IoT Based Smart Agriculture Monitoring System Using Renewable Energy Sources

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Abstract*— A revolutionary strategy for enhancing agricultural practices and reducing agriculture's carbon footprint is an internet of things (IoT)-based smart agricultural observation system driven by energy from renewable sources. This system uses energy from renewable sources such as solar power along with sensors, automation,and data analytics to monitor and improve the growth of crops while minimizing resource loss. The system collects data on soil moisture, temperature, humidity, and other environmental parameters using sensors, which are then sent to a centralized platform for analysis. Based on the dataanalysis, the system can automate irrigation, fertilization, and pest control, reducing the need for manual interventionand the utilization of energy from non-renewable sources. The integration of energy from renewable sources into the internet of things (IoT)-based smart agricultural observationsystem increases its sustainability and cost-effectiveness. Using solar or wind power to power the system reducesreliance on traditional power sources, resulting in lower energy costs and lower carbon emissions. Because of its scalability, the system is also suitable for small-scale farmers who may not have access to conventional power sources. In summary, an IoT-based smart agriculture monitoring systempowered by solar energy is a promising approach to improving agricultural practices while promoting sustainability. This system has the potential to revolutionize agriculture by increasing crop yields, reducing resource waste, and promoting environmentally friendly practices.

Keywords*— IoT, agriculture, renewable source, sensors, environmental parameters.

I. Introduction

The Internet of Things (IoT) is evolving to provide intelligent solutions to a variety of applications, including transportation, healthcare, and agriculture. More than the internet and ICT put together, the Internet of Things will have an impact on society [1-3]. Our environment is being redesigned by smart gadgets and other networking equipment on the Internet of Things to make it more correlated, adaptable, and communicative. IoT systems include embedded devices with network connectivity as well as sensors that allow machine-to-machine communication. IoT should be used to integrate these works smoothly and efficiently, with sensors indicating waste level and collection routes to the server. This will save time and money. [4] The smart city should include a smart solid waste management system to manage the enormous generation of solid waste and shortage of land for dumping. In this paper, explainable artificial intelligence (XAI) for the Internet of Things is discussed. The latest [5] advancements in edge XAI structures and support for 6G communication services in IoT applications are also presented. This paper offers a comprehensive overview of the creation of XAI-based frameworks for potential IoT use cases. These are the various application of IoT.

By using the Internet of Things (IoT) idea of smart farming, farmers can utilize a mobile application to watch and monitor air humidity, temperature, and soil moisture elements that can affect plant growth. Furthermore, it's not always feasible in real-world circumstances to use timers to operate the pumps in conventional watering systems. [6][7] A scalable network architecture for monitoring and managing farming and agriculture in rural areas to satisfy particular needs. An embedded web server is used for the purpose of remote monitoring and control. The system for remote monitoring and control for door access is developed using Raspberry Pi embedded web server. [8] The access to the door can either be provided through application or the concerned web page. The web page is developed using PHP which is used as embedded server-side scripting language. By removing dead plants and grass from the yard, smart irrigation systems can contribute to water conservation. [9] They can also be configured to release precise amounts of water in a targeted area. A solution is suggested to show the viability of automatic irrigation and ongoing monitoring. These papers are used in the field of monitoring. In IoT one of the most well-known electrical prototyping boards for usage in the workplace, industry, research, and agriculture is the Raspberry Pi. IoT is frequently utilized to link devices and gather data. The system's microcontroller is a Raspberry Pi 4 Model B. Temperature, humidity, and soil moisture in the immediate area are detected by the DHT22 and soil moisture sensor, and the findings are displayed on the computer and smartphone. To create a decision support system, these sensed features will be sent toa remote station where they will be processed and evaluated [10-12]. Using a Raspberry Pi 3 board and OpenCV-Python, this paper develops a device that counts people and identifiesthose who are not maintaining social distance [13]. Crowd control during the

