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Techno Agri for New Cities by Smart Irrigation

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Abstract

Agriculture is the most important source of food production. It also plays a crucial role in the gross domestic product of the country. But there are various constraints in traditional methods of agriculture. These constraints include excessive use of water during cultivation of crops, time, money, etc. In order to overcome the various constraints involved in the agriculture sector, there is a need for an evolved irrigation system. This paper aims at developing an automated smart irrigation system with the help of the Internet of things. Its aim is to maintain an adequate amount of water needed by the crop by monitoring the amount of soil moisture, temperature, and humidity in the soil. The data of temperature and humidity are maintained in the database for backup. The data are used for crop rotation and also help the farmer for the selection of appropriate crops. We can also verify the different types of soil appropriate for different crops using this model. These will also benefit the farmers as they will be able to monitor the irrigation of the crop from a distant location. It would also save the time of the farmer and reduce the labor work. The manuscript deals with the IoT-based smart agriculture device, which can be developed as a useful product and be proved as a game changer in the next-gen agriculture. In South Asian continent, farmers are economically poor, and they will be highly benefitted by this application, if developed commercially. Smart cities concept in India will be supported by this.

***Keywords*:** Arduino, soil moisture sensor, humidity and rain sensor, esp8266 wi-fi module, dht-11, smart irrigation, IoT

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1.1 Introduction

Agriculture can be defined as a technique of cultivating the soil, growing crops and raising livestock. Agriculture is considered as the main source of food and fabrics. Cotton, wool, paper and leather are all agricultural products. Agriculture also provides wood for construction materials and other household activities. Before agriculture became an important factor people used to spend most of their lives searching for food and hunting wild animals. But around 2000 years ago, agriculture became the most important source of food and most of the Earth's population became dependent on agriculture.

Water is a basic need of every living being in this world. It plays a vital role in carrying out day to day activities in human life. Agriculture is an area where water is required in a large quantity for better growth of the crops. But due to overuse of water the ground water level is depleting very rapidly. The main reason for this problem is the population growth and its increasing demand for water requirements. Overconsumption and wastage of water is another major problem, which is leading to water crisis in this world. Water crisis may lead to economic decline and poor living conditions if we continue the current scenario of water usage [5, 12].

With the estimated growth of the world's population to 8 billion by the year 2050, the requirement for crops and food will also increase rapidly. On the other hand, the temperature is likely to increase by 4 to 5 degrees in the next few years due to global warming. Some climate models describe that there would be an increase in concentration of carbon dioxide on the crops. Therefore, climate change has the potential in affecting the productivity of agriculture. It is expected that there would be an increase in yearly dry days to about 15 extra dry days in the next few years. Which means that the dry areas would likely receive less rainfall throughout the year. This will have a direct impact on the total growth of agriculture [13].

Water is considered as the most important substance for running our life properly. Our bodies need water to function properly. According to Science humans can survive for weeks without food, but can survive only a few days without water. But we humans are depleting the fresh water sources very rapidly because we are not bothered to use the water in an efficient manner [13].

The Earth's temperature is rising due to global warming and the hotter the earth will be the more would be the demand for water. The shortage of water will lead to less production in the agricultural field and thus the water crisis will become a food crisis. The main source of freshwater is

groundwater, which is decreasing very rapidly. Ground water level could be increased by using the technique of rainfall harvesting [21].

Smart irrigation devices are the components that we are using in this project which will first analyze the climatic conditions like rainfall and temperature and then the will automatically operate the process of irrigation. Devices like rainfall, temperature, and humidity and moisture sensors are able to give precise values, which are used by Arduino to carry out the automated irrigation process. These values are used to match the threshold values and then the water pump is turned ON and OFF accordingly. Thus, using these smart irrigation devices, we can reduce water wastage, as well as increase the productivity [8].

