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IOT BASED CROP FIELD MONITORING AND IRRIGATION AUTOMATION MODEL FOR FUTURE GENERATIONS

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Abstract: The Internet of Things refers to a network of interconnected physical devices and other items that may exchange data and perform other tasks across a network. With the help of IoT, the agriculture sector can produce enough food to sustain the predicted 9.5 billion people who will be living on Earth by 2050. An Internet of Things based crop-field monitoring and automated irrigation system, commonly known as a "Smart farming system," may assist to increase crop productivity while decreasing waste. To automate the irrigation process and keep an eye on the crop-temperature, field's humidity, and soil moisture, a monitoring system is developed in this study. Sensor readings are sent wirelessly to the Thing speak API server. It is possible to see the sensor readings graphically on a specially created website. JavaScript Object Notation (JSON) is used to encode the data. Because of the irrigation system's automation, watering is initiated only when soil moisture drops below a certain level that ensures healthy crop development. The dashboard on the web site and the mobile app designed for farmers get the alerts on a regular basis. The farmer may check up on the fields whenever and wherever they like.

Keywords: 28TIoT, Sensors, Automated Irrigation, Systems Integration and Crop yield.

1. INTRODUCTION

Agriculture predates modern humans. From the earliest stages of human history, agriculture has been the cornerstone of human progress. It's a place where progress in technology is often repeated. Increases in agricultural output are a major priority for the Nigerian government because of the country's status as a developing nation. Despite the fact that over 70% of the population works in agriculture, the nation imports a great deal of its food. That is due in large part to the fact that agriculture in Africa's most populous country does not make use of modern techniques. There's a wide chasm between the academic institutions and the people who really cultivate the land. Soil moisture, temperature, humidity, pH, sun radiation, and many other environmental conditions all play critical roles in a plant's growth and development. In order to make informed choices and meet informational demands, farmers need access to agricultural information and relevant expertise. Due to a lack of accessible water data, the typical Nigerian farmer is now forced to operate solely during the brief rainy season.

Some crops, including corn, sorghum, and millet, can only be grown at specific times of the year. By creating a knowledge management system in the agricultural sector, questions from farmers about crop behavior and the surrounding environment may be addressed using multimedia resources that are both readily available and simply digestible. Utilizing ICT has opened up new horizons for expanding and promoting agriculture in many different contexts and settings throughout the globe's poorest nations. The need of energy, electricity, and expensive equipment—all of which are essential to agricultural progress but are in short supply in Nigeria—has been rendered unnecessary thanks to technological advances in wireless networking and mobile communication. Many new agricultural efforts, including ones involving the production of rice and tomatoes, have been made possible thanks to the proliferation of ICT in a variety of fields. In the not-too-distant future, IoT has the potential to revolutionize our way of life by fostering more effective industries, linked vehicles, and better urban environments. On places like the developing world, where resources like energy and cable transmission lines are few, the Internet of Things might have the largest influence in agriculture. These limitations may be overcome, in particular through the IoT system, by making use of the readily available solar technology, wireless transmission systems, and internet. By 2050, the world's population is projected to reach 9.5 billion, with a large share of that increase occurring in emerging nations like Nigeria. Therefore, the agricultural sector has to adopt IoT in order to feed such a large population. The increasing need for food must be satisfied despite obstacles including harsh weather, rising temperatures, and the environmental effect of intensive agricultural methods. Growers and farmers may save money and increase output by using IoT-based smart farming to track and manage anything from fertilizer use to tractor mileage.

Smart farming is high-investment, high-tech method mass-producing healthy and environmentally-friendly food. The process entails integrating information and communication technology (ICT) with conventional agricultural methods. As part of the Internet of Things in smart farming, sensors are integrated into a system to keep an eye on the crops. Thus, farmers may check on their fields no matter where they happen to be. Smart farming that relies on the Internet of Things is far more productive than traditional farming.

Due to the unreliability of monsoon rains, irrigation has become crucial in the agricultural sector. Water shortage has presented significant difficulties for agricultural production. Large amounts of technical expertise are needed to improve the efficacy of irrigation systems. Agriculture and irrigation are inextricably linked since both are necessary for survival. This connection exists because water is fundamental to the maintenance of all life.

