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Implementation of IoT and Machine Learning for Smart Farming Monitoring System

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Abstract

In a country like mine, Ethiopia where there are 94 million people, agriculture is the main driver of the country's economy contributing to 45% GDP and 85% of the population are farmers, Traditional methods used by farmers aren't sufficient enough to serve the increasing demand and so they have to hamper the soil by using harmful pesticides in an intensified manner. As to increase farm productivity by understanding and forecasting crop performance in a variety of environmental conditions this paper focuses on emerging different automation practices like IoT, Wireless Communications, Machine learning and Artificial Intelligence, Deep learning as part of the industry's technological evolution.

Keywords: Smart farming; IoT .

1. Introduction

AI and the Internet of Things (IoT) are steadily transforming agriculture in ways that could save over 815 million people, or 11% of the world's population, from hunger: most especially in Africa, where the sector accounts for 32% of GDP and two-thirds of employment [2].

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The most popular applications of AI in agriculture appear to fall into three major categories: Agricultural Robots, Crop, and Soil Monitoring and Predictive Analytics [3] and IoT's application in several areas, such as connected industry, smart-city [6], smart-home [4], smart-energy [5], connected car, smart-agriculture [7,11], connected building and campus, health care, logistics, among other domains. The world is turning to the use of AI and IoT combined with data analytics (DA) to meet the world's food demands in the coming years. It is predicted that IoT device installations in the agriculture sector will increase from 30 million in 2015 to 75 million by 2020 [1]. The use of IoT and AI will enable smart agriculture which is expected to deliver high operational efficiency and high yield [1]. In understanding the potential impact of all these technologies, examples are beginning to abound. When Nature Sweet in the US adopted AI to monitor its tomatoes, it increased its harvest by four percent in the very first harvest [2]. As of now, three-quarters of Africa's farmers practice traditional farming techniques that deliver low yields, despite agriculture being their main source of livelihood [2]. But, to illustrate the change that is possible, app developers, such as Kenyan botanist and biochemist, Samuel Kamya, are delivering new solutions that could lift the continent's agricultural output [2]. Over the years, the platform is being used by farmers in Malawi, Mozambique, and Zimbabwe, as well as South Africa, and recently enabled sugar farmers in South Africa to detect crop problems early enough to prevent up to 20% of crop failures [2]. AI is now helping with supply chain tracking and market positioning. Typical has been a coffee traceability solution that has been launched in Ethiopia, based on mobile technology, analytics and the Internet of Things. The solution is now tracking as many as five million bags of coffee through all stages of the supply chain, helping firms achieve fair trade and organic certification for their products. The system has been a major boost for the coffee industry in Ethiopia, enabling farmers to better compete in the international coffee market and lifting Ethiopian coffee exports [2]. The possibility that lies ahead is for machines that solve problems through physical interactions within an environment. Although such machines are yet to arrive in African agriculture in a big way, they offer the hope of vastly improved soil management and better coping strategies in the face of droughts. For Africa, the use of the Internet of Things and artificial intelligence offers the hope of multiple food security solutions and a more productive sector continent-wide.