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COVID19 pandemic can be accomplishedusing this technique. IoT powered smart grids take an innovative approach to the issues of renewable energy penetration: Artificial intelligence powered computation can be used with accurate and current data. The deep learning framework is used to tackle the issue of storage control in the presence of unpredictability in the production of renewable energy. Itsuggests a paradigm for better highway energy management based on wireless energy re-distribution of acquired renewableenergy with the assistance of unmanned aerial vehicles and byutilizing useful data collecting from numerous renewable energy sources via the Internet of Things. In this sense,it additionally offers an Internet of Things (IoT)-enabled self- powered adaptive and automated home energy control system [14-16]. The system's objective is to modify consumption patterns in response to the availability of independently producedrenewable energy. Temperature is one of the parameters that are most closely monitored in a variety of industrial and commercial applications. Temperature sensors for the IoT are frequently small, low-power devices that can also measure humidity. Thisresearch compares the performance of an IoT temperature system to that of an industrial system. A temperature monitoring system was built using a DHT22 temperature sensor. [17]The system uses sensors attached to a data concentrator module to measure the effective current draw of the monitored equipment. This data concentrator module retains the data gathered by the sensors and does preliminary processing before transmitting it to an IoT platform. Alex-net architecture and convolution neural networks were used to create automatic fire extinguishing systems based on deep learning that can both detect human presence and fire. [18] To find the best configuration of neural network parameters, tests were run.

II. PROPOSED ARCHITECTURAL DESIGN

In this proposed design the main objective is to make the farmers ease of work and save water. First, in this design, two LDR sensors are used. These sensors are used to measure the light intensity from the source of these sensors. These two sensors are kept on opposite sides of the solar panel. Then the solar panel is attached to a servo motor for the purpose of tilting. At initial the solar panel should be at 90 degrees. So that when the sunlight hits the LDR sensor with the help of a servo motor the solar panel gets tilted according to the light. Then the data acquired from the solar panel are sent to Raspberry Pi. DHT11 sensor is used here. Using the DHT11 sensor we can measure the temperature and humidity in the air. Soil Moisture is also used here. The main purpose of the soil moisture sensor is to measure the moisture content in the soil. Likewise Ultrasonic sensor is used here to measure the level of the water. The data acquired from all three sensors are sent to the Raspberry Pi. In Raspberry Pi, the data acquired from all three sensors are trained and tested. Machine learning algorithm is used to train the data. The data acquired from these sensors as well as the data from the solar panel are displayed in LCD display. In Raspberry Pi, the data from these sensors are trained for a period of 25 cycles. After the completion of 25 cycles, the data automatically gets stored in Thing Speak. Thing Speak is used as a cloud in this proposed idea. Also, in Raspberry Pi, while training the data if the temperature gets above 40 degrees the motor tends to power on.

A. Proposed Architecture

In an Internet of Thing (IOT) based Smart Agricultural Monitoring System using energy from renewable sources the inputs are gained from the DHT11, Ultrasonic, Soil Moisture sensors, and Solar Panel. The measured readings from the DHT11, Ultrasonic, Soil Moisture sensors, and Solar Panel are made to view in the LCD display. Then they are trained and tested. the output will be produced in actuators such as a motor.

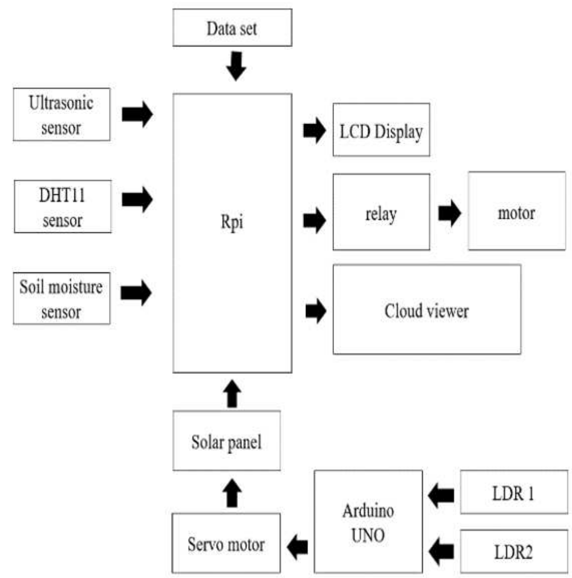

Fig 1 : Architecture of the proposed design

Soil Moisture Sensor: A soil moisture sensor is a piece of technology thatcalculates how much water is in the soil. Farmers, gardeners, and landscapers use it to manage plant watering schedules, avoid overwatering, and cut down on water waste. Soilmoisture sensors come in a variety of designs, including capacitive, resistive, and tensiometer models.

DHT 11 Sensor: A low-cost, digital humidity and temperature sensor called the DH11 is used in projects that call for continuous temperature and humidity monitoring. The DHT11 sensor'stemperature and humidity readings are transmitted to the Raspberry Pi in this suggested design.