Irrigation is the process of applying measured quantities of water to plants at regular intervals to facilitate crop production. Soil moisture is known to be a major factor in plant bionetwork, and so irrigation relies on it. Root rot, fertilizer leaching, and water pollution are all consequences of too-high soil moisture levels. Root respiration and root development are also stunted when gas exchange between the soil and the atmosphere is prevented. The proper amount of moisture must be maintained for the best growth of the root and overall development of the crop. Water is essential for seed germination and absorption of nutrients by the plant. Irrigation is a time-tested method that has undergone several refinements throughout the centuries. For instance, our predecessors used buckets and watering cans to irrigate their crops, whereas now we still use flood irrigation and sprinkler irrigation. Several problems have arisen with these methods, including the loss of valuable nutrients in the soil, the spread of harmful pests, the waste of large amounts of water, and several other unfavorable outcomes on farms. This is one area where automated irrigation systems may prove to be rather cost-effective, since they assist to reduce water waste. Automatic watering systems, however, may reduce costs even more. Manual watering of plants is inefficient since it does not focus on the roots with any particular accuracy.

Automated irrigation systems, on the other hand, may be set to only water certain areas when necessary, which helps to save water. For as long as the light shines, technology will aim to simplify and improve people's lives. To that aim, it seeks to connect rural communities to the digital world by giving farmers access to tools that automate tedious tasks like watering and monitoring crops, while also helping them save money, time, and energy. Wireless technologies, networking, mobile devices, etc. have allowed technology to leap over the need for costly and resource-intensive machinery. Through field unit feedback and parameter modifications through device control in the irrigation system, automated operations are initiated to maintain an optimal performance level.

Consequently, the goal of this system is to automate the irrigation process while simultaneously providing precise analysis of meteorological conditions and sensor data from the agricultural field (such as soil moisture, temperature, and humidity).

Wireless transmission is used to transfer sensor data to a web server database. Due to the automatic irrigation system, water is only delivered to the crops when the moisture and temperature on the field drop below the threshold set by the crop's water need. The farmer's Smartphone app receives regular updates that keep him abreast of what's occurring on the land. This allows farmers to check in on their fields from any location at any time.

2. System Design and Integration

It is possible to improve results by monitoring environmental conditions in the farm even when we are not physically there. This is due to the sensors' in-situ presence and continuous operation during the plant's growth cycle. The primary objective here is to create a system that will keep an eye on the weather and other environmental factors affecting crops, and then use that data to automate the farm's watering schedule based on the current temperature, humidity, and soil moisture levels. This will allow the administrator (farmer) to manage the data in real time (Figure 1). In this setup, the central node is a Thing speaks API that relays data to the management node through a user's desktop or mobile device. The Internet of Things (IoT) enables automated crop-field monitoring and irrigation, which tracks a wide range of growth-promoting factors for plants. This network of wireless sensors collects and sends data from the field over Wi-Fi. Through the data presentation, the data is transformed into a form that can be understood by humans. Web developers' frameworks and mobile apps do the heavy lifting of analyzing and displaying these numbers to end users. To transmit temperature, humidity, and soil moisture data from a farm field to a distant user via the internet, the MCU (Microcontroller) of an ESP8266 NODE was modified to accommodate a DHT11 temperature and humidity sensor and a soil moisture sensor. With these feedback sensor values, the control system may operate automatically. To inform the farmer of these values, an LCD panel shows them.