2. Literature Survey

Internet of Things is a completely new technology that has given mankind the power any system from anywhere in the world. It is basically the exchange of huge amounts of data between the various components of the network, how they connect and work with minimum human supervision. IoT can have various applications in the day-to-day life of humans, like, smart irrigation, better healthcare systems, power plants and smart city, intelligent transportation and so on. IoT and embedded systems can be used to make the irrigation system smart and self-sufficient. Many systems have been developed for conserving water, some are basic while the others are technologically very advanced. In the system [12], a LoRa based communication system is used for smart irrigation. It consists of a LoRa communication module, a solenoid valve and a generator. The LoRa module is used as a gateway to send the data from the nodes to the cloud via wireless transmission. The irrigation can be controlled by a mobile application in this system. It is shown that the transmission distance is reliable for the proposed system. In another experiment [13], the Fishers' linear discriminant analysis (LDA) approach was put to use. In this system, a database is created in order to calculate the amount of water required by the plants for optimum growth at a particular time. The database created contains various parameters such as the soil moisture content, leaf condition of the plants, humidity level and the amount of water required by the plants for the particular set of parameters is calculated. The parameters are determined by retrieving the color of the soil and the plants images using the Fishers' LDA technique. The RGB values of the images are used to indicate the moisture level in the soil. In [14], an MQTT based smart irrigation system is presented. It is used to collect all the relevant data including parameters such as, temperature, humidity and light intensity, from the field for continuous analysis and to deploy a system for smart irrigation, improving the crop quality and yield. The [15], presented a project for a smart agricultural system using IoT. The most prominent feature of this solution was the rain water harvesting technique. This project includes the prevention of crop spoilage due to flooding during rains and also recycling the harvested rain water effectively and efficiently. It consists of an alarm as well so as to protect the crops from the animals. All this is done by interfacing the sensors, and the GSM and the Wi-Fi modules to the Arduino. Some of the proposed solutions have also based their systems on mobile applications. The proposed method in [16] has used parameters such as temperature and soil moisture in a mobile integrated system using IoT for monitoring. The plants can be monitored and the water supply can be controlled through a mobile application in this system. The system proposed in System [17] is based on a mobile application system. It works on the readings from a soil moisture sensor from the field. The drip service is the switched on/off based on the real time readings and the plants are watered. There is a camera that is used to take the pictures of the plants and the healthy plants are differentiated from the diseased ones through image processing. In [20] the system presented is based on a java graphical user interface. It allows the controlling and monitoring of the field using an android phone. It can even control the number of drips using the application through a wireless sensor network system. After so many experiments, researchers have found that the yield and growth in the agricultural sector has decreased by a great amount. Thus, it has become necessary for the humans to introduce technology in the various aspects of agriculture and reduce human efforts so as to improve the yield and quality of the crops. It would also be helpful in the much needed conservation of fresh water resources and minimize the water and fertilizer requirement in agriculture. The controlled irrigation techniques and the supply of optimum amount of water at the right time would not only increase the plant growth and yield but would also help in conserving water.

3. Proposed System

In this paper, the proposed system is based on the development of a smart irrigation system. The proposed system will develop an optimized smart solar-powered farm vegetation yield, minimize energy consumption, environmental effect through real-time monitoring from sensor data to optimize water consumption and increase crop production with no limitation to season. The vital components that will be in this system are shown in the architectural model. The model consists of the NodeMCU that works synchronously with the sensor nodes that are deployed in the field. The sensors are deployed on the field in a way that they act as the end devices of a point to point network. An end device has the following characteristics:

- It must be connected to a local network before transmitting data.
- It can allow any peripheral devices to be connected.
- It can only send out data and cannot change the data.

The information collected is then sent by the NodeMCU to the receiver network in this case the Thinkspeak network which in turn communicates with the relay and the motor. From this platform the automated irrigation based on the current conditions that have been collected by the sensors. The system also sends out a text message alert to the farmer.

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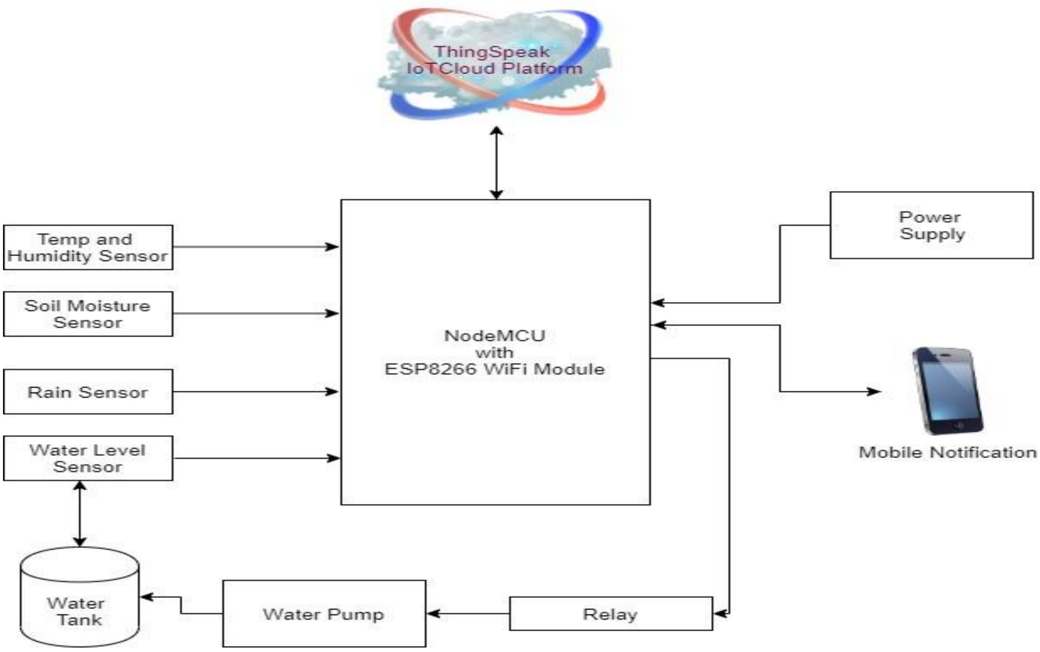

