Smart Precision Agriculture using IoT Data Analytics

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Abstract

Smart farming based on IoT technologies enables farmers to reduce waste and enhance productivity ranging from the quantity of fertilizer utilized to predicting which crop is best in which weather condition using NPK levels, enabling efficient utilization of resources such as water, electricity, etc.

By using Data Analytics, farmers can make informed decisions about when and how to irrigate, and fertilize remotely, leading to improved crop performance and reduced input costs. In addition, analytics can be used to optimize irrigation schedules, identify, and diagnose problems early, and predict potential issues before they even occur.

Overall, the use of IoT and analytics in precision farming can help to increase crop yields, reduce water, and unnecessary chemical inputs, and improve the sustainability, profitability, and conversation of the land resources of agricultural operations.

INTRODUCTION

Smart precision farming uses various sensors to accumulate data onto a cloud server. It stores values of PH, temperature, and water content at a particular time. An analysis is made to improve cost management and reduce waste, which improves all aspects of the production cycle.

The Internet of Things (IoT) is a network of interconnected devices that can communicate with each other and with external systems to collect and transmit data. It is a key component of smart farming. It turns normal farms into smart farms. On the surface, a smart farm operates just as it allows farmers to monitor and control various aspects of their operations remotely, including irrigation, fertilization, temperature, and humidity.

Combining predictive analytics with IoT technology allows farmers to make informed decisions about their operations based on data-driven insights. For example, a farmer can use predictive analytics to forecast the likelihood of inadequacy in NPK levels and adjust fertilizer spray schedules accordingly. Similarly, they can use IoT sensors to monitor soil moisture levels in real-time and adjust irrigation accordingly.

Overall, the use of predictive analytics and IoT in smart farming can help farmers optimize their operations and improve efficiency, leading to increased crop yields and profitability.

LITERATURE SURVEY

High speed networks such as WiGig networks, Cognitive Radio Networks(CRN), and Machine Learning methods can accelerate data collection and validation from the field. [1] [3] [4] [5]

Nurzaman Ahmed and Debashis De proposed a scalable network architecture for monitoring and controlling agriculture and farms in rural areas which reduces network latency up to a certain extent. Using fog computing and Wi-Fi-based long-distance network in IoT, it is possible to connect the agriculture and farming bases situated in rural areas efficiently. A cross-layer-based channel access and routing solution for sensing and actuation improve the communication range and throughput. [2]

Madalina MioaraAnghelof, George Suciu, Razvan Craciunescu, and Cristina Marghescuused used Message Queuing Telemetry Transport (MQTT) interfaced to an android application which allows the user to view and set the environmental conditions. Environmental parameters are measured through several sensors to decide and control the appropriate climate conditions for each crop and provided a smart greenhouse that automatically improves the quality of the culture, directly reducing the consumption of resources and increasing the harvest potential.[6]

Abhinav Sharma, Arpit Jain, Prateek Gupta, and Vinay Chowdary focused on the prediction of soil parameters such as organic carbon and moisture content, crop yield prediction, disease and weed detection in crops, and species detection. They used ML with computer vision for the classification of a different set of crop images to monitor crop quality and yield assessment. This approach was integrated for enhanced livestock production by predicting fertility patterns, diagnosing eating disorders, and cattle behavior based on ML models using data collected by collar sensors, etc. Intelligent irrigation which includes drip irrigation and intelligent harvesting techniques are also reviewed which reduces human labor to a great extent. The data obtained from the deployed sensors were processed and analyzed using ML algorithms to make farming practices more controlled and optimized. ML algorithms were also used for weather and rainfall prediction based on the data obtained from sensors, climatic records, and satellite images.[7]

TheerayodWiangtong and PhaophakSirisuk developed a versatile controller to monitor and control temperature and relative humidity in different ways to serve different types of use. Control methods including timer, hysteresis control, and condition control, were arranged in different sequences and periods of time. Eight multifunction output ports were available for actuators or loads. Temperature and humidity in a greenhouse were controlled in predefined ranges to suit planting processes. Data on the cloud was monitored in real-time on a PC or mobile application.[8]

