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AGRICULTURAL MONITORING USING IOT

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Abstract: **The Internet of Things is completely changing the way agriculture functions, offering new solutions for ageold difficulties faced by farmers. Long-standing hindrances to successful farming practices are being transformed through IoT technology, empowering farmers to have real-time data on such critical factors as soil moisture, temperature, weather conditions, and crop health. This information is gathered through wireless sensor networks, which actively monitor environmental variables, detect pests, track water levels, and identify looming threats such as animal incursions or weed growth. The same IoT-based systems also enable remote control and automation of agricultural processes utilizing microcontrollers, cameras, and GPS-based monitoring. These new approaches integrate their technologies to smartly boost productivity while cutting operational costs and improving sustainability in farming practices. In developing an IoT-based system for smart farming, this paper offers sensors with wireless communication and remote monitoring, supporting decision-making for optimum crop growth and ensuring that continuous improvements continue to be applicable in scalability and adaptability while guaranteeing that farmers can take advantage of modern technologies that promote sustainable farm management**

***Keywords* – : Internet of Things (IoT),Smart agriculture, Wireless sensor networks, Remote monitoring, Soil moisture, Temperature monitoring ,Microcontrollers, GPS based monitoring, Water level tracking ,IoT sensors**

INTRODUCTION

The Internet of Things is changing most industries, and agriculture is not the exception. Given the rapid pace at which technology advancements are taking place, it is essential to integrate IoT solutions into farming to address the problems in farms around the world. IoT makes it possible for devices and systems to be connected to one another so that their coordination would yield real-time monitoring, automation, and data-driven decision-making. IoT technologies, such as those that rely on wireless sensor networks and connected devices, can be used to create insights into soil conditions, weather patterns, crop health, and environmental factors affecting farms. The indepth analysis of these factors by farmers enables them to optimize resources, increase crop yields, and subsequently save costs. Even though developments in IoT-based smart agriculture have shown excellent results through a number of pilot projects and research, complete automation has yet to be adopted fully in the fields. This encompasses other features such as technical sophistication, cost, and scalability. Therefore, the paper will explore into how the success of the development of an integrated system-tobe used in agriculture for automating various agricultural processes and presenting practical solutions that assist the farmer in enhancing productivity and sustainability in farming practices can be made possible by harnessing IoT.

PROBLEM DEFINITION

Irregular water distribution, poor soil quality, and unpredictable weather conditions have been cited as major challenges facing farmers in modern agriculture. These result in suboptimal crop growth as well as low productivity in agriculture. Uneven distribution of water leads to inefficient irrigation because either excess or shortage of water damage crop yields. Furthermore, poor quality of soil prevents crops from receiving nutrients, leading to the diminishment of crop developments. Traditionally, farmers relied on manual observations and guesses pertaining to soil fertility, weather conditions, and pest control. It is highly vulnerable to mistakes. Inefficient use of the available resources, overuse of pesticides, and inaccurate use of the irrigation system transpired due to a lack of real-time, correct data. Current agricultural systems have inadequate tools to provide timely, accurate information to make appropriate decisions.

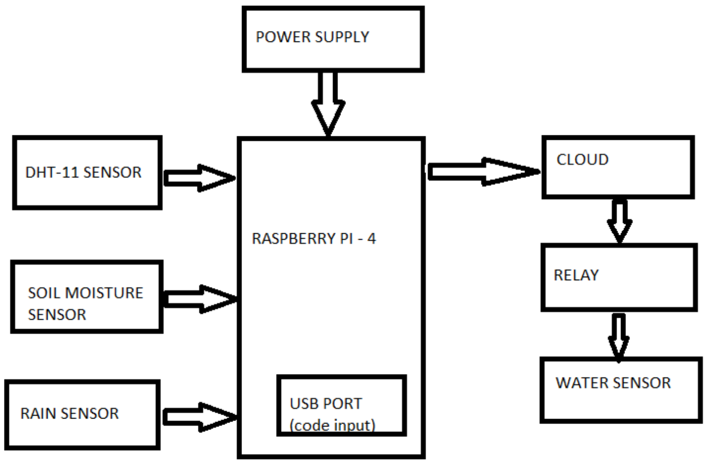

FIG 1: CONNECTIONS AND LABELS

Hence, among farmers, poor yields and high operational costs often haunt them poor yields and high operational costs often haunt them. This research proposal aims to face the above stated challenges with the help of an integrated IoT-based decision-making support system. The proposed system makes use of wireless sensor networks to provide real-time soil moisture, temperature, humidity, and water levels. This shall help to make appropriate decisions on the irrigation processes, variety selection, and the control measures against pest diseases, thereby indicating higher productivity and lower costs with more sustainable agricultural production. It aims to help farmers develop an automated solution which helps defeat the variability of environmental conditions, while allowing them to improve their overall efficiency in managing a farm.

