THE MAGIC DUO OF IOT AND BLOCKCHAIN: TRANSFORMING AGRICULTURE WITH REAL TIME DATA AND TRANSPARENCY

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ABSTRACT

Technology is revolutionizing agriculture, Internet of Things and Blockchain technologies have teamed up to bring us smart agriculture. In this paper, we'll dive into the world of IoT-powered farming, with a focus on real-time crop monitoring and eco-friendly sales. Imagine having access to all the key data about your crops in real-time – soil moisture, temperature, humidity, and their health status. well, with IoT sensors and devices in the fields, that's exactly what we're need about! The ability to make informed decisions based on accurate, up-to-the-minute intel is an absolute game-changer.

Blockchain integration comes into play, keeping a safe, unchangeable record of all this valuable data. No more guessing games – everyone involved in the supply chain can access this information, ensuring transparency and trust from farmers to consumers. And that's not all. With blockchain, we can confirm the organic and sustainable farming practices endeared by many consumers. Let's face it – with concerns over food safety and the environment, proving the authenticity of our products is essential. Shoutout to farmers who are rocking the eco-friendly farming scene!

Simplifying the process of selling crops, blockchain-enabled smart contracts emerge as a win-win solution for both growers and consumers. No more extended periods waiting for payments or dealing with middlemen. Instead, transactions are automated and swift, keeping the entire process efficient and profitable for everyone.

Consumers can now have the confidence to trust the provenance of their fruits and veggies, fostering the connection to sustainably sourced produce. Digital agreements and a secure online database, ensuring transparency, security, and automation.

The integration of these dynamic duos in agriculture – IoT and Blockchain – leads to increased productivity, sustainability, and food security.

Key words: IoT; Blockchain technology

1. INTRODUCTION

The world of smart agriculture, where farmers are using technology to revolutionize their farming practices. This tech-savvy approach allows farmers to monitor crop health, soil moisture, and other important factors in real-time. And it's all about maximizing those crop yields.

Blockchain technology is the superhero of transparency in the agricultural realm. With blockchain, farmers can now track their produce throughout the supply chain, ensuring that they get paid fairly for their hard work. No morework or shady dealings – just good old transparency brought to you by technology.

Blockchain is like a magical database that stores information in blocks linked together, creating a secure and unchangeable record. You can't mess with the chain without everyone's approval, making it a reliable source of truth for tracking orders, payments, and all the nitty-gritty details.

Now, let's consider data. In the traditional agriculture setup, IoT components generate tons of data every minute. This data is then stored in databases for analysis and decision-making. But these databases lack the security measures needed to protect against data breaches.

That's where the proposed system steps in, using blockchain and Ethereum to securely store data from IoT components related to irrigation. By storing data in blocks using smart communication protocols, we ensure high data security and integrity. Plus, with Ethereum's decentralized applications, we're taking the power away from a single entity and giving it back to the people – or in this case, the farmers.

When it comes to the hardware, we've got NodeMCU and Arduino playing major roles. These low-power embedded systems are all about efficiency and performance, making them perfect for IoT applications. And let's not forget about the sensors – rainfall, light intensity, soil moisture, temperature, and humidity sensors are the important for smart agriculture, providing crucial data for decision-making.

But the real magic happens when we bring it all together into a smart agricultural system. With enhanced crop monitoring and sustainable crop selling, farmers can now make informed decisions, optimize resources, and ensure fair practices in the supply chain. It's a game-changer for the agricultural industry, bringing us closer to a more efficient and sustainable future.

In paper [1], a smart real time monitoring agriculture system was developed for IoT-based agriculture data analysis.

In paper [2] the authors introduced IoT based smart agriculture system for Indian farmers

In paper [3], the authors developed a smart agriculture system using IoT for providing information on soil, water supply, condition of the plants to the farmers.

In the paper [4] authors proposed a theoretical approach to investigate the impact of blockchain on operational supply chain transparency.

In the paper [5] authors presents a literature review of industry 4.0 and other various related technologies which is now transitioning away from sensors and data technology and toward actionable intelligence technology.

In the paper [6], authors analyzed soil moisture levels and apply auto irrigation to the crops using IoT based agriculture monitoring system.

In [7], Samuel et al. described various techniques for crop selection, crop sowing, weed detection, and system monitoring using Machine learning and IoT.

II. SYSTEM HARDWARE

To set up the IoT environment for a smart agricultural system, we have selected a variety of hardware components, including the ESP8266 Node MCU.