MaherinMizanMaha, Sraboni Bhuiyan, and Md Masuduzzaman proposed a smart sensor system supported by actuators to automate farming and provide a precision farming experience using IoT. The system helps persons with inferior knowledge of technology to understand and maintain the system with a new device namely Smart Board. The board helps to monitor the status of the farm and to send action commands to farm machinery. This work also helps the practice of e-governance by setting a simple but effective data exchange between the government and farmers. Farmers will get benefitted as the smart board will keep them up to date on government agriculture-related announcements. It is a systematic mixture of many technologies including a smart sensor network system.[9]

SYSTEM MODEL

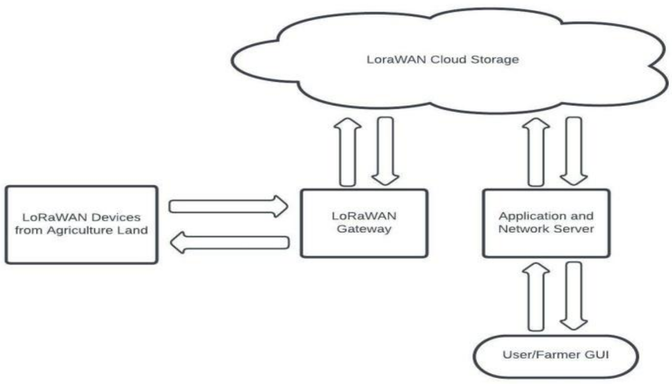


Fig 1 Proposed System Model

DESCRIPTION

Farmers are in continued debt due to many reasons in the recent past. However, bringing them out of poverty is a simple task to achieve. Farmers primarily rely on their past experiences to decide on which crop to sow for the following term. This is mostly done based on experience and luck. This uncertainty of yield can be replaced with precise outputs/yields by using Precision Farming using IOT devices. These devices analyze soil and the atmosphere, giving them ultimately power(data) to easily increase their chances of better yield.

Some farmers employed new methods to monitor soil quality, but the accuracy of the methods was subpar, thereby giving them an incorrect result, which is not helpful. To eliminate this imprecision, this paper brings about a new way to tackle the problem with the help of already existing information on ideal values of soil parameters for achieving of the highest crop yield. This data is used to draw conclusions for the farmers and helps in finding the right crop for the term with minimal costs.

Some Sensors are installed at uniform distances across the length and breadth of the farmland to collect accurate soil data. It includes nitrogen, potassium, phosphorous levels, temperature, Ph levels, and Electrical conductivity (EC) of the soil at a particular time stamp. This data is collected by LoRaWAN devices which are sent through a secure gateway and stored in a cloud. LoRaWAN is a low-power, wide-area networking protocol built on top of the LoRa radio modulation technique. It can transmit data to long distances with less power, But the only drawback to LoRaWAN is that it cannot transmit huge amounts of data.

Keeping this in mind, we employed LoRaWAN architectures for the remote monitoring of data with less cost than standard methods. When this data is stored in the cloud, it uses the application/networking Server as a medium to connect with the farmer’s GUI application.

As the farmer may not understand the meaning of the values that are recorded, we sought to clarify these things by giving them simple prompts. The application sends notifications as per the soil parameters and prompts them to fill in the missing fertilizers or the required water. This prompting is done by modelling the dataset using a machine learning model (Support Vector Machine Algorithm).