IoT abbreviates to the Internet of Things. IoT is considered as a milestone when we talk about the evolution of superior technology. IoT comes into mind when we try to automate things. IoT can be applied in various sectors such as home automation, surveillance systems, and in the agriculture sector, there is a wide range of applications of IoT. As we already know that the crops require proper care for better yielding and irrigation is the most dominating factor that affects it most. Due to irregular monsoon, cultivated plants do not grow properly and result in low production. Using advanced technology like IoT, we can overcome this problem. By planting different sensors in the field, we can record important factors like temperature, humidity of the air and soil moisture content and make decisions accordingly using microcontrollers. Irrigation will be done automatically when the moisture of soil falls. It will be more helpful in the areas where there is a lack of water supply and fewer rainfall readings. The use of IoT in an irrigation system can bring a new revolution in the agriculture sector [10, 12].

The soil moisture of the field can be figured out by various techniques, such as by using the thermogravimetric method or by using a gypsum block and tensiometer methods. These methods are old and are put back by time domain reflectometry, frequency domain reflectometry, and optical sensor technology. Soil moisture estimation based on sensors provides data, which is real time, at an affordable cost. The sensor-based irrigation has a lot of positive points over the traditional method. It collects data that are real time and can be interpreted accordingly by different smart modules. It is cost-efficient and time-saving [11, 14].

- Productivity increase,
- Less water consumption,
- Almost zero manpower consumption,

- Cost efficient,
- System have weather resistance,
- Most efficient use of water.

Drip-irrigation System (Traditional): The most efficient way of irrigation is the traditional drip irrigation system. It allows water to ooze at the plant roots, resulting in less water wastage. It also helps in the efficient utilization of fertilizer, which is absorbed by soil uniformly with steady irrigation [12, 15].
Irrigation with Timer System: The best way to reduce water wastage in irrigation is by making a schedule. An irrigation system with an automatic timer can prevent over-watering in the field and can prevent from damaging the crop due to excessive irrigation. It helps to manage the water requirement for each season. It is cost efficient and reduces wastage of water while irrigation [12].
Smart Irrigation System: It uses MATLAB along with wireless sensors and IOT. Very good for the water usage optimization and can be operated remotely. It has auto and manual mode, which are very helpful, and cloud implementation makes it highly applicable [12, 16].

Research Objective
In this fast-growing digital world, we have thrust our thinking limit and are trying to replace normal brains with an artificially created one. Using AI we can make an intelligent machine. Machine learning with deep learning, ANN, CNN, sensors can intensify the machine work, which results in the development of more superior technology. The use of AI and ML in the agriculture sector along with different sensors to capture data can bring revolution and give birth to a happy and prosperous era [6].

1.2 Literature Review

The paper by Bobby Singla and others tells about how we can effectively control the water supply in our agricultural field. Sensors that are used for this application are DTH-11 sensor and soil moisture sensor. The information is provided on farmer mobile phones using Wi-fi and Arduino. In this manuscript, the DTH-11 temperature sensor and soil moisture sensor are connected to the input pins of Arduino Uno. The analog values produced by Arduino Uno are converted to digital output by the microcontroller. The obtained values are displayed by the mobile application. The motor

is switched on/off based on the value obtained from the microcontroller with the already defined threshold value. The abovementioned system is found to be efficient in reducing the cost of the farmers and optimizing their agricultural production. The maintenance required by the system is also less [1, 17].

Rawal, Shrishthi and other team has found in their paper proposes an irrigation system which maintains and decides the required soil moisture content through automatic watering. The value obtained from soil moisture sensors helps to determine the exact quantity of water needed for irrigation. The system is divided into hardware and software components. Hardware comprises systems such as sensor, Arduino-uno whereas the software consists of a webpage displaying the data from the microcontroller. The sprinkler control is achieved using a threshold value. The value obtained from the system decides whether to turn on/off the sprinkler. The reading obtained is then put forward on the farmers' website. The system uses value obtained from the microcontroller to on/off the sprinkler. This prevents the loss of the farmer and thereby avoiding crop damage [2, 18].

