Smart Farming System with Reverse Water Control Technique

M.SAKTHIVEL, M. RADHAKRISHNAN

[1]Computer Science and Engineering, Malla Reddy College of Engineering, Secunderabad, INDIA

Abstract: Automation in agriculture is gaining more importance among the farmers as it lessens their workload in many ways, resulting in a higher output and fewer human resources being used intervention. The main challenge in the agriculture sector is improving farming efficiency and quality without constant physical monitoring to full fill the speedily increasing demand for the food. In addition to the growing population, the climate circumstance is also a huge challenge in the agricultural industry. The aim of this research paper is to provide a smart farming model based on the Internet of Things using clustering to deal with adverse conditions. In this model, we use many types of sensors for various purposes, such as soil moisture, air pressure, rain detection, and humidity sensors. The data will be gathered and automatically calculated on the cloud. The smart agriculture sector can be adopted from crop control, collection of useful data, and analysis automatically. The goal of this study is to show how the Internet of Things (IoT) may be used to monitor climate, soil conditions, humidity, temperature, and water delivery to fields. The main purpose of this paper proposes a cost-effective smart irrigation technique, which helps in saving the extra water flowing in the land. This extra water can be saved in a separate water storage tank, which can be utilized for multiple purposes. The proposed solution involves very fewer components, which reduces the complexity of the system, and it is very cost effective and the IoT based Smart Farming System being planned using this report, various sensors and a Wi-Fi module are linked to produce a live data feed that can be accessed online.

Keywords: Arduino, Sensors, Wi-Fi Module, Automation, Intelligent Controller, Smart Irrigation.

Received: March 8, 2022. Revised: September 11, 2022. Accepted: October 2, 2022. Published: November 2, 2022.

1. Introduction

The development of information technology has made several impossibilities possible. Our cell phones, tablets, and the emergence of "smart" technology have dominated the market and elevated it to the status of the new industry standard throughout the years. Smart irrigation systems are one such technology which have attracted the interest of many researchers and have been evolving and improving for about a decade. This smart irrigation sector where water waste is minimized and is no longer sustainable socially, economically and conventionally as well. The idea and development of smart irrigation systems is basically focused on reducing human efforts as well as reducing resources (water) and power consumption (electricity). Insatiable demand for convenience and comfort and also to overcome natural barriers, there is a constant pull on technology to develop more and more. On the other hand, growing demands for food due to population growth put farmers to face many issues regarding the quantity and quality of crops which in fact made another challenge on researchers to develop and approach a fine smart irrigation system that would provide farmers a smart tool which would support them in yielding quality crops.

Although a smart irrigation system has been developed, so far no solution is obtained to measure accurate flow of water along with availability of data over websites which could be fetched from anywhere in the world. Therefore, throughout the project, our top priority has been to design an irrigation system that offers all of the aforementioned features in addition to standard smart irrigation features like measuring the field's moisture profile to prevent crops from water logging issues and temperature sensing to allow one to check the environment's temperature because crops are also temperature-sensitive. The calculation is done by using different sensors. Further another advantage of the developed irrigation system is that it would keep the farmer up to date and also aware before any adverse situation comes in.

Enabling the farmer to maintain control over the land around-the-clock.

In recent years, many of the farmers were not able to go forward in agriculture or raise their standards; instead, they are prone to heavy loss that includes even death of farmers in various parts of the country. Farmers are facing a lot of problems due to the manual operation involved in the traditional agricultural system. To overcome the demerits of the traditional agricultural system, many researchers gave enormous solutions, where the agricultural systems are automated through the Internet of Things (IoT) technology. This section presents the remarkable technologies developed in the agricultural domain that helps farmers to carry out the agricultural process in an easier way. In order to perform the proposed technique, a detailed study was carried out with respect to various automation techniques.

Nowadays, water shortage and flooding has become an unpreventable issue to tackle. Water plays a significant part in the day to day life of a human being. Agriculture industry and lands are already facing drought problems, so with the help of current technology this issue can be sorted out to some extent.

