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Berries of Low-Cost Smart Irrigation Systems for Water Management an IoT Approach

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Abstract
Irrigation is a time-honored process that regularly requires more physical effort and is used in agriculture. Sensors and microcontrollers can automatically water plants by detecting when they need to be watered and behaving appropriately. This procedure is known as "determining when the plants require water." When you go through this procedure, is known as "determining when the plants require water". The use of automation technologies can enhance production rates, costs, and resource use efficiency. The major purpose of this project is to develop and create a microcontroller-based system capable of autonomously watering plants while also supplying cultivators with essential information. This will be achieved by developing and building a system with the necessary capabilities.
Keywords: IoT, smart irrigation system, soil moisture sensor, motor, evapotranspiration controllers, and pump.

1. Introduction
Let us now take a closer look at our portable electronic equipment. It includes a variety of functions, including adaptive brightness, mobile gyroscope, voice recognition, GPS tracking, and face recognition, to mention a few. Each of these components has its own set of benefits, but what if they could collaborate to create a more visually appealing environment for end users? For example, the phone's brightness will alter depending on my current GPS position or the direction I am looking at on the screen (Sharma, H. K. 2022). The Internet of Things (IoT) is the process of linking everyday goods such as electronics, software, and sensors to the Internet so that they may gather and exchange data automatically this means that human intervention is no longer required (IoT) (Bwambale, E et, al. 2022).
The term "Things" refers to everything that may be accessed or linked over the internet and that individuals may come across in their daily lives. This term is commonly used while discussing the Internet of Things. IoT is a highly advanced automation and analytics technology that provides comprehensive solutions for a product or service. It focuses on artificial intelligence, sensors, networking, electronic devices, and cloud communications, among other topics (Bwambale, E, et, al. 2022). The Internet of Things (IoT) contributes to a system with improved levels of performance, control, and transparency. We can link everything in our environment because we utilize a platform, such as a cloud, to store all of the data. For example, the ultimate house would allow us to link various pieces of home equipment (such as our air conditioner and lights) and operate them all from a single platform (Prabhakar, M. 2022).
We have a platform that allows us to connect to our automobile, monitor its gas level and speed, and track its whereabouts. We can also maintain track of its location at all times. It would be ideal if all of these devices could connect and communicate on the same platform. So, the temperature of the room may be adjusted to my liking (Hadidi, A., Saba, 2022). For example, if I want the room temperature to be 25 or 26 degrees Celsius when I get home from work, the air conditioner will start ten minutes before I arrive, depending on where my car is. This will allow me to obtain the desired temperature. IoT can assist achieve this aim (IoT) (Di Martino, 2022).
As a result, IoT has become an essential component of our daily life. It has been employed in nearly every aspect of our life. Some of the most useful IoT-based systems are smart agricultural systems such as precision agriculture and irrigation systems, smart home automation systems, smart medical systems, smart transportation systems, smart supply chain management systems, smart city systems, smart wearables, and many others. For two to three decades, we were completely unfamiliar with them, yet now we rely on them for our everyday routine chores. This research paper concerns IoT-based smart irrigation systems (M. Usha, 2019). People's lack of access to clean water is becoming an even greater worry, especially in countries bordering the Mediterranean or in southern Asia, like India. Drought is most likely to affect Europe's Mediterranean-region states.
Climate policy and water management are now intricately connected (Iqbal, W. 2021). A range of factors can influence water management, such as the amount of water used by specific sorts of businesses or how different degrees of warming affect a variety of water resources. When addressing water resources and agricultural methods, climate change and its ramifications are frequently discussed (Metri, P., & Kumari, S. 2022). People have been considering the best strategies to adapt to shifting water conditions as a result of the anticipated consequences of global warming. Taking these steps will guarantee that there is enough water for human use, food production, and the maintenance of natural ecosystems (Tausif, M. et, al. 2023). Furthermore, it is critical to ensure that both the drinking water that people use and the water that is returned to the natural environment are free of pollutants. Climate change may cause a decline in water quality, an increase in salt in water and soil, a loss of biodiversity, an increase in the amount of irrigation required, and maybe an increase in the cost of emergency and cleanup actions (Kaur, J et, al. 2022). As a result of these considerations, there has been an increase in the number of studies examining various solutions for reducing the amount of water consumed by irrigation systems. Some of the study findings suggest that in addition to developing new technology, new social, economic, and environmental policies must be introduced to enhance water management (Kanade, P., & Prasad, J. P. 2021).

