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IOT-BASED REAL-TIME SMART DRIP IRRIGATION MONITORING AND CONTROL SYSTEM USING ESP32 MICROCONTROLLER

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ABSTRACT
The conventional irrigation methods for agricultural land necessitate human involvement. Irrigation technology that is automated can reduce the amount of human interaction. The primary goal of this project is to give farmers access to an automated irrigation system that will save them time and money. The sensor uses a widely used technology known as the "Internet of Things" to detect changes in the soil's humidity and autonomously water the area. By automating farm operations, the agricultural sector can become intelligent and dynamic instead of manual and static, increasing output while requiring less human oversight. A shared network of objects or things that can communicate with one another and offer internet connectivity is known as the Internet of Things (IOT). The suggested drip irrigation system uses an IOT web server in conjunction with soil moisture, temperature, and humidity sensors. The two operating modes of the suggested system are manual and automatic. If one of the soil moisture sensors indicates that the soil is dry, the pump will automatically switch on; if all of the soil moisture sensors in the field indicate that the soil is wet, the pump will automatically turn off. Regardless of whether the soil is wet or dry, we can use a web server to operate the irrigation pump in manual mode. Data can also be sent to the web server via the ESP32 micro controller. A web application is used to read and analyze data from the web server. Control commands are then transmitted to the micro controller via the internet. Using 16*2 and IOT web server modules, each project status is shown on an LCD. The Arduino IDE program is used to design the suggested system with an ESP-32 microcontroller. The ESP32 microcontroller is controlled by a 5V regulated power source.
Keywords: ESP-32 Microcontroller, IOT-Web server, Soil Moisture Sensor, Temperature and Humidity Sensor, Irrigation Pump, Drip irrigation System.

1. INTRODUCTION
With a population of over 1.2 billion and growing daily in India could face severe food shortages in 25 to 30 years, necessitating the growth of agriculture. Due to the absence of rainfall, farmers now face the challenge of water scarcity. The primary goal of this project is to give farmers access to an automated irrigation system that will save them time and money. As technology develops, there's always an opportunity to lower hazards and simplify tasks. Micro controller and embedded systems solve a lot of issues. A sensor microcontroller system is used in this application to accurately regulate the water system for gardens. Installing sensors to track soil moisture and temperature in the field does this.

Fig.1. Drip Irrigation System

In order to run an irrigation system and repair water as needed while reducing unnecessary water use, smart irrigation systems calculate and measure the amount of moisture already present in the plants. A moisture sensor in an intelligent automatic plant irrigation system focuses on watering plants on a regular basis without human supervision. An operating amplifier (Op-amp) comparator and a timer are the main components of the circuit, which activates a motor by driving a relay. The hardware used by the system is susceptible to change depending on the surroundings. The necessity of smart irrigation may be questioned. When irrigation is done by hand, the amount of water that plants or crops need is not tracked. Water remains available even when the soil is sufficiently moist. Since the plants don't absorb this water, it is a waste. Thus, a mechanism is employed to track the water needs. For a plant requirement, software can be used to modify and optimize many components of the system. The system made use of a variety of components that are, nonetheless, simple to utilize. Following collection, this data is routed to a cloud server where machine learning techniques might be applied. To improve efficiency and reduce waste, the system uses the study to determine whether to raise the water flow rate or the watering schedule. A more efficient use of the water resources that are available and less waste could emerge from the system using this information to make well-informed decisions regarding when and how much water to discharge. New methods in a number of fields have been made possible by recent technological advancements. There are now more options to automate previously unattainable aspects of human existence as IoT development has progressed. A smart irrigation system is one example, In addition to reducing unnecessary water use and increasing crop yields and plant health, this also optimizes efficiency by supplying water at the exact moment it is required. Smart irrigation systems with IoT capabilities offer a state-of-the-art solution to the conventional issues with water management that farmers have traditionally faced. These devices combine sensor data, weather data, and advanced control algorithms to maximize water consumption, conserve resources, and increase agricultural productivity. Intelligent irrigation systems will be increasingly crucial in advancing environmentally conscious farming practices as research and engineering advance.

