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IoT Based Air, Water, and Soil Monitoring System for Pomegranate Farming

Altaf O. Mulani*, Arti Vasant Bang[1], Ganesh B. Birajadar[2], Amar B. Deshmukh[3], Hemlata Makarand Jadhav[4] and Kazi Kutubuddin Sayyad Liyakat[5]

Department of Electronics and Telecommunication, SKN Sinhgad College of Engineering, Pandharpur-410401 (Maharashtra), India
[1]*Department of Electronics and Telecommunication, Vishwakarma Institute of Technology, Pune-411048, (Maharashtra), India*
[2]*Department of Electronics and Telecommunication, FTC College of Engineering and Research, Sangola-413307 (Maharashtra), India*
[3]*Department of Electronics and Telecommunication, Anantrao Pawar College of Engineering and Research, Pune-411009 (Maharashtra), India*
[4]*Department of Electronics and Telecommunication, Marathwada Mitra Mandal's College of Engineering, Pune-411052 (Maharashtra), India*
[5]*Department of Electronics and Telecommunication, Brahmdevdada Mane Institute of Technology, Solapur-413002 (Maharashtra), India*
*(e-mail: draomulani.vlsi@gmail.com)

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ABSTRACT

The emergence of the Internet of Things (IoT) has revolutionized every aspect of the average person's everyday life by enabling knowledge and insight into everything. The term "Web of Things" refers to an organization of things that self-designs. The development of Astute Shrewd Cultivating, or IoT-based devices that further expand farming and make it more productive and waste-free, is revolutionizing horticulture creation on a daily basis. This project aims to provide an Internet of Things (IoT) framework for monitoring the quality of the air, water, and soil for pomegranate cultivation. Ranchers will benefit from this framework since it will provide them with up-to-date information on temperature and soil dampness for sustainable ecological observation, increasing their overall yield and item quality.

Key words: IoT, monitoring system, pomegranate farming, blynk web dashboard

INTRODUCTION

As the world's population continues to rise. It will require more food, and the demands on farming will increase due to people's changing lifestyles. Furthermore, a range of industrial and commercial demands cause farming grounds to shrink with time. Engineers are therefore under pressure to design systems that optimize agricultural output while consuming the least amount of resources. Among the recognized natural resources are water and organic fertilizers. Workers in the agriculture industry have also been diverted to other industries. The automation of all that farming is capable of generating was another outcome of this.

Ranchers will benefit from IoT solutions that are designed to provide incredible yields, benefits, and ecological protection, all of which will aid in closing the stockpile request hole. The implementation of IoT innovation in accuracy horticulture ensures optimal asset application to generate high agrarian yields and reduced operating costs. Programming, IT services, specialized equipment, and wireless connectivity are some of the IoT innovations for agribusiness.

Farmers and ranchers may boost output by optimizing anything from the quantity of compost used to the number of automobile trips made from the homestead using smart farming that incorporates the Internet of Things, as well as by utilizing resources like electricity and water. A Web of Things (IoT) smart farming system is designed to automate the water system and use sensors (such as light, stickiness, temperature, soil moisture, crop health, and so forth) to screen the yield field. From anywhere, ranchers can keep an eye on field conditions. Moreover, customers can choose between manual and automated solutions for traveling the necessary distances in light of this information. For instance, the rancher can use sensors to initiate irrigation in the event that the soil's moisture level decreases. As a result, astute cultivation is a great deal more effective than traditional cultivation methods. These are the main ways that the Internet of Things could alter horticulture. Executives, sensors, control frameworks, robots, autonomous cars, computerized equipment, variable rate advancements, movement identifiers, button cameras, and wearable devices are essential components in this kind of ranch that gather data from sophisticated agrarian sensors. This information can be utilized to assess employee performance, hardware expertise, and overall organizational health. When one can predict the outcome of creation, it is possible to sort for better item circulation. In agriculture, horticultural robots—both aerial and terrestrial—are employed to handle a variety of agricultural cycles, such as planting, watering, assessing crop well-being, splashing, inspecting, and soil

RELATED WORK

It is advised to continue working on the Programmed Savvy Water system Framework (Premalatha 2019). IOT is used by the 1.2 billion-strong and constantly growing Indian population. Because of this, there will be a serious food scarcity in 25 to 30 years, which will force agriculture to expand. The lack of rain is currently causing farmers to struggle with a water scarcity. Shah et al. (2018) presented studies on soil testing using the Internet of Things; soil analysis is becoming into a vital part of successful modern farming. Soil testing is done using a variety of techniques. It took a lot of time and effort to analyze the findings of previous soil testing, which was carried out at laboratories and research centers. Advances in digital and electrical technologies have made it possible to evaluate soil using a variety of portable sensors. The internet of things has made it feasible to link sensors to the internet. By combining these sensors with the Internet of Things, we intend to do soil testing at any time and anywhere. Sapkale and Patil (2022) complete the soil monitoring system's Internet of Things operation. High-tech, capital-intensive farming is one way to supply people with wholesome, sustainable food. The main topics of this review are the advancements in mechanical interaction computerization (RPA), artificial intelligence (AI), and the Internet of Things (IoT). These advancements make it possible to build a system that screens the harvest field and automates the water system architecture by using sensors, such as those that measure light, mugginess, temperature, and soil dampness. Ranchers have effective means to keep an eye on the state of their homesteads. The development of a soil moisture monitoring system based on LoRaWAN. Civic personnel use and transport an Internet of Things (IoT) gadget that detects the moisture content of soil because they are worried about water system drills (Johansson, 2021). The Web of Things device is a working model that needs the LoPy4 extension board 3.1 from Pycom and three AAA batteries. The model is not appropriate for extensive scope testing due to its size, cost, and power consumption. Sindhu and Indirani (2018) focuses on soil testing made possible by Internet of Things technology. The first and most important business in our country is horticulture. An excessive amount of compost may result in a crop yield of lower quality. In this way, estimating the amount of supplements in the soil is essential to enhancing plant development. Choosing the amount of additives that are in the soil is the main responsibility. One of the most important and practical soil parameters is pH esteem, which is measured to determine soil maturity. Khatri and Sharma (2017) designed improvements to an innovative continuous pH monitoring and control system for urban wastewater using the Web of Things for horticultural and agricultural applications. This work presents a revolutionary Internet of Things (IoT)-based continuous pH monitoring and control system for civil waste water that may be used in farming and gardening. In response to India's green dissatisfaction, the amount of water needed for all businesses—including farming, agriculture, and industry—has expanded dramatically in recent years. Khatri and Sharma (2017) create an Internet of Things-based system for water quality monitoring (IoT). Bangladesh's coastal regions have limited access to consumable water due to complex hydro-topographical systems. Furthermore, transboundary stream issues and a propensity for natural disasters make this part of the country more difficult to supply with safe water than others. Concerns concerning ensuring that beachside networks have fair and equal access to clean drinking water may arise as a result of modern chemicals. It might be argued that having access to clean drinking water in one's community is both essential to sustaining one's health and a fundamental human right. A framework for continually monitoring stream water quality using the Web of Things was suggested to be investigated (Chowdury et al., 2019). The ebb and flow approach to water quality assessment involves a labor-intensive, manual cycle of work. This study suggests a methodology for monitoring water quality using sensors. A microcontroller for handling the framework, a few sensors, and a communication framework for hub-to-hub and intra-hub communication are the fundamental components of a remote sensor network (WSN). Continuous data access can be achieved through the use of Web of Things (IoT) technology and remote monitoring. Gosavi et al. (2019) suggested creating a pH reader using an Internet of Things base. The pH peruser, an electrical device, is based on a microcontroller and measures the pH of an example. In this project, we test a sample paper strip's corrosiveness using the tiny ATMEGA328 microcontroller. A low voltage power supply powers the cradle circuit, chip, and variety sensor. The output of the variety sensor can provide a signal to the microcontroller. Karthikeyan et al. (2021) suggested studies on smart gardening with moisture control and temperature monitoring based on the Internet of Things. Every element of human existence has been transformed by the Internet of Things (IoT), which has also improved and enhanced productivity at work. In order to boost agricultural output and cut waste, smart farming primarily makes use of Web of Things (IoT) advancements including sensors, regulators, Wi-Fi modules, and distributed computers. Mutyalamma et al. (2020) suggested using the Web of Things to measure the pH, moisture content, temperature, stickiness, and supplement upsides of the soil in clever farming. Today, clever horticulture moderates a lot of cultivation-related concerns. Ranchers have access to important information and data by connecting a variety of sensors, actuators, and other implanted devices to the "Web OF THINGS (IOT)" to monitor plant development. to preserve the soil's pH, moisture content, and supplement level in order to produce harvests that are generally of high quality. In light of the Web of Things, a bright temperature and moisture screen is suggested to be improved. In colder climates with heavy stickiness (Devade et al., 2022), the coronavirus pandemic spreads swiftly. Many people know the climate in which they live. A clever framework for climate checking is needed in order to assist such individuals. The proliferation of temperature and relative dampness sensors can be advantageous for a clever temperature and mugginess constant monitoring and revealing framework in light of the Internet of Things (IoT). Working on The Pomegranate Farming Ultimate Guide should be continued. Pomegranate growing requires dry, semi-arid locations; cold winters and hot summers promote fruit production (Sawant 2023). You can think of pomegranate plants as drought- and frost-tolerant. The optimal temperature range for fruit development is between 35 and 38 °C. Pomegranate farming works best at an elevation of 500 meters above sea level. An investigation into the pomegranate creation innovation recommended for arid areas (Kumar et al., 2018). Iran gave rise to the pomegranate (*Punica granatum* L.), a major crop for dry and semi-bone-dry regions. Elevated temperatures, erratic precipitation patterns, and consistent dry seasons are characteristics of parched regions. In addition, the water-holding capacity and nutrients in this dirt are deficient. A dry location's natural conditions are not conducive to plant support, thus choosing an organic product crop is essential for generating income. Provisional plans to enhance the soil moisture monitoring system The term "Web of Things" refers to the network of devices interacting with each other via the internet (IoT) (Raghuveera et al., 2019). Using unique IDs, each item is connected to every other one, allowing information to be shared between them without the need for human input.Structuring Your Paper

