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Cloud Computing Based Smart Irrigation System for Big Farms

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Abstract – The main purpose of this study is to determine the optimum consumption of water and the required water consumption in agricultural irrigation systems. A smart irrigation system includes utilizing innovation to optimize and computerize the watering of plants. It regularly utilizes sensors, climate data, and automation systems to deliver the appropriate amount of water at the right time, thus increasing efficiency and conserving resources. The increase in water needs compared to the increase in population growth requires management of water sources and saving consumption. With progression in innovated technologies, we will set up a system that controlled the irrigation such that there's productive usage of water and make an ease of work for the farmers. By using internet of things and embedded technology, a cloud based smart irrigation system have been implemented in this work.

In this system, the required amount of water is accurately supplied to the plants by obtaining the required information regarding moisture of soil, temperature levels and changes in lighting intensity, which is provided via sensors. These sensors are connected through peripheral devices deployed in the work field to collect information about the weather and soil condition and send this data to the nearest wireless server that will store it on the cloud. Field workers will be able to monitor changes in parameters through dashboards on a website integrated with cloud storage. IoT utilization enables the workers in the field to make an estimation of the required amount of water within the upcoming days. These technological means enable us to study, compare and analyze data for different times during the year and find different ways to reduce and conserve water consumption.

Keywords *– Smart irrigation, Internet of Things (IoT), Sensors, Cloud computing, Water conservation*

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I. INTRODUCTION

Water resources are considered as one of the most important elements for all living organisms on Earth. Failure to manage water properly can result in the loss of these vital resources. Depletion and unnecessary and excessive energy consumption, as well It causes effects such as decreased product efficiency [1]. That is why many countries are developing new strategies to increase sustainability. Food production and emphasizing the require for successful management of water resources. The greater efficacy of automated irrigation planning may be related to its capacity to self-tune the watering requirements based on the specific characteristics of each plot and its quicker responsiveness to changes in soil, plant, and weather conditions [2]. Creating an ideal irrigation strategy requires experience as well as making the necessary measurements. So, Irrigation is planned in many countries In line with the experiences of farmers and technical advisors [3]. In this context, achieving precise and sustainable irrigation enables farmers to save time and reduce the need for expertise, it reveals the fact that they need to implement irrigation using digital and technological infrastructure.

Beside technological developments, smart systems play an important role in agricultural irrigation planning and irrigation systems. This depends on the system's ability to meet the requirements of the self-irrigation system according to each agricultural plot of land, in addition to responding quickly to changes in soil, plant and air conditions. Mathematical methods such as control models help determine and implement optimal irrigation management [4]. One of the water planning methods is the Food and Agriculture Organization Penman-Monteith Method (FAO-PM) recommended by the Food and Agriculture Organization of the United Nations (FAO). Automated water system planning based on the FAO water balance model and humidity sensors has been the subject of significant investigate over the past few decades [5]. The FAO Soil-Water Balance approach is often used to calculate irrigation requirements by comparing inputs to outputs in the soil and plant system.

With new generation advanced technology, simple and detailed methods have been used to improve smart irrigation systems. One of the simplest approaches has been automatic systems that turn the irrigation system on or off when soil moisture is above or below pre-set thresholds. In slightly more complex systems, water amounts are determined using feedback from plant or soil sensors. These and similar irrigation systems are insufficient to determine the water needs of the plant, cause more water to be consumed than necessary, and cannot optimize the energy and cost spent [6]. Energy costs make up about 40%-60% of the water costs spent in irrigation systems. Today's shortage of water resources and increased energy demand in irrigation systems make optimal irrigation planning mandatory.

In this project report, a smart irrigation system will be proposed that relies on technologies used in Internet of Things systems, by using data obtained from soil moisture, temperature, and light intensity sensors to calculate the optimal parameters for watering cultivated soil, by using a cloud computing environment to monitor, analyze, and store data, and control data. On irrigation processes [7].

The aim of this project is to guide farmers and urge them to use effective methods of crop production and to help them in times of drought due to lack of rainfall. The manual strategy of irrigation the crops leaves the farms uncultivated because of shortage in water during dry seasons which comes about in decrease of crop retainability [8].