Today’s technology requires a user-friendly device which is economical in cost and most effective as well and which is provided by Arduino board. In today’s generation, it is very convenient to send the notification to the IoT platform because of widespread use of smartphones and PCs. The whole system is distributed into two sections. The first section comprises setting up an Arduino Board and interfacing it with the several sensors. The second section consists of developing the IoT platform and integrating to the server. The ESP 8266 Wi-Fi module is used because of which the transmission becomes simpler and faster. It consists of two motors, one for the water pump, and second for the fertilizer pump. It also helps the owner to monitor the system anywhere throughout the world. After getting the proper information about the field, farmers can turn ON/OFF the motors parenthetically. This system is simple to implement. This System is designed to improve the security, flexibility and to remove the flaws of the existing system.

2. Literature Survey

In order to perform the proposed technique, a detailed study was carried out with respect to various automation techniques. This section explains the various techniques designed and implemented by various researchers in order to increase the production in agriculture. Rajkumar et. al presented an efficient and smart agricultural system based on IoT [1] to monitor the level of water flow to the crops and when it gets exceeded, the information will be sent to the corresponding user via sms through IoT module. In [2], Prosanjeet J Sarkar discussed in detail about the various digital monitoring systems and effective utilization of available resources. The author also addressed the remote monitoring system that runs on IoT protocol, which increases the production in agriculture. A smart and efficient agricultural monitoring system was framed and implemented by Sierra et. al in [3], which mainly focused on optimal usage of water in the agricultural farms. A mobile application was developed and the related information was sent to the registered user from time to time which assures that the water consumption is controlled. In [4], Raspberry PI based automatic soil moisture monitoring system was designed and developed in order to monitor the soil level of water using APLA robotized irrigation system framework. Vinita Tyagi et al [5] proposed an IoT based system specifically designed for acquiring the analog data from air and soil through sensors. In addition, the author discussed transferring the collected data through an external website with the help of an Arduino board that used ATMEGA 328 chip. In [6], Yuvraju and Priyanga implemented an IoT based irrigation and agricultural monitoring system that includes a color sensor for providing the leaf color which helps in selecting the type of pesticide to be given at appropriate time in order to avoid the damage of plants. Mythili et al [7] worked on IoT based smart farming and monitoring system in order to control monitoring system using IoT was presented by Terteil Ali et al [8], which acted as decision making system based on the parameter variation that happens in the farming. The information related to parameter is sent to mobiles phones of the farmers. Many sensor based smart agriculture monitoring system [9] using IoT was described by Sanjay N. Patil and Madhuri B. Jadhav. This system includes sensors such as humidity, rain detector, temperature and soil moisture, which provides the data, related to respective parameters. Lashitha Vishnu Priya et. al [10] discussed the IoT based smart agriculture monitoring system that presents an efficient sensor innovation and coordination of remote systems. Crop-field monitoring system and irrigation automation by IoT [11] was designed and developed by Sukumar et al., where the set of data are collected and transferred to web server through wireless transmission. In [12], Srishti Rawal described an efficient watering system that avoids over watering to specific plants. The control unit was designed using ATMEGA32P on Arduino platform. The information received from the sensors are regularly updated in a webpage using GSM-GPRS SIM900A modem, which helps the farmers to check whether the sprinklers are turned ON/OFF. Govardhan et al. [13] designed and developed an IoT based automatic irrigation system that saves time, money and power so that farmers can be benefited in ways. In [14], Bhagyashree A. Tapakire & Manasi M. Patil presented the Thinkspeak based smart agriculture system, which consists of raspberry pi, sensors, pi camera and a motor driver for efficient operation. The data collected from the sensors are transmitted and stored in Thinkspeak cloud. Recent Trends on Sensors and IoT systems for irrigation in precision agriculture was discusses by Laura Gracia et al. [15]. Various parameters such as water quantity and quality, soil characteristics and weather conditions are discussed in detail.

Sonal M et.al [16] proposed a water dripping system to avoid scarcity of water as it is a big issue nowadays, also it prevents the soil from becoming more acidic or basic by using a PH sensor. All the data is sent to android app and according to that the motor is operated and which makes this system costlier. Cruz et.al [17] proposed a system which is based on the Artificial Neural Network. This system used a neural network toolbox from MATLAB to implement it for proper and balanced use of water. This system is hard to understand and it fails to deliver real time data to the user. Pushkar Singh et.al [18] implemented a smart irrigation system using Arduino which gives real time data of moisture and temperature of the soil with the help of sensors. This system also uses a water flow sensor for a controlled irrigation system. However, it is unable to provide up-to-date data on the soil's PH level.