METHODOLOGY

Block Digram

As seen in the Figure 1 below The Node MCU has many interface modules connected to it. Locally variable data as well as a variety of procedures and statuses are shown on 16x2 LCD panels. A PH Sensor is attached to a Node MCU to measure the PH of the water used for farming. An NPK sensor is connected to a Node MCU in order to read the values of nitrogen, phosphorus, and potassium in the soil being tested. The soil moisture test is connected to the Node MCU in order to read the soil moisture value. The humidity value of the atmosphere is read by connecting the DHT 11 sensor and Node MCU. The NPK, soil moisture, humidity, and pH sensors' data are sent and received via SMS messages using a GSM modem. The IOT Module, which is a section of the code, is internally written as ESP8266, which has an embedded WiFi chip. This enables it to connect to a WiFi hotspot and establish communication between Node MCU and the IOT Cloud platform.

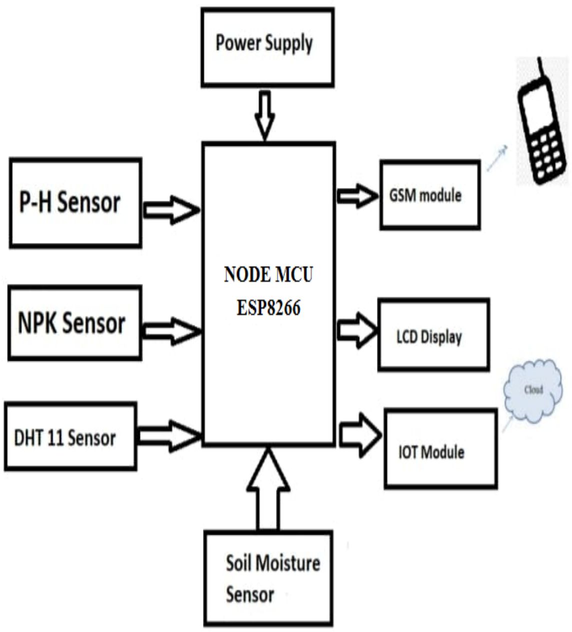

Fig. 1. Project Block Diagram Hardware Part.

Hardware Setup

Real time implementation was done using the set up shown in Figure 2.

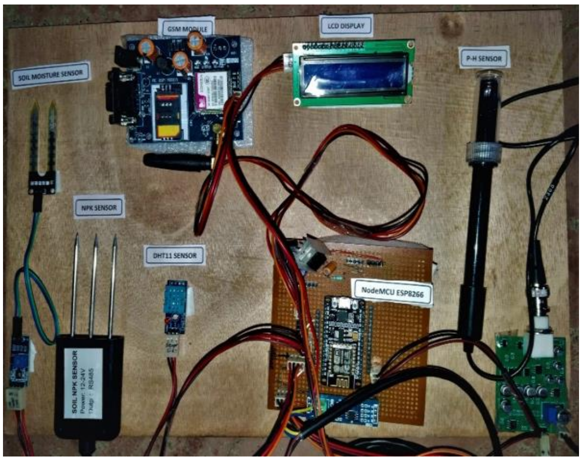

Fig. 2. Actual project Hardware setup.

Algorithm

Algorithm Define Variables

1. Define BLYNK_TEMPLATE_ID, BLYNK_TEMPLATE_NAME, BLYNK_AUTH_TOKEN from online Blynk platform.
2. Define SDA_PIN, SCL_PIN for LCD Interfacing
3. Define NPKRX, NPKTX, REDE pins.
4. Define DHT11 pin
5. Define float phAnalog, ph, humidity
6. Define byte SoilMoistureVal
7. Define SSID, Pass to connect wifi
8. Define NPK sensor Query Frame as byte array for Nitrogen, Phosphorous, Potassium data read.
9. Define variable NitrogenVal, PhosVal, PotaVal, RxLen;
10. Define pattern array.
11. Define byte array to store Response of NPK sensor as NitroValues, PhosValues, PotaValues.
12. Define Sotfware serial at port NPKRX, NPKTX.
13. Define strings for GSM interface RxData, RxData2, SIMString, SMS_Num, SMS_Msg, RxSMS.
14. Define variables RunTime, SIM_Check, NW_Check, repeat, RefLoc, RefComma, check, RefOK

Algorithm Setup Code

1. Initialize UART serial port at 9600 baudrate.
2. Initialize software serial port with NPK sensor at 4800 baudrate.
3. Blink LED_BUILTIN 10 times. It gives time user to jack in the connectors of sensors.
4. Initialize I2C communication with LCD display
5. Display LCD message “LCD Initialize.”
6. Set GPIO pin connected to Soil Moisture sensor as input
7. Set REDE pin as low for NPK sensor
8. Set NitrogenVal = 0; PhosVal = 0; PotaVal = 0;
9. Run EnableNWRegistration() Function. It sends AT+CREG = 1 command to GSM Modem.
10. LCD Message display “Enable NW Regt”
11. Flush all Serial port buffer data.
12. Run DeleteAllSMS() function. It sends AT + CMGD = 0,4 command to GSM Modem. It deletes all SMS stored in SIM card memory.
13. LCD message display “Delete Old SMS”
14. Flush out all serial port buffer data.
15. Run SetSMSAlert() Function. It sends AT+CNMI=2,1,0,0,0 command to GSM Modem. It Enables SMS alert over UART indicating Node MCU over serial port that a SMS is received.
16. Set RunTime = 0, SIM_Check = 0, NW_Check = 0, repeat = 0
17. Begin blynk server sync with BLYNK_AUTH_TOKEN, ssid (SSID Name), pass (SSID Password).
18. LCD Message display “WIFI CONNECTED

Algorithm Loop Code

1. Set and define TempVal = 0, FByte = 0, icount, chk
2. LCD Message Display “DHT Sensor”.
3. Set icount = 0

4. If icount < 20 and chk ≠ DHTLIB_OK, else goto step 7
5. Read DHT11_PIN response from DHT Sensor
6. Loop 20 times until response is DHTLIB_OK, if not goto step 4
7. If chk, reply from DHT sensor is DHTLIB_OK, goto step 8, else 10
8. Read humidity reading from DHT sensor, store to Humidity.
9. Display humidity value on LCD.
10. Read input pin SoilMoistureIN, digital input from Soil Moisture sensor.
11. Display soil input reading on LCD.
12. Set FByte = 0
13. Read nitrogen value from function ReadNitrogen(). It sends the query frame to NPK sensor, in reply of it received the response frame from NPK Sensor. The response data is stored in NitroValues array.
14. Now match the pattern is present in NitroValues. If pattern found set FByte = 1
15. If FByte = 1 read nitrogen value from NitroValues array and store to NitrogenVal
16. Display Nitrogen value on LCD
17. Set FByte = 0
18. Read phosphorous value from function ReadPhos (). It sends the query frame to NPK sensor, in reply of it received the response frame from NPK Sensor. The response data is stored in PhosValues array.
19. Now match the pattern is present in PhosValues. If pattern found set FByte = 1
20. If FByte = 1 read phosphorous value from PhosValues array and store to PhosValues
21. Display phosphorous value on LCD
22. Set FByte = 0
23. Read potassium value from function ReadPota (). It sends the query frame to NPK sensor, in reply of it received the response frame from NPK Sensor. The response data is stored in PotaValues array.
24. Now match the pattern is present in PotaValues. If pattern found set FByte=1
25. If FByte = 1 read potassium value from PotaValues array and store to PotaVal
26. Display potassium value on LCD
27. Read analog pin A0, for PH sensor reading.
28. Convert Analog value to voltage. Voltage = phAnalog*(3.3/1023)
29. Convert voltage to PH value. PH=3.3*voltage.
30. Display PH value on LCD.
31. Upload and sync with Blynk server by uploading Humidity to V0, NitrogenVal to V1, PhosVal to V2, PotaVal to V3, ph value to V4 respectively.
32. If NW_Check = 0, network is not found, goto step 33, else goto step 36
33. Run NW_Check_Function(). It will send AT+CREG? Command to GSM Modem. In response of the command we can find if SIM Card is registered on Network or not.
34. If SIM Card registered on network set NW_Check = 1, display message on LCD "NW Detected", else keep it 0 and display message on LCD "NW Searching…".
35. Flush out serial buffer register.
36. If NW_Check = 1, means SIM Card in Network and we can wait for SMS. Display message on LCD "Waiting SMS".
37. If any data on serial port available(Means GSM Modem sent alert message regarding SMS received), display message "SMS Received"
38. Run function ReadSMS() to read sms and store it to SMS_Msg. In this function we find the string "CMTI" if string matched this alert for SMS Received. From reference extract sms from received data (which is the mobile number).
39. Display received SMS Message data on LCD.
40. Now send the SMS containing the all readings of sensors.
41. Sent AT+CMGS = SMS_Msg, then send the strings "Humidity=" + Humidity, ", Nitrogen=" + NitrogenVal, ", Phosphorous=" + PhosVal, ", Potassium=" + PotaVal, ",PH=" + ph. It is our data string.
42. At the end of SMS send 0x1A (d'26), it is indication character of SMS end.
43. It will send the SMS to the SMS_Msg (which is mobile number received in SMS)
44. Display message on LCD "SMS Sent"
45. Now delete all SMS by sending command AT + CMGD = 0,4