HARDWARE SPECIFICATION

Raspberry Pi: The Raspberry Pi 4 Model B is the latest offering from the Raspberry Pi Foundation, a single-board computer designed for quite a number of applications, including education, DIY projects, and embedded systems. It contains the Broadcom BCM2711 SoC on board, powered by a quad-core ARM Cortex-A72 processor running at 1.5 GHz. But the 64-bit ARM CPU in this model does serve a huge performance boost over previous models, and it can be used for media centers, for home automation, and it is capable of light server duties. The Raspberry Pi 4 is also available in three memory configurations: 2GB, 4GB, and 8GB of LPDDR4-3200 SDRAM, promising a significant increase in both speed and capacity over previous versions. This increased memory allows for smoother multitasking and better performance for memory-intensive applications. Networking on the Raspberry Pi 4 is strong, featuring a Gigabit Ethernet port for wired networking, allowing speeds of up to 1000 Mbps, a significant jump from previous models' 10/100 Mbps Ethernet. Pi 4 also employs 802.11ac Wi-Fi (dual-band 2.4 GHz and 5 GHz) and Bluetooth 5.0 for other wireless connectivity; therefore, it is easy to connect to a wide range of wireless networks and devices. Raspberry Pi 4 offers 2 CSI camera ports and 2 DSI display ports thus facilitating the easy integration of cameras and touchscreens in projects. The 5V USB-C power supply will power the device, and it should be able to operate over a wide range of voltage from 4.75V to 5.25V.

FIG 2: RASPBERRY PI-4

DHT-11 Sensor: One of the most widely used digital sensors for measurement of humidity and temperature is the DHT-11, which is cheap, user-friendly, and stable for basic applications in environmental monitoring.

1) **Humidity Measurement:** The DHT-11 can measure relative humidity between 20 and 50 C.
2) **Temperature Measurement:** The DHT-11 can measure temperature between 0°C and 50°C with an accuracy of ±2°C. The measurement is not as accurate as that in the costlier sensors, yet it is acceptable for general use where precision is not highly required.

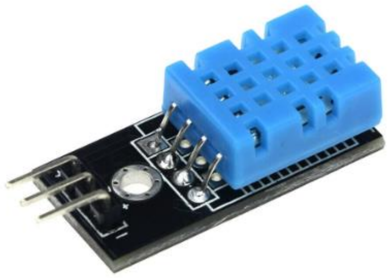

FIG 3: DHT-11 SENSOR

Soil Moisture Sensor: Among the most used and cost-effective sensors made specifically to measure the moisture level in soils, the YL-69 Soil Moisture Sensor has so valuable information available, thus being very appropriate for controlling irrigation and environmental monitoring applications. It operates according to the electrical resistance principle, where the resistance between two probes inserted into the soil changes depending on the moisture content. When the soil dries up, the resistance between probes will be high because there is less water within it. It is established that this lowers the conductivity of soil. If the soil becomes wet, then the resistance will be low because water enhances the ability of the soil to conduct electricity. This differential of resistance is then translated into an analog output of voltage that can be easily read by a micro controller such as an Arduino or Raspberry Pi, thus deducing the quantity of moisture in the soil.