The goal A smart irrigation system improves the effectiveness and efficiency of the irrigation process by utilizing data-driven decision-making and Internet of Things (IoT) technology. The suggested drip irrigation system uses an IOT web server in conjunction with soil moisture, temperature, and humidity sensors. The two operating modes of the suggested system are manual and automatic. If one of the soil moisture sensors indicates that the soil is dry, the pump will automatically switch on; if all of the soil moisture sensors in the field indicate that the soil is wet, the pump will automatically turn off. The need to produce more food to meet the demands of a growing world population has put a great deal of strain on water supplies. Water shortage is becoming a major issue in the agricultural industry, necessitating the development of more durable and efficient irrigation techniques. The solution to this issue may lie in smart irrigation systems made possible by the Internet of Things (IoT).

2. LITERATURE SURVEY

For the socioeconomic development of many nations, agriculture is the most crucial industry. To irrigate their land, farmers and gardeners rely on bore wells and rainfall. Growing houseplants is a popular pastime and health benefit for many urban dwellers. Researchers [1] have proposed that indoor plants can boost worker productivity in offices. But because of their hectic schedules, they can't water their houseplants when they're on vacation or when they're on holiday. Additionally, water is unintentionally wasted when it is used without planning. Keeping plants alive and adequately watered is an issue that office workers, farmers, and gardeners all face. Turning on and off a manual water pump when necessary requires human intervention while watering plants. They must pause other crucial tasks in order to pump water and wait for the soil to be adequately irrigated. An IoT-based automatic watering system that only waters plants when the soil's moisture content is determined to be low can completely eliminate this issue. Significant water and energy savings as well as lower irrigation costs can result from this [2][3]. Through the use of sensors to measure soil moisture and water level, this project employs a microcontroller to regulate the water flow. The soil moisture sensor signals the microcontroller based on the soil's moisture content. If the plants need water, the water motor irrigates them until the ideal moisture content is achieved. In addition, the system can send the owner an SMS alert in the event that the main water supply is running low. Not only will this automatic watering system help farmers and home gardeners water more effectively, but it will also function in every climate. Numerous researchers have worked on automated irrigation systems since the Internet of Things (IoT) has taken center stage in their attention. To improve irrigation systems or address current issues, numerous researchers have proposed a variety of automated irrigation systems [4, 5, 6]. The Internet of Things (IoT) security, automatic self-watering systems, and other shortcomings in IoT technologies have all been examined by the researchers in [7]. Soil moisture sensors and a lightweight Raspberry Pi 3 Model B have been used. They determined that it is crucial to pay closer attention in order to assure security and talked on the most recent developments in IoT system deployment for irrigation and agricultural management. In order to control crop irrigation, the researchers have also proposed a 4-layer architecture. The study in [8] has mostly concentrated on enhancing agricultural fields by offering a wirelessly connected, low-cost monitoring system for the efficient and successful utilization of water resources. In order to create the system, an Arduino Controller was used, along with a distributed sensor network that was constructed using sensors for water level, temperature, humidity, and soil moisture. The data is posted to the cloud server by the Arduino controller after it has read the values from the sensors. Additionally, Dinio et al. [9] have presented an irrigation method that uses three (3) distinct sources: pond water, groundwater, and fertigation. It is an irrigation scheduling system that also controls flow. The control system's PCB has an Arduino female header that serves as a connection hub for external wire, including solenoid valves and Arduino. In comparison to manual irrigation, the system's average error rate is 3.86%, which is relatively low when taking plant irrigation variation into account. In [10] An Internet of Things (IoT)-based automatic watering system that can address all the issues has been suggested in this study after a thorough analysis of all the aforementioned watering systems in earlier research. The goal of this project is to automatically regulate the water supply and save water for plants of all sizes. People can take pleasure in cultivating plants without worrying about forgetting or taking a vacation. To ensure that the plants are never dehydrated and to alert the owner to water leaks in the supply system, this system can only provide water when necessary. Using data from a variety of sources, including satellite imagery, ground sensors, and weather models, the system produced accurate projections. The method might reduce water consumption by up to 50% and boost crop yield by up to 30%, the study found. A survey of the many kinds of smart irrigation systems and their parts was provided in the "Smart irrigation system" review paper by Zaman et al. (2020) (see [11]). This article covers several types of sensors, including weather sensors and soil moisture sensors. A more efficient use of the water resources that are available and less waste could emerge from the system using this information to make well-informed decisions regarding when and how much water to discharge. New methods in a number of fields have been made possible by recent technological advancements. There are now more options to automate previously unattainable aspects of human existence as IoT development has progressed. A smart irrigation system is one example, which use Internet of Things (IoT) sensors to precisely manage and control crop and plant watering [12]. These devices combine sensor data, weather data, and advanced control algorithms to maximize water consumption, conserve resources, and increase agricultural productivity. Intelligent irrigation systems will be increasingly crucial in advancing environmentally conscious farming practices as research and engineering advance. An intelligent irrigation system's goal is to achieve the best potential plant growth and health. Because the technology delivers the right amount of water at the right time, it helps reduce plant stress, disease, and decreased output caused by under- or over-watering. A steady, optimal soil moisture content is beneficial to plants and crops. With smart irrigation systems, we can precisely target the root zone, perhaps achieving "precision watering." The irrigation system may be operated remotely, which makes things easier and more convenient. Power consumption reduction is another goal of smart irrigation systems. Utilizing sensor data and intelligent algorithms, the system can turn on irrigation systems, water pumps, and valves only when necessary, significantly reducing energy expenses. This objective is in line with environmentally responsible practices and end-user savings [13]. Traditional irrigation methods have negative effects on the environment, utility costs, and water waste. When applied to irrigation systems, IoT can provide a number of benefits. Environmental indicators such as soil quality and water consumption are recorded by smart irrigation systems. Water demand forecasts, irrigation strategy optimization, and pattern detection are just a few of the applications for which this data may be utilized [14]. This information helps landscapers and farmers make better decisions, use resources more wisely, and boost output.