NodeMCU:

NodeMCU is an open-source development board and firmware based on the ESP8266 Wi-Fi module. It is widely used for IoT (Internet of Things) applications due to its low cost, ease of use, and versatility.

Low-power embedded systems:

Less battery consumption, high performance are the inverse factors that play a significant role during the design of electronic systems. IoT products might have a range of power management strategies implemented at the design level , or they have some sophisticated on-chip features helping to keep power consumption low.

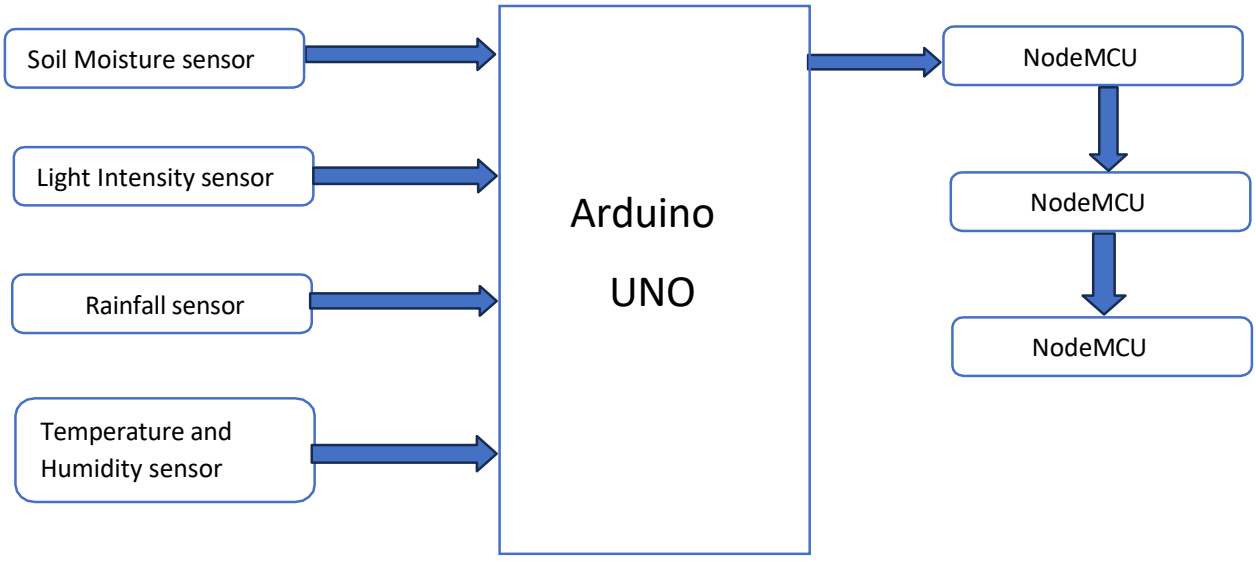

Figure 1 Block diagram of proposed method

Node MCU ESP8266:

The Node MCU ESP8266 is an extensively employed development board in IoT applications, providing a versatile and cost-effective approach to connect devices to the internet. It features Wi-Fi and programming capabilities, facilitating speedy prototyping and deployment of IoT solutions

Arduino UNO :
Arduino UNO is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online.

Sensors:
Sensors are the major part of any IoT application. It is a physical device that measures and detects certain physical quantities and converts it into signal which can be provided as an input to processing or control unit for analysis purpose.

Rainfall Sensor:
A rainfall sensor 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

Light Intensity Sensor:
A light sensor is an electronic sensor that can detect the intensity of light. It can detect the intensity of light in the surrounding environment. Light sensors measure illuminance, which can be used to measure more than the brightness of a light source. Because the illuminance decreases as the sensor moves away from a steady light, the light sensor can be used to gauge relative distance from the source.

Soil Moisture Sensor:
Moisture sensor used to decide the moisture content in the cultivation. The Soil Moisture Sensor uses capacitance to measure dielectric permittivity of the surrounding medium. In soil, dielectric permittivity is a function of the water content. The sensor creates a voltage proportional to the dielectric permittivity, and therefore the water content of the soil [8].

Temperature and Humidity Sensor:
Temperature and Humidity Sensor is devices that can convert temperature and humidity into electrical signals that can easily measure temperature and humidity.