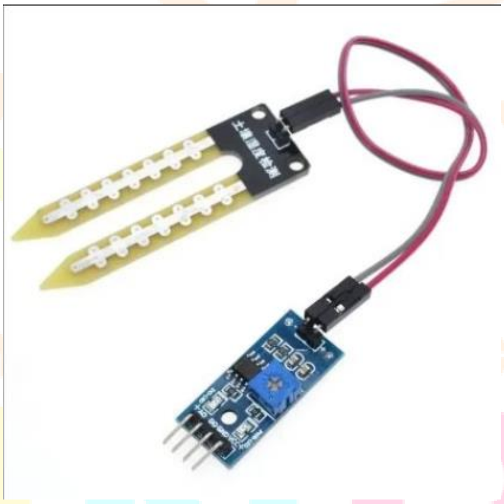

FIG 4: SOIL MOISTURE SENSOR

Relay: The Relay is an electrically operated switch meant to control circuits with high efficiency and reliability. Since it can be mechanically operated by an electromagnet, it may also use other forms of operation by the application of solid-state technology that can serve to switch circuits. In this regard, its ability to switch circuits under different means of operation makes it very useful for applications that require the control of a single circuit or multiple circuits by a low-power signal. Relays can be used in many systems where low-power signals control much larger circuits. They are therefore versatile as well as reliable for different electrical applications.

FIG 5: RELAY

Rain Sensor: A Rain Sensor is an electronic device that is capable of detecting the presence of water and operates by a conductive plate or a series of exposed traces that are going to react with the occurrence of rain water; then the droplets do come into contact at the surface of the sensor. This ensures the creation of a conductive path, signaling the occurrence of rain. This signal might then be processed by a connected micro controller or other electronic systems to determine how such should trigger specific actions.

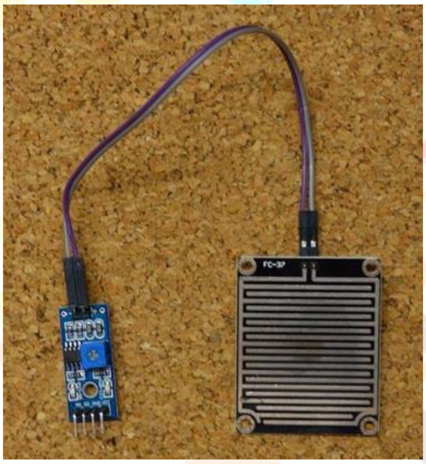

FIG 6: RAIN SENSOR

Micro Submersible water pump: The Micro Submersible Water Pump is a compact, low-power water pump with very versatile and efficient fluid handling for a wide range of small-scale applications. Operating with a power range of 3-6 volts DC, the pump best suits the power of low-voltage devices and is generally used in projects where compactness and energy efficiency are important. With its submersible design, the pump can, therefore, be operated even when completely submerged in water and, thus can be used to move water or other liquids reliably with great reliability in enclosed or tight spaces.

FIG 7: WATER PUMP

SOFTWARE SPECIFICATION

Python: It can really be a very useful tool for every hardware component used within a research project, such as relays, micro submersible water pumps, and rain sensors. Using Python, we could create our own code for automating control and monitoring sensor data with potential interactions among those various components in real-time, too. With languages such as [RPi.GPIO] or [gpiozero] for a Raspberry Pi setup, the user could quite easily set up and manage the connections between the sensors and actuators

ThingSpeak: ThingSpeak is a cloud platform which enables the collection, storage, and analysis of real-time data in the context of IoT applications. It is developed by MathWorks and allows creating connections with sensors, devices, and many other sources of data to the cloud; it visualizes data through dashboards, custom-made by users. It supports data logging, event triggering, and integration with MATLAB for advanced data processing and analytics, which makes it even more valuable for researchers and developers on IoT projects. ThingSpeak is multiprotocol compatible and supports multiple devices, hence also capable of seamless integration with hardware platforms that are very popular such as Arduino and Raspberry Pi. One of the great advantages is probably to be able to generate communication channels that can be used to monitor data in real-time, which are highly applicable in the concept of environmental monitoring, smart agriculture, and predictive maintenance. It also has the functionality of automation to trigger an action based on specific data thresholds set in ThingSpeak. Summary, ThingSpeak is a very strong and friendly tool that simplifies the development, testing, and deployment of IoT projects by making it easier to manage and analyze IoT data for applications