The above-mentioned systems use multiple technologies that would be helpful in the proposed system. But the use of the technologies in the above system increases the manufacturing cost of the system significantly. Pricing of a system related to farming matters a lot in countries like India where the condition of the majority of farmers is not prosperous. By referring to state of art, we observed that there is a need for an efficient irrigation system that must display soil moisture values, crop suggestions, weather forecasts, and also automatically switch the motor ON/OFF by considering soil moisture values along with manual controlling of a water pump. To the best of our knowledge, no such system exists with all integrated features. We propose a system that includes all of the above stated essential features of an irrigation system to make it work intelligently. The major contribution of the proposed work is:

The proposed system provides a one stop solution for farmers that resolves their problems with ease of use. From the detailed study, it is inferred that a lot of techniques were designed and implemented for obtaining better results in terms of crop yield, operational time, system complexity and so on. The proposed system is designed based on the concept of saving water that operates at two different periods: normal time and rainy time and it is explained in detail in the following sections.

3. Proposed Technique

The proposed system will provide ease to farmers in terms of irrigation, by providing an automated irrigation system, weather prediction, and notification regarding new government policies. The proposed system suggests to the farmers about crops that are suitable for a particular region and the amount in which they were harvested last year for better results.

Also, the proposed system provides the farmers with the data of past years' crop harvest and the government's suggestion regarding the crops that should be grown in the area, this is done using prediction analysis techniques based on the past year's data. Hence stabilizing the production of crops and thereby decreasing the crop wastage and major fluctuations in the price of crops.

Automatic maintenance of agricultural fields with proper irrigation. The system consists of a water level indicator, sensors, relays, signal conditioner, micro controller, IOT modem and a pump motor. The controller receives the signal from the sensors and controls the irrigation accordingly. The pump motor is ON and OFF through the relay. A touch sensor continuously monitors the fields so as to alert the farmer of any animals that might enter the fields knowingly or unknowingly. The status of the land is intimated to the server through IOT.

A.

Fig. 1. Modern irrigation system

While the traditional irrigation systems do the assigned task, there are no systems that provide an acknowledgment when an action is performed by the system. Hence, SMS acknowledgment system is introduced where the user can get the real time update. To send SMS acknowledgment, a GSM module is made use of. GSM module is a special module which not only helps in sending SMS but can also be used to receive SMS, make or receive calls, access the internet using GPRS data and much more. All these applications are based on serial communication. SIM900A is the most widely used GSM module currently available. This is very popular as Indian mobile operators operate at a frequency of 900MHz. It mainly consists of 6 accessible pins which are Vcc, Ground and two each of Tx and Rx pins. Tx and Rx are the commonly used pins as it operates on the principle of Serial Communication.

Interacting with the GSM module by interfacing with Arduino used to the help of built in functions like send() and receive() that are added in GSM.h header file in recent updates to Arduino IDE it has become easy to send and receive text messages.

The soil moisture sensor is being used to detect the soil moisture from the soil and then it is compared with the threshold value that has been set. The threshold value is to be decided based on the agricultural database in the system that has been built based on the type of soil and crop. The soil type of the farm is detected based on the GPS location of the field that farmers have selected for crop harvesting. The soil moisture sensors shown in the architecture are used to detect the moisture from the soil and send the information to the microcontroller and so is be the function of temperature sensor and humidity sensor. The processing and decision-making tasks are performed in the micro-controller and the signal is sent to the relay to switch the water pumps on/off. We now explain the overall working of the proposed system.