Control Units:
It is a unit of small computer on a single integrated circuit containing microprocessor or processing core, memory and programmable input/output devices/peripherals. It is responsible for major processing work of IoT devices and all logical operations are carried out here

Cloud computing
Data collected through IoT devices is massive, and this data has to be stored on a reliable storage server. This is where cloud computing comes into play. The data is processed and

learned, giving more room for us to discover where things like electrical faults/errors are within the system.

Networking connection:
In order to communicate, internet connectivity is a must, where each physical object is represented by an IP address. However, there are only a limited number of addresses available according to the IP naming. Due to the growing number of devices, this naming system will not be feasible anymore. Therefore, researchers are looking for another alternative naming system to represent each physical object .

Data Collection:
An IoT device data collection system boosts productivity by automating sensor data gathering, eliminating the need for manual collection. Accurate real-time insights. IoT data collection enables real-time monitoring and prompt issue resolution for businesses. Better decision-making

Data Storage:
The internet of things (IoT) is the term given to the network of billions of devices that use sensors, software, and other technologies to collect and share data over the internet. IoT devices can be as small as the smartwatch on your wrist collecting health and fitness data.

III. SOFTWARE TOOLS

1. Visual studio code – Used to write a code.

2. Node - Nodes maintain network security and consensus. They validate transactions and verify data. Nodes ensure agreement on the state of the Blockchain.

3. Ganache - Ganache is a personal Blockchain for Ethereum development . It provides a user-friendly interface to view and debug transactions, events, and Blockchain states.

IV. IMPLEMENTATION PROCESS:

- The initial step is to set up connections between the components we are utilizing. Here we are using the Arduino UNO and NodeMCU.
- The Arduino UNO acts as a transmitter and the NodeMCU acts as a receiver.
- The Arduino IDE (Integrated Development Environment) is used to write the computer code for Arduino UNO and NodeMCU and upload this code to the physical board.
- ThingSpeak is an IoT analytics platform service that allows to aggregate, visualize and analyze live data streams in the cloud.
- After compilation we get the data that should be stored in ThingSpeak. Here in ThingSpeak, we are using an API key to connect blockchain and ThingSpeak
- Here we are using the ganache to obtain bitcoins from Ethereum for Blockchain usage. To run the entire application at once, we have written the code in Visual Studio Code using Python.
- The following commands must be executed the Main Program of the application
    - truffle compile
    - truffle migrate
    - cd src
    - python app.py

- A link is generated to display the final output in the node.
- EX : http://127.0.0.1:9001

Prototype:

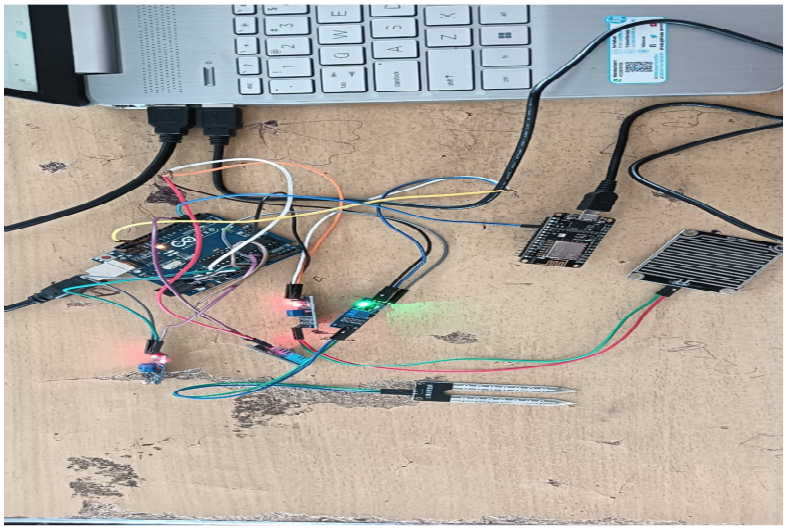

Figure 2 Prototype

IV. RESULTS:

Inputs:

- The data collected from rainfall sensor, temperature and humidity sensor, soil moisture sensor and light intensity sensor are applied as inputs.

Output:

- The output values obtained are used to predict health condition of the crop, soil moisture , temperature , humidity , etc.
- The threshold values of temperature is 0 to 50 degrees and the humidity value should be above 40 for moderate value, soil moisture value should be above 1000 for moist condition and for dry condition it should be below 1000 and the light intensity sensor is based on average value of dark and light values of the atmosphere and the rain sensor value is 1023.
- This allows the farmers to monitor the crop and while monitoring the crop we can store the information in the Database . So we can recommend cost for the crop which we produce.
- The predicted results thus obtained on comparing threshold values and obtained values are shown in figure 3 below.