Nandhini and their team of researchers revealed that the proposed irrigation system helps to regulate the flow of water in the system. By using these systems, we can make effective use of water. The system uses soil and humidity sensors to find the level of moisture and humidity in the soil. The sensed values are then displayed on the screen. This system also uses various sensors, such as pH sensor, pressure sensor, DTH-11 sensor to find the sensed values from the Arduino UNO. The sensed values are then sent to be displayed on the screen of the web page application. If the value on the sensor crosses the threshold value, then the pump is turned on/off automatically. The main objective is to find the effective, user-friendly solution to the given problem. Due to readily available updates from the server, users can know about crop fields anytime [3, 19, 21].

In their experiments of agriculture, Aman Kumar and team proposed that their system is an automated irrigation system designed to save the time, power, and money of the farmer. By using these systems, we can make effective use of water. The system uses soil and humidity sensors to find the level of moisture and humidity in the soil. The sensed values are then displayed on the screen. The sensed values are then sent to be displayed on the screen of the web page application. If the value on the sensor crosses the threshold value, then the pump is turned on/off automatically. The main objective is to find the effective, user-friendly solution to the given problem. Due to readily available updates from the server, users can know about crop fields anytime [4, 20].

1.3 Components Used

Arduino System
Arduino UNO is basically a microcontroller, which has both hardware, as well as software components. Multiple sensors could be connected at a time to the Arduino board, and these sensors gave values to Arduino with the help of program codes. The board also consists of LED, which glows when our values are matched. We can run Arduino either by connecting to our computer or by using DC power supply. The main concept is to run a physical device by using software. With the help of programming, we can easily automate various devices using Arduino. An Arduino board generally consists of analog and digital pins, a USB port, a power jack as well as a reset button (as per Figure 1.1) [8].

Sensors Used in our Research Work
In this project, we are using three types of sensors in order to calculate the soil, as well as atmospheric conditions. Sensors used are soil moisture sensor, humidity, and temperature sensor, as well as rainfall sensor.

Soil Moisture Sensor
The moisture of the soil plays an important role in the irrigation of a field. The soil moisture sensor is a kind of sensor which is used to measure the content of water within the soil. Moisture of the soil is dependent on the amount of water within the soil. If the soil is dry, it will have less moisture as compared with the wet soil. The moisture sensor works by inserting it into the field and the water content in the soil is reported in the form of percentage. There are multiple uses of soil moisture sensor:

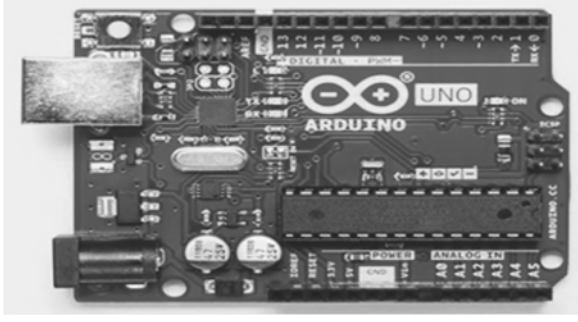

Figure 1.1 Basic Arduino Uno, microcontroller [8].

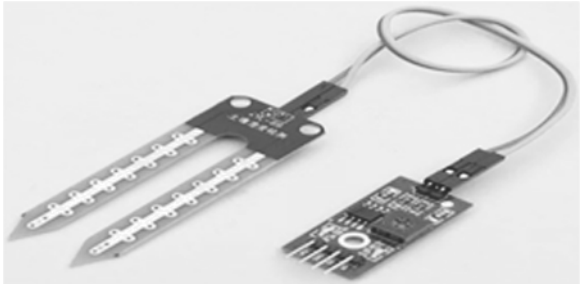

Figure 1.2 Soil moisture sensor [8].

- Agriculture
- Landscape Irrigation
- Research (as per Figure 1.2) [8].