Analysis

DHT Sensor: The humidity of the atmosphere is measured using a DHT sensor. For demonstration purposes, we placed a DHT sensor close to the mouth so that we could blow air out of it to show the change in humidity.

Soil Moisture Sensor: Soil moisture sensor is used to detect moisture of soil. Output is digital means 1 or 0, threshold of comparison can be set by on board present register for desired moisture level on soil.

NPK Sensor: The NPK sensor's response output is not always exactly in sync; occasionally, the initial pattern character is discovered to be offset in the response frame. In these cases, we must perform a pattern search frame to determine the frame's reference starting point before we can read the NPK sensor's value. To verify changes in values, we can add plain water or any other type of uria water to the demo.

PH Sensor: In order to evaluate the PH sensor, we must examine the liquids that are currently valued. To mimic the functioning of a PH sensor, however, plain clean water with a PH of about 7.5 is utilized for testing purposes.

GSM Modem: The SIM card placed in the GSM modem needs to fit snugly in the SIM slot. Moreover, the SIM service provider needs to offer service in the band that the SIM900A datasheet specifies. In other words, since the GSM modem is a 2G modem, the SIM card needs to be able to look up 2G networks and register for them. For SMS to be sent, the SIM service needs to have enough SMS balance available.

Blynk Web Dashboard: Blynk web dash board displays the value of sensors as sent by sync cycle on Node MCU Code. It also shows graph chart. History value can be view by various other facilities of Blynk platform.

CREATING IOT INTERFACE ON BLYNK WEBSITE

Creating New Template

It is a structure under which we can define various variables which need to interface on IOT platforms. The variable store the data sent by Node MCU hardware. Figures 3 and 4 shows the process to create New Template.

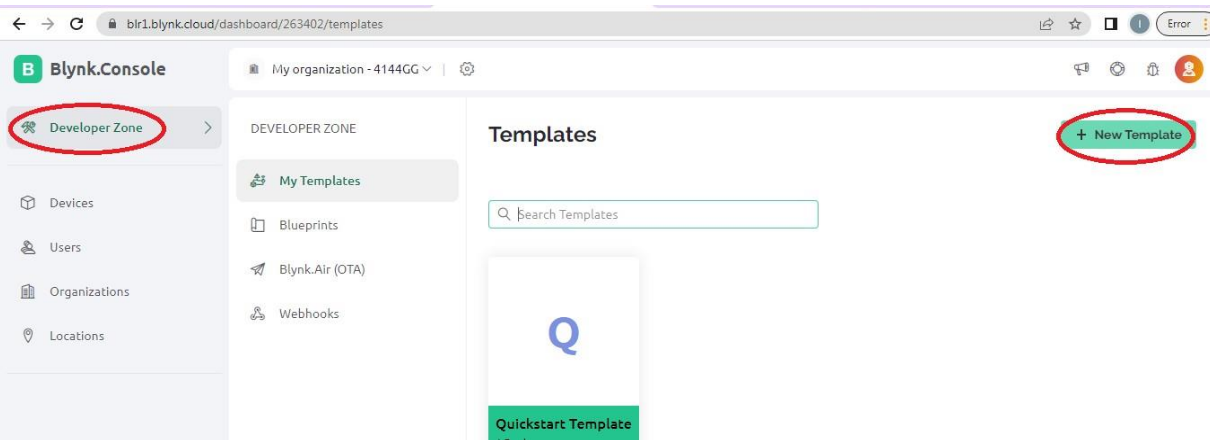

Fig. 3. Go to Developer zone → Click New Template.

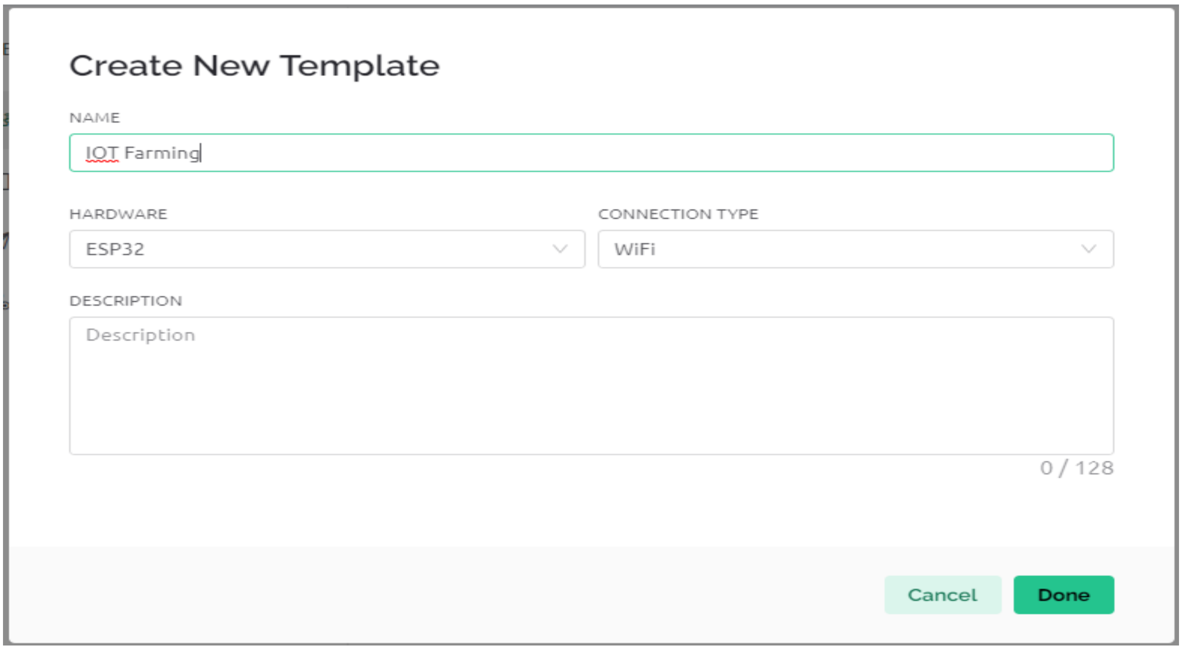

Fig. 4. Create New Template Done. Enter Name, Select Hardware "ESP32", Connection type "WIFI" → Done.

Set Up Data Streams

Each data stream store a specific value sent from Node MCU hardware. So to store each sensor value we will create unique data stream variables.

To create new data stream (or variable to interface between hardware and Blynk), we can create two type of data stream to read/write values. Digital pin for turn on/off related operations. Analog pin for reading and displaying analog values. Figures 5-8 shows the process to Set up Data streams.

To create Digital data pins click on “Virtual Pin”.

Fig. 5. Click “Data streams” → Click “New Data stream”.

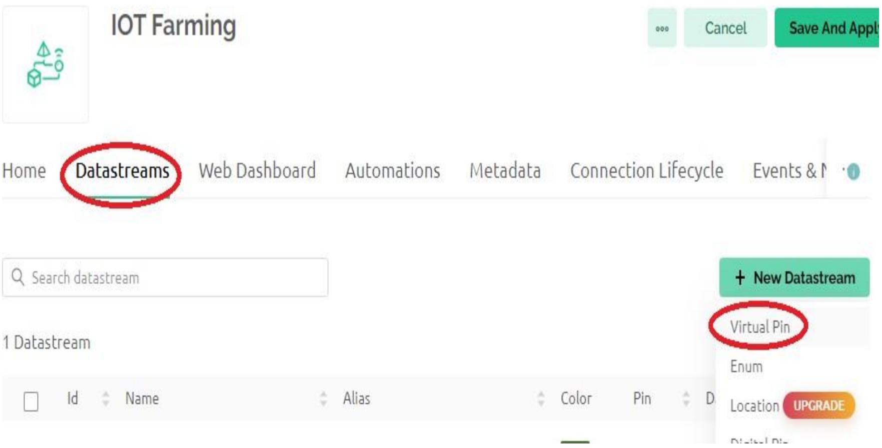

Fig. 6. Under Data stream Select Virtual Pin.