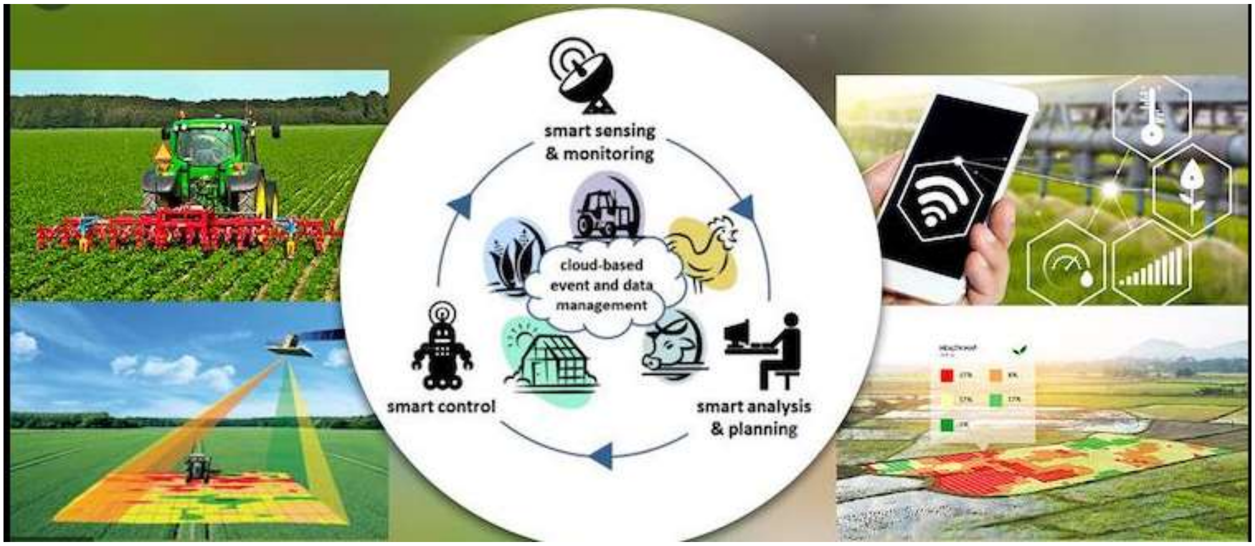

Fig 1. Overview of system design

2.1 Sensor data acquisition design

The ESP8266 NODE MCU (Figure 2) was modified to accommodate the DHT11 temperature and humidity sensor, the soil moisture sensor, and the YL 69, allowing for the collection and transmission of environmental data from a farm field to a distant user through the internet. With these feedback sensor values, the control system may operate automatically. The LCD panel is displaying the current readings.

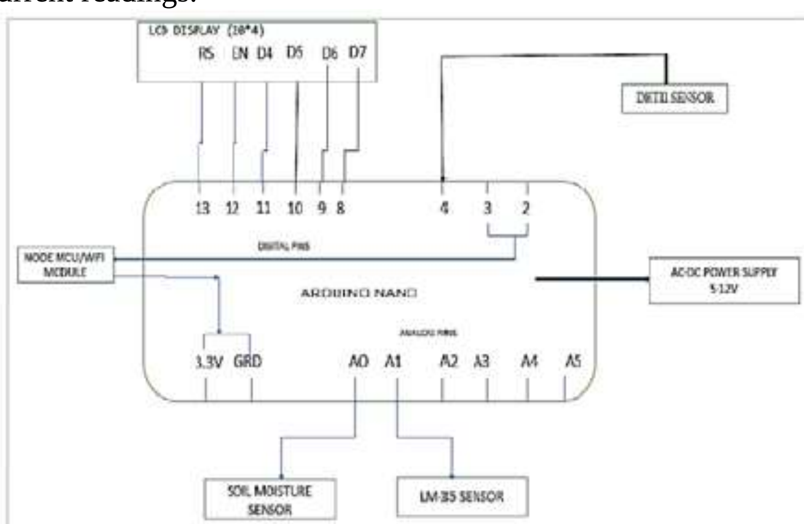

Fig 2. Sensor data acquisition design

In order to upload the sensor data to the server, it must be communicated wirelessly. The field data is sent to the server via the internet using a WI-FI module included into the node MCU. Data collected in the field are relayed wirelessly through the WI-FI module of the Node MCU ESP8266 and stored in the web server database "Thing speak" via an online connection. The data

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are periodically downloaded and saved to a database. Processing the data entails comparing readings from the field's many sensors with those determined in advance. Crop-specific threshold values are used. This is because varied water requirements across crops need such a distinction. Also, various plants need varied ranges of temperature and humidity. Sensor data also change depending on the weather. Summer and winter soil moisture conditions are different. Summer, winter, and wet season all bring their own temperature and humidity swings. After taking into account the aforementioned factors, a predetermined cutoff value is established. If the soil moisture reading drops below the threshold, the motor will turn on, and vice versa. The farmer may even start the engine from his phone if he has the right app. We created a receiver for the Internet of Things using a NODEMCU ESP8266 Express Wi-Fi board and a custom algorithm for exchanging information via HTTP. The hypertext transfer protocol means of communication between the Wi-Fi module and the rule engine of the web design and development system.
Any microcontroller may connect to a Wi-Fi network by using the NODEMCU ESP8266 Wi-Fi module, which is a self-contained system on chip (SOC) with an integrated TCP/IP protocol stack. In order to analyze the collected field data, draw useful conclusions, and display the results for the general public, it is crucial that a web server and online dashboard be developed as part of the project. The data was analyzed with a custom algorithm written in Python, JavaScript, and MATLAB, and a web dashboard was built and hosted so that users could easily access the visualized data in the form of graphs and meter gauges. The web server was set up one Thing speak, an open source IoT cloud platform from Math works with built-in functionalities to run MATLAB code. The android framework was used to create the mobile app. The field may be monitored and managed from anywhere with the aid of the mobile app. Mobile app data is retrieved from the Thing speak API using PHP script. On order to show the data in an android device, the android retrieves it and encodes it in JSON (JavaScript Object Notation). The application's user interface was developed so that field monitoring and manipulation could occur on the device.