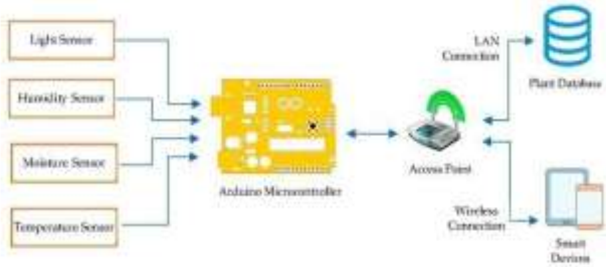

Fig. 2. System Architecture

A smart, simple, efficient and complex free system is proposed for the purpose of saving water from the cultivating land in two different situations, viz., normal and rainy. The systems developed till date addressed the issues such as conversion of manual process into automation which includes the activities such as turning ON/OFF of the motor, collecting data with respect to various parameters such as temperature, pressure, humidity etc., and transferring the data through IoT technology and storing them in cloud for further analysis.

But the proposed system aims at saving the excess water flowing in the land once the moisture level is reached according to the crops cultivated in the land. The excess water from the land will be pumped back to the storage tank using the RPT. The flow diagram of the proposed reverse pumping system is presented in Fig. 4. The system proposed is so simple in such a way that it consists of two AC motors, a moisture sensor, an intelligent controller and a storage tank.

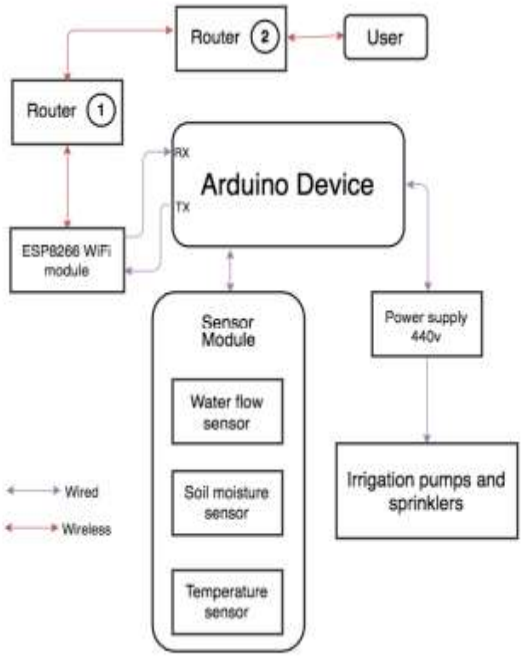

Fig. 3. Smart irrigation using ESP8266

Also the proposed system is designed in such a way that it benefits the farmers under two different climatic conditions: normal and rainy season. Under normal season, when the system is turned ON, the water from the well is drawn and it is flown into the field where the crop is cultivated. Once the crop gets the required level of water, the moisture level will be sensed and the data will be sent to the controller. When the value is found to be correct, the Motor 1 will be turned OFF based on the command received from the controller so the motor will be turned OFF immediately. In this criteria, only the required amount of water will be passed on to the land and so no wastage of water will be there. The information pertaining to this operation will be sent as an SMS to the user's mobile number.

Under Rainy season, when the system is turned ON, the water starts flowing into the field. The moisture level of the soil will be higher than the expected level due to rain. In this case, the time required for the water flow under the rainy season will be less when compared to that of the normal season. The data related to moisture content present in the soil will be passed on to the controller via moisture sensor in order to control the action of the motor. At the same time, if the rain is heavy, more quantity of water might get accumulated in the field, which leads to the damage of the crops. To overcome this, an AC motor and a storage tank is kept additional to the existing system. The controller, on receiving the information from the sensor, activates the Motor 2, which helps in sucking the excess of water from the field and pumping it back to the storage tank. The stored water can be utilized for future use.

Fig. 4. Storage Tank Dataflow diagram

4. Implementation Details and Result Analysis

The development in irrigation practices using wireless communication facilities allows the sharing of real time information with the user and such services have huge potential in the market. The proposed technique is implemented on an Arduino microcontroller and Windows 10 64-bit Operating system, Intel(R) Core (TM) i5-7200U CPU @ 2.50GHz 2.71GHz, x64-based processor, 8.00 GB RAM. The soil moisture sensor in the proposed system is shown in Figure 5. Using capacitance, the soil moisture sensor monitors the soil's dielectric permittivity, or water content. It creates a voltage according to the measured dielectric permittivity of the soil and averages the measured value of the entire sensor.