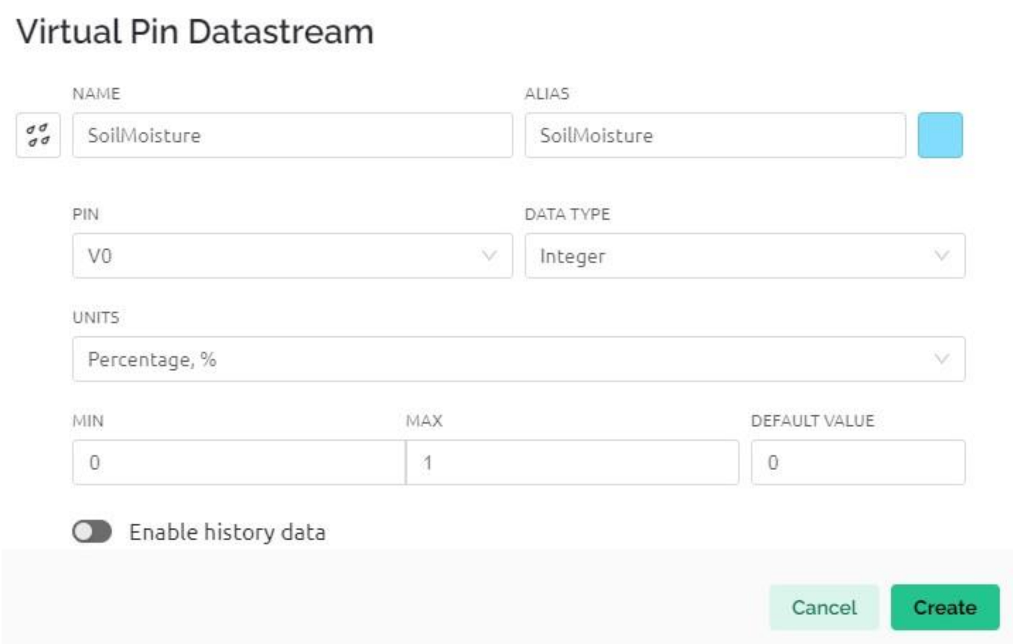

Fig. 7. Define virtual pin data stream setup values3. Type “Name”, select virtual pin from PIN (V0, V1, ...), Data Type (Integer, float, string), Units, Minimum Value, Maximum Value and click on “Create”.

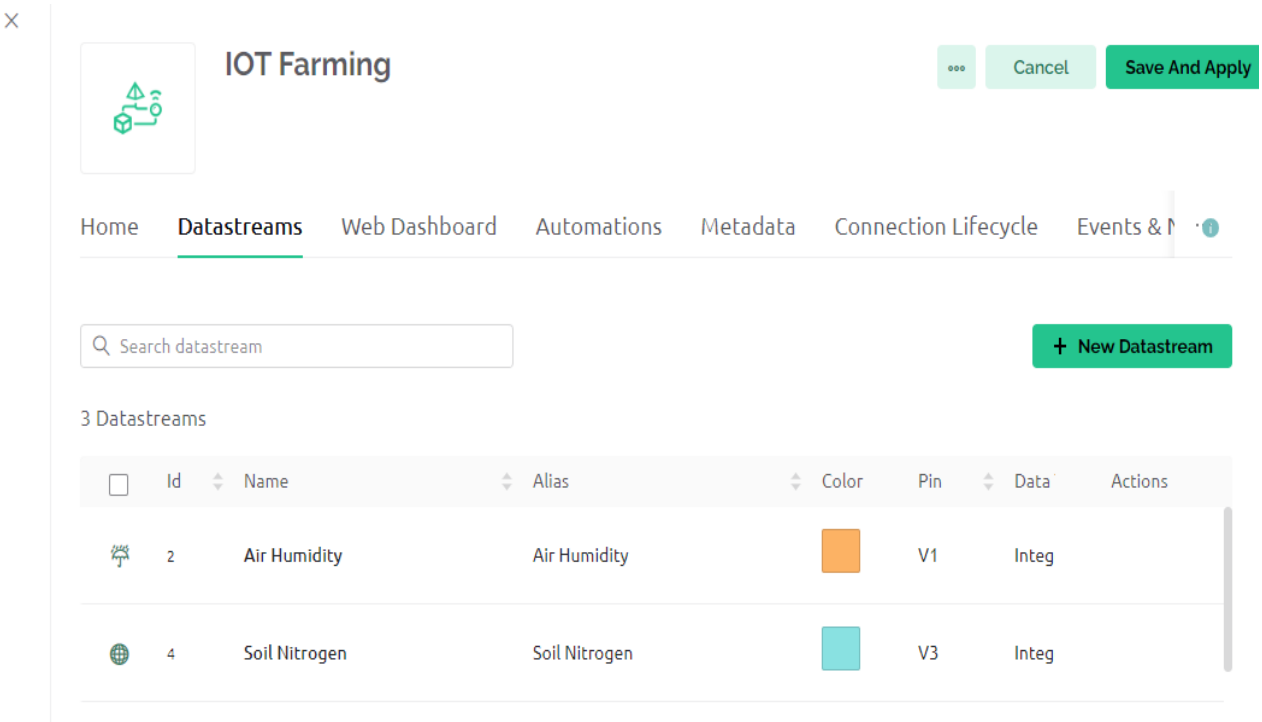

Fig. 8. List of all data streams created for storing values.

Number of Data streams created can be seen under Data streams tab.

Here we need to remember that to sync the data stream value we need to use Pin defined (v1, v2, ...) on Node MCU hardware.

Add New Device on Dashboard

Adding a new device to the Blynk dashboard is a straightforward process.

- Tap the "+ Add Device" button or the device addition icon on the dashboard.
- Choose one of the following methods based on your hardware and connection type:
  Templates: Select a pre-configured template for your device if you already created one on the web dashboard.
  Manual Setup: Manually set up the device by entering the required parameters such as hardware model, connection type (Wi-Fi, GSM, Ethernet), and token.
  Figures 9-14 shows the process to Add New Device on Dashboard.

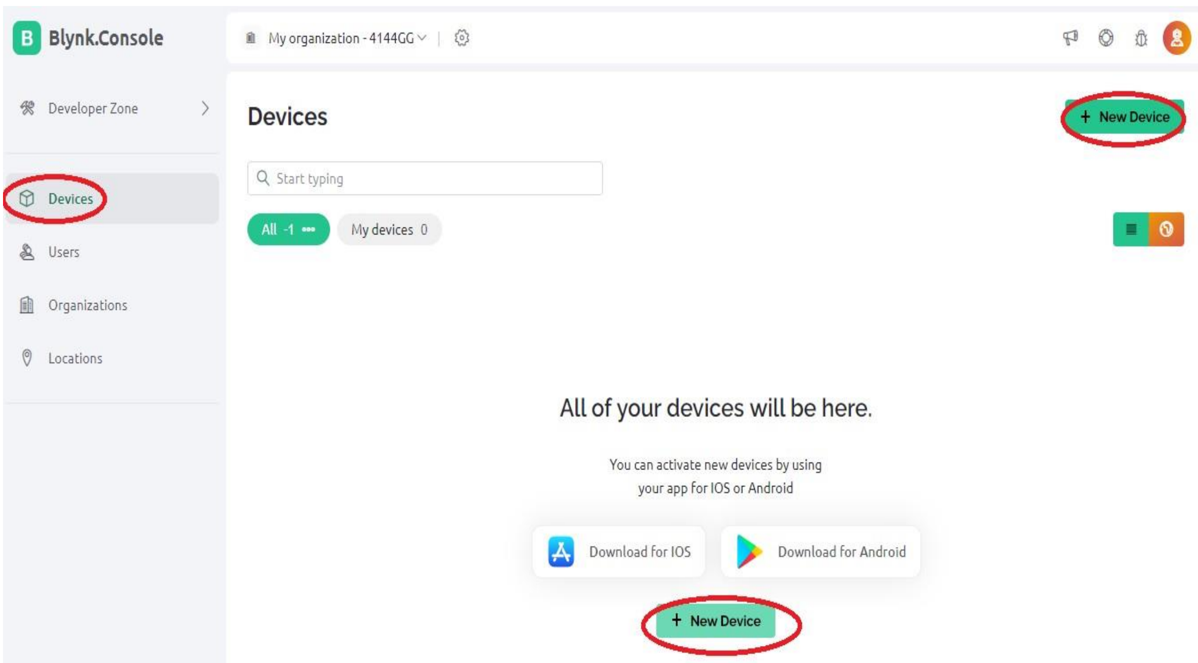

Fig. 9. Create Dashboard (Add New Device) Go to Devices → Click on 'New Device'.