Table 1 Data collected from various sensors

S.No.	Date & Time	Unique ID	Light Intensity Sensor Reading	Rain Sensor Reading	Temperature Sensor Reading	Humidity Sensor Reading	Soil Moisture Sensor Reading
1.	03-04-2024 08:27:59	93	6.0	1011.0	33.9	52.4	1015.0
2.	03-04-2024 08:28:15	94	6.0	1011.0	33.9	52.4	1015.0
3.	03-04-2024 08:28:32	95	6.0	1010.0	33.9	51.7	1014.0
4.	03-04-2024 08:28:47	96	6.0	996.0	33.9	51.8	1012.0
5.	03-04-2024 08:29:04	97	7.0	996.0	33.9	51.6	1013.0
6.	03-04-2024 08:29:20	98	6.0	995.0	33.9	51.6	998.0
7.	03-04-2024 08:29:20	99	6.0	995.0	33.9	51.6	998.0
8.	03-04-2024 08:29:20	100	6.0	995.0	33.9	51.3	998.0

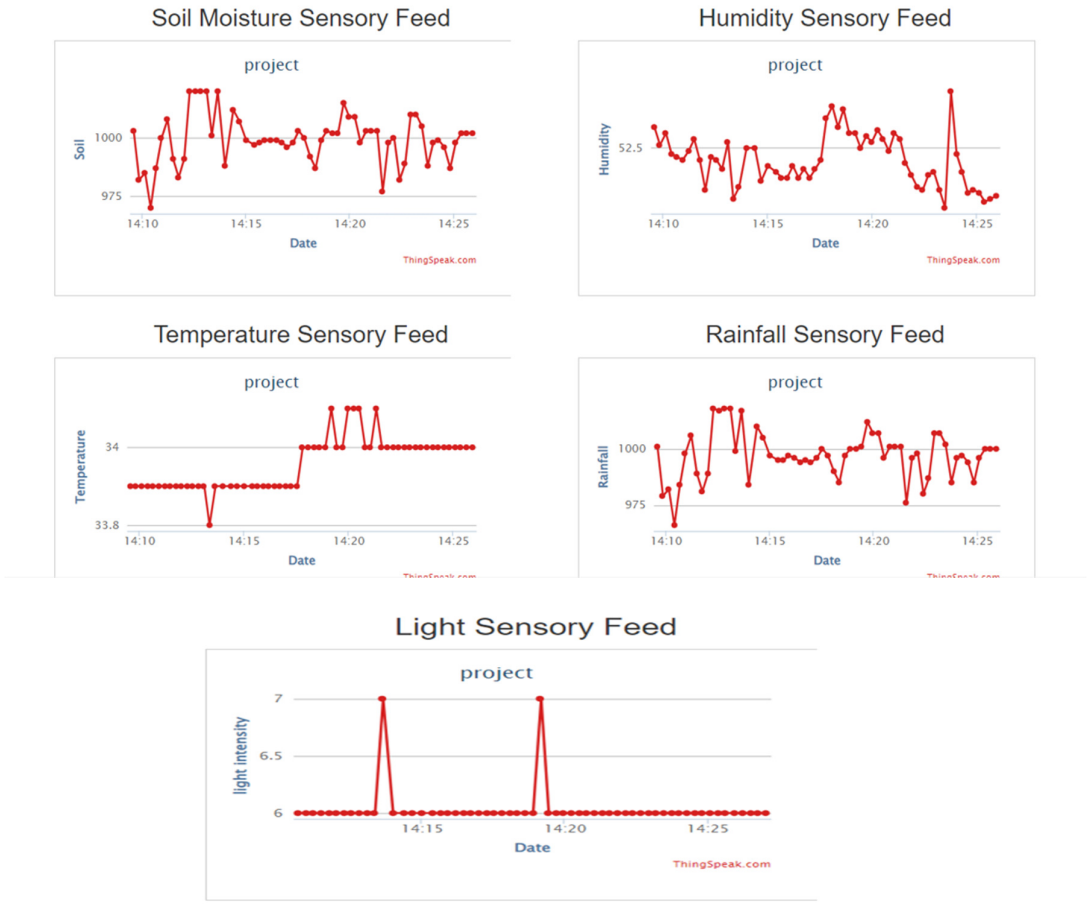

Figure 3 Graphical Analysis of all Sensors

Table 2 Soil moisture Sensor Reading analysis

S.No.	Date & Time	Unique ID	Soil Moisture Sensor Reading	Event type	Warning	Recommendations
1.	03-04-2024 08:27:59	93	1015.0	It's dry	Soil lacks sufficient moisture for healthy plant growth	Increase irrigation frequency or water application to ensure plants receive adequate moisture
2.	03-04-2024 08:28:15	94	1015.0	It's dry	Soil lacks sufficient moisture for healthy plant growth	Increase irrigation frequency or water application to ensure plants receive adequate moisture
3.	03-04-2024 08:28:32	95	1014.0	It's dry	Soil lacks sufficient moisture for healthy plant growth	Increase irrigation frequency or water application to ensure plants receive adequate moisture
4.	03-04-2024 08:28:47	96	1012.0	It's dry	Soil lacks sufficient moisture for healthy plant growth	Increase irrigation frequency or water application to ensure plants receive adequate moisture
5.	03-04-2024 08:29:04	97	1013.0	It's dry	Soil lacks sufficient moisture for healthy plant growth	Increase irrigation frequency or water application to ensure plants receive adequate moisture
6.	03-04-2024 08:29:20	98	998.0	It's a moist	Soil moisture is moderate but it may require monitoring to prevent water logging	Monitor soil moisture regularly to prevent over watering. Adjust irrigation schedule as needed to maintain optimal moisture levels
7.	03-04-2024 08:29:20	99	998.0	It's a moist	Soil moisture is moderate but it may require monitoring to prevent water logging	Monitor soil moisture regularly to prevent over watering. Adjust irrigation schedule as needed to maintain optimal moisture levels
8.	03-04-2024 08:29:20	100	998.0	It's a moist	Soil moisture is moderate but it may require monitoring to prevent water logging	Monitor soil moisture regularly to prevent over watering. Adjust irrigation schedule as needed to maintain optimal moisture levels