LITERATURE REVIEW

The adoption of IoT in agriculture has been transformative, enabling farmers to monitor and control soil moisture levels in real-time as well as employ automated systems for enhancing crop yield and resource management. Many studies outline the benefits of IoT-driven solutions to support modern agriculture through intelligent data collection, automated irrigation, and enhanced decision making processes. Anand Nayyar and Er. Vikram Puri (2016) provides an in-depth discussion on IoT-based smart sensors in agriculture citing the impact of IoT on agriculture by using direct data provision to farmers from the actual environmental condition. The framework presents an opportunity for" smart" farming, enabling sensors that monitor parameters such as temperature and soil moisture in a way that resources will be maximally utilized and be able to produce quality yields. This model supports sustainable agriculture by empowering farmers, especially those of the underserved categories who face limited access to technology and fluctuating climate conditions, with live data to increase their productivity. Agricultural monitoring in the past was purely by manual checks on the parameters of soil moisture and temperature, which is subjective, labor-intensive, and lacks consistency. Recent studies have shown promise with IoT-enabled WSNs, where connected sensors transmit real-time data with minimal human interference to provide precision. With increasing scarcity of water worldwide, one of the critical IoT-based irrigation systems has been widely adopted for conserving water in agriculture. It ensures proper irrigation only based on the time of need by making use of temperature and moisture in soil sensors by controlling the fields' conditions. Strategically locating these sensors limits water usage, supports sustainable agriculture, and at the same time, facilitates interference free communication technology through smart sensors and irrigation systems to ensure even more water efficiency in these systems. It stores real-time sensor data as well as visualizes it through a cloud-computing platform, namely, ThingSpeak. By incorporating MATLAB, the analysis of data makes it easy to access data and improve decision making for crop management, hence strong for remote field monitoring. For example, sensors for moisture, humidity, and temperature are put in the plant root zone for evaluation of accessibility of water and nutrient; the data collected is handled by microcontrollers that control irrigation according to soil requirements. Many of these systems are driven using solar photovoltaic cells and thus ideal for remote agricultural fields that have less or even no access to electricity. Others use a combination of IoT and drip irrigation so that farmers can remotely control crop conditions using minimum amounts of water. Data transmission to a central system enables the farmer to monitor their field remotely, although some require stable internet connectivity in order to keep accessing data. Recent studies have recently proposed advanced IoT prototypes that not only monitor soil moisture but also control actuators like relays and submersible water pumps. This study applies remote cloud platforms for the control of systems and allows for automatic transmission and hence automation of responses within predefined thresholds.

METHODOLOGIES

System Design and Components: System and Component designs is the system with the central controller. In this case, Raspberry Pi is used as the central controller because it collects data from the connection with other sensors and even controls the action based on predefined conditions. The Capacitive Soil Moisture Sensor measures the amount of moisture in the soil by giving water only if it becomes dry. This efficient use of water promotes water resource conservation and maximizes the effective irrigation. Environmental Parameters Such as Air Temperature and Humidity are Consistently Monitored by the DHT-11 Humidity and Temperature Sensor for the Satisfaction of Crop Growth The system will incorporate a Rain Sensor to detect rainfalls avoiding unnecessary irrigations thus through the detection of rainfall, it will activate the relay which stops the running water pump and avoids the over irrigation of the crop and conserves water. This sensor measures the pH level of the soil, a critical parameter regarding the availability of nutrients for crops and to inform farmers on how appropriate amendments of the soil could ensure better cultivation. Relay Module 5V acts as an electronic switch to the water pump, turning on or off according to the conditions of the soil moisture as well as the rain. This relay is operated by the Raspberry Pi so that the pump will run only when needed. The last piece of the system is the Water Pump; a submersible micro water pump, 3-6V DC, which is on depending upon the real time readings of soil moisture. The above irrigation system will continuously maintain the right level of moisture in the soil for healthy crop growth with the least amount of usage of water.

System Setup and Connections: From here, it interfaces sensors to the GPIO pins of the Raspberry Pi. For example, for a soil moisture sensor as well as a pH sensor, which deliver analog signals, analogto-digital converters (ADC) are connected and these ADC convert these analog signals into digital form so that the digital form of acquired data can be processed using the Raspberry Pi. In such integration with a relay and a pump, it allows for controlling the water pump through data received by sensors, to which Raspberry Pi sends a control signal that determines either the activating or deactivating of a water pump with regard to the level of moisture, for instance, or in some other aspects of an environment. The secure and stable power supply is very important in making sure that the Raspberry Pi, sensors, and pump functions do not get disrupted. For places where connectivity to the grid is hard, solar panels can be merged in as a source of sustainable power since it would ensure a constant supply of energy to the system. Another factor of importance is its integration with ThingSpeak, which makes the system accessible via remote access. The entire information from sensors such as soil moisture, temperature, and humidity is forwarded to the cloud where it is processed and visualized. This enables farmers to access their crop and irrigation systems from anywhere with internet connectivity. They will be able to see their crops' environmental situation and the status of their irrigation system in real-time. So, integration with ThingSpeak ensures the effect of remote control and monitoring and facilitates improved system efficiency.