The proposed system consists of two motors, one to supply water from well to fields and the other to pump the excess water from field to storage tank. In the practical scenario or the fields ac motors are to be used. For the prototype, we are making use of low capacity submersible motors for both the purposes.

Arduino UNO is one of the most widely used boards for carrying out various low and medium level projects. This gained its wide attention as it is very easy to program. It has a dedicated editor to write the code, a compiler to compile the same which gives HEX file of the developed code and later the HEX file can be uploaded in the microcontroller using another program. The entire process of building a microcontroller will be taken care of by Arduino IDE called Integrated Development Environment.

From Fig. 5, it is seen that two motors (dc motors for the purpose of prototype) are employed: one to draw the water from the well and another motor to suck the water from the field once the level of water increases in the field.

This task will be carried out by the moisture sensor, which passes the data to the intelligent controller and when the moisture level below the required criteria, the motor will be in idle position and when the moisture level exceeds the required criteria, the intelligent controller will turn on the motor and then starts pumping the excess water from the field to the storage tank. In this way, the crops in the field can be saved and excess water saved in the storage tank can also be used for some other purposes in the future.

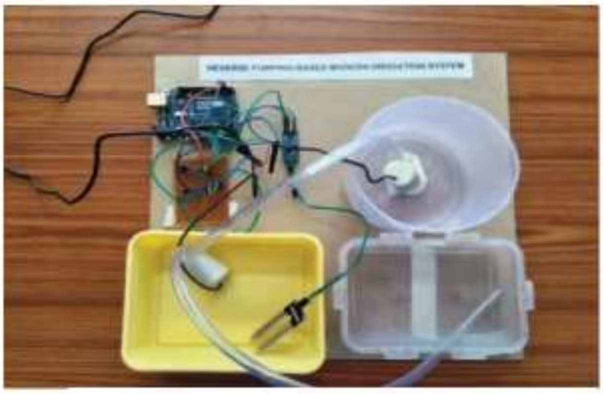

Fig. 5. Prototype developed for the proposed system

A brief about the working procedure along with a few scenarios are explained as follows:

The primary requirement is to determine the state of the rain drop sensor to know if it is heavily raining, moderately raining or not raining. If it is heavily raining, then the user is given frequent instructions to take some action or intelligent controller automatically ON, such that the crops do not get damaged.it is moderately raining, then no other action is taken until the rain gets heavier. if it is not raining, then the status of the soil moisture sensor is considered.

If the soil is dry, then the motor is turned ON for a specific time. When the sub-threshold time is reached, and the motor is still in ON state, a warning message is sent to the user asking to turn OFF the motor manually. When the threshold time is reached, and the motor is still in ON state, the device is automatically turned OFF and the user is notified about the action that is taken. If the soil is moist then no action is taken. Simultaneously the DHT sensor continuously monitors the temperature and warns if the temperature rises beyond the threshold value. Similarly, if the humidity increases it indicates that it is about to rain.

This cycle repeats for every defined amount of time. The process starts only when the appliance is manually turned ON by the user. This can be done by pressing the ON button on the website. Figure 5 shows a sample SMS screenshot that the user receives when the system takes action.

Fig.8 shows the image of the Arduino Uno esp8266 that is used in the proposed system. The microcontroller provides 32 pins including 17 GPIO pins, 4 ground pins, and 3 3volt output pins.

The notice is delivered to the user using Firebase Cloud Messaging (FCM). FCM establishes a secure data link between the server and the devices. It's a free, battery-friendly way to deliver alerts to users on iOS, Android, and the web.