2.2 Automation of Irrigation System

Once instructions are received via a desktop computer, a mobile device, or a web application, the irrigation system is fully automated. The Node MCU communicated with the relay to activate the electrical switches. For those unfamiliar, a relay is a switch that is controlled by electricity. Solid State Relay is employed as the relay in this case (SSR). A relay is a switch that activates or deactivates a circuit when an external voltage is supplied across its terminals. Figure 3 depicts the workflow for the automated watering system.

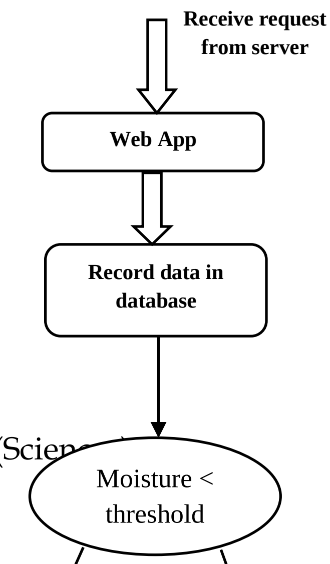

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Fig. 3 Process flow for irrigation

2.3 Software Implementation

To programme the Node MCU's Arm processor to link sensors and other types of components and to carry out operations in both the local and global domains with the aid of library functions, the Adriano IDE was utilized. To store, analyze and visualize the sensor data using MATLAB, a Thing speak account was also established using Math works account setup, where the login username and passkey were generated. There was provided a Thing speak channel ID, API read key (2DD8XG6ZPNL4DHZO) and API write key (N46QM36MDLSOUEXM). A total of four shapes were fashioned underneath the channel; they mirror the values for the field and the water pump's regulation that were determined via measurement. In Figure 4, we see a flowchart detailing the steps taken to put this programme into action.

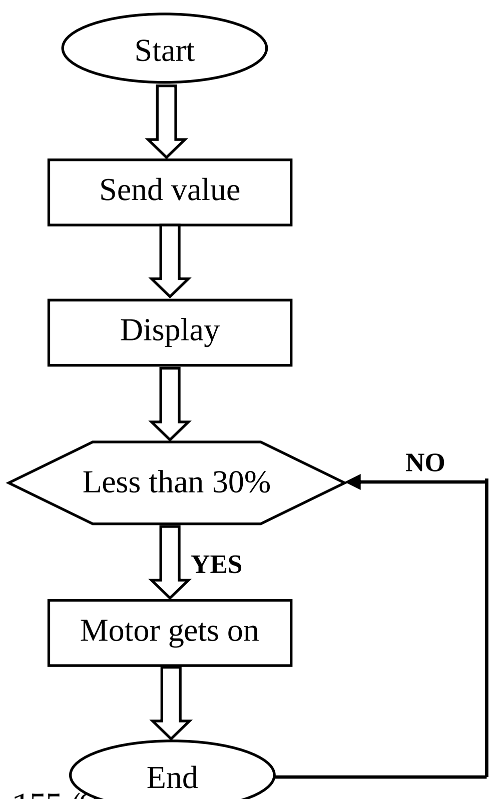

Fig. 4 Software implementation flowchart

3. Results and Discussions

By use of a breadboard, the Node MCU's ARM CPU is linked to the various sensors measuring environmental conditions. Data collected by these sensors is sent to a server through the internet. Figure 5 depicts the overall circuit integration, including the connections between all the components for monitoring and irrigation automation.