Software Development and IoT Integration: The software development for Raspberry Pi is also quite important as this is what makes up the case to handle data acquisition, make decisions, and communicate with cloud services. The core part of developed software includes a set of Python scripts that carry out a list of operations. A python code that retrieves data from the different sensors-soil moisture, temperature, humidity, pH, and rain sensors-is written. The data are then analyzed to make logical decisions. For instance, if the soil moisture has been below the predefined threshold for some time, then the signal through the relay transmitted by the Raspberry Pi will activate the water pump. If it is raining, then the water pump will automatically de-activate. Later on, the data of temperature and humidity log can be provided with the information of any alteration happening in environmental factors which may affect crop growth for proper decisions from the farmer's end. Moreover, the readings, taken by the pH sensor with pH values, will also provide useful data regarding soil acidity to guide the enhancement of its quality by the farmers. Since it integrates with ThingSpeak for cloud-based remote monitoring by sending sensor data to be visualized, the system configures channels in ThingSpeak to receive data from each sensor and has created specific triggers or alerts there to alert users if values exceed or drop below certain thresholds. In case it falls below the tolerable level of soil moisture, ThingSpeak can send an alert automatically, or else, the water irrigation system could adjust itself according to the required input values obtained from sensors. Farmers receive very informative field conditions on every internet-enabled device: smartphones, tablets, and computers via personalized dashboards. Dashboards keep the farmer aware of all vital aspects concerning soil moisture, temperature, humidity, and rainfall, which all eventually responds to the crop environment. Moreover, the capacity of the farmer to execute MATLAB analyses against historical sensor data is supported by ThingSpeak and allows decision support. Using the analysis for trends in soil moisture and environmental factors, the system will be able to predict the need to irrigate, therefore preventing over-irrigation and wasting water. The predictive capability optimizes irrigation schedules, which is a critical aspect of conserving water and increasing yield further. It also has an automated alert system that can send some notifications by email or SMS when certain conditions are met. For instance, when the moisture content in the soil falls to a certain level, the system may inform the farmer of the current state, which will allow him to take necessary action or, alternatively, trigger suitable responses such as turning on a water pump. These warnings keep the farmer updated about the states of his farm even as he is away from his land because he can act in time and keep perfect growing conditions for his crops. This integration of data analytics and remote monitoring enables farmers to manage their fields more effectively, enhancing productivity and sustainability.

Testing, Calibration, and Maintenance: Testing and calibration are essential steps to ensure that the IoT-based agricultural aid system works efficiently. System testing follows where each part is being tested in isolation, and then integration testing to make sure that indeed the sensors are giving the right data, and the relay is working fine in its task to activate the water pump. Sensor calibration also has to be made sure of appropriately used threshold values are being utilized for each crop's need and to adjust the possible variability with local soil pH level. The system is then put in place and field tested in an actual agricultural environment. This test allows the evaluation of how the system works, including the reliability thereof, under real conditions as well as the necessary adjustments to be made to optimize performance. Routine maintenance also ensures that the system will have long-term reliability. These include a regular check of sensors and wires, wiring connections, etc. The system also requires updates because the crop as well as environmental conditions change over time. Changing threshold values and updating logic of control as the conditions change further ensure that optimality is obtained and proper monitoring and management of irrigation can be done based on the needs of the crops as well as that of the environment.