PARAMETER	TOMATO	POMEGRANATE	CAPSICUM	RICE	BOTTLEGAURD	BRINJAL
Best Soil	Fertile loam	alluvial sandy loam	Sandy Loamy soil with compost	Clay, Slit & Loam	Sandy loamy soil	Silt loam and clay loam
Ph	6-6.8	6.5-7.5	5-5.7	6-6.7	6.5-7.5	5.5-6.6
Moisture	12%-18%	12%-16%	80-90%	20%-28%	80%-90%	20%-30%
EC (mS/M)	2.0-5.0	5.0-6.0	1.8-2.2	1.7-2.1	5.8-6.0	1.5-2.2
NPK	15:15:15	154:77:231	155:55:45	120:40:40	6:12:12	200:75:75
Temperature	21-24℃	23-32℃	20-25℃	21-37℃	20-32℃	13-21℃

Fig 2 Ideal Surveyed values

time	water_soil	conduct_soil
23/09/22 11:27	26.12	234
23/09/22 11:07	26.13	235
23/09/22 10:47	26.12	234
23/09/22 10:27	26.12	235
23/09/22 10:07	26.13	235
23/09/22 09:47	0.00	0
24/08/22 15:18	50.69	719

time	ph1_soil	bat	temp_soil
02/01/23 12:45	1.94	3.321	26.80
02/01/23 12:25	1.94	3.319	26.70
02/01/23 12:05	1.94	3.315	26.60
02/01/23 11:46	1.94	3.319	26.50
02/01/23 11:05	1.95	3.321	26.20
02/01/23 10:05	1.94	3.317	26.30

time	k_soil	p_soil	n_soil
27/08/22 13:28	16640	8192	5888
27/08/22 13:26	15616	7680	5632
27/08/22 13:24	16640	8192	5888
27/08/22 13:22	16640	8192	5888
27/08/22 13:20	16640	8192	5888
27/08/22 13:18	16640	8192	5888
27/08/22 13:16	16640	8192	5888

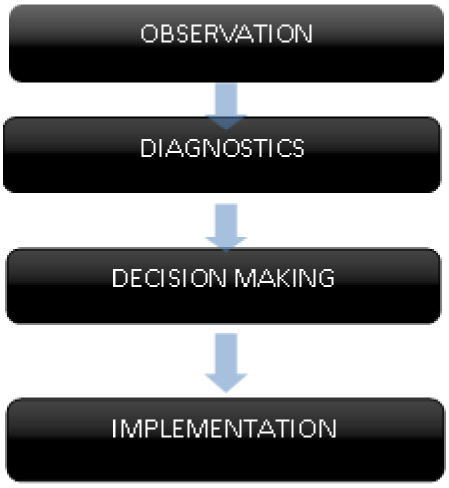
Fig 3 Retrieved Values from the rice field

Support vector machines (SVMs) can be used in precision farming for a variety of tasks, such as yield prediction, soil mapping, and crop classification. To use an SVM for precision farming analysis, you would first need to collect and preprocess the relevant data. This might include data on the crops, soil conditions, weather, and other relevant factors. Next, you would need to select and tune an SVM model and use it to train on the data. Finally, you can use the trained SVM model to make predictions or classify new data points.

The retrieved values undergo analysis with use of Support Vector Machine algorithm and are compared to the ideal values, here, the retrieved values are in the ideal range, therefore, the monitored paddy field is in ideal condition.

This data can not only be predicted for small-sized agricultural lands but also for large farming lands. When applied to lands bigger than the standard size, it could also help in increasing the farmer's side income, like cattle rearing, which is dependent on crop yield.

This process can be categorized into 4 sub-processes. They are:



Uses IOT technology to gather a vast range of data

Uses Artificial Intelligence and Machine Learning to come up with the best solution

Data is analyzed to identify trends and patterns and help find the root of any issue

Suitable measures are taken to solve the problem and boost overall farm efficiency

Farmers may be able to better control expenses and waste by having more control over the production process. The likelihood of losing the produce will be reduced by the discovery of irregularities/patterns in crop growth or livestock health.

All operations, including irrigation, pest management, fertilizing, and other ones used throughout the production cycle, can gain from better automation with sensors and actuators. Process automation closes the loop by acting based on IoT data, going beyond the simple collection of data.

Farmers will have more control over the production process with the aid of smart farming. Automation allows them to uphold higher crop quality and comply with growth capacity criteria.

Agriculture nowadays is competing. Despite poor soil conditions, dwindling land availability, and growing weather variability, farmers must produce more. Farmers can monitor their products and environmental conditions in real-time thanks to IoT-enabled agriculture. They can quickly gain insights, anticipate problems before they arise, and decide how to prevent them using knowledge.