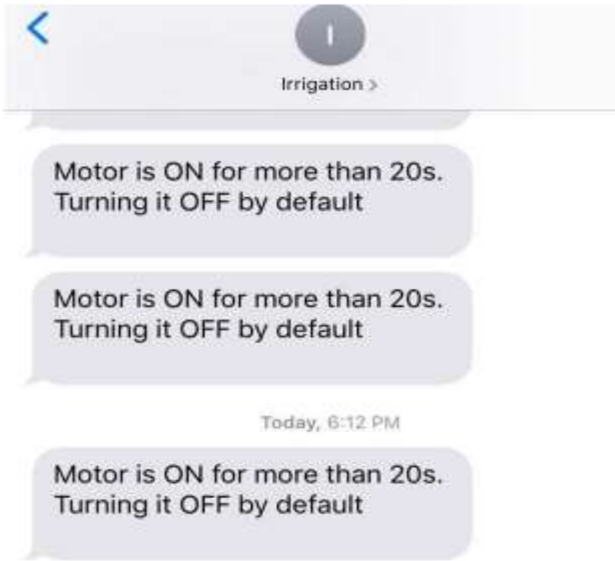

Fig. 6. SMS sent by system to user

Firebase is a cloud service supplier and backend as a service company. Firebase provides a special platform for building mobile and web applications. It can update and build applications in real-time. Firebase stores data in JSON format [13]. Google Analytics for Firebase is connected with notification messages, allowing users access to extensive engagement and conversion statistics.

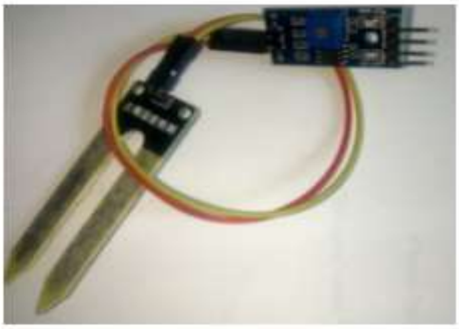

Fig. 7. Soil moisture sensor

Table 1 shows the reading of the soil at different points of time. The reading number 1 to 4 has been taken while the system was working in an automatic state whereas the reading 5 has been taken by keeping the system in manual to increase the water content in the soil and then shifting it to automatic.

The primary purpose is to acknowledge the user whenever there is a critical action taken by the system. Arduino's built-in function "digitalRead()" helps track current status of sensors

Fig. 8. ArduinoUno esp8266

When the temperature is between 28-35 the motor is in off state, whereas when the temperature is between 40-46 the motor is in on state.

When the moisture is less than 1000, the motor will be in off state. Whereas when the moisture is greater than 1000, the motor will be in one state.

Table I. SENSOR VALUES

Time	Temperature	Moisture	humidity	Motor status
1	28	700	35	Off
1.10	30	1000	37	On
1.15	35	900	39	Off
1.20	40	1010	45	On
1.25	43	1050	47	On
1.30	45	1100	51	On

In this proposed model, we have taken the threshold value limit of 1000. The threshold value decides sprinkler status. A binary value of 1000 is set because it's a general case value for almost all the crops, i.e. a state at which the soil is neither too moist or too dry, this limit is not adequate for the plants that require stagnant water for instance rice. This means, if the reading of the sensor exceeds threshold value, sprinklers will be turned On. The threshold value is calculated using Eqn.(1)

$$(\Sigma_i^n S_i)/n = \tau \qquad (1)$$

Where, S_i is reading the i^{th} sensor and n is the number of sensors.

The above formula will help the system in deciding the moisture value for multiple circumstances and also the average soil moisture value of the field.

Decision making statement for independent use of sensors: if (Sensor value is greater than 1000) set sprinkler pump pin to HIGH else set sprinkler pump pin to LOW.

5. Result and Discussion

The proposed system web application based Smart Irrigation System using Internet of Things is state-of-art and represents the new features that can help to ease the work of farmers. focuses on irrigation using IoT and GSM, this would increase the cost of the system significantly. Therefore, the proposed system uses Wi-Fi to operate the system.

The proposed system features are,

- Provides both automatic and manual control of sprinklers, so that the farmers can also operate the system manually with a touch button.
- Provides Past year's crop production data, so that farmers can give a better thought to what kind of product they need to harvest.
- Provides weather prediction, so that farmers can get to know the future weather and set their farming practice schedule accordingly.
- System switches from automatic to manual automatically, in case weather prediction is rainy. This feature saves the crops from overwatering.
- Provides timer-based irrigation, so in case farmers want to irrigate the field manually for a particular time they can set a timer for that amount of time.
- Wi-Fi based system. As the system is Wi-Fi based this would reduce the technology cost for farmers in case they are in the range.
- A cost-effective smart irrigation technique, which helps in saving the excess of water flowing in the land. This excess water can be saved in a separate storage tank, which can be utilized for multiple purposes.