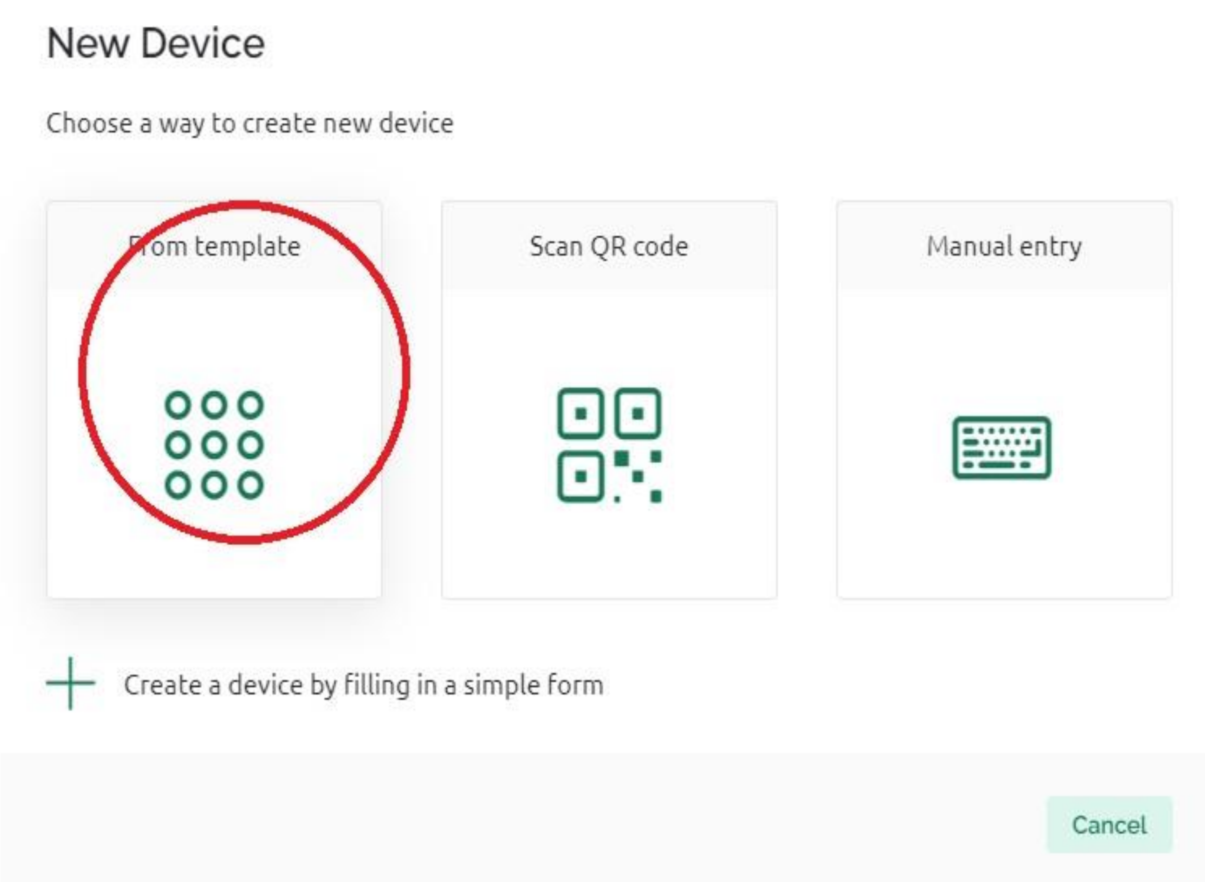

Fig. 10. Select proper template type.

Click on ‘From Template’.

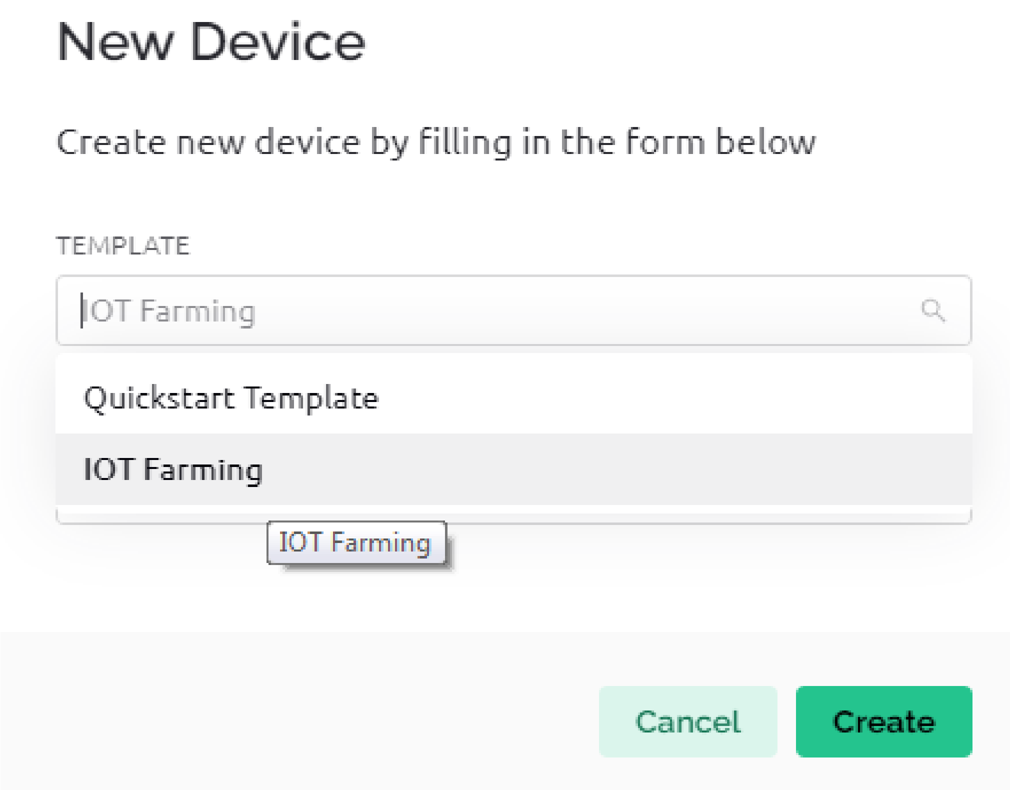

Fig. 11. Select Device Web Dashboard name Select.

Template from drop down.

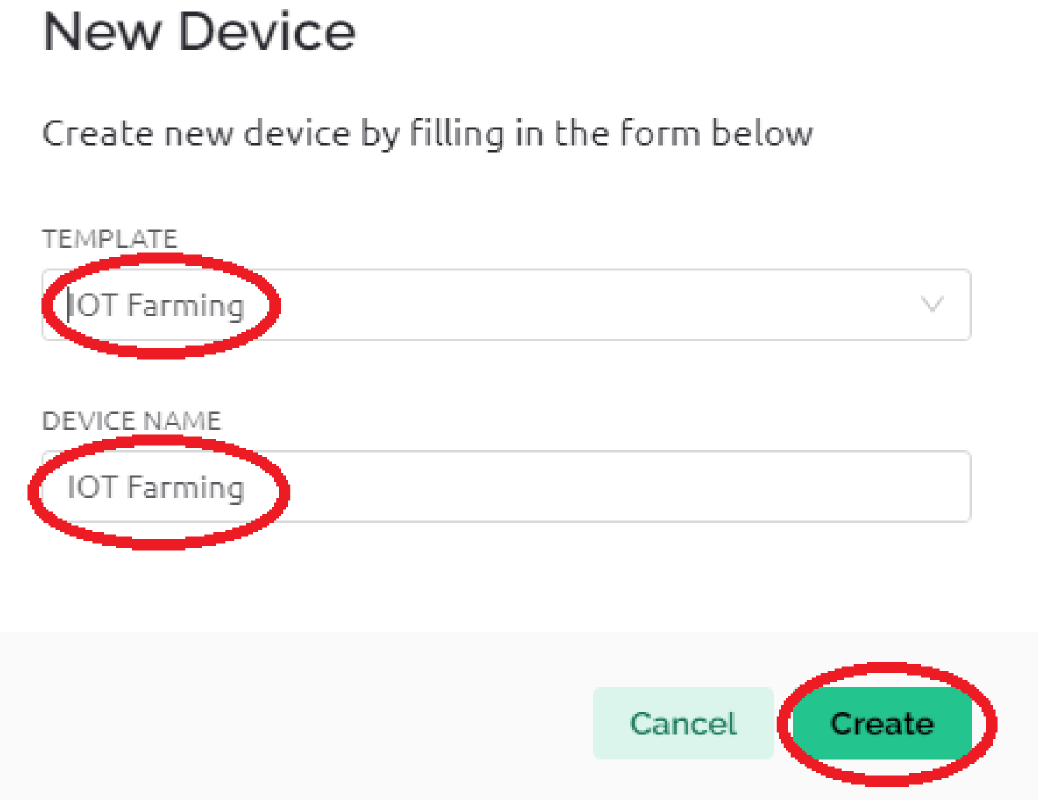

Fig. 12. Creating new device.