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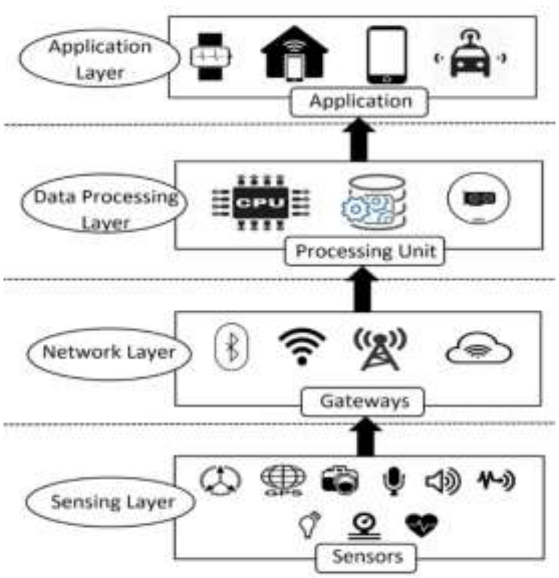

Figure 1: IoT Four-Tier Architecture (Y., & Lee, K. G. 2020)

2. Literature Review

A center pivot is a type of mechanical irrigation system that waters farms in a circular pattern around an axis point located in the system's core. When combined with a center pivot irrigation system, the use of innovative Internet of Things applications improves water management, automates agricultural labor, reduces costs, and has the potential to assist farmers in making more appropriate decisions by providing precise real-time information. This data will be collected and analyzed in the future for decision-making reasons. With the aid of our equipment, we can design an irrigation technique based on certain parameters and perform a certain action that determines whether or not we can irrigate when we can begin and complete the operation, and the amount of water required. We are presently living in the age of IoT technology, thus this is now possible. Our System for the Irrigation Process offers this technique, which we describe in our article alongside an overview of the entire system (Blessy, J. A. 2021).

It has been observed that irrigation systems provide a valuable contribution to optimal irrigation techniques, potentially enhancing the use of continuing research and development aimed at increasing process sustainability and lowering expenses. Improving irrigation systems improves water-use efficiency and contributes to the United Nations Viable Improvement Goals, particularly Goal 6 and Target 6.4. This study will help researchers and farmers obtain a better knowledge of irrigation technologies and develop an appropriate strategy for executing irrigation-related activities. Automatic watering systems are essential for water management; this development might play a significant role in lowering water use. Sensory systems help farmers obtain a better understanding of their crops, minimize their environmental impact, and conserve resources. These current technologies allow for good soil and weather monitoring and water management (Reyad, O, et, al. 2020).

A data fusion model is used to merge data from many sources with different characteristics. This data consists mostly of user irrigation records, historical weather data, online monitoring sensor data, and weather forecasts, which are used to simulate and forecast correct watering demands via a long short-term memory (LSTM) network. By combining a data fusion model with a long-range (LoRa) network, this study presents an intelligent irrigation system that optimizes watering schedules. Designing a cloud platform enables irrigation control, an Android application interface, and network administration. On average, the proposed solution conserves 94.74% more water than traditional manual setting methods. Saving water when irrigating plants is a major concern since water has a significant impact on human society. The water flow-based power production technology enables the node to remain energy-independent, resulting in maintenance-free operation throughout its life cycle (Ragab, ey, al. 2022). The suggested hybrid remote-controlled device used a Radial Function Network and GPS to operate the irrigation system, anticipate temperature, maintain constant air pressure, and minimize water-content humidity. Water is an essential resource, and agriculture's capacity to harness it to feed the globe is a tremendous benefit to civilization. Using this technology, you may control the position of equipment from a distance to do duties such as weeding, watering, monitoring humidity, frightening away birds and animals, and keeping surveillance. Environmental degradation and high population increase have had a severe influence on water resources, which are critical to global development. Thus, it is expected that the design will meet all criteria for water use, total operating expenses, labor, energy consumption, and productivity. This study focuses on using an IA management system to enhance farming practices and yields. It manages and maintains smart solar irrigation systems using environmental data from the Internet of Everything and IoT sensors (Obaideen, et,al. 2022).