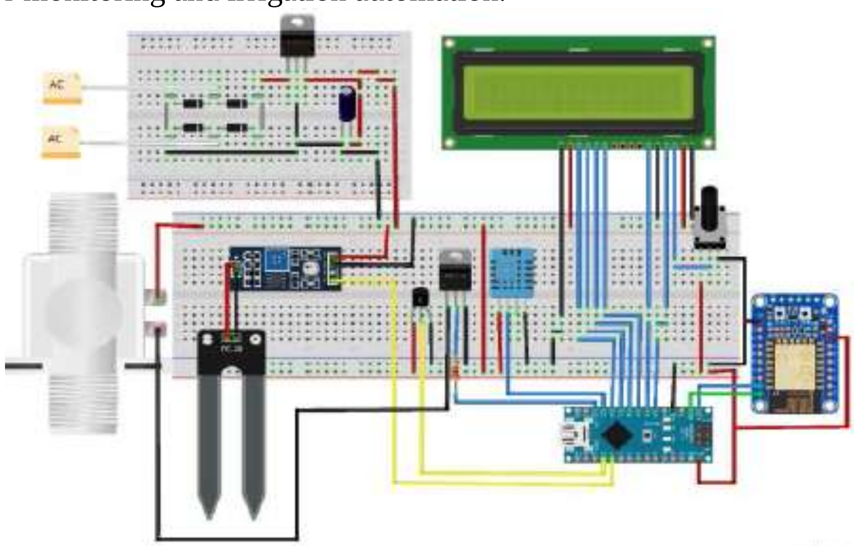

Fig.5 Integration of the full circuit

With Thingspeak's data export feature, compiled data is neatly organized and formatted in an Excel spreadsheet. Math works Thingspeak was used to display the data in real time that had been collected from the prototype satellites. The data visualization was made available on a web dashboard that anybody may view instantly. The web-based dashboard provides visual indicators of sensor readings, satellite activity, and data transfer rates.

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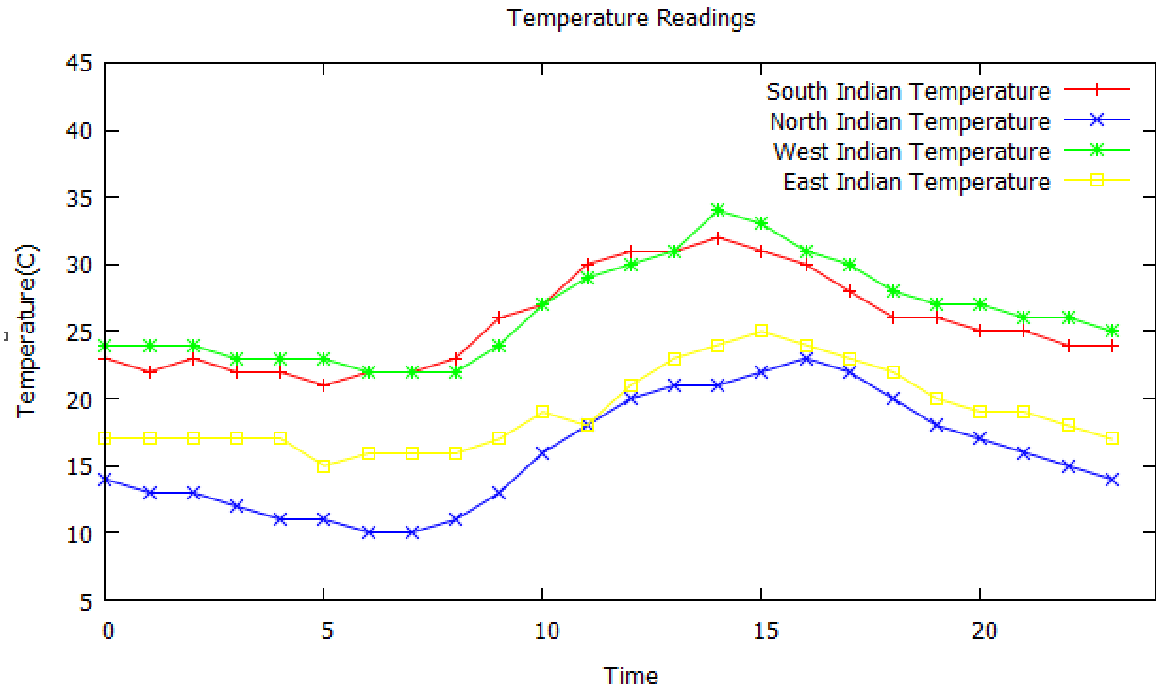