Temperature and Humidity Sensor

Temperature and humidity sensor (DHT11) is a combined low cost sensor that gives values for both temperature, as well as humidity in the environment. It works by inserting the sensor in the Arduino board and it gives climatic conditions of the surroundings. Humidity measurements do not mean to measure humidity directly; rather they depend on the measurement of quantities such as temperature, pressure, mass, resistivity to calculate humidity. These sensors give the output as digital values, which make them easy to interface and use with microcontrollers, such as Arduino, Raspberry Pi boards (as per Figure 1.3) [8, 9].

Rainfall Sensor

The rainfall sensor is a device that is used to calculate the amount of rainfall in a particular area. This sensor is used as a water preservation device,

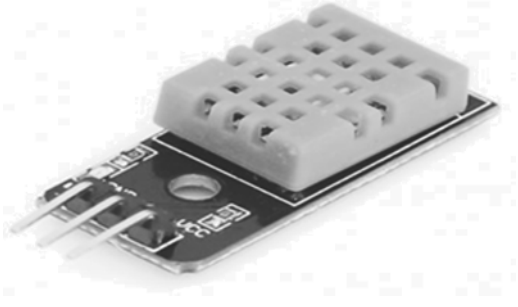

Figure 1.3 Temperature and humidity sensor [8].

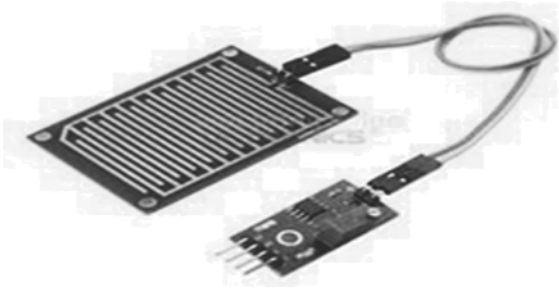

Figure 1.4 Rainfall sensor [8].

and this is connected to the irrigation system to check if there is rainfall going on and if the condition is true it shuts down the system at the time of rainfall. This sensor includes a board with nickel coated line, and it works on the resistance principle. When the rain droplets fall in the nickel coated board it gives the value of rainfall in the area. The four pins of the sensor are inserted in the Arduino while the board is kept in the field to calculate values (as per Figure 1.4) [8].

1.4 Proposed System

Various sensors, microcontrollers, the android application can be used for making an automatic irrigation system. We generally go for low-cost humidity, temperature, and soil-moisture sensors. These sensors are connected to Arduino and continuously monitor the field.

The collected data by the Arduino through sensors are transmitted to the user wirelessly so that they can control the system remotely. The smart android application compares the value received from the sensors from its database and takes the appropriate decision. The proposed system has two modes auto and manual.

When the auto mode is on, the system acts automatically without any human interruption, while with manual mode ON, the motor can be operated with just a click of the switch. The motor toggles accordingly with soil moisture value, if the value is below the threshold motor turns ON else remains in OFF state.

The sensors are joined to the Arduino Uno and the hardware communicates through a microcontroller (ESP8266) which is a wi-fi module.

All sensor values are displayed on the mobile interface so that the user has a continuous reach of the condition of the field. Programming of Arduino Uno is done in Embedded C.

We program the board that it transmits the sensor value and motor condition to the user and can also control the motor when the auto mode is engaged. The coordination of four sensors and the motor is controlled by the program fed on the board. The system continuously monitors the soil moisture content and keeps sending to the user, if the sensor gets low reading, it turns the motor on and on, reaching the requisite state it turns it off. All these functionalities are governed by a set of code fed on the board.

The user and board communicate via the wi-fi module (ESP8266). It has a quite considerable range. The threshold value will be set in the board and android application.

The moisture of the soil will be different in the winter and summer season and also the humidity and temperature. The threshold value is formulated after the consideration of different environmental and climatic conditions. The system turns the motor on automatically if the reading goes below the threshold and vice versa. The former can also operate the motor manually using the android application. Below are the block diagram and data flow diagram of the proposed model (Pl. refer the Figure 1.5 to Figure 1.9 for the different diagram of our proposed model).