3. EXISTING SYSTEM

The majorities of current systems do not account for the threshold moisture value and water the field at random intervals, which results in either excessive or insufficient field irrigation, which ultimately impacts crop output. Some situations have a fixed moisture threshold, which has additional drawbacks. It is suggested that soil moisture be monitored and that irrigation be carried out only when the moisture content falls below a certain threshold.

A suggested prototype that aims to save time and prevent issues like continual monitoring is required. By automatically giving plants or gardens water based on their needs, it also contributes to water conservation. There is always the possibility of lowering hazards and simplifying labor as technology develops. Systems with embedded and micro controllers can solve a variety of issues. Farmers must follow a schedule for irrigation under the proposed system, which varies depending on the crop, soil, and weather. Precision agriculture and water management can only be achieved with a web-based intelligent drip irrigation system. Because the entire system is web-based and microcontrol based, it can be operated remotely, eliminating the need to worry about when to water based on crop or soil conditions. In order to allow the user (farmer) to make decisions, a micro controller is utilized to collect sensor readings of the soil, such as soil moisture, temperature, air moisture, and light. With a web-based intelligent irrigation system, farmers may make decisions about how to manage water on their farms without having to keep track of irrigation schedules.

4. PROPOSED SYSTEM

An automated plant watering system is developed to optimize water utilization for agricultural crops. For agricultural crops, an automated plant watering system is created to maximize water use. In the root zone of the plants, a dispersed wireless network of soil moisture sensors is part of the system. They decide how much water needs to be provided based on the threshold value. They have experience with irrigation or water spraying systems that operate automatically. To ascertain the amount of water and the state of the soil, they chose to use various metrics. An automated water supply system for residential metropolitan areas shown that water resources can be efficiently managed with such a system. With the use of a soil moisture sensor, this "Smart plant watering system" is designed to provide an automatic irrigation system that, without human assistance, switches the pumping motor on and off in response to the earth's moisture content. These methods are very practical and reasonably priced, and they have the advantage of reducing human influence. An ESP-32 microcontroller is used in this smart plant watering system project. It is configured to receive input signals based on the soil's moisture content and output those signals to a mobile app that controls the pump. The IOT-WEB's suggested methodology Because there is no unforeseen water use, controlled smart intelligence soil moisture control and automated plant watering reduce the amount of physical labor required by the farmer.

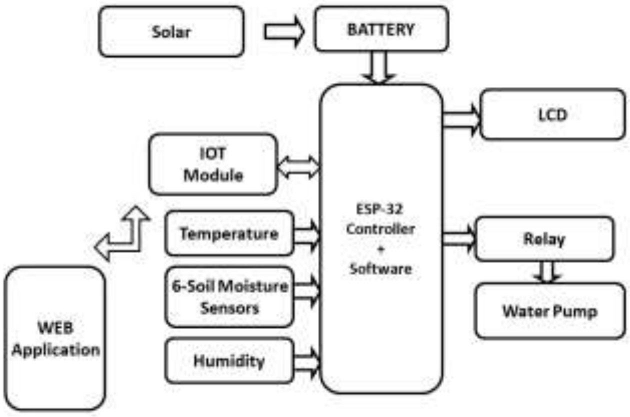

Fig.2. Proposed block diagram

WORKING MODEL:

An IOT web server and sensors for soil moisture, temperature, and humidity are used in the suggested drip irrigation system. The suggested system can operate in both manual and automatic modes. When operating in automatic mode, the pump will automatically switch on if any one of the soil moisture sensors indicates that it is dry, and it will automatically turn off when all of the field's soil moisture sensors indicate that it is wet. In manual mode of operation, we can use a web server to regulate the irrigation pump regardless of how wet or dry the soil is. The data can also be sent to the web server by the ESP32 micro controller. Web applications allow for the reading and analysis of data from the web server, followed by the transmission of control orders to the micro controller via the internet. The IOT web server modules and 16*2 LCD monitor each project status. The Arduino ide program is used to design the suggested system with an ESP-32 microcontroller. To operate the ESP32 microcontroller, a 5V regulated power source is utilized.

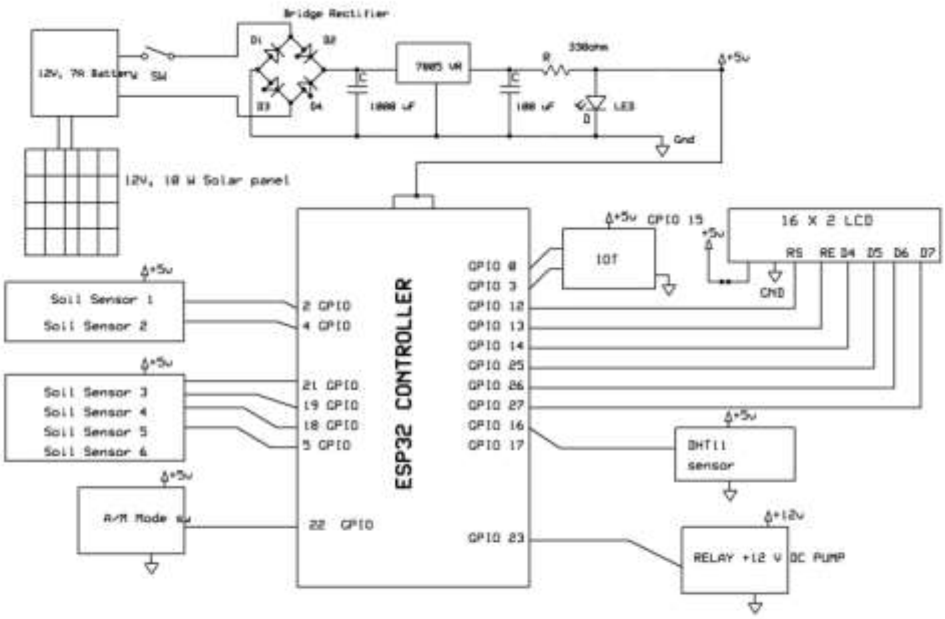

Fig.3. Proposed Circuit diagram

In this project we are using ESP-32 Microcontroller. It has total 30 pins. The 230v Ac is converted into 5V of DC.IOT modules is connected to 0^{th} and 1^{ST} pins of GPIO, LCD Module connected to GPIO 12, 13, 14,25,26,27 pins. DHT sensor connected to GPIO16th. Relay and pump motor connected to 23^{rd} pin GPIO. Mode switch is connected to 22^{nd} pin of GPIO. 6 Soil moisture sensors connected to 2, 4, 21, 19,18,5 pins of GPIOs. This proposed model is solar power based operating system. 12V solar panel connected to 12V Battery and then converts to 5v dc and executes the system.

3.1 Hardware Requirements: Any operating system or software program's most typical set of needs is for the hardware, or actual computer resources. A list of hardware compatibility is frequently included with a list of hardware requirements.

- soil moisture sensors
- Relay
- Power Supply
- ESP-32 Microcontroller
- 12v dc Pump
- DHT Sensor

3.2 Software Requirements: establishing the software resources and prerequisites that must be installed on a computer in order to optimize an application's functionality is the focus of software requirements

- IOT-WEB Server
- Arduino IDE Compiler
- Embedded C

5. RESULTS

Fig.4. Drip irrigation field setup

Figure 4 demonstrated that acquiring the agriculture land and ploughing land to make irrigation setting up. Aquired 100 Square feet Area and neatly setup plant growing irrigation model using bricks and soil.