The throughput is 11.57% greater than the Tree Cluster-based Data Gathering Scheme (TCDGS), while the residual energy saved is 4.54% more than the TCDGS. In this study, a novel approach dubbed "Enhanced Cluster Head-based Data Gathering" (ECHGS) is described as a solution to reduce time and energy in an Internet of Things (IoT)-based smart irrigation system for agriculture. The Internet of Things (IoT) is a novel technology that is being utilized in a variety of applications, including home and workplace automation, hospital monitoring, network device monitoring, industrial issues, and smart agricultural monitoring systems. To maximize energy and throughput, techniques such as cluster tree, clustering, and Tree Cluster-based Data Gathering Schemes (TCDGS) are employed. The suggested technique selects the cluster head for a collection of sensor nodes depending on its workload and energy consumption. The cluster head is the node with the greatest energy remaining and the least amount of work to do. Its function is to collect data and get it to the server node as soon as feasible. Throughput enhances network performance and is defined as the average quantity of data that can be effectively sent in a given length of time (Gong, et, al. 2022).

Within the scope of this research, we suggest an intelligent and cost-effective irrigation system for agricultural applications. Modern farming relies on automated and remote monitoring and management systems linked to fog, cloud, and IoT networks. Using a hardware sensor and a microcontroller unit, we created a prototype that can determine temperature and relative humidity. When selecting whether or not to start the motor, we employ some sensors, each of which offers us a distinct collection of information and values. To further describe the system, we provide a core algorithm and a flowchart. Our Internet of Things-based automated system development creates an automatic irrigation system that notifies us remotely via mobile SMS about the irrigation area's particular (Iqbal, et, al. 2023).

Agriculture is India's largest economic industry. Water is required for successful irrigation. The farmer's principal task is to water the crops on the field. During this investigation, the irrigation system was controlled using an Internet of Things-based automation system. As a result, there is less need for people to actively participate. The findings of this analysis will reveal which crops perform best in a particular soil. The land receives a suitable amount of water for irrigation whenever it is necessary. When the water level in the field reaches a certain height or minimum level, the sensor detects it and turns off the pump motor automatically. Agriculture in most developing countries, including India, is heavily reliant on old energy sources to power motors and pumps, resulting in excessive water usage and waste. As a result, contemporary research focuses on finding more efficient and competent means of utilizing abundant renewable resources, such as solar energy. The Internet of Things (IoT) is a quickly growing and possibly game-changing technology that enables agricultural fields to autonomously monitor and control their operations, reducing dependency on human labor. An Internet of Things (IoT) based solar-powered smart irrigation system allows you to solve issues like water and electricity scarcity to the fullest extent feasible. This article describes the design and construction of an Internet of Things (IoT)-based solar-powered smart irrigation system, which can be managed and monitored using GSM and ESP8266 (Padmanaban et,al. 2022).

To create and test an IoT-based system in loamy soil, we employ a wireless connection between soil moisture sensors and an automatic check gate. The system was implemented and tested. Sensors should be placed at a depth of 37.5 millimeters, 25% of the length from the intake, when the soil has a higher moisture deficit, and at a depth of 7.5 centimeters, 75% of the length when the soil has a lower moisture deficit. Soil moisture sensors with three capacitances were set at depths of 25%, 50%, and 75% of the field's length (15m, 30m, and 45m). Three operation schedules based on sensor location were investigated for soil moisture shortages of 40%, 30%, and 20%. A wireless network was created using a LoRa module and a GSM module to connect capacitance-based soil moisture sensors to an automated check gate (Gnanavel, S, et, al. 2022).

The developed CSIS with the S-BIS technique is ideal for watering date palms in arid areas because it improves irrigation water utilization and causes date palms to produce more fruit. The CSIS validation revealed that employing sensor-based irrigation scheduling (S-BIS) rather than time-based irrigation scheduling is a more effective technique for watering palm plants than traditional methods (T-BIS). This study aimed to run a contemporary subsurface irrigation system using cloud-based Internet of Things technology. This would allow date palms in arid locations to get more water and be more effectively controlled. The developed CSIS with the S-BIS technique is ideal for watering date palms in arid areas because it improves irrigation water utilization and causes date palms to produce more fruit. The CSIS validation revealed that employing sensor-based irrigation scheduling (S-BIS) rather than time-based irrigation scheduling is a more effective technique for watering palm plants than traditional methods (T-BIS).