Solar Panel: Solar energy is converted into electrical energy by solar panels, an electronic device. Direct current (DC) electricity generated by solar panels can be used to power a variety of devices or stored in batteries for later use.

Raspberry Pi: A low-cost, credit-card-sized computer called the Raspberry Pi is useful for a wide range of tasks, including robotics, home automation, and Internet of Things (IoT) projects. It is made up of an input/output (I/O) system on a chip (SoC) with a CPU, memory, and peripherals. The I/O ports onit are diverse and include USB, HDMI, Ethernet, Wi-Fi, Bluetooth, and GPIO.

Servo Motor: A servo motor is an electronic device that precisely positions or rotates an output shaft through feedback control. A motor, a control circuit, and a feedback mechanism make upthe device. Here, a servo motor and an LDR sensor are utilized to tilt the solar panel in accordance with the position of the sun.

Ultrasonic Sensor: An electrical gadget known as an ultrasonic sensor uses sound waves over 20 kHz to calculate distance. It is made up of a transmitter and a receiver that collaborate to calculate the separation between a sensor and an object.

B. Flow chart of the proposed work

The proposed model's flow is shown in below Figure.2 for the IoT-based smart agriculture surveillance system that uses renewable energy sources. This flow shows us the way to go through the whole proposed idea. By Figure.2 we were going to use sensors like the DHT11 and the soil moisture sensor to assess the weather temperature. The data is then delivered to the raspberry pi once the temperature and humidity readings from the two sensors are compared. The pumping time is created, the motor is turned on for the appropriate pumping time and the data is stored in the cloud if the reading falls below the threshold water level value. The user is alerted and the motor is turned off if the readings from both sensors above the threshold water level.

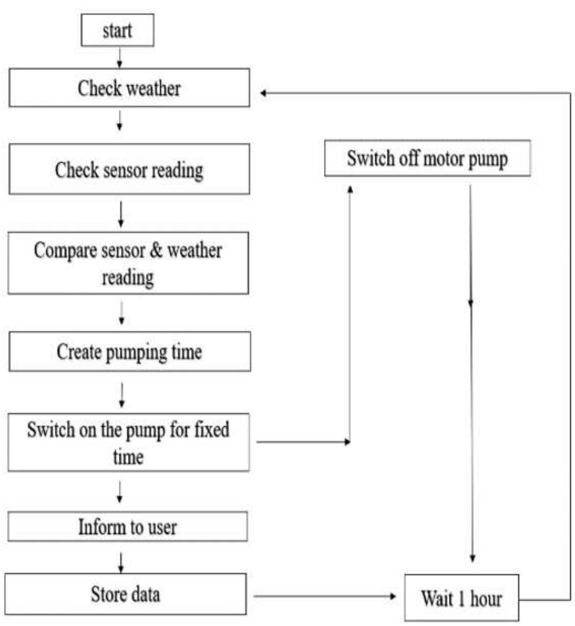

Fig 2: Flow chart of the proposed work

Here, the water level is measured using an ultrasonic sensor. Daily living is continued in this manner.

C. Flow chart of the proposed work

A servo motor and two LDR sensors are attached to the solar panel to tilt, which is in response to sunlight falling on the LDR sensors. Figure.3 depicts the working flow of a solar panel tilting. In this proposed idea, a servo motor is attached to one end of the solar panel, and the two LDR sensors are attached to the opposite sides of the solar panel for the purpose of detecting the sunlight. The servo motor and the two LDR sensors are connected to the Arduino Initially, the servo motor is set at 900.