GRAPHS AND RESULTS

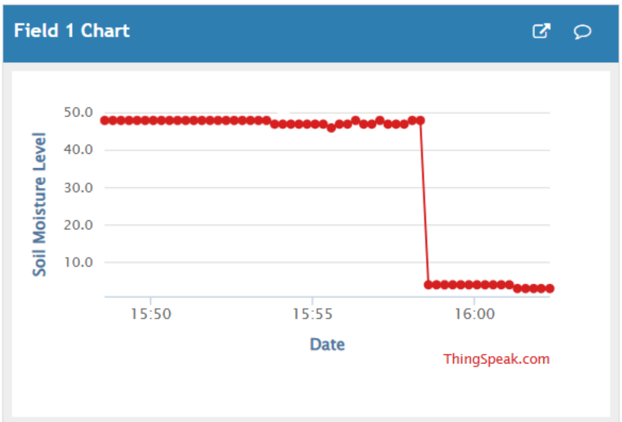

FIG 8: SOIL MOISTURE

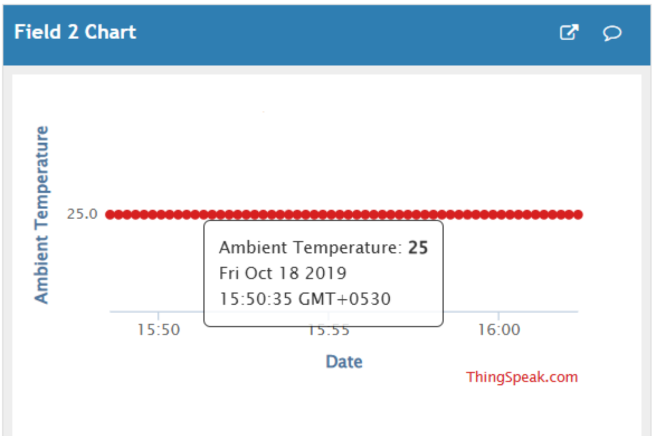

FIG 9: TEMPERATURE READINGS

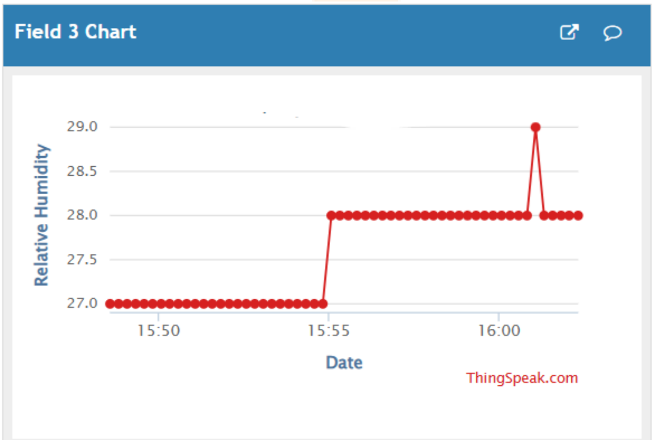

FIG 10: HUMIDITY READINGS

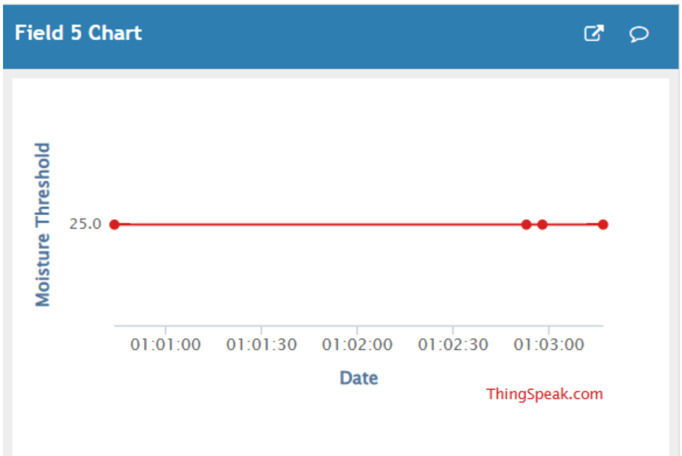

FIG 11: MOISTURE THRESHOLD

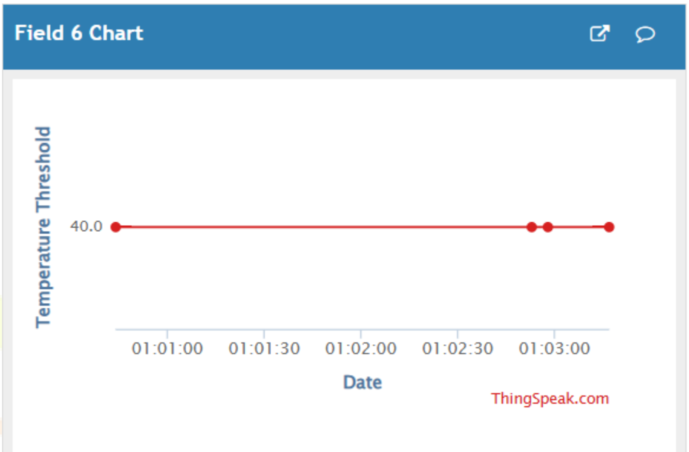

FIG 12: TEMPERATURE THRESHOLD

CONCLUSION AND FUTURE WORK

Therefore, problems of modern farming are addressed through the IoT-based smart agricultural aid system, which links sensors and automated control in terms of enhanced irrigation, monitoring of environmental conditions, and improvements in crop yield. Beyond its real-time data application from soil moisture sensors, humidity sensors, pH sensors, and rain sensors, it makes use of ThingSpeak for knowledge analysis as well as remote monitoring to empower farmers to make more reasoned decisions and resource management. It cuts off human interference, saves water and is a way of being supportive towards sustainable farming systems for the development of smart technology in farming. Additional sensors, such as nutrient monitoring, could be added to advance the understanding of soil health. Another enhancement of the system can be through GPS-based automation for location-based irrigation or alternative renewable energy sources like solar panels that might make the system sustainable in remote areas with no electricity supply. With such changes, the IoT-based agricultural aid system can be developed to come up with more accurate and intelligent responses to the challenges faced by farmers in an uncertain climate and resource availability condition.

REFERENCES

[1] Fan TongKe" Smart Agriculture Based on Cloud Computing and IOT" Journal of Convergence Information Technology vol. 8 no. 2 pp. 1 Jan 2013.
[2] S. R. Nandurkar, V. R. Thool, R. C. Thool, "Design and Development of Precision Agriculture System Using Wireless Sensor Network", IEEE International Conference on Automation, Control, Energy and Systems (ACES), 2014.