This study aimed to run a contemporary subsurface irrigation system using cloud-based Internet of Things technology. This would allow date palms in arid locations to get more water and be more effectively controlled. We developed, installed, and tested a completely automated controlled subsurface irrigation system (CSIS) that allows us to monitor and manage the amount of irrigation water from a remote location. Compared to typical surface irrigation methods, CSIS's S-BIS and T-BIS were able to reduce irrigation water usage by 64.1% and 61.2%, respectively (TSI). CSIS with the S-BIS technique, CSIS with the T-BIS method, and TSI consumed a total of 21, 04, 22,76, and 58.71 m3 palm1 of irrigation water each year, respectively. The S-BIS ensured that the date palm received the proper amount of irrigation water at the appropriate time and delivered it directly to the root zone where it was required (Padmaja, C, et , al. 2022).

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Current irrigation methods, such as unequal water distribution, manual reporting of mocha discharge by OFWM, changing a farmer's water turn at night when he does not need water at his assigned time, and tail-end user issues such as too much or not enough water to meet farmer needs, make it difficult to provide water to farmers fairly and efficiently. Farmers are unable to obtain their fair share of water as a result of this. Using a smart watering system is one solution to this problem. These systems employ IoT-powered sensors to monitor water levels and send feedback to the user. This is only one possible answer to the problem at hand. This study discusses the Internet of Things (IoT), with a focus on its possible uses in irrigation systems. Then, to help farmers with their problems, we suggest an architecture for an IoT-based irrigation system that employs a wireless sensing network. The Raspberry Pi is the primary processing unit of a smart irrigation system based on the Internet of Things (IoT) that aims to increase the amount of water produced while lowering costs (Abioye, E.et, al. 2021).

The smart water management platform, or SWAMP, is an IoT-based smart irrigation program that seeks to maximize the productive use of freshwater in agricultural contexts. EEWMP is a smart irrigation system based on the Internet of Things (IoT), with sinks, fusion centers, and open-source clouds distributed in the field. Both models' performance is evaluated based on their energy consumption, the amount of time the network is stable, the number of packets transported to their destination, and the percentage of packets delivered. Precision agriculture is critical for today's world, especially in countries with limited water supplies, rich land, and large people. Specifically, these countries require precision agriculture the most (Hamdi, et, al. 2021).

In this study, a pH sensor, flow sensor, and soil moisture sensor are used to control an irrigation system in the agricultural field. This irrigation system is known as an intelligent irrigation system (IIS) since it functions using the Internet of Things (IoT). Irrigation systems are the backbone of agriculture because they help to reduce water waste, calculate the appropriate water consumption for each crop, and increase agricultural output. Using IoT technology that can turn water pumps on and off, the status of the soil may be monitored based on soil factors such as water flow and moisture. To determine the ideal quantity of water delivery, sensors collect data on soil conditions and wirelessly send it to a database on a web server. The data is stored in the recommended server database, and the authors employ the concept of a dashboard; it uses the HTTP protocol to control the water pump on agricultural land. The paddy crop, or rice, was included in this study since water is required for the sustenance and growth of rice plants. The results of the trials show that this strategy is more successful than the present irrigation system, which is conventional and unadventurous (Ullah, R, et, al. 2021).

3. Proposed Framework

A microcontroller, in this case an Arduino UNO, is utilized to build a smart irrigation system and is critical to the smooth operation of any automated system. Temperature, water level, and soil moisture sensors are all connected to the microcontroller. This is how the sensor data is sent to the Arduino UNO. When the microcontroller gets a signal from the sensors, it sends a suitable output to activate the relay and start pumping water based on soil and ambient conditions. This soil moisture sensor detects electrical potential in the soil to offer information about its status. The output voltage is then calculated by subtracting the input voltage plus the reference voltage.

If the reference voltage exceeds the soil condition indicated in the voltage, a relay signal can be used to mechanically water agricultural land. If the reference voltage is less than the voltage recorded for the soil condition, the pump will not function. If the order is reversed, the relay does not activate and the pump remains in the OFF state (Sharma, B. B., & Kumar, N. 2021). Figure 1 depicts the flow of a control view block diagram. The soil moisture sensor provides an analog signal to the microcontroller whenever it transmits a signal. Following that, the signal is transformed into a digital format. The microcontroller has finished the program that was running on it, and the signal is now being transferred to the relay circuit.