In this proposed model, the information collected through sensors will play the important roll utilizing these data to gives an estimated amount of required water for crops according to environment situation through collecting data from temperature, soil moisture and light intensity sensors. Moreover, valves have an essential role in providing a path for water to enter and exit the field. The valve opens/closes according to the instructions sent by the client.leads to large amounts of water can be spared and over-watering of plants can be avoided utilizing this technique [9]. t

The information collected from the sensors, such as soil moisture, temperature, and lighting intensity which deployed around the agricultural crops, will be sent to the nearest gateway. The data is then transferred to the cloud through the portal, where it’ll store the recorded data sequentially after linking it to the database system. Then the threshold value is decided agreeing to the normal climate condition of the surrounding area, and its value is set during installation. The user will be alerted by the system through sending a message or notification, when the soil moisture threshold has been exceeded by sensed value, then then desired action done by the user according to the situation of land. Ones the owner performs the required action it instantly sends response to the database which in turn provides request to the controller and the motor turned on and the valves gets opened up outlet of water into the fields until the moisture level reach the threshold value. Thus, the surplus outlet water can be stored to be used during dry season. Hence, gathering of water can be done with effective usage of water. The database can be also useful in giving accurate agriculture information. A detailed study of the sensor values can also predict the yields percent. This can also prove beneficial in suggest the farmer to put extra manure or fertilizer for meeting its demand.

II. Materials and Method

The Internet of Things is the physical connection between different devices over the Internet, where data is collected, exchanged, and controlled. While cloud computing provides on-demand online access to computer resources and services. This system complies by collecting data from sensors in real-time with the aim of automating irrigation by comparing threshold values. Obtained information from the sensors can be stored the Thing Speak platform, as this platform provides sufficient space to store, monitor and analyze the data and make decisions based on the information received from the sensors and the impact of each value on decision-making after performing the calculations to obtain the optimal result through which the appropriate action is carried out.

A. Proposed System Architecture and Description

The proposed system enables the farmer to irrigate the field from wherever he is, which reduces his effort. different soil parameters coming from the soil moisture sensors will be sent to the Arduino Uno. As the soil values change, they will be compared with the threshold values via the Arduino, and commands will be sent to the relay to start or stop the motor to begin the watering process for the crops. All information will be uploaded to the cloud platform (Thing Speak) via the Esp8266 Wi-Fi module to be stored and analyzed later to obtain the ideal irrigation method and managing the amount of water needed for each specific period of time. The motor can be controlled via the Android application by the user, and different soil values are obtained through the cloud platform, which will help farmers in the irrigation process. Figure (1) Overview of the proposed system architecture.

Farmers can access the data from anywhere, and can choose a different threshold value for irrigation based on seasons and crops. They can also plan and schedule the optimal utilizing of water resources. With out mechanisms to track amount of water in the soil, farmers must monitor plants and examine the soil manually, and this is a cumbersome process and takes a lot of time and effort. This can be done by means of a smart system that alerts the farmer when the water level drops below the limits set by the farmer [10].

For measure the moisture level in the soil, a soil moisture sensor is used for measuring. After that the data is sent to IOT Gateway. Then this information will be uploaded to the cloud platform by IOT gateway using ESP8266 Wi-Fi Module. The cloud platform in the proposed system includes a web server, a database, and decision logic. The data coming from the Internet of Things portal is stored in the database. In addition, the decision on the necessity of watering plants is made through decision logic. For example, in the developed system, the temperature threshold is maintained at 25°C. the database will trigger decision logic when the temperature exceeded the threshold. It will then send a notification to the farmer via the application on the phone. Depending on the farmer's action, whether to turn on/off the irrigation, a signal will be sent to the cloud and from the cloud to the gateway, which will then send a signal to turn on the relay and turn on the water pump [11].

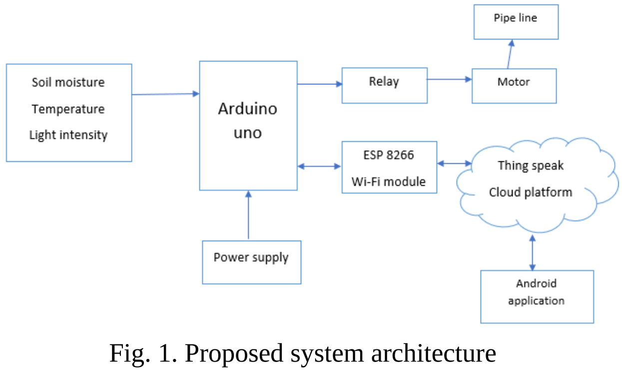


Fig. 1. Proposed system architecture

An IoT-based smart irrigation system uses real-time data to make irrigation decisions. The farmer needs his own data, such as a user name and a special password, to enter the application.