Fig. 6 Data Visualization of temperature using DHT11

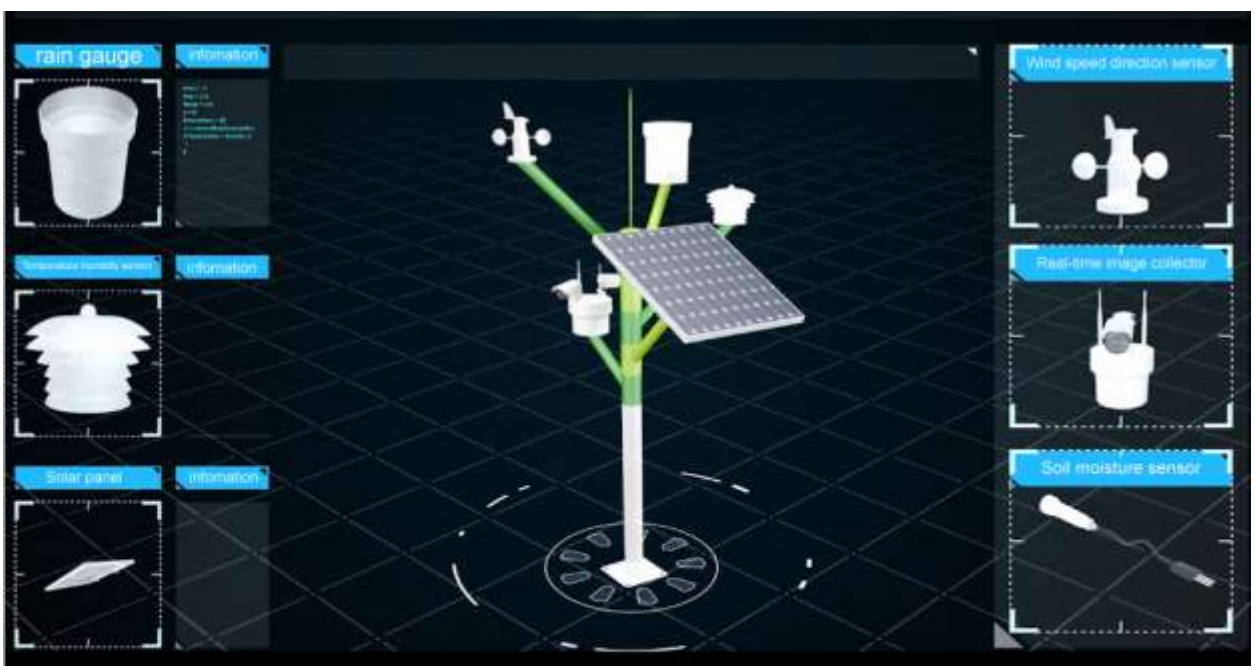

Fig.7 Data Visualization of relative humidity and soil moisture using DHT11 and YL-69 sensors

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When all of these factors are taken into account, it becomes clear that close attention to these measures is critical for healthy plant development. To alleviate some of the burden on the farmers, a system has been developed to keep tabs on everything mentioned above, send out regular reports detailing what's been going on in the fields, and trigger automatic responses to any problems that arise. When these measurements are recorded and saved to the Thingspeak database, they can be seen and displayed on the custom-built website (Figures 6 and 7), eventually leading to precision farming.

4. Conclusions

In addition to sensing, reading, and storing data, the system may also produce actions based on the collected information. Information stored in a database may be accessed for years to come, aiding researchers and ensuring that any anomalies can be investigated and fixed to save any unnecessary pain in the future. The system's intuitive web and mobile app interface ensures that it can be used by anybody, regardless of prior experience. When the soil moisture drops below the threshold, the system automatically decides to irrigate in accordance with the instructions it has received. Because of how efficient it is, farmers can really afford to use this technique. Due to the lack of internet access in certain outlying farms, this work may be repurposed to include a GSM module for texting farmers. There may be less need for human intervention in the system's monitoring if artificial intelligence modules are included into the system's intelligence or decision-making component.

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