The signal delivered through the relay circuit indicates whether the motor is turned on or off. When the temperature goes below a particular threshold, the moisture content of the earth reaches a saturation point. If the current-voltage exceeds the reference voltage, a "low signal" is sent to the microcontroller. The microcontroller will then send the motor a "logic 0" command, causing it to stop pushing water into the reservoir. The comparator, located within the sensor, determines the voltage the sensor transmits.

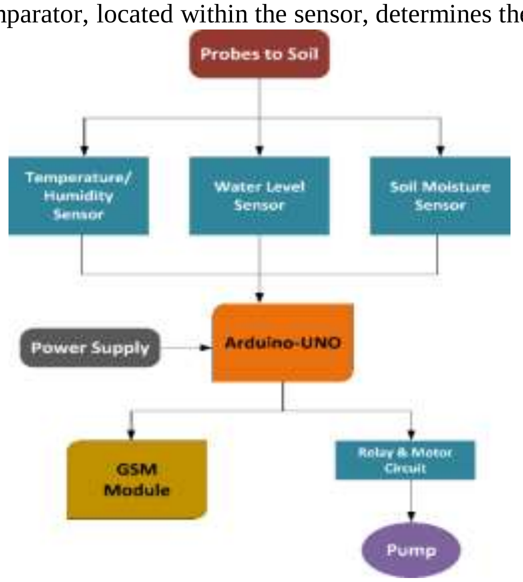

Figure 2: Block Diagram of Proposed System (Islam, M. S. 2014)

Once the sensor is installed in the field, the environment will be more favorable. A high degree of conduction suggests that the substance has a large amount of water. This is because water is a great conductor of electricity. Following that, the signal is transferred, and the motor will stop operating once the necessary signals have been transmitted. When there is no conduction, which shows that there is no water, the Arduino sends the signals required to activate the motor, assuring that there is no water by preventing conduction. When the signal to turn on the motor is transmitted, the relay's switch closes, allowing the motor to start. This makes it possible to connect the motor to the circuit, allowing water to be pumped to the plants. Similarly, if the control signal orders the motor to turn off, the relay switch is opened, and the motor receives no power as a result. As a result, the motor will stop running. As a result, the plants are assured to receive the proper amount of water at the correct time, as specified by the software burnt into the Arduino. In this circumstance, there is no reason to conduct such regular inspections on them (Lee, K. G. 2020).

- **GSM**

Global System for Mobile Communication," as the name implies, is a system primarily used for mobile communications. GSM allows the user to obtain information on the pump's state, such as whether it is turned on or off. This GSM module uses TDMA to transfer messages from the network to the user.

- **Relay**

The relay provides the pump with critical information. It determines whether or not the pump should be switched on. So, the relay is a critical component of this system for watering plants. These relays function as switches, opening, and closing when the timing is appropriate.

- **Pump**

A pump is a component that contains a motor that converts the energy of an electric current into mechanical energy. Pumps can also be referred to as pumping mechanisms. Because of this circular movement, the water in the tank or well is under increased pressure. Because of the high pressure, water is extracted from the well and used on farms.

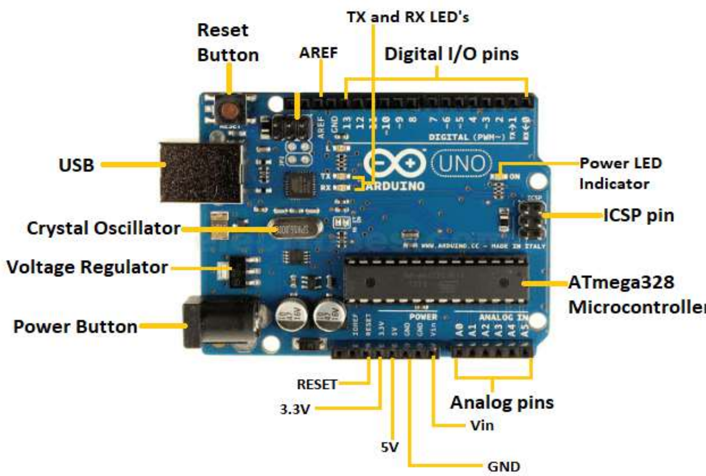

Figure 3: Arduino UNO Microcontroller

4. Discussion

Figure 2 depicts the fundamental design of the Arduino Uno microcontroller. This watering system relies heavily on Arduino to function. The Arduino, which is configured to accept analog inputs, has received the sensor values. The digitization of analog signals is handled by the necessary microcontroller. These signals are used to control the digital output relay. After processing, the data is returned to the GSM Module. These digital outputs are generated by the previously loaded code on the microcontroller. Figure 3 displays the soil moisture sensor mentioned in the text. A soil moisture sensor measures the moisture content of the soil. The moisture level sensor is driven by resistance. A low resistance value in soil indicates a high moisture content. When resistance is great, the earth becomes exceedingly dry. It is the microcontroller's responsibility to respond to this signal and switch the relay on and off.