Automation is also introduced through IoT solutions in agriculture, such as demand-based irrigation, fertilization, and robot harvesting.

RESULTS

The things mate server houses both our network and application servers. The network server's data is unreliable. The network server acts as a conduit between the gateway and the application server. As soon as the data is saved on the application server, it is removed from the network server.

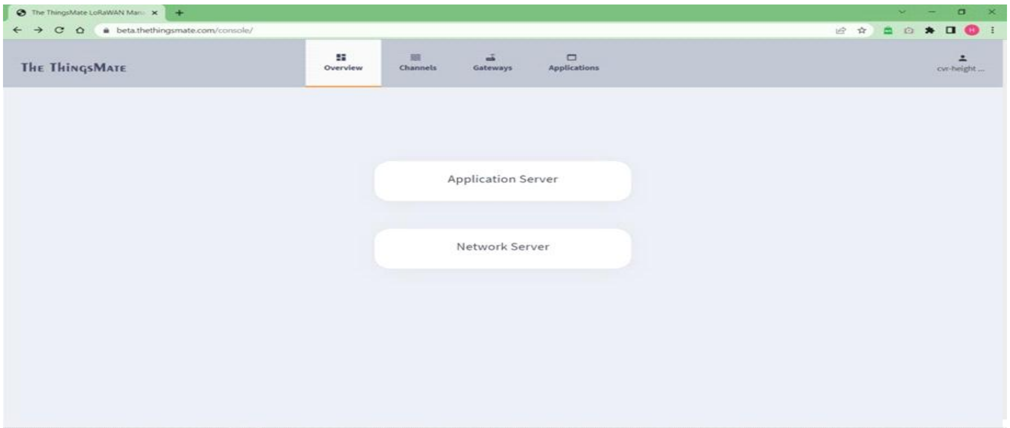


Fig 4 The ThingsMate Home Page

The network server presents the dynamic live data in a structured manner. It offers a broad understanding of end device and gateway security pseudo codes. Live data and end nodes' locations are received which shows us the precise timing of the data transmission as well as the path of the transmission, such as the gateway receiving the data from the end node or the application server.

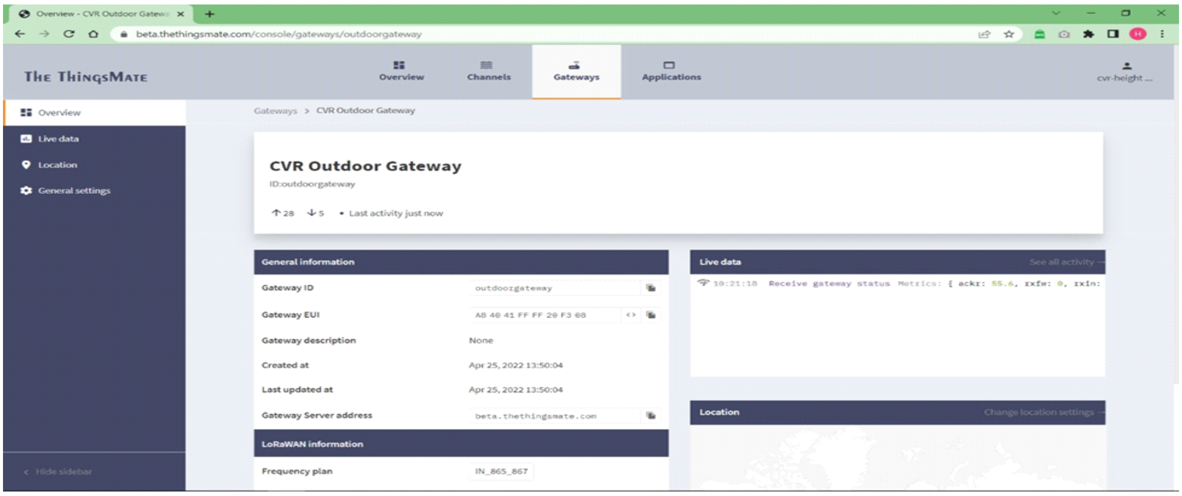


Fig 5LPS8 Gateways General Information (Gateway Overview)