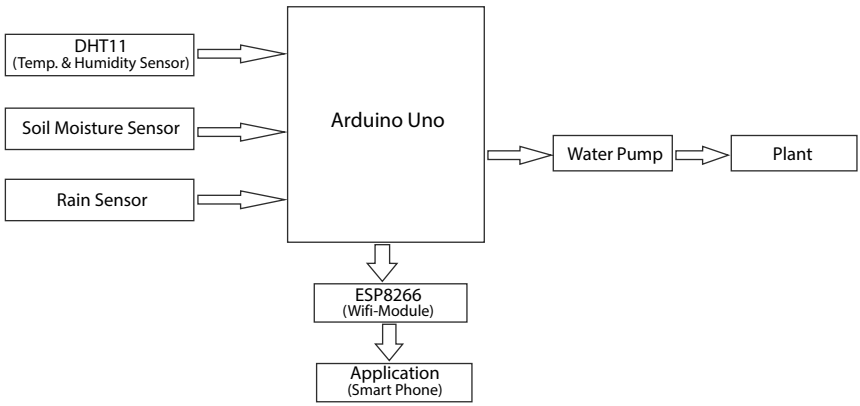

Figure 1.5 Block diagram of smart irrigation system using IoT: future prospective for agriculture.

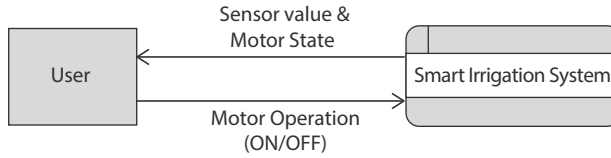

Figure 1.6 Data flow diagram of smart irrigation system using IoT: future prospective for agriculture (level 0).

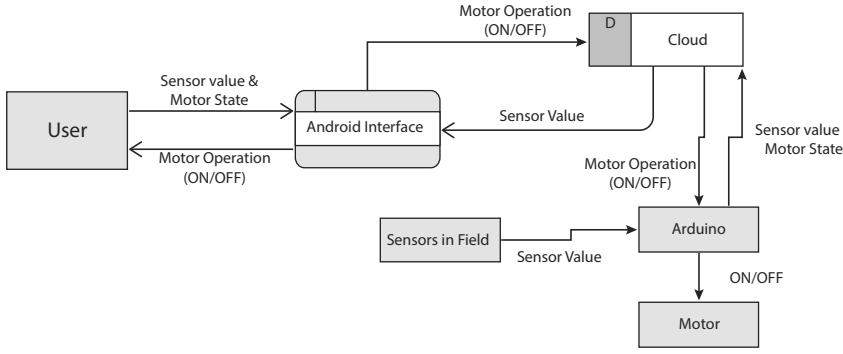

Figure 1.7 Data flow diagram of smart irrigation system using IoT: future prospective for agriculture (level 1).

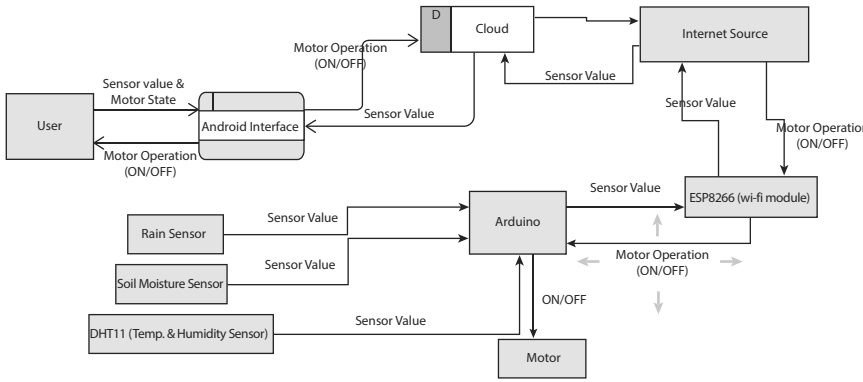

Figure 1.8 Data flow diagram of smart irrigation system using IoT: future prospective for agriculture (level 2).