Figure 1: System Design

The proposed smart farm monitoring system consists of the following experimental resources.

4.1. NodeMCU development board

NodeMCU is an open-source IoT development platform which includes a firmware system development board that runs on ESP8266 Wi-Fi SoC. It has its own voltage regulator module and USB-UART. It is very convenient for development. The pin rules, the breadboard also has a big advantage in the wiring. The NodeMCU development board features GPIO, PWM, I2C, 1-Wire, and ADC. It provides hardware advanced interfaces that free application developers from complex hardware configurations and register operations. The development language of NodeMCU is not only Lua but also C++, Python (MicroPython) and Java (Smart.js). We use the CP2102 version of the board here, as shown below.

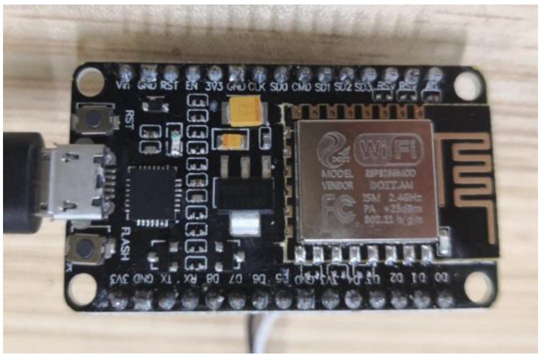

Figure 2: The appearance of the NodeMCU based on the ESP8266 development board

4.2. DHT11 temperature and humidity sensor

DHT11 digital temperature and humidity sensor, which is a temperature and humidity composite sensor with calibrated digital signal output, which has good reliability and stability. The DHT11 includes an NTC temperature measuring element and a resistive sensing element connected to an 8-bit microcontroller. The calibration coefficients are stored in the OTP memory (write once, not erasable) in the form of a program. These calibration coefficients are called internally during the processing of the detection signal. It uses a single-wire serial interface to make system integration simple and fast. The DHT11 is small in size and low in power consumption and is available in a 4-pin single-row pin package for easy connection.

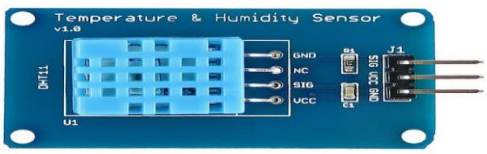

Figure 3: DHT11 Temperature and Humidity Sensor

4.3. Soil moisture sensor

Soil Moisture Sensor is used for measuring the moisture in the soil and similar materials. The sensor has two large exposed pads that function as probes for the sensor, together acting as a variable resistor. The moisture level of the soil is detected by this sensor. When the water level is low in the soil, the analog voltage will be low and this analog voltage keeps increasing as the conductivity between the electrodes in the soil changes. This sensor can be used for watering a flowering plant or any other plants that require automation. Technical Specification: 3.3V to 5V; Analog Output; VCC external 3.3 V to 5V.