Fig.5. Field Planting setup

Figure 5 demonstrated that acquiring the agriculture seed and plant types for irrigation. Planted all seeds and some live plants. Regularly sprinkle water and pesticides to the plants. After 7 Irrigation model set up came out.

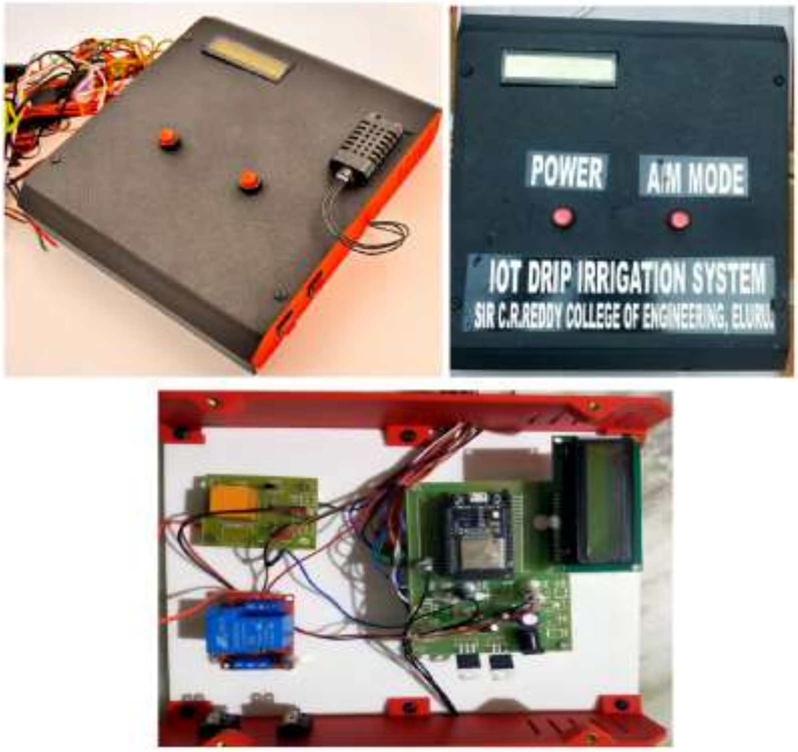

Fig.6. IOT- Drip irrigation Micro Control Unit

Figure 6 explains that micro control unit for complete drip irrigation system. This is the mother board to the entire project. This MCU continuously monitor the irrigation field water threshold levels and automatically, manually controls the irrigation pump. All the 6 soil sensors data, temperature and humidity data will be post into IOTWEB server for Real time Monitoring and controlling .

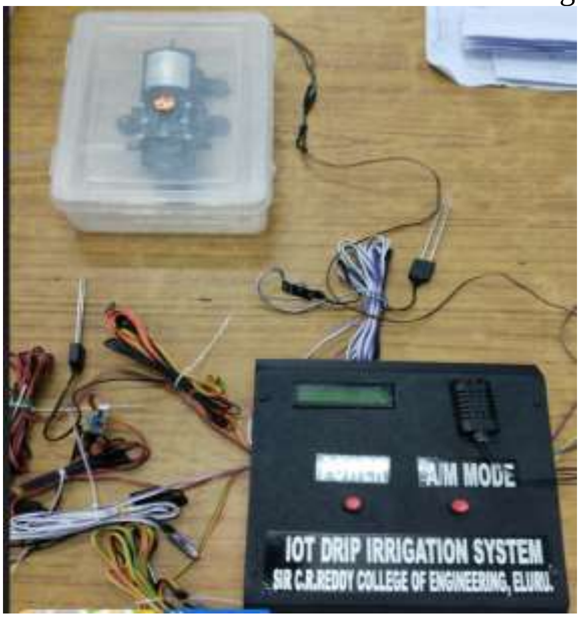

Fig.7. Proposed Output model

Figure.7. Proposed Output model describe that final output module with Microcontroller unit, Input Sensors and Output Pump. All sensors will be dipped at the roots of the plants. Sensor data will be post on LCD and server. Depends on the mode and sensor data Pump will be automatically turn ON and OFF

Proposed system with output controlled Irrigation Pump.

Fig.8. Real Time drip irrigation Implantation in Field

Figure 8 demonstrate the Real Time drip irrigation Implantation in Field. This Proposed system consists two modes of operation manual and automatic mode. In automatic mode of operation pump will be automatic turn on if any one of the soil moisture sensor shows dry and pump will be automatically turn off when all the soil moisture sensors in the field show wet data. In manual mode of operations we can control the irrigation pump through web server irrespective of soil wet and dry. The ESP32 micro controller can also transmit the data to web server.