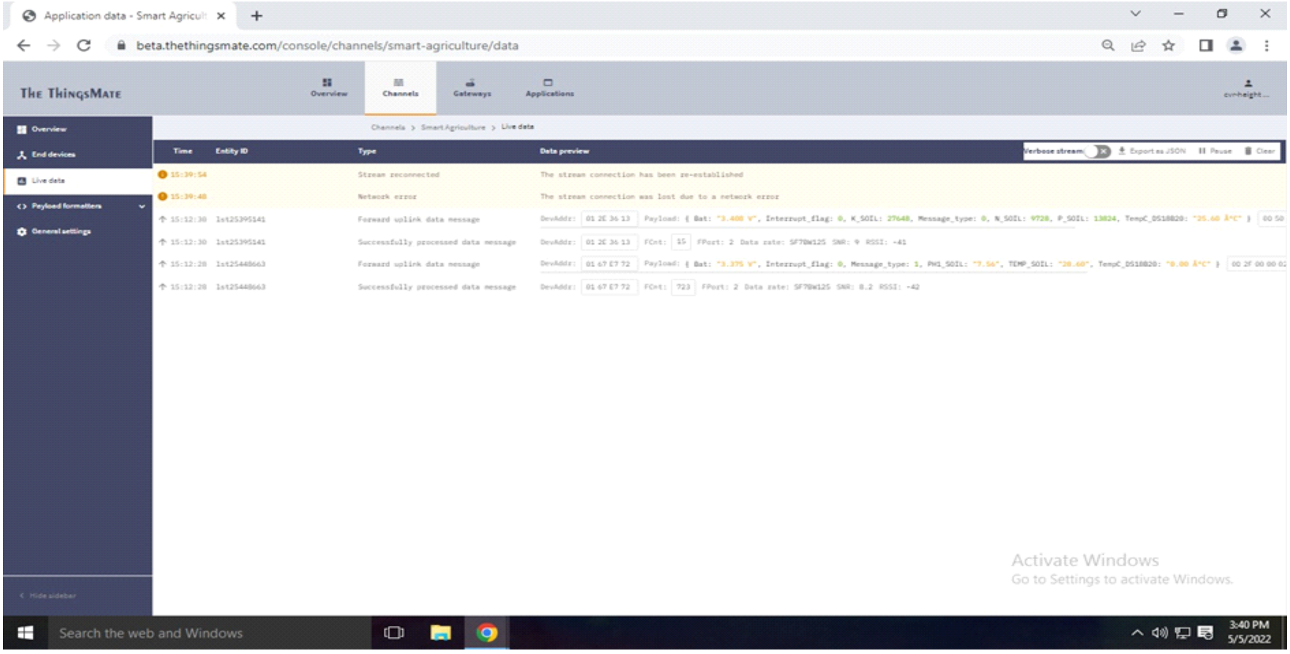


Fig6 Live Data Received by the Gateway DLS08

Data from the end nodes are sent as packets with hexadecimal information in the form of a preamble, mac payload, and CRC. This aids in real-time data monitoring.

• Preamble includes the dev address and end node's pseudo code.

• The real data that needs to be sent is in the Mac payload.

• CRC to help with error reduction.

