav, and Omkar D. Bhawane, "Au-tomatic Irrigation System Using Soil Moisture Sensor and Arduino,"International Journal of Innovative Research in Electrical, Electronics,Instrumentation and Control Engineering (IJIREEICE), vol. 9, no. 5,pp. 51–54, May 2021

[3] S. Singh, "A Research Paper on Automatic Irrigation System," Journalof Emerging Technologies and Innovative Research (JETIR), vol. 5, no.8, pp. 83–87, August 2018.

[4] S. Harishankar, R. Sathish Kumar, S. K. P., U. Vignesh, and T. Vivek-nath, "Solar Powered Smart Irrigation System," Advance in Electronicand Electric Engineering, vol. 4, no. 4, pp. 341-346, 2014.

[5] K. R. Muvva, R. K. Akurathi, H. Kadali, and S. J. Damacharla, "SoilMoisture Content Based Automatic Motor Pumping for Agriculture,"Journal of Emerging Technologies and Innovative Research (JETIR),vol. 9, no. 8, pp. 1–4, Aug. 2022.

[6] V. Kumar, R. Babu, and R. Srinivas, "A study

on automated microirrigation using soil moisture sensors," ResearchGate, 2022.

[7] S. Kumar and K. R., "Automatic irrigation system," ResearchGate, 2024.

[8] S. Akman, "Smart irrigation system," Proc. Int. Conf. Electrical andElectronics Engineering (ICEEE), 2018.

[9] M. A. Ragab, M. M. Badreldeen, A. Sedhom, and W. M. Mamdouh,"IoT based smart irrigation system," Int. J. Ind. Sustain. Dev., vol. 3,no. 1, pp. 76–86, 2022.

[10] M. Tendulkar, P. Malaravan, J. Jerald S, M. C, and S. Mahendran,"Smart Irrigation System," Int. J. Innov. Res. Technol., vol. 3, no.10, pp. 1–5, 2017.

[11] Gandhimathi, M., "Smart Irrigation System Based on Soil MoistureUsing IoT," Journal of Emerging Technologies and Innovative Research,vol. 10, no. 3, pp. 59-60, Mar. 2023.

[12] Dr. Geetha S, Dr. Y. Asnath Phamila, P. Vaishnavi, Y. Lakshmi SaiCharitha, T. Jayasri, Manchikanti Bhumika, and Nelakurthi SudheerKumar, "Automatic Watering System using Soil Moisture Sensor andRTC Timer with Arduino," International Journal of Advanced Researchin Science, Communication and Technology (IJARSCT), vol. 2, no. 1,pp. 55-60, Feb. 2022.

[13] H. Y. Truneh and T. M. Balcha, "Moisture Based Automatic IrrigationSystem," Global Scientific Journal, vol. 9, no. 8, pp. 927-930, Aug. 2021.

[14] K. G. M. R., S. Mahin, N. K. L., M. A. B. I., and S. S., "Au-tomatic Irrigation System Using Soil Moisture Sensor," Institute ofScholars (InSc), 2020.

[15] R. S. Ferrarezi, S. K. Dove, and M. W. van Iersel, "An AutomatedSystem for Monitoring Soil Moisture and Controlling Irrigation Using Low-cost Open-source Microcontrollers," HortTechnology, vol. 25, no.1, pp. 110–118, Feb. 2015, doi: 10.21273/HORTTECH.25.1.110.

[16] Srilikhitha, M. M. Saikumar, N. Rajan, M. L. Neha, and M. Gane-san, "Automatic Irrigation System using Soil Moisture Sensor andTemperature Sensor with Microcontroller AT89S52," in Proceedingsof the 2017 International Conference on Signal Processing and Com-munication (ICSPC), Coimbatore, India, 2017, pp. 186–190, doi:10.1109/CSPC.2017.8305835.

[17] J. Gutiérrez, J. F. Villa-Medina, A. Nieto-Garibay, and M. A. Porta-Gándara, "Automated Irrigation System Using a Wireless Sensor Network and GPRS Module," IEEE Transactions on Instrumentation and Measurement, vol. 63, no. 1, pp. 166–176, Jan. 2014, doi:10.1109/TIM.2013.2276487.

[18] A. Joshi and L. Ali, "Smart Irrigation System Using Arduino and GSM Module," in Proceedings of the 2017 International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS),Chennai, India, 2017.

[19] A. N. Samanta, M. Halder, T. Dhank, S. Roy, G. K. Das, and J. Datta,"Auto Irrigation System Using an Arduino Uno and Soil Moisture Sensor," American Journal of Advanced Computing, vol. 2, no. 2, pp.1–6, Dec. 2023.

[20] M. Dursun and S. Ozden, "A wireless application of drip irrigation automation supported by soil moisture sensors," Scientific Research andEssays, vol. 6, no. 7, pp. 1573–1582, Apr. 2011.