Type Device Name and Click ‘Create’ button.

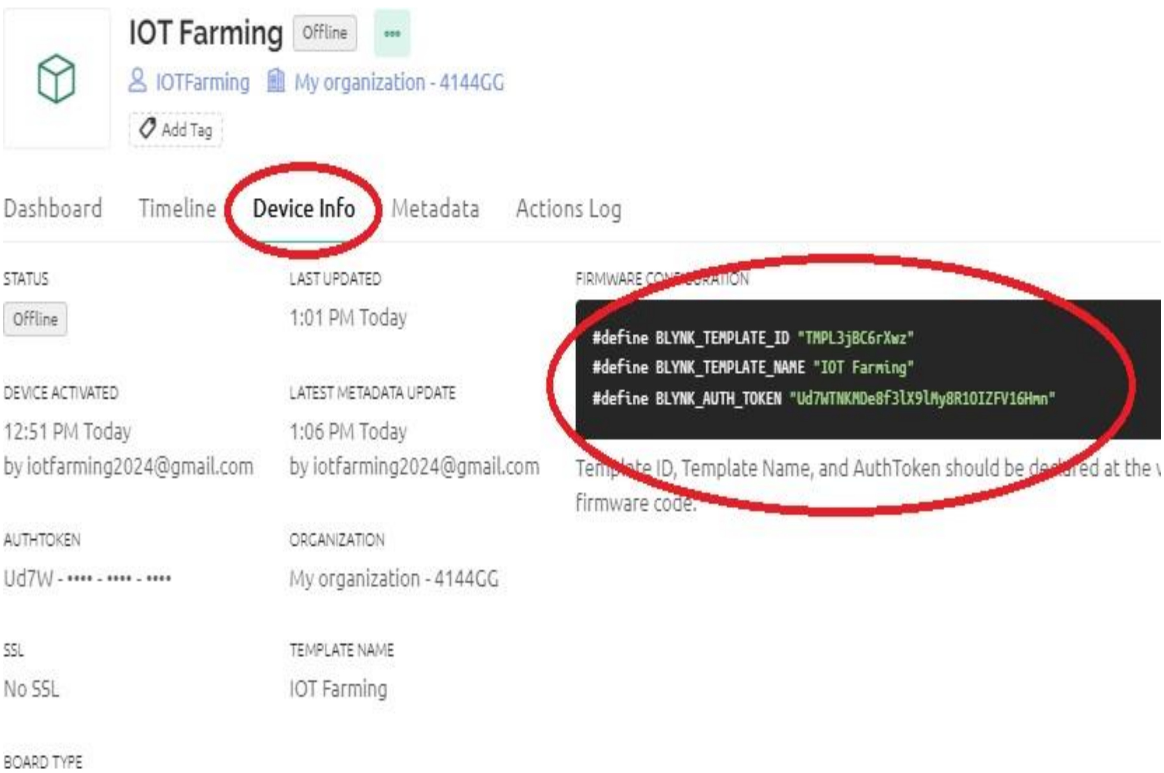

Fig. 13. New device is created.

Create Web Dashboard

In previous sections we created variables and now we will create GUI dashboard and will link each widget box to the data stream variable. Figrue 14 shows the blank Blynk Web Dashboard.

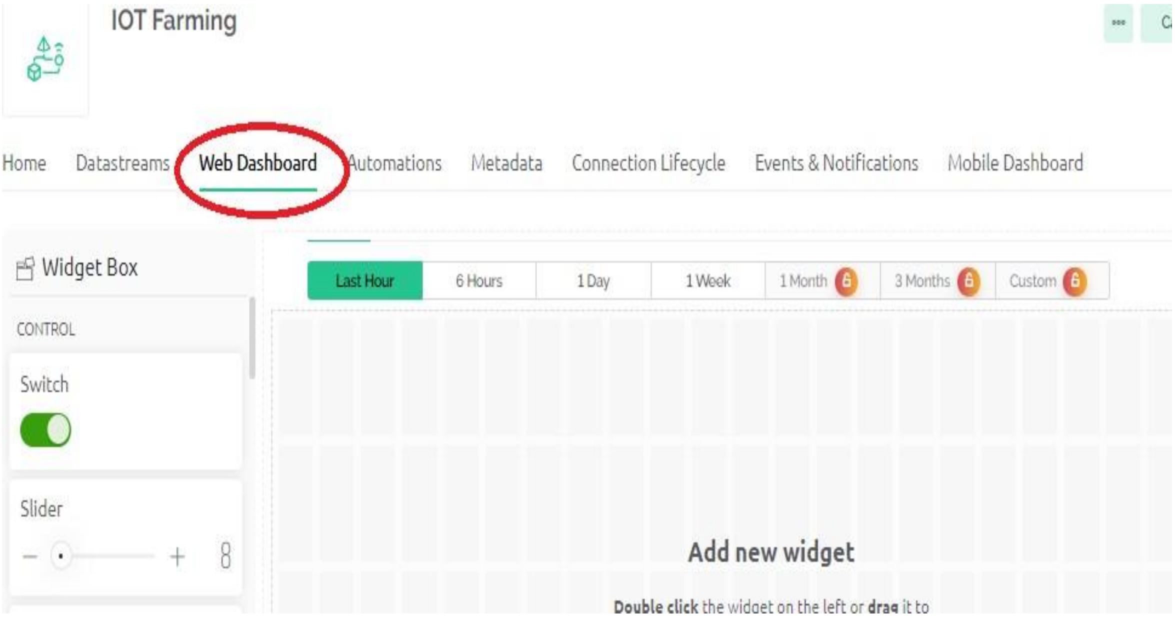

Fig. 14. Blynk Web Dashboard blank.

Under "Web Dashboard" new widget box will open, where we can put various control and monitoring boxes.

Add Label

Add "Label" and drag and drop to Widget area.
Click on "settings icon
Under "Label Settings", Add title name on "Title" and Select which virtual variable value to display on it.
Figures 15-20 shows the process to add label.

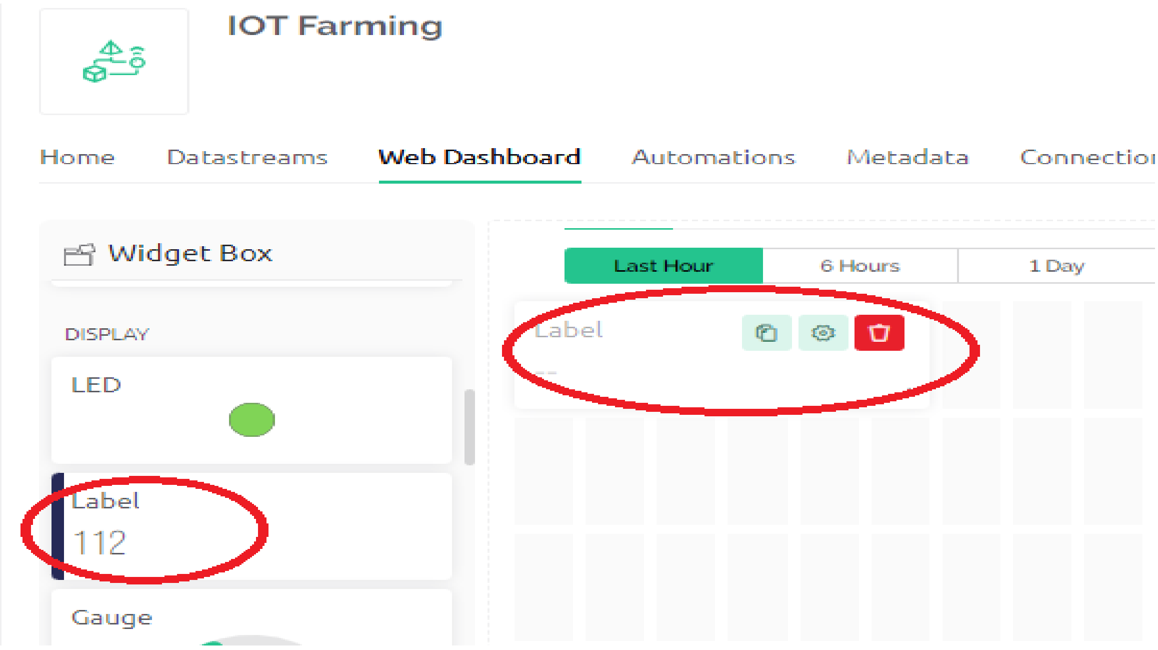

Fig. 15. Drag Label on web dashboard Select.