Table 3 Temperature Sensor Reading analysis

S.No.	Date & Time	Unique ID	Temperature Sensor Reading	Event type	Warning	Recommendations
1.	03-04-2024 08:27:59	93	33.9	Warm	Risk of heat stress in some crops	Provide shading or adjusting irrigation to cool plants
2.	03-04-2024 08:28:15	94	33.9	Warm	Risk of heat stress in some crops	Provide shading or adjusting irrigation to cool plants
3.	03-04-2024 08:28:32	95	33.9	Warm	Risk of heat stress in some crops	Provide shading or adjusting irrigation to cool plants
4.	03-04-2024 08:28:47	96	33.9	Warm	Risk of heat stress in some crops	Provide shading or adjusting irrigation to cool plants
5.	03-04-2024 08:29:04	97	33.9	Warm	Risk of heat stress in some crops	Provide shading or adjusting irrigation to cool plants
6.	03-04-2024 08:29:20	98	33.9	Warm	Risk of heat stress in some crops	Provide shading or adjusting irrigation to cool plants
7.	03-04-2024 08:29:20	99	33.9	Warm	Risk of heat stress in some crops	Provide shading or adjusting irrigation to cool plants
8.	03-04-2024 08:29:20	100	33.9	Warm	Risk of heat stress in some crops	Provide shading or adjusting irrigation to cool plants

Table 4 Humidity Sensor Reading analysis

S.No.	Date & Time	Unique ID	Humidity Sensor Reading	Event type	Warning	Recommendations
1.	03-04-2024 08:27:59	93	52.4	Moderate Humidity	Condition are generally suitable for main crops	Monitor humidity regularly to maintain consistently
2.	03-04-2024 08:28:15	94	52.4	Moderate Humidity	Condition are generally suitable for main crops	Monitor humidity regularly to maintain consistently
3.	03-04-2024 08:28:32	95	51.7	Moderate Humidity	Condition are generally suitable for main crops	Monitor humidity regularly to maintain consistently
4.	03-04-2024 08:28:47	96	51.8	Moderate Humidity	Condition are generally suitable for main crops	Monitor humidity regularly to maintain consistently
5.	03-04-2024 08:29:04	97	51.6	Moderate Humidity	Condition are generally suitable for main crops	Monitor humidity regularly to maintain consistently
6.	03-04-2024 08:29:20	98	51.6	Moderate Humidity	Condition are generally suitable for main crops	Monitor humidity regularly to maintain consistently
7.	03-04-2024 08:29:20	99	51.6	Moderate Humidity	Condition are generally suitable for main crops	Monitor humidity regularly to maintain consistently
8.	03-04-2024 08:29:20	100	51.3	Moderate Humidity	Condition are generally suitable for main crops	Monitor humidity regularly to maintain consistently