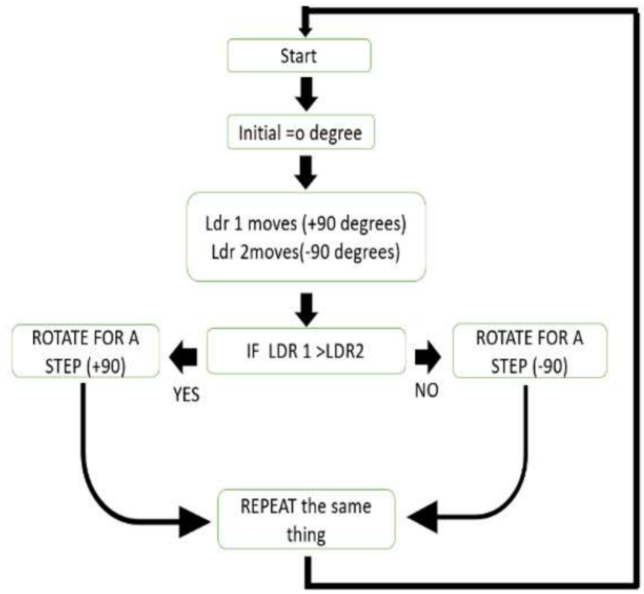

Fig 3 : Flow chart of solar panel tilting

When the sunlight falls on LDR sensor 1, it tends to move at +90 degrees, and when the sunlight falls on LDR sensor 2, it tends to move at -90 degrees. The figure.3 depicts the process of tilting the solar panel.

III. Recurrent neural network algorithm(RNN)

The algorithm used here is the machine learning algorithm. In the machine learning algorithm, the RNN algorithm is used.

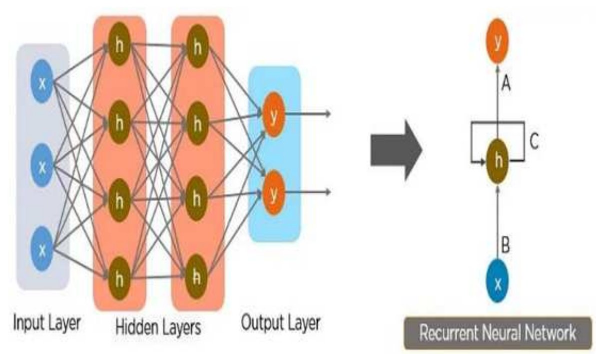

Fig 4: Framework of RNN algorithm

Recurrent neural networks recognize input's sequential features and make use of patterns to predict the following likely scenario. The Figure.4 shows the framework of RNN algorithm.

Three layers make up the fundamental RNN algorithm: an input layer, a hidden layer, and an output layer. Sequential data is received by the input layer and processed by the hidden layer. The hidden layer retains information from previous time steps and combines it with the current input to generate an output. The output layer generates the final prediction based on the information processed by the hidden layer. In this proposed idea, the output will be taken from the DHT11, Soil Moisture, Solar Panel, and Ultrasonic sensors for 25 cycles, and then these data will be compared with the data from the previous 25 cycles. Then the difference between the current and prior datasets will be compared and the output will be given.

A. Dataset

A relevant dataset would include sensor data that captures the environmental conditions in order to develop an IoT-based smart agriculture surveillance system that uses the energy from renewable sources. The following types of data should be present in the dataset, Environmental Condition: This includes data on temperature, humidity, and soil moisture. The crop's water needs, nutrient uptake, and overall growth are all influenced by these variables. Figure.5 depicts the data of temperature, humidity and soil moisture is stored to train the RNN algorithm and get the output for 25 cycles. The information is gathered from these devices based on the weather in Virudhunagar.

S. No	TEMP	HUMIDITY	SOIL MOISTURE	OUTPUT
1	24	65	869	1
2	20	85	900	0
3	22	75	869	1
4	24	65	867	0
5	26	60	860	1
6	29	55	866	0
7	35	40	500	1
8	30	59	866	0
9	28	58	869	1
10	26	60	825	1
11	23	66	865	1
12	24	62	865	0
13	14	64	862	0
14	29	68	863	0
15	24	69	867	0
16	24	82	800	1
17	24	72	756	1
18	24	75	845	0
19	25	76	762	1
20	21	71	854	0
21	22	60	675	0
22	24	70	825	0
23	26	80	754	0
24	26	65	762	1
25	25	62	900	1

Fig 5: Dataset of proposed design

The Figure.5 depicts the dataset that is used in this proposed ideafor training the RNN algorithm. The data of temperature, humidity, and soil moisture are stored in the dataset.

IV. HARDWARE SETUP

The hardware setup for the proposed idea of IoT based smart agriculture surveillance system that uses the energy from renewable sources is shown in below figure 6.