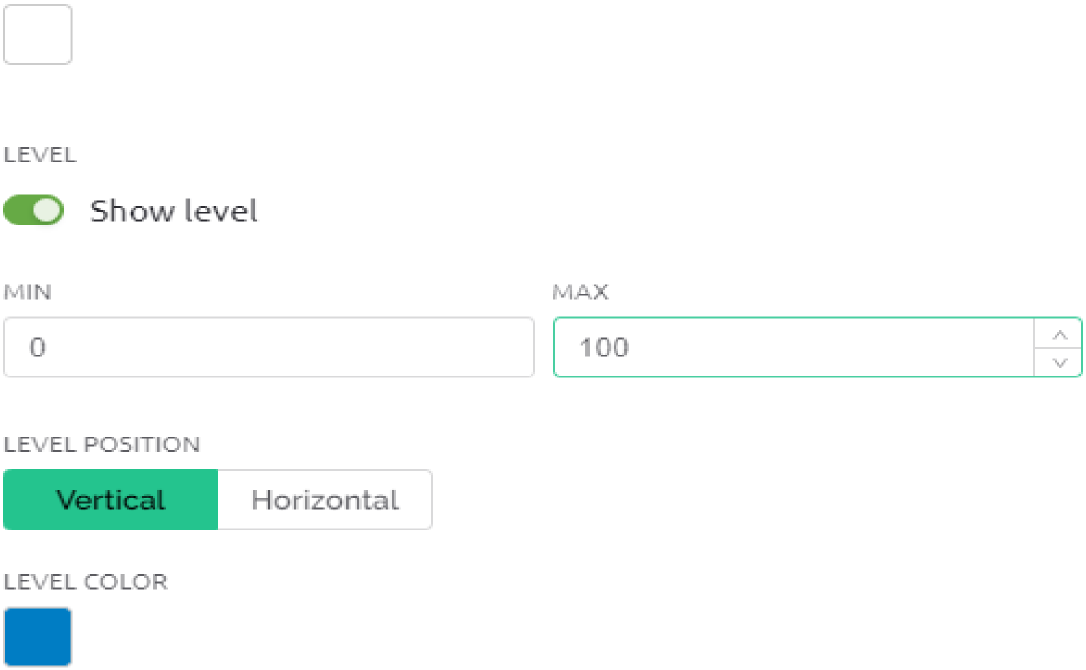

Fig. 16. Widget value range setup.

As shown in above figure we can setup the minimum and maximum value under which the value can vary.

This way we can drag label for each variables like Nitrogen, Phosphorous, Potassium, Air Humidity (DHT11) and PH Value.

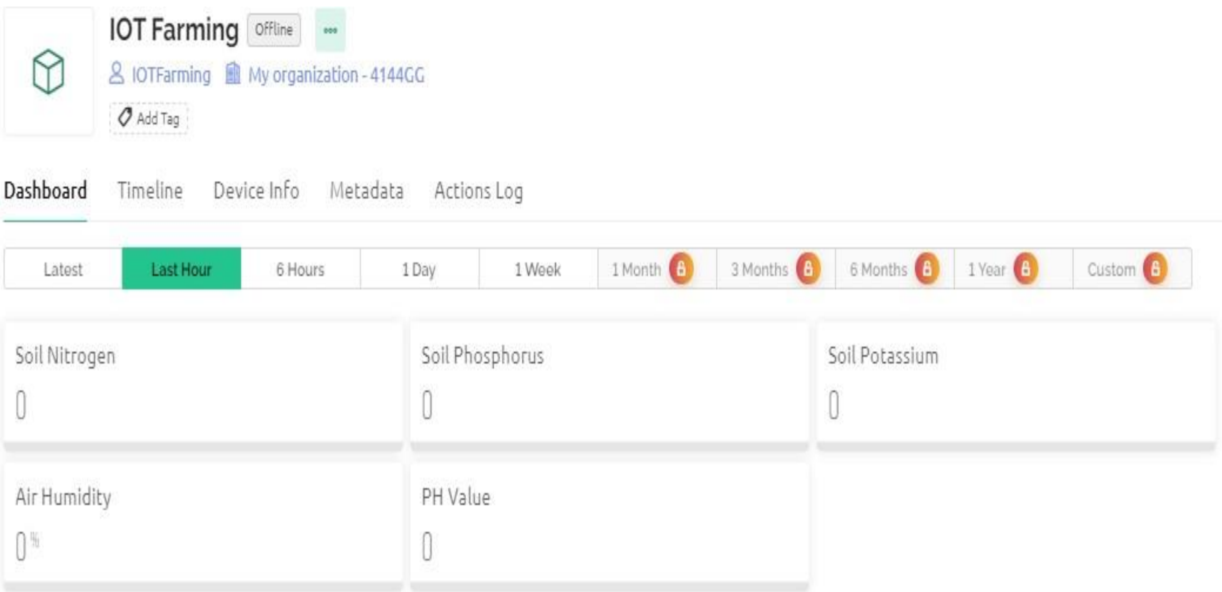

Fig. 17. Complete web dashboard.

Create whole "Web Dashboard" layout and after finalizing click on Save button.

Add Graph

We can display graph by placing widget on the web dashboard so the variation can be monitored.

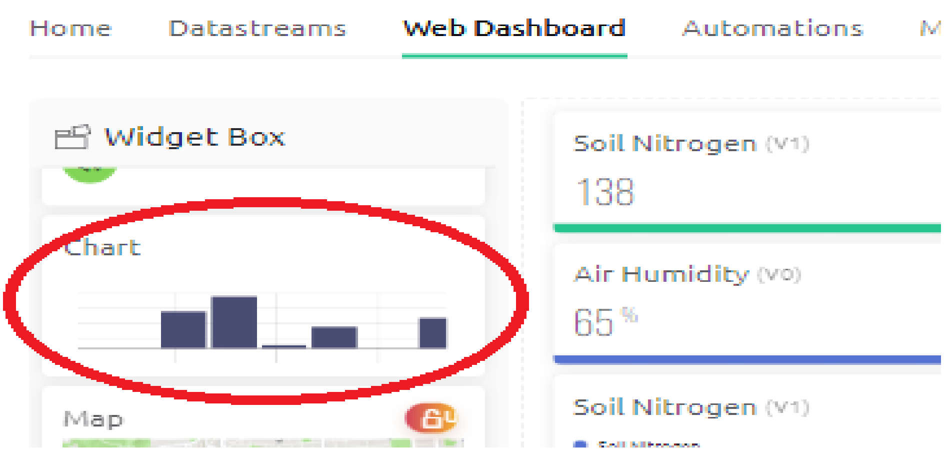

Fig. 18. adding Chart to widget.

Select "Chart" from widget box and drag on "Web Dashboard" Space. Go to Chart settings and set the parameters.
Add "TITLE", click on "Add Data stream" and select the variable which want to show on Chart, Here select PH Value. This way the PH value will be displayed on that Chart widget.

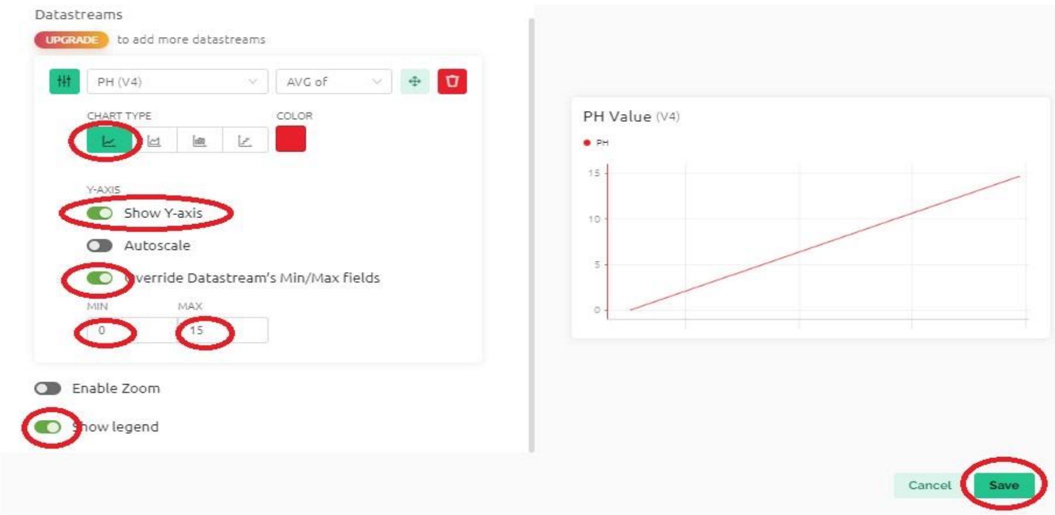

Fig. 19. Various Chart settings.

Select above highlighted options and click on SAVE

Then final click on "Save and Apply" button to select Device Web Dashboard changes.

Fig. 20. Web Dash board including Chart of all variables.

RESULTS

With the use of this technology, crop output can be increased through digital farming by monitoring different soil parameters, such as moisture content. We are able to monitor a plant's growth and resource needs remotely because of technology.
A GSM modem will respond to an SMS with all of the sensor data included, as seen in the figure above. It is quite useful when we are unable to keep an eye on sensor data on the IOT web dashboard. We can monitor the state of the soil and get sensor data via SMS. Figure 21 shows the SMS Received of sensor data.