Table 5 Light Intensity Sensor Reading analysis

S.No.	Date & Time	Unique ID	Light Intensity Sensor Reading	Event type	Warning	Recommendations
1.	03-04-2024 08:27:59	93	6.0	Moderate Light	Suitable light levels for most plants	Monitor for any changes and adjust lighting as need for optimal growth
2.	03-04-2024 08:28:15	94	6.0	Moderate Light	Suitable light levels for most plants	Monitor for any changes and adjust lighting as need for optimal growth
3.	03-04-2024 08:28:32	95	6.0	Moderate Light	Suitable light levels for most plants	Monitor for any changes and adjust lighting as need for optimal growth
4.	03-04-2024 08:28:47	96	6.0	Moderate Light	Suitable light levels for most plants	Monitor for any changes and adjust lighting as need for optimal growth
5.	03-04-2024 08:29:04	97	7.0	Moderate Light	Suitable light levels for most plants	Monitor for any changes and adjust lighting as need for optimal growth
6.	03-04-2024 08:29:20	98	6.0	Moderate Light	Suitable light levels for most plants	Monitor for any changes and adjust lighting as need for optimal growth
7.	03-04-2024 08:29:20	99	6.0	Moderate Light	Suitable light levels for most plants	Monitor for any changes and adjust lighting as need for optimal growth
8.	03-04-2024 08:29:20	100	6.0	Moderate Light	Suitable light levels for most plants	Monitor for any changes and adjust lighting as need for optimal growth

Table 6 Rainfall Sensor Reading analysis

S.No.	Date & Time	Unique ID	Rainfall Sensor Reading	Event type	Warning	Recommendations
1.	03-04-2024 08:27:59	93	1011.0	Light Rain	Light rain may not provide sufficient moisture for crops especially during dry spells	Consider supplemental irrigation if the rainfall is insufficient. Monitor soil moisture to ensure adequate hydration for plants
2.	03-04-2024 08:28:15	94	1011.0	Light Rain	Light rain may not provide sufficient moisture for crops especially during dry spells	Consider supplemental irrigation if the rainfall is insufficient. Monitor soil moisture to ensure adequate hydration for plants
3.	03-04-2024 08:28:32	95	1010.0	Light Rain	Light rain may not provide sufficient moisture for crops especially during dry spells	Consider supplemental irrigation if the rainfall is insufficient. Monitor soil moisture to ensure adequate hydration for plants
4.	03-04-2024 08:28:47	96	996.0	Light Rain	Light rain may not provide sufficient moisture for crops especially during dry spells	Consider supplemental irrigation if the rainfall is insufficient. Monitor soil moisture to ensure adequate hydration for plants
5.	03-04-2024 08:29:04	97	996.0	Light Rain	Light rain may not provide sufficient moisture for crops especially during dry spells	Consider supplemental irrigation if the rainfall is insufficient. Monitor soil moisture to ensure adequate hydration for plants
6.	03-04-2024 08:29:20	98	995.0	Light Rain	Light rain may not provide sufficient moisture for crops especially during dry spells	Consider supplemental irrigation if the rainfall is insufficient. Monitor soil moisture to ensure adequate hydration for plants
7.	03-04-2024 08:29:20	99	995.0	Light Rain	Light rain may not provide sufficient moisture for crops especially during dry spells	Consider supplemental irrigation if the rainfall is insufficient. Monitor soil moisture to ensure adequate hydration for plants
8.	03-04-2024 08:29:20	100	995.0	Light Rain	Light rain may not provide sufficient moisture for crops especially during dry spells	Consider supplemental irrigation if the rainfall is insufficient. Monitor soil moisture to ensure adequate hydration for plants

V. CONCLUSION

The integration of blockchain and IoT technologies in agriculture offers a promising path towards smarter, more efficient, and sustainable farming practices. The proposed strategy utilizes the sensor gadgets to recognize the parameters like soil moisture levels, Rainfall levels, light intensity level and the temperature and humidity level for the crop growth.

Enhanced crop monitoring through real-time data and predictive analytics, coupled with a transparent and fair supply chain, can significantly improve both productivity and profitability for farmers. This transparency ensures that farmers are paid fairly for their produce based on accurate and verifiable data.

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