The farmers are still using old methods of manually monitoring the crops. When this task is automated, it reduces the burden on farmers by a huge margin. The natural resources need to be supplied in a limit to the crops as excess supply or shortage of supply will damage the crops. The introduction of GSM shield which intimates the user about the status of the motor and sensors in a conditioned manner has eased the users' experience. In case the user turns OFF a motor and there is no acknowledgment received then it can easily be understood that the appliance is not working in the expected way. Also, the automatic turn OFF feature not only reduces the energy usage but also saves the additional cost that might be incurred and prevents the crops from getting damaged. The implementation of a web-based control for the entire setup has made the setup more accessible. It was also observed that the entire setup was very cost effective and reliable.

The soil moisture sensor is being used to detect the soil moisture from the soil and then it is compared with the threshold value that has been set. The threshold value is to be decided based on the agricultural database in the system that has been built based on the type of soil and crop. The soil type of the farm is detected based on the GPS location of the field that farmers have selected for crop harvesting.

The soil moisture sensors are used to detect the moisture from the soil and send the information to the microcontroller and so it is the function of temperature sensor and humidity sensor. The processing and decision-making tasks are performed in the micro-controller and the signal is sent to the relay to switch the water pumps on/off. The proposed system provides a one stop solution for farmers that resolves their problems with ease of use. The proposed system also provides farmers with updates and notifications regarding the latest government schemes related to farmers and farming. Thus, the system will ease farming practices and might improve the condition of farmers economically.

6. Conclusion

The proposed methodology helps the farmers in saving their crops cultivated in their fields from natural causes like heavy rain, excess flow of water from wells and also reduces the manual intervention, since the information related to the entire process will be sent as a message to the users' mobile number. In actual scenario, the dc motors have to be replaced by ac motors. This prototype has been designed in order to save the water, which is flowing in excess into the agricultural fields, which in turn saves the crop cultivated in the field. Due to this, the water scarcity can be eliminated to a larger scale.

That manual work is reduced, and watering is automated. Healthy plants can be grown with limited use of water and electricity. Even elderly people can easily do farming. IOT plays a major role in the agricultural field. This study mostly applies to the topic of agriculture. The paper has been used to grow plants and it was successfully grown by automatic process. It helps us to achieve a healthy farming system. Increasing agriculture also aids in improving the nation's economic situation.

The existing system works by collecting moisture data from the field using moisture sensors, then this data is sent to the server-side and on this data further processes are conducted based on this data. After being processed by the server, the system's final output is shown to the user. As a result of examining the existing systems, we have concluded that the suggested system would not only assist farmers, but will also assist them in digitizing their agricultural activities, allowing them to get the most out of their practices without being reliant on the weather. The proposed system will automate the farming practices, provide the farmers with weather prediction, and the suitable crop for harvesting based on the past year's data. The proposed system will not only help the farmers in irrigation practices but will also improve the condition of the current farming practices. The proposed system provides a feature of automatic and manual irrigation to the farmer. The system also provides suggestions of a suitable crop to the farmer based on their location and its last year's crop harvest quantity. It also uses prediction analysis to anticipate the quantity of each crop that will be harvested this year based on the previous year's data.

Also, the system provides a feature of the weather forecast and in case if it is "Rainy" the sprinklers will switch from automatic to manual mode this would prevent the overwatering of fields, saving them from getting rotten and increasing the efficient use of water. The proposed system also provides farmers with updates and notifications regarding the latest government schemes related to farmers and farming. Thus, the system will ease farming practices and might improve the condition of farmers economically. The future work and developments might improve the proposed system and be more fruitful to the farmers and studies related to the proposed work.

References

[1] Rajakumar, G., Saroja Sankari, M., Shunmugapriya, D. and Uma Maheswari, S.P. (2018). IoT Based Smart Agricultural Monitoring System. Asian Journal of Applied Science and Technology, 2(2): 474-480.

[2] Sarkar, P.J., and Satyanarayana, C. (2016). A Survey on IOT based Digital Agriculture Monitoring System and their impact on optimal utilization of Resources. IOSR Journal of Electronics and Communication Engineering, 11(1): 01-04.