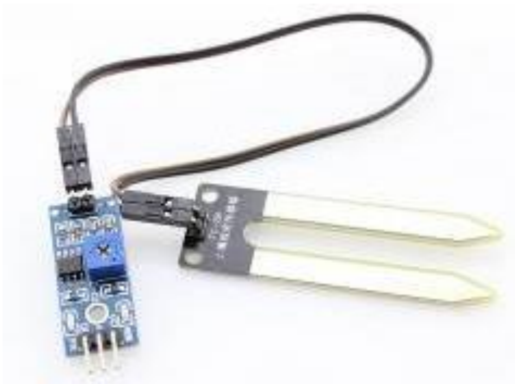

Figure 4: Soil Moisture Sensor

4.4. Water Level Sensor

The water level sensor is an easy-to-use, cost-effective high level/drop recognition sensor, which is obtained by having a series of parallel wires exposed traces measured droplets/water volume in order to determine the water level. Easy to complete water to analog signal conversion and output analog values can be directly read Arduino development board to achieve the level alarm effect.

Figure 5: Water Level Sensors

4.5. Rain Sensor

This is one kind of switching device which is used to detect the rainfall. It works like a switch and the working principle of this sensor is, whenever there is rain, the switch will be normally closed.

Figure 6: Rain Sensor

4.6. ThingSpeak Cloud Platform

ThingSpeak is an easy-to-use cloud-based IoT for prototyping and small-scale production applications that allows you to aggregate, visualize, and analyze live data streams. The Integration with The Things Network allows you to seamlessly forward data from The Things Network to ThingSpeak for analysis and visualization allowing users to create instant visualizations of live data once you send data to ThingSpeak from your devices using MQTT or REST APIs.

5. Explaining the System Design

The sensors are connected to NodeMCU and the solar-powered power supply. The NodeMCU receiving the data from all the sensors and uploads the information to the cloud server (ThingSpeak server). After receiving the data from all the sensors and uploading it on the server the system will compare the values received from the sensor with the threshold values set already and If the values are less than the threshold values set already, which then automatically runs an algorithm which predicts the Rain. If the prediction “It Will Not Rain” then the farmer will receive a notification message with all Sensed data, plus to Turn ON the irrigation system which can be done easily by using the Smart Farm Monitoring App or by simply sending a text which then the relay switches ON the actuator (water pump or irrigation). The irrigation system will stay ON until the soil reaches the moisture level set. When the threshold value is reached, then the relay automatically switches off the actuators.

5.1. Automation of Farm

The proposed smart farm monitoring system will be designed by dividing the system into several tasks which were hardware implementation, software implementation, and prototype testing. The hardware is a major part of executing the automated weather and irrigation system that makes it possible to run all the specific tasks. All the physical processes involving the system only can be accessed by the hardware after instructions were executed by the microcontroller.