S.No	Temperature	Humidity	Mos1	Mos2	Mos3	Mos4	Mos5	Mos6	Pump_status	Date
1	28.90	66.00	Dry		Dry	Dry	Dry	Dry	Pump-ON	2024-10-16 21:23:54
2	35.20	90.00	Wet		Dry	Wet	Dry	Wet	Pump_OFF	2024-10-16 20:15:32
3	31.30	75.00	Dry		Dry	Dry	Dry	Dry	Pump_ON	2024-10-16 20:00:05
4	32.40	91.00	Dry		Dry	Dry	Dry	Dry	Pump-ON	2024-10-16 19:57:54
5	32.00	91.00	Dry		Dry	Dry	Dry	Dry	Pump-ON	2024-10-16 19:57:41
6	31.70	92.00	Dry		Dry	Dry	Dry	Dry	Pump-ON	2024-10-16 19:57:31
7	31.50	92.00	Dry		Dry	Dry	Dry	Dry	Pump-ON	2024-10-16 19:57:21
8	31.20	92.00	Dry		Dry	Dry	Dry	Dry	Pump-ON	2024-10-16 19:57:11
9	31.10	92.00	Dry		Dry	Dry	Dry	Dry	Pump-ON	2024-10-16 19:57:06
10	31.10	92.00	Dry		Dry	Dry	Dry	Dry	Pump-ON	2024-10-16 19:57:01
11	31.00	92.00	Dry		Dry	Dry	Dry	Dry	Pump-ON	2024-10-16 19:56:51
12	31.00	93.00	Dry		Dry	Dry	Dry	Dry	Pump-ON	2024-10-16 19:56:45
13	30.90	92.00	Dry		Dry	Dry	Dry	Dry	Pump-ON	2024-10-16 19:56:35
14	30.80	93.00	Dry		Dry	Dry	Dry	Dry	Pump-ON	2024-10-16 19:56:30
15	30.70	92.00	Dry		Dry	Dry	Dry	Dry	Pump-ON	2024-10-16 19:56:25
16	30.70	93.00	Dry		Dry	Dry	Dry	Dry	Pump-ON	2024-10-16 19:56:20
17	30.80	92.00	Dry		Dry	Dry	Dry	Dry	Pump-ON	2024-10-16 19:56:15
18	30.80	93.00	Dry		Dry	Dry	Dry	Dry	Pump-ON	2024-10-16 19:56:10
19	30.90	93.00	Dry		Dry	Dry	Dry	Dry	Pump-ON	2024-10-16 19:56:04
20	31.10	93.00	Dry		Dry	Dry	Dry	Dry	Pump-ON	2024-10-16 19:55:59

Fig.9. IOT-WEB Application model

Figure 9 demonstrate the IOT-WEB Application model. All the 6 soil sensors data, temperature and humidity data will be post into IOT-WEB server for Real time Monitoring and controlling . in the web application every sensor status will be updated with date and time along with pump mode weather it is manual or automatic mode. Its very easy to the farmer to monitor the irrigation and control the water pumps. It's very easy to do cultivation by using IOT technology.

6. CONCLUSION

In conclusion, developed and implemented Real-Time IOT Drip Irrigation System successfully. The Proposed drip irrigation system uses an IOT web server in conjunction with soil moisture, temperature, and humidity sensors. The two operating modes of the suggested system are manual and automatic. If one of the soil moisture sensors indicates that the soil is dry, the pump will automatically switch on; if all of the soil moisture sensors in the field indicate that the soil is wet, the pump will automatically turn off. Regardless of whether the soil is wet or dry, we can use a web server to operate the irrigation pump in manual mode. Data can also be sent to the web server via the ESP32 micro controller. A web application is used to read and analyze data from the web server. Control commands are then transmitted to the micro controller via the internet. The device can irrigate the plants automatically only when necessary, save energy, and conserve water. The system may aid in the health and optimal growth of plants because it is made to water them at the ideal time. Plant water needs, weather, and soil moisture levels may all be precisely monitored. Water conservation is just one advantage of a smart irrigation system. Through web interfaces or mobile apps, users may conveniently and flexibly monitor and control the system from a distance. By doing away with manual watering activities, the automation features save time and labor. Because water efficiency reduces costs, this study has demonstrated that the application of IOT and automation can lead to significant advancements in farming.

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