[3] G. Vellidis , M. Tucker, C. Perry, C. Kvien, C.Bednarz, "A Real-Time Wireless Smart Sensor Array for Scheduling Irrigation", National Environmentally Sound Production Agriculture Laboratory (NESPAL), 2007
[4] K. Lakshmisudha, Swathi Hegde, Neha Kale, Shruti Iyer, "Smart Precision Based Agriculture Using Sensors", International Journal of Computer Applications (0975- 8887), Volume 146-No.11, July 2011.
[5] Q. Wang, A. Terzis and A. Szalay, "A Novel Soil Measuring Wireless Sensor Network", IEEE Transactions on Instrumentation and Measurement, pp.412–415, 2010
[6] S. Li, J. Cui, Z. Li," Wireless Sensor Network for Precise Agriculture Monitoring," Fourth International Conference on Intelligent Computation Technology and Automation, Shenzhen, China, March 28-29, 2011.
[7] Venkata Naga Rohit Gunturi, "Micro Controller Based Automatic Plant Irrigation System" International Journal of Advancements in Research & Technology, Volume 2, Issue-4, April2013. [
8] Muhamad Azman Miskam, Azwan bin Nasirudin, Inzarulfaisham Abd. Rahim;" Preliminary Design on the Development of Wireless Sensor Network for Paddy Rice Cropping Monitoring Application in Malaysia"; European Journal of Scientific Research ISSN 1450-216X Vol.37No.4,2009

[9] Terry Howell, Steve Evett, Susan O'Shaughnessy, PaulColaizzi, and Prasanna Gowda, "Advanced irrigationengineering: precision and precise", The DahliaGreidinger International Symposium 2009.
[10] S.Reshma and B.A.Sarath Manohar Babu, "Internet of things Based Automatic Irrigation System using Wireless Sensor Networks" presented at International Journal and Magazine of Engineering, Technology, Management and Research, vol-03, Issue-09, Sep2016
[11] D.D. Chaudhary1, S.P. Nayse2, L.M.Waghmare, "Application of wireless sensor networks for greenhouse parameter control in precision agriculture", International Journal of Wireless & Mobile Networks (IJWMN) Vol. 3, No. 1, February 2011.
[12]]Joaquín Gutiérrez, Juan Francisco Villa-Medina, Alejandra Nieto-Garibay, and MiguelÁngel Porta Gándara" Automated Irrigation System Using a Wireless Sensor Network and GPRS module" , Ieee Transactions On Instrumentation And Measurement, Vol. 63, No. 1, January 2014.