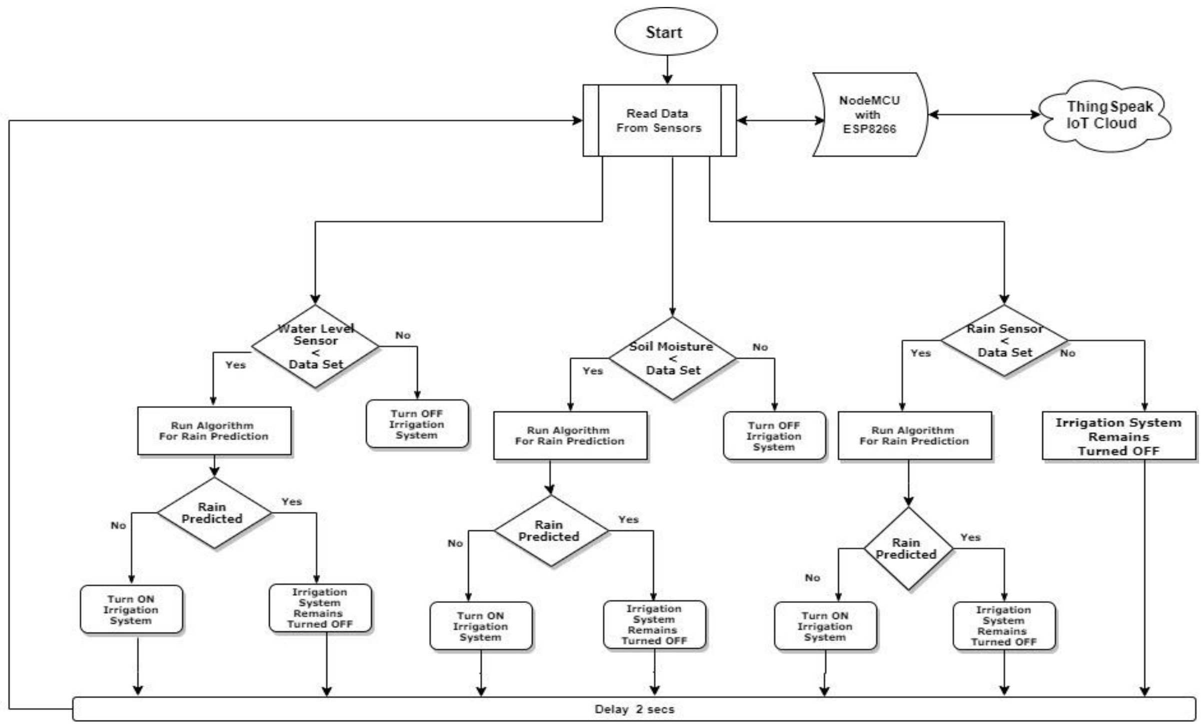

Figure 7: Flow Diagram

6. Results and Discussion

After designing the system, we did the implementation and tested. All the actuators and algorithms run smoothly. The soil moisture, temperature, humidity and water level were measured using the sensors. The data from the sensors was transferred to the ThingSpeak IoT Platform with the embedded ESP8266 Wi-Fi module successfully. The result of a monitored system on the ThingSpeak channel are shown in the figures below.