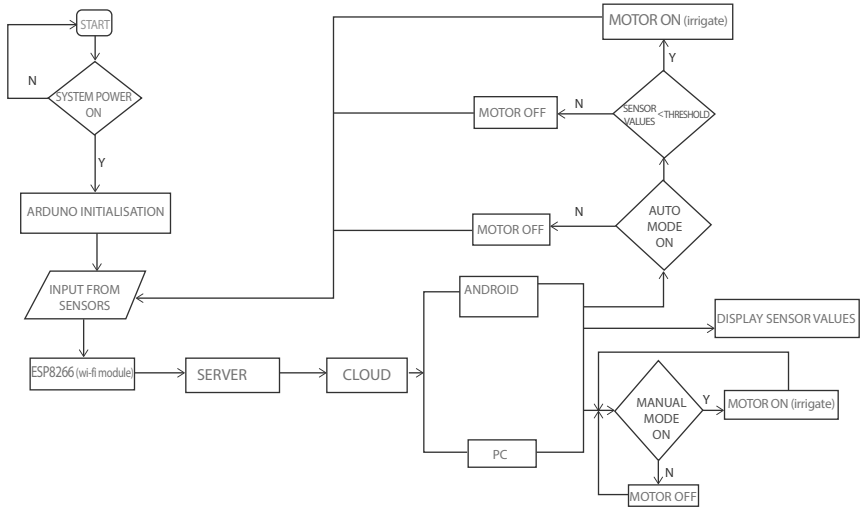

Figure 1.9 Activity diagram/flowchart of smart irrigation system using IoT: future prospective for agriculture.

1.5 Android Mobile Application for Smart Irrigation

The Android Mobile application is used to automate the activity of irrigation. The application's user interface consists of a login page where the farmer has to enter the login credentials to enter the main functioning page. The farmer first has to create his/her account in order to use the application. This is an extra security feature added so that nobody can misuse the system. There are two options on the login page, one to sign up and other to login. If the user is new, he/she first has to make his account, and then he will be able to login successfully (as per Figure 1.10).

1.5.1 Main Page

Home Page of our working App after successfully logging in from the login page, the farmer will be able to access the main page of the application. Here on this page all the values from the sensors would be displayed. If the farmer wants to manually operate according to the current values, then he can manually turn the ON/OFF button or he can use the automation button, which will automatically turn the motor ON/OFF when the Threshold values are matched (as per Figure 1.11).

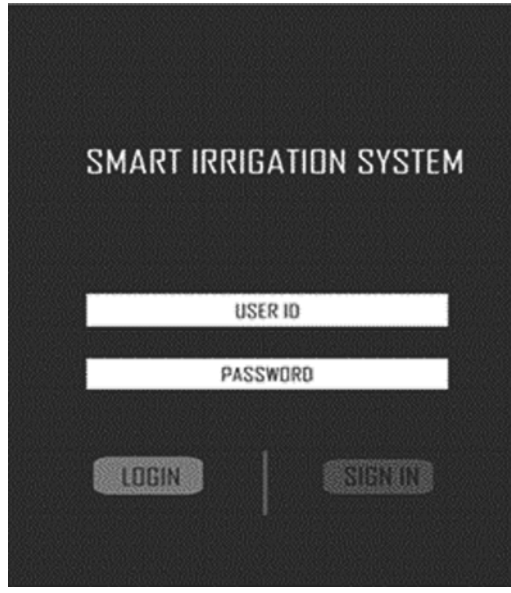

Figure 1.10 Login page of the app of smart irrigation system.

Figure 1.11 Home page of our working app.

1.5.2 Snapshot of Working Model (ICs and Working Model)

In this project, multiple sensors are connected to the Arduino board which will give their respected values when inserted in the field. We will program the Arduino in such a way that it will automate the process of the irrigation.

The user's job is to only start the motor pump or if he desires, he can switch off the motor by just one click.