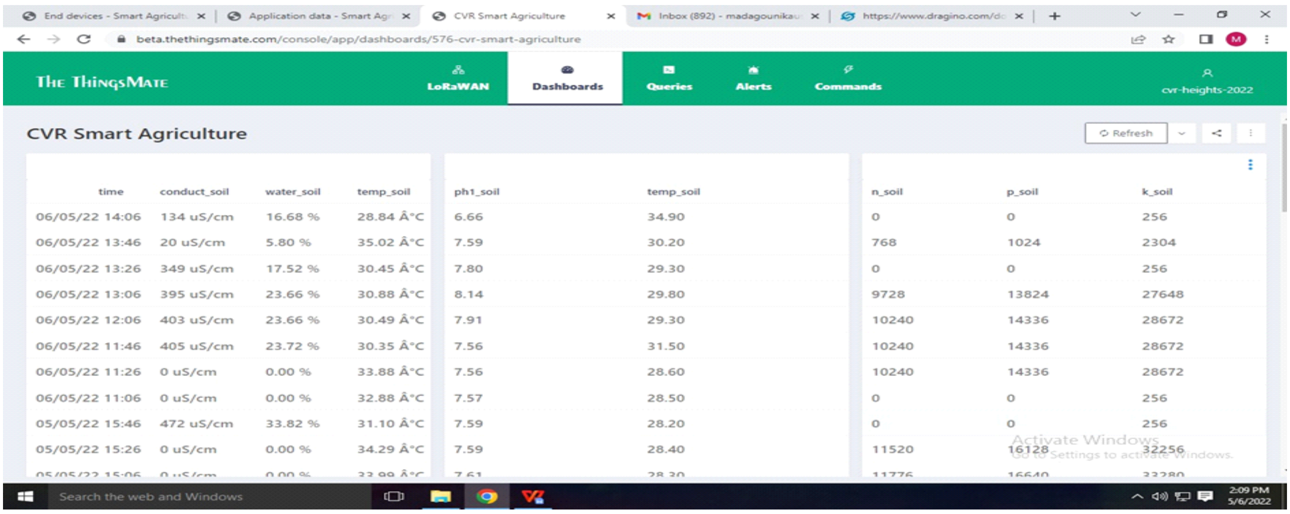


Fig 7 The data received on the Dashboard

This query section in the application server is meant to be accessed only by the authorized service provider