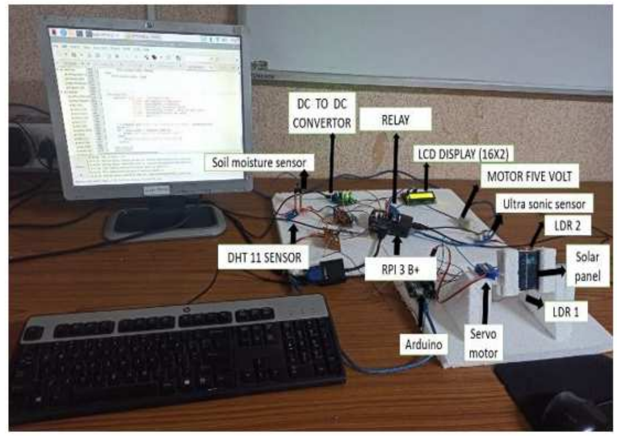

Fig 6: Hardware setup of the proposed architectural design

The Figure 6 depicts the hardware setup for this proposed idea, which includes components such as a Raspberry Pi, an Arduino UNO, an LCD display, a solar panel, a servo motor, a DC motor, a relay, a DC-to-DC converter, a DHT11, an LDR, an ultrasonic sensor, and a soil moisture sensor. The output is viewed after the necessary connections have been made. The initial data from the Solar Panel, Ultrasonic, DHT11, and Soil Moisture Sensor are displayed on the LCD display. The Arduino UNO is linked to a servo motor in order to tilt the solar panel in response to light. A LDR sensor is used to detect light. The Raspberry Pi is used to collect data from all the sensors, train them, and then output the results for 25 cycles. Then the data acquired after the 25 cycles are send to Thing Speak.

V. RESULTS AND DISCUSSIONS

According to the results of this study, the adoption of IoT-based smart agriculture systems with renewable energy sources can benefit farmers and assist enhance agricultural operations. It can also successfully monitor and adjust environmental parameters including temperature, humidity, and soil moisture. This helps farmers to maintain ideal growing conditions for their crops, which can contribute to higher agricultural yields in the long run.

A. DHT11 Sensor Results

The information received from the DHT11 sensor is sent to the Raspberry Pi. The temperature and humidity data are then trained and compared to previous data, and the results are shown in Figure.7.

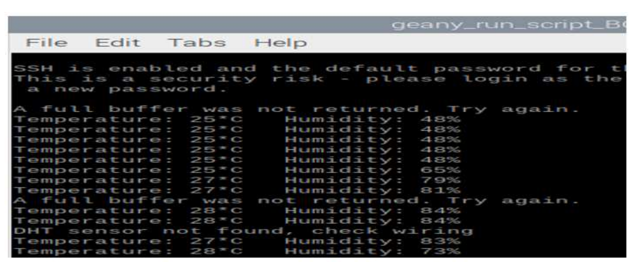

Fig 7: DHT11 sensor results

The Figure.7 shows the output of the temperature and humidityfrom the DHT11 Sensor in the Raspberry Pi.

B. Ultrasonic Sensor Results

The data received from the Ultrasonic sensor is sent to the Raspberry Pi. The distance between the object and sensor is calculated and the data are then trained and compared to previous data, and the results are shown in Figure 8.

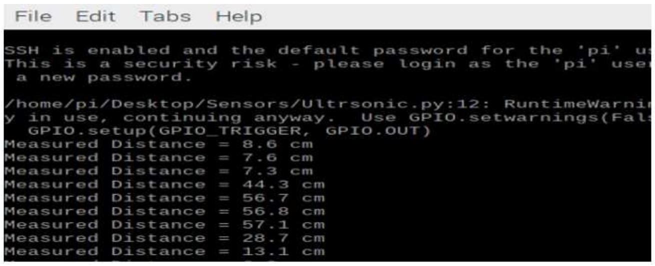

Fig 8: Ultrasonic Sensor Output Result

The Figure.8. shows the output of the calculated distance between the object and the sensor from the Ultrasonic Sensor in the Raspberry Pi.

C. Solar Panel Results

The solar panel receives the data by focusing the light on the panel. The received data is shown in Figure.9

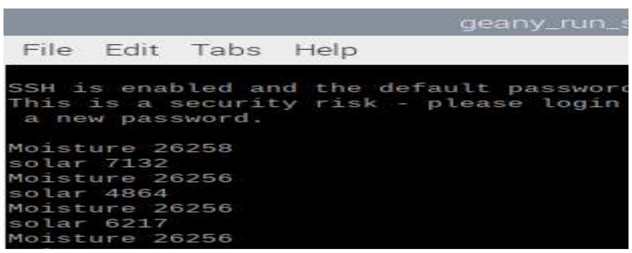

Fig.9.Solar Panel Output Results

The Figure.9 shows the output of the Solar Panel in the RaspberryPi by focusing on the distance between the and the solar panel.