On starting the motor pump, the following conditions will work:

1. The user can switch OFF the motor manually with the help of an android application.
2. The motor pump will automatically get switched OFF on reaching the threshold value of soil moisture.
3. If it is already raining in the field then the motor pump will automatically turn OFF because watering the field is not required if it is raining outside. Once the rain stops and the conditions go under the required threshold value then the motor will again turn ON. This helps in saving water resources and electricity (as per Figure 1.12).

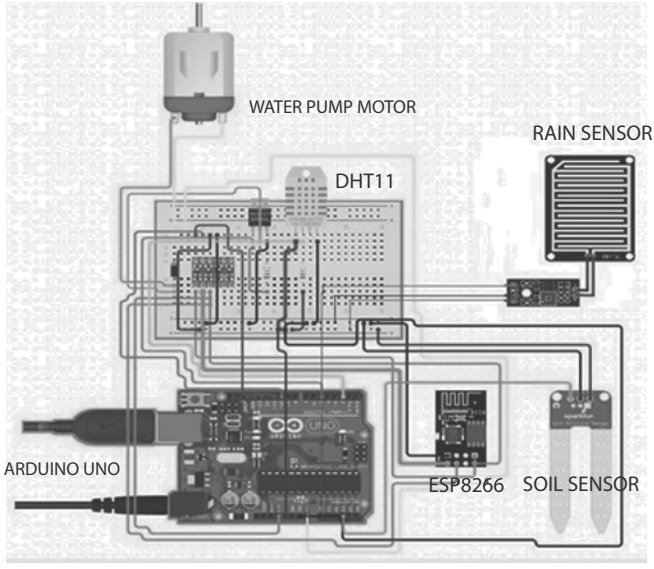

Figure 1.12 Proposed system of smart irrigation system using IoT: future prospective for agriculture.

1.6 Novelty

There are many smart irrigation projects available in the market but they are generally very expensive, and they work only for a bigger region whereas this project can also work for a small land, and it is also inexpensive and efficient as compared to other projects. With the factor of low cost, any farmer could easily buy and use it. It is also very simple in design and working is also very easy as compared to other projects so it can be used by anybody. The maintenance cost is also very low. The project aims in reducing the water wastage while working in an efficient manner.

1.7 Future Research Work

The proposed model is highly effective and is cost-efficient. It will be more effective when used along with the drip-irrigation system. There are a lot of possibilities in this model. Research can be done to make it more cost-efficient using alternate semiconductors, the interface can also be enhanced and more functionality can be added. There is a possibility of improving the server connectivity which will be very beneficial. By applying different AI and ML algorithms it can be made more advanced. Overall, the model is more than enough and can be advanced with future work and research as there are always possibilities for improvement.

Using AI and ML, we can make a system smart enough that can act on its own and water the field when needed. We can also develop a system smart enough that can monitor the condition of crops and inform the former who can act accordingly, which finally results in good production [7].

1.8 Limitations

Apart from the advantages, it has its limitations. The ICs are not much compatible with the weather and require waterproof protection which increases the cost. We have to use multiple sensors to record value as it has a small range so there are possibilities of human error while implanting the sensors. Sometimes, sensors do not work as expected which require proper attention to good and precise results. With proper knowledge and skill, this mode can be very beneficial and helpful to the agriculture sector. The limitations of the model can be reduced with good research work.

1.9 Conclusions

The abovementioned proposed model Smart Irrigation System Using IoT: Future Prospective for Agriculture is much realizable and cost-efficient for less consumption of water while irrigating the field. This system is very beneficial in the region with less rainfall, hence helps in sustainable development. Irrigation of the field can be done in a much smarter way using this model. This model will be very useful in minimizing the consumption of water while irrigation and the saved water can be used for other purposes which results in the conservation of water. This model is eco-friendly and does not harm the field in any way. With multiple sensors, we can locate the area which requires water and irrigate that area only. It requires less maintenance and is highly effective in the reduction of water consumption. With proper irrigation, the productivity increases and results in greater profit. The future work is to make the interface much more detailed and add more functionality to the system.

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