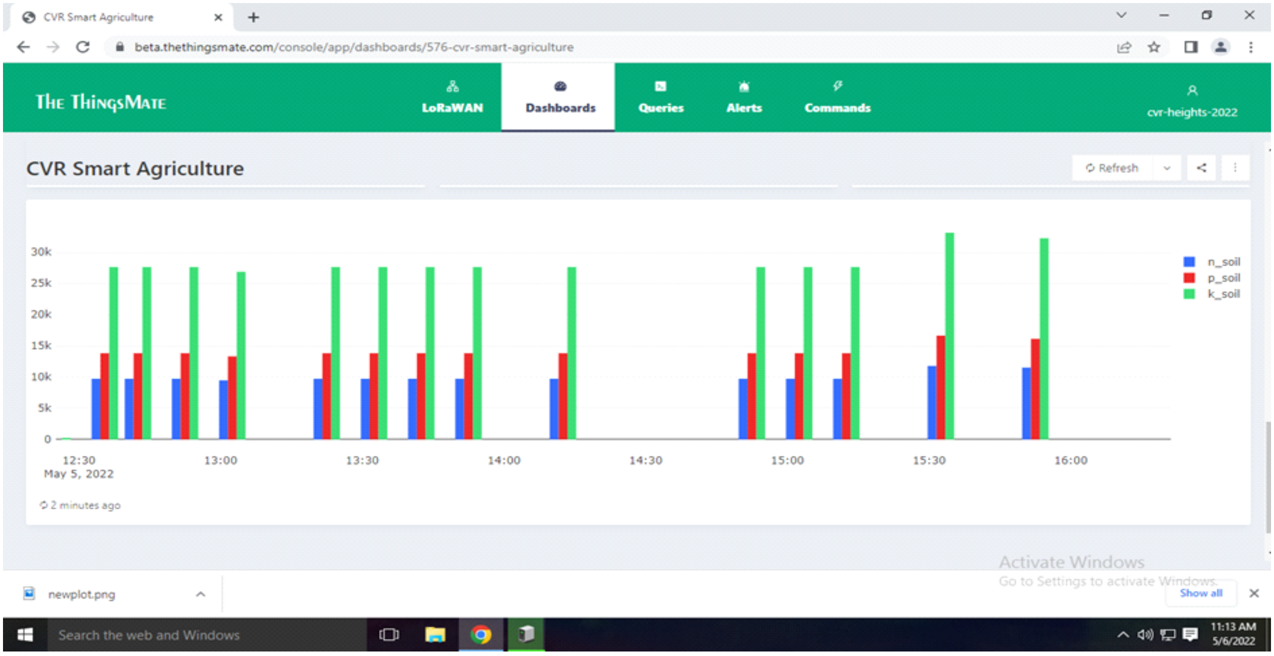


Fig 8Bar chart depicting the NPK values of the soil

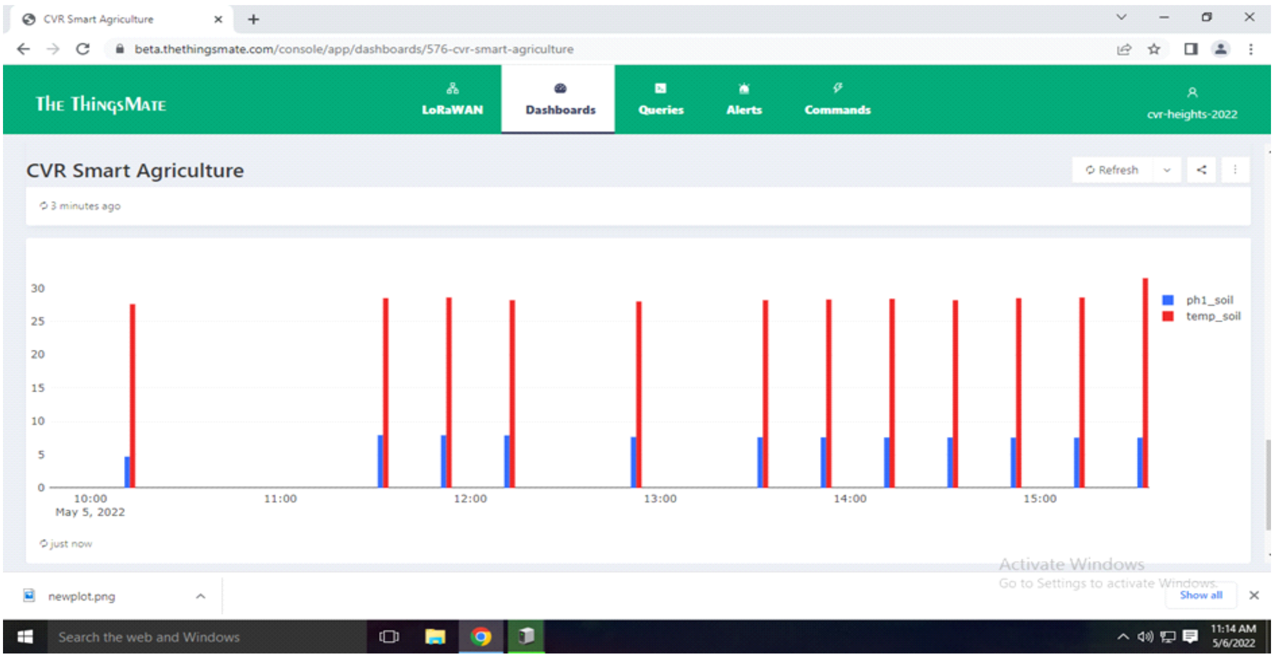


Fig 9Bar chart depicting the pH and Temperature of the soil

Fig 10 Taking soil attributes from plants near the college

CONCLUSION

Our proposed LoRaWAN-based precision agricultural solution intends to primarily boost plant productivity by supplying the required amount of water, nutrients, and maintaining the right soil PH and temperature. Costs are reduced by using less fertilizer, hiring fewer workers, and spending less on continuous GSM device maintenance. People can use this LoRaWAN-based system to monitor their land from anywhere in the globe, including remote areas without access to a public network.

FUTURESCOPE

Fig 11Difference Between OTAA & ABP Activation methods

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