Then he is allowed to choose the irrigation method and choose the crop for that season. The proposed system is implemented in three parts: 1- Sensing 2- Processing 3- Distributing information

Measurement of physical variables is done in the sensing stage, as this stage includes measuring temperature, soil moisture, and lighting intensity. The sensors are collected on the Arduino Uno microcontroller board. This panel acts as a gateway to send data to the cloud [12]. After sending this data by the ESP8266 Wi-Fi module, the data is processed in the cloud. The sensor data is saved in the database in the cloud, in addition to that decisions are made in the decision logic unit based on the sensed data. In the final stage in terms of information distribution, the outputs of the decision logic are sent from the cloud to the Android application and then to the Internet of Things portal [13]. Below is the overall algorithm for the smart irrigation system. Figure (2) shows the complete flow chart of the proposed algorithm.

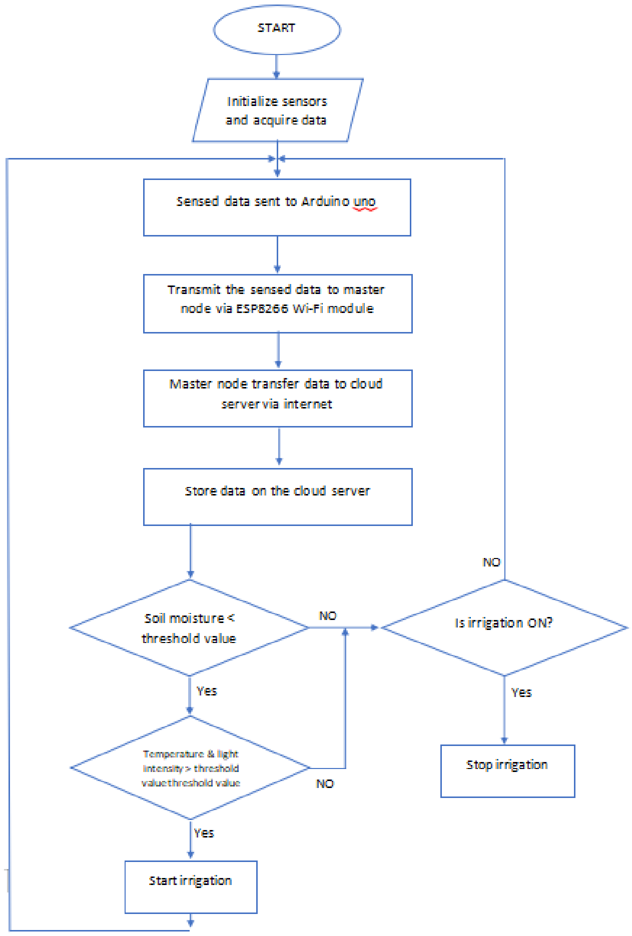


Fig.2. Flow chart of proposed irrigation algorithm

B. System design and implementation

With the system designed and implemented in the study, water resources and irrigation are used efficiently, so that the parameters of the area can be monitored at any time and place via a computer or smart device with internet access. To make an irrigation decision, the soil moisture value has crucial importance. Although rain is an influencing factor for humidity parameters, but it cannot immediately reflect its effect on the parameter values. for this reason, the system must be monitored and intervened at any time. In such systems, the threshold value is specified once and it is defined in the system.

The used sensors in this design are composed mainly of three types (Soil moisture, DHT22 and LDR).

The DHT22 temperature and humidity sensor is an advanced sensor that outputs a calibrated digital signal. It is highly reliable and stable in long-term studies. İt Contains 8-bit microprocessor and responds quickly. HL-69 contains sensors for measuring humidity. The sensor is also factory calibrated and hence easy to interface with other microcontrollers. With an accuracy of ±1°C and ±1%, the sensor can measure temperature from 0°C to 70°C and humidity from 10% to 90%. Thus, this sensor can be the best option to measure in this range.[15]

The MH soil moisture sensors are made to calculate the volumetric water content of the soil by using the soil's dielectric constant, also known as its bulk permittivity. You might think of the dielectric constant as the electrical transmission capacity of the soil. As soil's water content rises, so does the soil's dielectric constant. The reason for this reaction is that water has a far higher dielectric constant than the other constituents of soil, including air. Consequently, a reliable estimate of the water content can be obtained by measuring the dielectric constant. When these probes are immersed in soil or liquid, resistance occurs, creating a potential difference between the probe terminals. Depending on the size of this potential difference, the amount of moisture is measured.