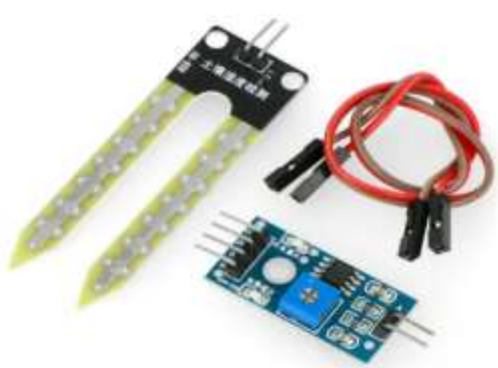

Figure 4: Measuring the soil

Instead of measuring the soil's actual water content, a soil moisture sensor uses a different soil attribute, such as its dielectric constant, electrical resistance, or interaction with neutrons, to calculate its volumetric water content. The connection between the measured value and soil moisture should be calibrated. This connection may vary based on the kind of soil, temperature, and electrical conductivity of the soil. Figure 5 may be used to determine how much water is in the tank. Inside the tank, a water level sensor is installed to determine the level of water. The reference value assigned to the sensor represents the basic minimum level that must be satisfied. If the water level falls below the reference level, the user receives information about it.

Figure 5: Sensor to Detect Water Level

Figure 6 depicts the temperature and humidity sensor in its entirety. The sensor will tell the mobile device whether the water level is greater or lower than the previously defined point. The photoelectric water level sensor derives its readings from the characteristics of light. Because it is sensitive and has no moving components, it is used in a wide range of modern applications. The corrosion-resistant probe is not only simple to install, but it can also tolerate tremendous pressures and temperatures. By watching how the air moves, the simple sensor depicted in Figure 5 can estimate both the temperature and the amount of water in the atmosphere. It operates between 3.3 and 5.5 volts.

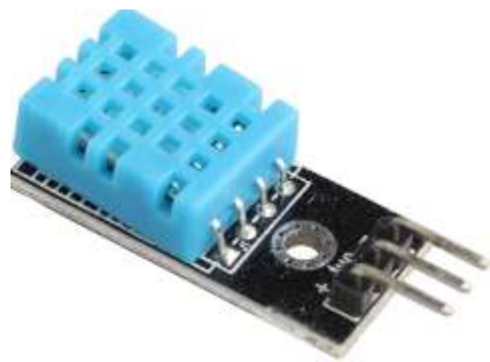

Figure 6: DHT11 Temperature and Humidity Sensor

The humidity gauge has a range of 20 to 90%. The temperature may be measured anywhere between 0 and 50 degrees Celsius. The temperature and humidity sensor has three pins that it may connect to. It has a communication port, a power ground, and power pins. An innovative irrigation system has been erected on agricultural land. The Arduino receives an analog signal from the moisture sensor, which is implanted in the ground and delivers its data to the Arduino. Furthermore, the Arduino receives analog inputs from the temperature, humidity, and water level sensors, which are processed by the microcontroller. Once the analog impulses are converted to digital analogs, the motor will begin to turn. The user receives message signals in the form of messages and is informed at all times whether the motor is turned on or off.

5. Conclusion

The intelligent irrigation system might be utilized for a variety of purposes, including reduced water waste and improved crop and plant health. In our project, we use a relay to regulate the on/off switching of the motor. The engine is connected to a water tank or storage system, which supplies the plants with the water they require to thrive. This project will ensure that the plant water levels remain at an optimal level. Water is provided to plants at precisely the proper time and amount. Plant growth and vigor may be maintained. Farmers save time and money on labor when they are relieved of the responsibility of monitoring the irrigation system. The reduction in water waste has had significant economic benefits. This endeavor helps the economy as a whole. The most efficient solution to agricultural water challenges is to use smart irrigation.

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