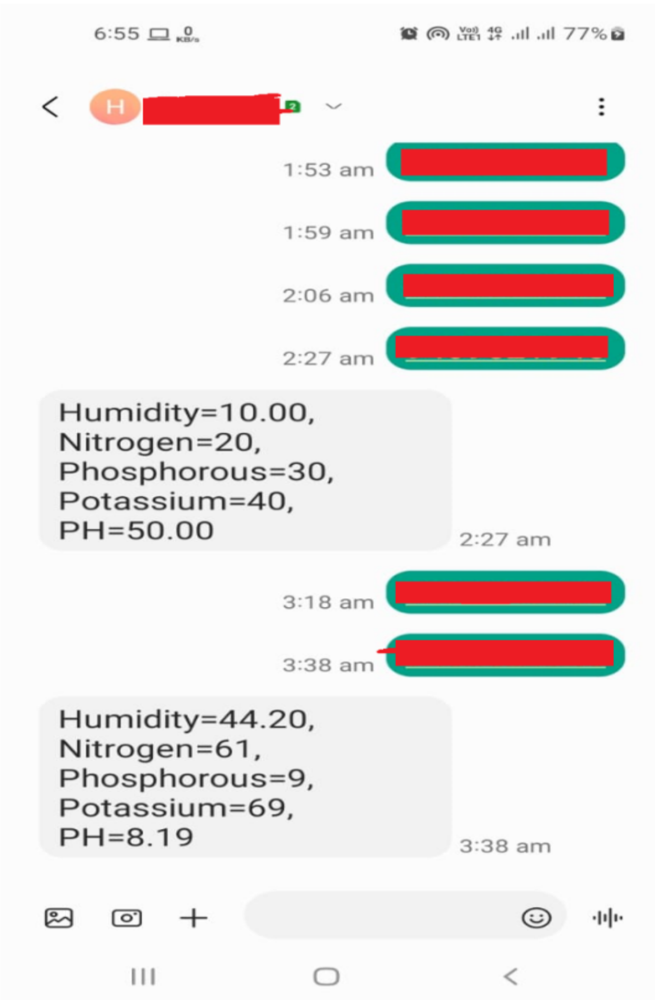

Fig. 21. SMS Received of sensor data.

When the Node MCU is linked to wifi, we may view sensor data on the online dashboard, as shown in the image above. We have the ability to track and confirm the value change. Figure 22 shows the Web dash board of sensor output.

Figure 23 shows us a graph or chart of the various sensor outputs. We can see how the graph is evolving and follow the changes in sensor data values as a function of changing air conditions. With the use of this mathematical data and historical chart, we can monitor farming conditions much more readily. We may also be able to boost crop yields by combining traditional farming practices with modern technology.

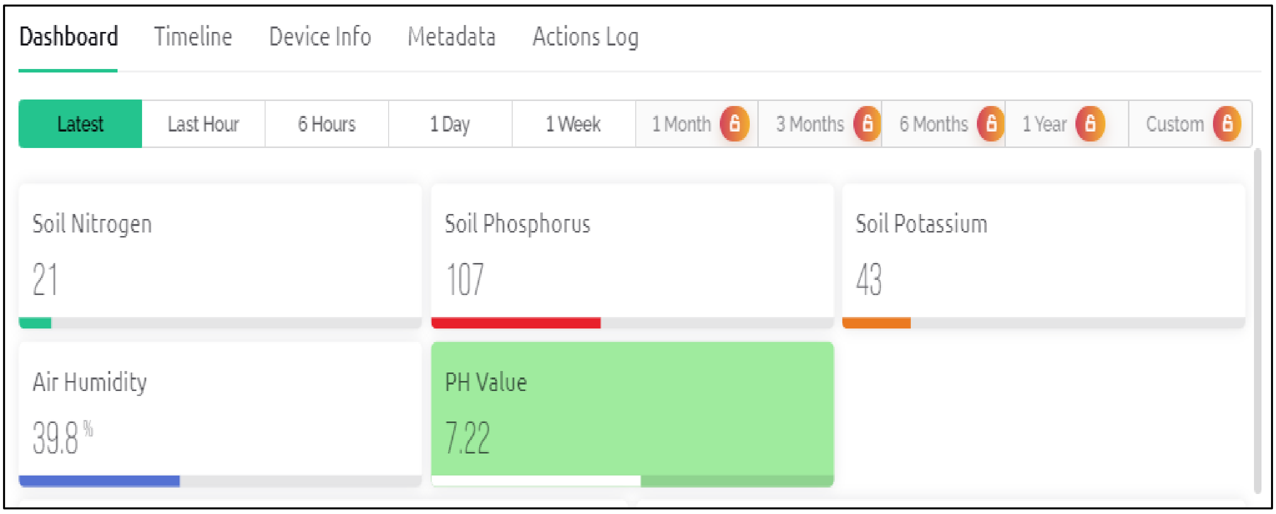

Fig. 22. Web dash board of sensor output.

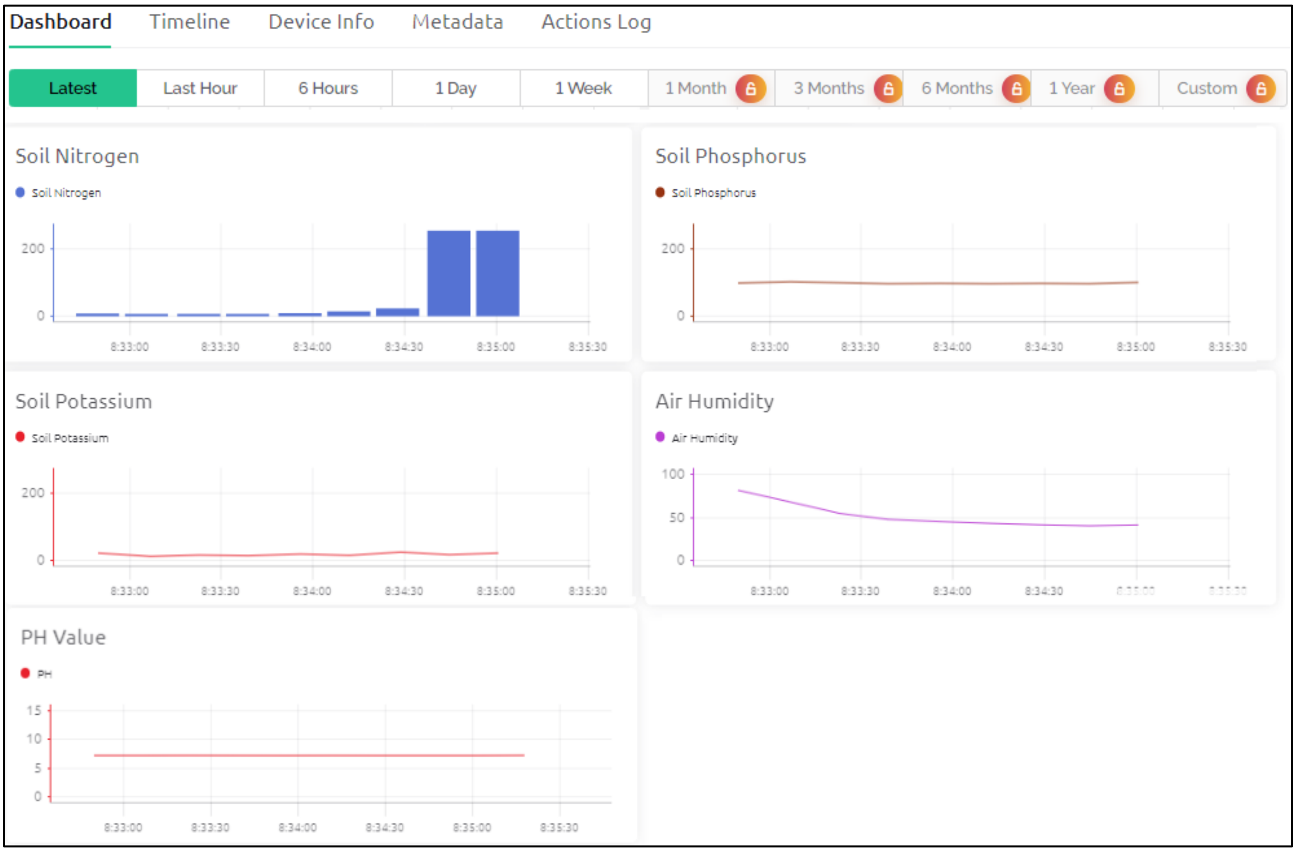

Fig. 23. sensor data graphs.

CONCLUSION

An innovative development in pomegranate farming is the "IoT-Based Soil, Water, and Air Quality Monitoring System for Pomegranate Farming". This solution uses IoT technology in conjunction with precision farming techniques to help farmers safeguard their crops, make informed decisions, and ultimately prosper in the fast-paced world of modern agriculture.

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