LDR (light dependant resistor) is a unique kind of resistor that operates on the principle of photoconductivity, which asserts that resistance varies with light intensity. The more intense the light, the lower its resistance becomes. It is frequently utilized as an automatic public light, a brightness meter, a light sensor, and in other places where light sensitivity is required. Another name for LDR is a light sensor. Typically, LDR are offered in 5 millimeters 8millimeters, 12 millimeters and 25 millimeters sizes

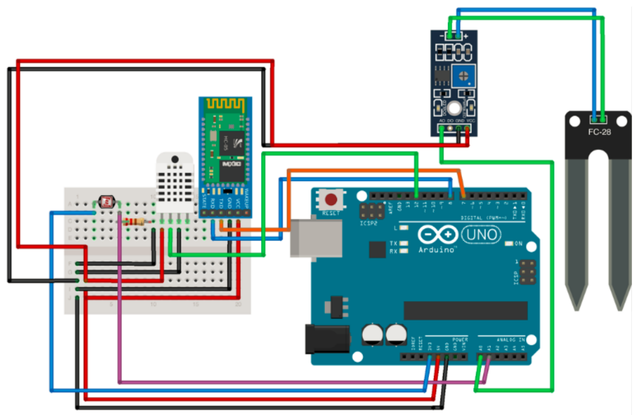


Fig. 3. Wiring diagram of control components

However, in the system designed in the study, the threshold value of the Arduino Uno is not specified in the controller and is used in the cloud. It is determined by Thing Speak, which creates the system. According to this specified limit value in the channel, all incoming data is scanned, and if it is below a certain threshold value, a Thing HTTP request is triggered by the React application and sent by the microcontroller card. A command is added to the Talkback controlled queue for execution. According to the command read by the talk back queue, the motor is turned on/off and irrigation management is performed. In a designed system, a partial control system that contains hardware components the IoT service that stores and visualizes it as it appears on the Internet is called a cloud system [10]. The control system, including wiring diagram in figure(3) and the hardware components of the system, is shown in Figure (4).

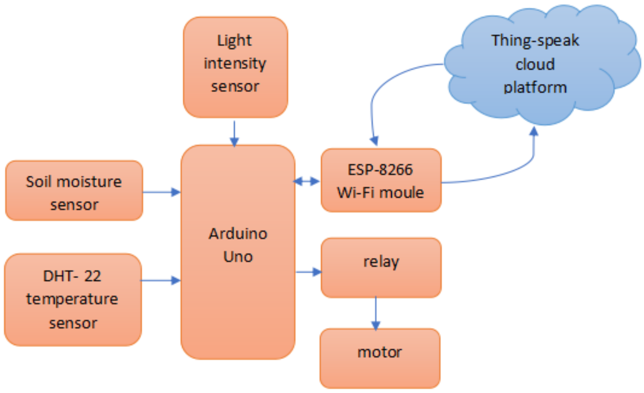


Fig. 4. Control components

Environmental variables that will affect The sensors used for measure the soil moisture coefficient, which has important value in making irrigation decisions. Sensor data is read by the microcontroller. This data is then serially sent to the cloud through the ESP8266 Wi-Fi module connected to the microcontroller. Figure (5) shows the recorded sensor values, which were visualized, and the command queue created in the cloud that was read by the microcontroller.

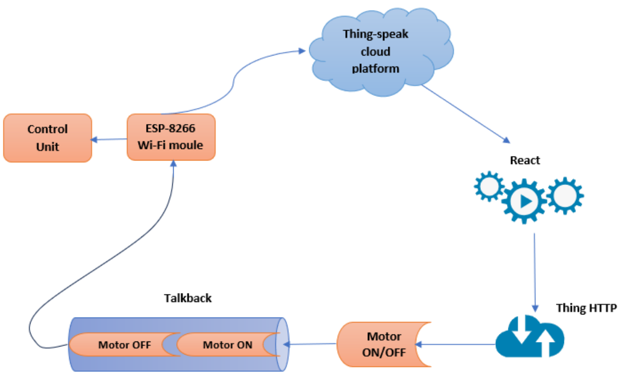


Fig. 5. Cloud System Components.

After connecting the control components and ensure remote monitoring of the system and to store the sensor data obtained from the field in the cloud, then registration is done in Thing Speak, which is an IoT service. A channel is opened here to save data [14]. The channel structure in Thing-Speak is similar to the table structure in a database. The areas where we will record on the channel and their names are specified. An image of the Thing-Speak channel used in this study is shown In Figure (6).