D. Overall Results

In the final result, the overall output from the DHT11, Ultrasonic, Soil Moisture sensors, and Solar Panel is displayed in the raspberry pi in Figure.10.

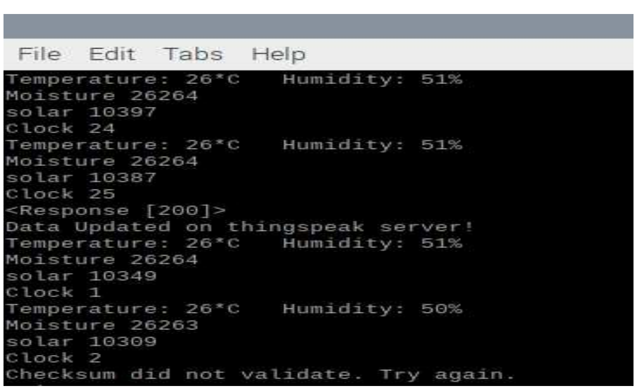

Fig 10: Final result

The Figure.10 shows the overall output from the DHT11, Ultrasonic, Soil Moisture sensors, and Solar Panel which are calculated for 25 cycles and then these results are sent to thing speak.

E. Thing Speak Results (Cloud Viewer)

Gather the input from sensor, view, and analyze real-time datastreams in the cloud with the Thing Speak IoT analytics platform service. The Hardware can provide data to Thing Speak, instantly visualize live data. The overall results from the DHT11, Ultrasonic, Soil Moisture sensors, and Solar Panelare sent to Thing Speak in Figure.11

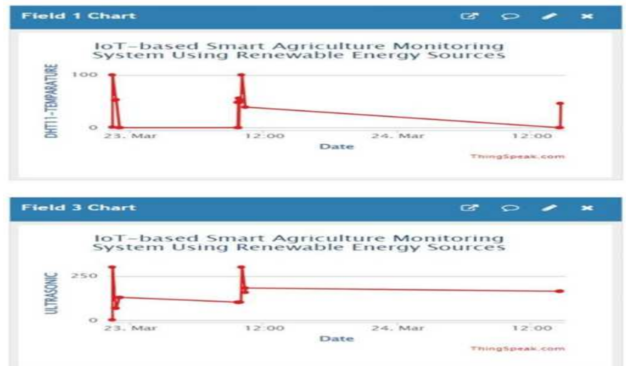

Fig.11. Thing Speak Result of DHT11Temparature

and Ultrasonic sensor

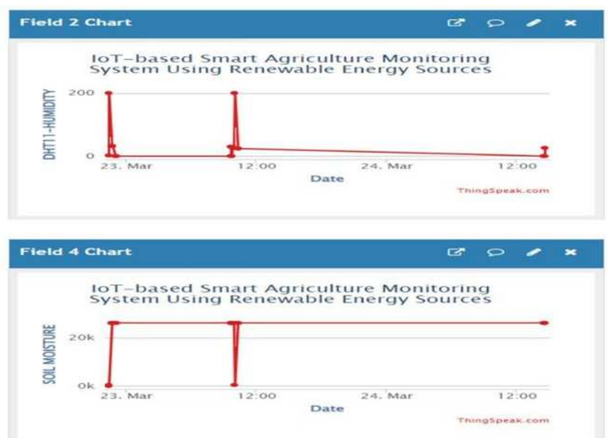

Fig.12. Thing Speak Result DHT11-Humidity and

soil moisture sensor

The Figure.11 and 12 depicts the data that are acquired from the DHT11, Ultrasonic, Soil Moisture sensors, and Solar Panel. After every 25 cycles of continuous requiring of data, those data are sent to thing Speak. It acts as a cloud by storing this data and showing it to the user.

VI. CONCULSION AND FUTURE WORKS

The use of renewable energy sources in an Internet of Things (IoT) -based smart agricultural surveillance system is a highly helpful option for the agriculture industry. This system combines IoT technology with renewable energy sources to give real-time monitoring of parameters like as temperature, humidity, soil moisture, and other environmental conditions.

This system can also improve crop yields, reduce water usage, and decrease overall operational costs for farmers. Overall, the IoT-based smart agriculture farm monitoring system using renewable energy sources is a highly as for future works our initiative is to run smart agriculture in a whole field by using our proposed idea.

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