[3] Sierra, J. E., Medina, B., and Vesga, J. C. (2017). Management system in intelligent agriculture based on Internet of Things. Revista Espacios, 39(8): 1-9.

[4] Anitha, R., Suresh, D., Gnaneswar, P. and Puneeth., M. M. (2019). IoT Based Automatic Soil Moisture Monitoring System using Raspberry PI. International Journal of Innovative Technology and Exploring Engineering, 9(2): 4375-4378.

[5] Vinita, T., Raman kumar., Gopal, F., Anant, G., Patel, J. B., and Manjeet, K. (2017). IOT Based Agriculture System. International Journal of Engineering Science and Computing, 7(5): 12446-12451.

[6] Yuvaraju, M., and Priyanga, K. J. (2018). An IOT Based Automatic Agricultural Monitoring and Irrigation System. International Journal of Scientific Research in Computer Science, Engineering and Information Technology, 4(5): 58-65.

[7] Mythili, R., Meenakshi Kumari., Tripathi, A., and Neha Pal. (2019). IoT Based Smart Farm Monitoring System. International Journal of Recent Technology and Engineering, 8(4): 5490-5494.

[8] Ali, T. A. A., Viraj, C., and Potdar, M. B. (2018). Precision Agriculture Monitoring System using Internet of Things (IoT). International Journal for Research in Applied Science & Engineering Technology, 6(4): 2961-2970.

[9] Sanjay, N. P., and Madhuri, B. J. (2019). Smart Agriculture Monitoring System Using IOT. International Journal of Advanced Research in Computer and Communication Engineering, 8(4): 116-120.

[10] Lashitha Vishnu Priya, P., Sai Harshith, N., and Ramesh, N. V. K. (2018). Smart agriculture monitoring system using IoT. International Journal of Engineering & Technology, 7(2.7): 308- 311.

[11] Sukumar, P., Akshaya, S., Chandraleka, GChandrika, D., and Dhilip Kumar, R. (2018). IOT based agriculture crop-field monitoring system and irrigation automation. International Journal of Intellectual Advancements and Research in Engineering Computations, 6(1): 377-382.

[12] Srishti, R. (2017). IOT based Smart Irrigation System. International Journal of Computer Applications, 159(8):7-12.

[13] Govardhan, S.D., Jancy Rani, S., Divya, K., Ishwariya, R., and Aegin Thomas, C. T. (2017). IoT based automatic irrigation system. International Journal of Recent Trends in Engineering & Research. 277-283.

[14] Bhagyashree, A., Tapakire., and Manasi, M. P. (2019). IoT based Smart Agriculture using Thingspeak.

[15] Laura, G., Lorena, P., Jimenez, J.M., Jaime, L., and Pascal, L. (2020). IoT-Based Smart Irrigation Systems: An Overview on the Recent Trends on Sensors and IoT Systems for Irrigation in Precision Agriculture. MDPI - Sensors, 20(1042): 1-48.

[16] William Isaac and Shashank Varshney, “An IoT Based System for Remote Monitoring of Soil Characteristics” presented in International Conference on IT(InCITe),2016.

[17] Joaquin Gutierrez and Juan Francisco, “Automated Irrigation System using Wireless Sensor Network and GPRS Module” presented at IEEE Transaction on Instrumentation and Measurement, 2013.

[18] Yunseop Kim and Robert G. Evans, “Remote Sensing and Control of an Irrigation System using a Distributed Wireless Sensing Network” presented at IEEE Transaction on Instrumentation and Measurement, Vol- 57, July-2008.

[19] William Isaac and Shashank Varshney, “An IoT Based System for Remote Monitoring of Soil Characteristics” presented in International Conference on IT(InCITe),2016.

[20] Joaquin Gutierrez and Juan Francisco, “Automated Irrigation System using Wireless Sensor Network and GPRS Module” presented at IEEE Transaction on Instrumentation and Measurement, 2013.

[21] Yunseop Kim and Robert G. Evans, “Remote Sensing and Control of an Irrigation System using a Distributed Wireless Sensing Network” presented at IEEE Transaction on Instrumentation and Measurement, Vol- 57, July-2008.