Each time the data reaches the Thing-Speak channel area, the react application performs the comparison operation with the specified threshold value in the cloud. In the React application The pattern of incoming data is tested in the form of frequency, condition type (numeric value, state, geographic location), conditional control and action to be taken when the specified condition is met. In addition, the Activate channel option will only be set the first time or every time the specified condition is met. React application that defines the soil moisture threshold value, test frequency, condition type, and application execution option It has been given in Figure (7).

Thing-HTTP requests (motor On and motor Off) appear in the React application If triggered on, it writes a command string to the Talkback queue on the channel. The Thing-HTTP request body consists of the key string and commands specifically defined for the talkback application. The Talkback queue has a FIFO (First in First Out) structure. TCP communicates with the ESP8266 module through the +IPD command the response queue is suitable for reading and interpretation by the microcontroller. The first read command from the queue is executed by giving a parameter to the function written on the microcontroller side. On the side of the device Irrigation system management is provided.

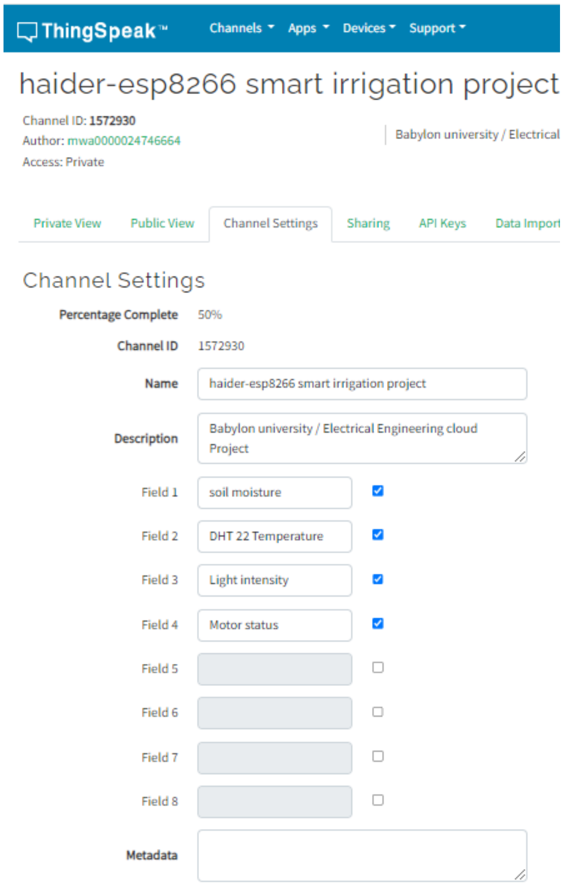


Fig. 6. Thing-Speak channel setting

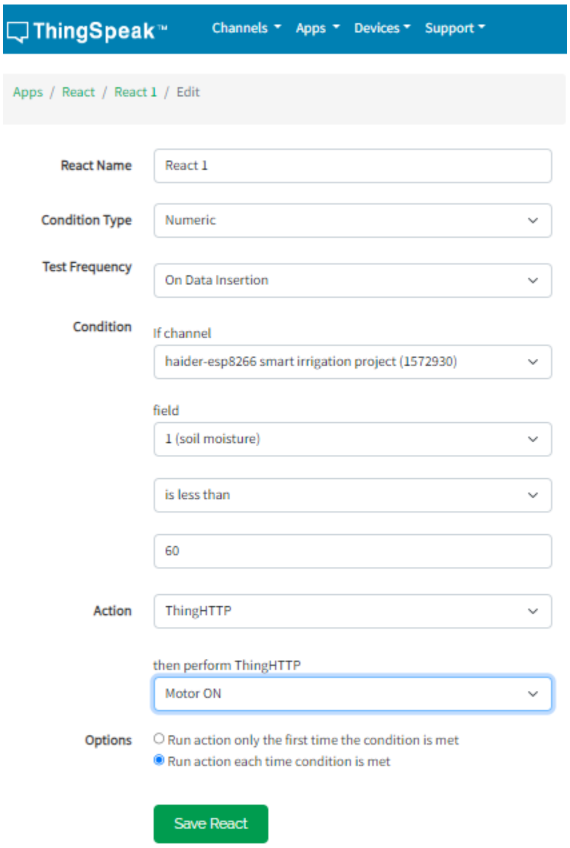
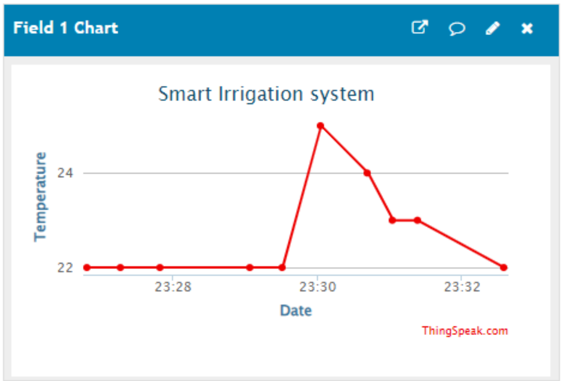