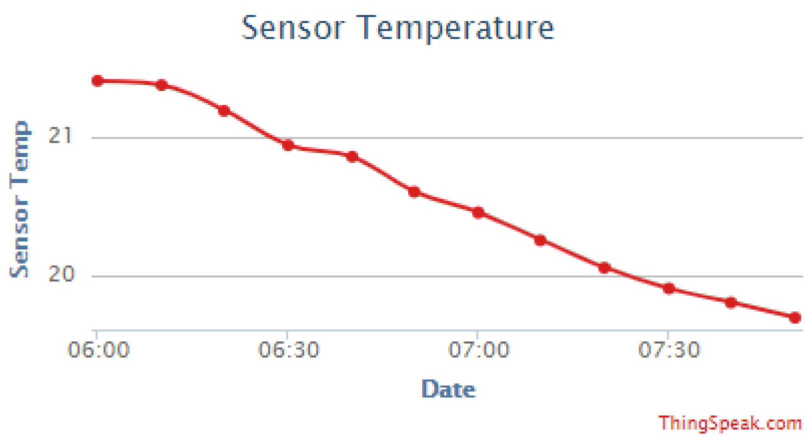

Figure 8: Temperature

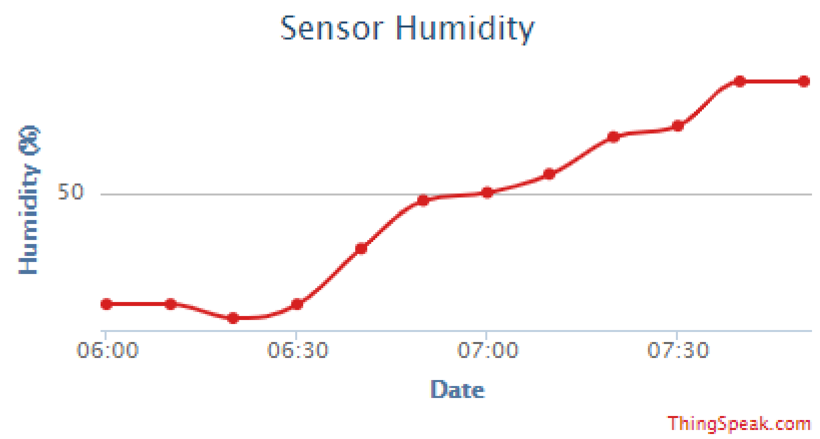

Figure 9: Humidity

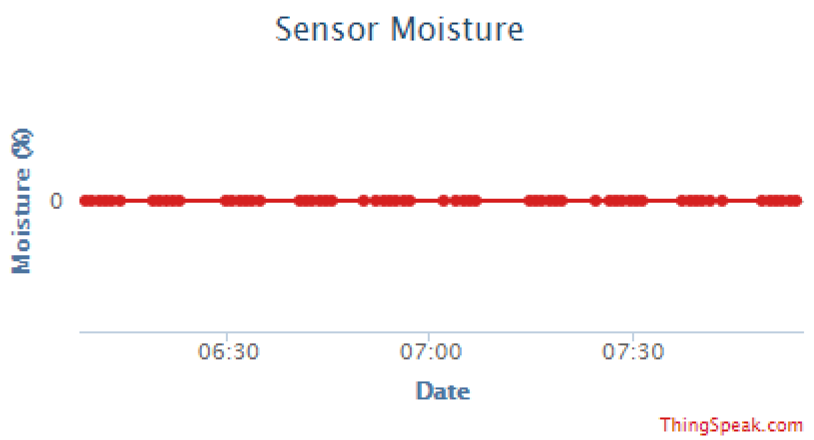

Figure 10: Soil Moisture

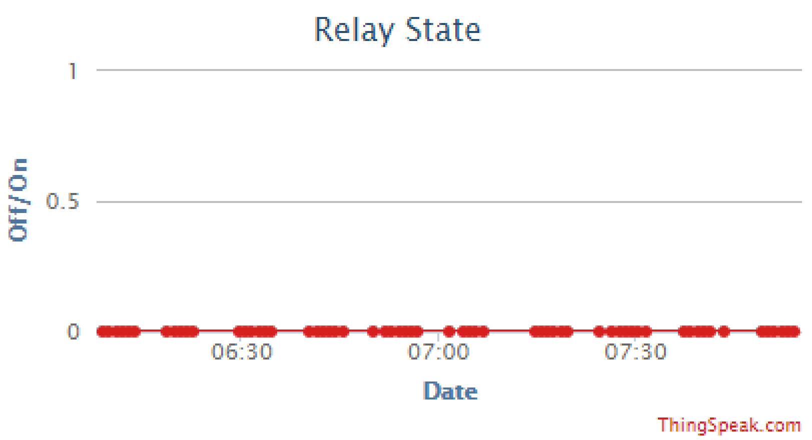

Figure 11: Relay State

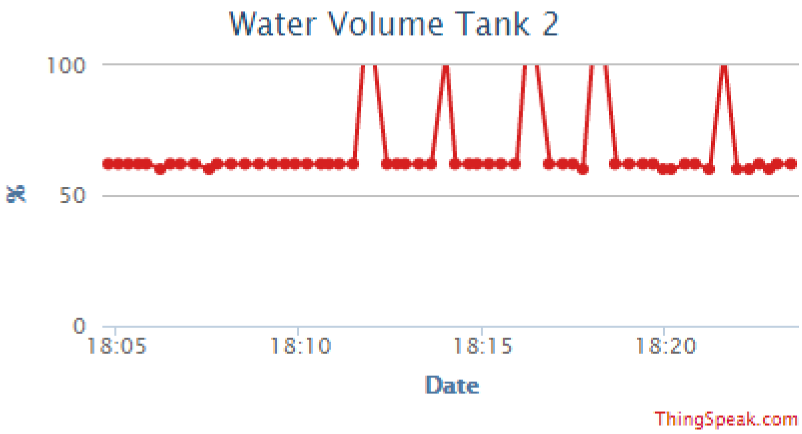

Figure 12: Water Tank Level

7. Conclusion

The proposed IoT based smart farming system setup is built for monitoring the crop field with the help of sensors (Water level, Humidity, Temperature, Soil moisture, etc.) and automating the irrigation system. The NodeMCU with embedded ESP8266 Wi-Fi module controls the monitoring system and the transfer of data to and from the sensors to the online server without human intervention. This continuous field monitoring triggers the appropriate events according to the requirement. It reduces the human effort and cost of farming to a certain extent. Smart sensors placed in the system is useful in a country like Ethiopia where the farmers are dependent on the rainy season and use traditional ways of farming. The proposed system will give the farmers the information received from the sensors and with the rain prediction algorithm in place, it will reduce water consumption. This system will help to create just the right moisture level in the soil for a given crop and reduce the dependency of farmers on the rainy season. It aims at empowering farmers with the decision-making tools and automation technologies that seamlessly integrate products, knowledge and services for better productivity, quality, and profit. In the future, this system will be extended to be able to have a prediction system to help farmers to be able to know when to harvest their crops based on when they planted the crops and the conditions that the crops were exposed to.

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