Fig. 7. React Application

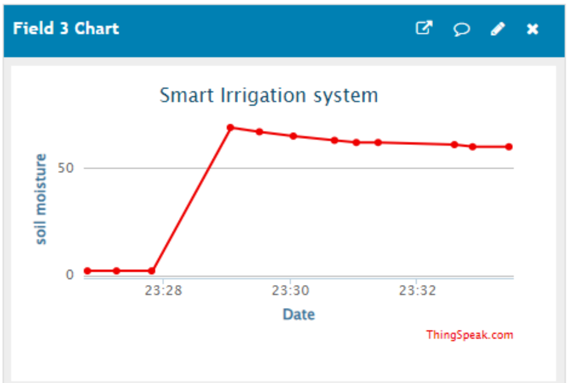
III.RESULTS

As aresult , Soil moisture is a critical parameter for developing a smart irrigation system. By enabling the soil moisture threshold value to be changed, unnecessary water usage was switched online. Soil moisture value, which is an important parameter in irrigation, is measured with sensors that monitor environmental conditions. It moves inversely proportional to the light value and temperature value, and directly proportional to the rain sensor. It has been observed that there is a tendency for change. Created based on data collected in the future determining the irrigation requirements for the pilot area with the model and growing it under current conditions It is planned to estimate the products that may be deemed appropriate. In addition, soil moisture status In case of wireless detection, the energy requirement Alternative sources will be used to meet the needs.

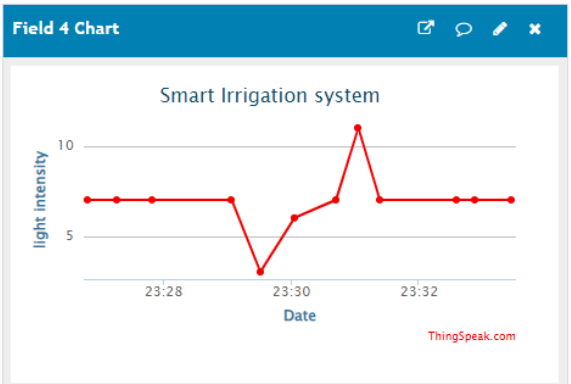
After the obtaining of the results from the cloud platform, the following results were shown below in figures. The fig (8) shows the results of temperature information changing over time, beside that in fig (9) the results of soil moisture variations, which is the fundamental data for understanding the state of the soil that the system depends on to triggered the actuators, in addition fig (10) showing the outcomes of the light intensity change in the area where the sensor is situated. Using the cloud platform's integrated apps, including React, ThingHTTP, and Talkback, a decision is made based on the information gathered.



Fig(8)



Fig(9)



Fig(10)

IV.DISCUSSION

As presented in the results that any change in the level of soil moisture such that the soil moisture value is less than what is required for a particular crop requires the operation of the irrigation system, which operates based on the commands coming from the cloud to the Arduino control unit through wireless communication, where the system works by giving the signal to the relay to operate the irrigation pump. The effect of information coming from temperature sensors and lighting intensity has an additional role in determining the irrigation period each time the pump is operated, depending on the weather condition in terms of the intensity of sunshine or in the event of rain, high air humidity, and low temperature.

V. CONCLUSION

Within the framework of preserving water sources and reducing the inappropriate use of irrigation on farms. We conclude from this study that by using technological means we can conserve water by reducing the amount of water wasted using irrigation, as farmers can monitor farm data on the cloud platform through available Internet applications and mobile devices. In addition, accurate statistics can be generated from data stored for long periods to calculate the least amount of water needed during the agricultural period, which enables farmers to challenge the obstacles of water scarcity during summer and drought periods.

In addition, it possible to conclude that by using this digital and technological structure we can successfully manage water resources by implementing precise and sustainable irrigation. Automating irrigation and reducing the amount of water thus saves the electrical energy consumed as well. Which requires optimal planning for irrigation in a mandatory manner. This will contribute effectively to increasing cultivated lands and rationing water consumption in times of scarcity and summer.

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