7208 : HINDUSTHAN INSTITUTE OF TECHNOLOGY COIMBATORE – 641032

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

# IMPLEMENTATION OF PROFICIENT AGRICULTURE USING IOT WITH MACHINE LEARNING AND MOBILE APPLICATION


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# PRESENTATION FLOW

1. Objective
2. Literature Survey
3. Limitation of Existing System
4. Proposed System Architecture
5. Proposed System Methodology
6. Technology Stack
7. Machine Learning
8. Implementation
9. Results and Discussion
10. Developments
11. Advantages and Disadvantages
12. Applications
13. Future Scope
14. References

# O B J E C T I V E

To design an Internet of Things ( IoT ) system using Peripheral Interface Controller ( PIC ) in the agricultural field to perform

- ✓**Crop Variety Prediction for Sowing by Machine Learning Technique**
- ✓**Automatic Irrigation**
- ✓**Leaf Health Status Detection by Machine Learning Technique**
- ✓**Soil Parameters Monitoring using Data Visualization**

and access the processes through the mobile application, ‘myDevices Cayenne’.

# LITERATURE SURVEY

| S. NO. | TITLE OF PAPER | JOURNAL | YEAR | INFERENCE |
|---|---|---|---|---|
| 1 | Microcontroller Based Drip Irrigation System Using Smart Sensor | Annual IEEE India Conference (INDICON) | May 2013 | The system **predicts germination of gummosis**, consists of Sensing unit, LCD, buzzer, wireless module and microcontroller. Sensing unit reads the different atmospheric conditions, consists of temperature sensor, relative humidity sensor and soil moisture sensor. The readings are given to microcontroller (PIC 16F877A). Microcontroller will display these reading on LCD as well as transmit it through wireless module (CC2500 module). Receiver consists of wireless module, serial communication device (RS 232) and personnel computer. Database is created with the help of asp.net, checking for reference condition and as it detects the reference condition of Gummosis disease, it will command the microcontroller through wireless module. |
| 2 | IoT Assisted Automatic Irrigation System using Wireless Sensor Nodes | International Conference on Computer Communication and Informatics (ICCCI) | Jan 2018 | Overall setup is Arduino, NodeMCU, Mobile sensors and Serial monitor screen. Each sample is fixed with an individual soil moisture sensor. The Arduino module is used to **read the analog input values from the sensors**. **The pumps are** switched off under normal conditions and **are programmed to operate only when the soil moisture goes below certain threshold levels which are specific to the plant**. This is entirely controlled by the Node MCU module. The status is immediately updated to user. |

# LITERATURE SURVEY ( Contd. )

| S. NO. | TITLE OF PAPER | JOURNAL | YEAR | INFERENCE |
|---|---|---|---|---|
| 3 | Smart Management of Crop Cultivation using IoT and Machine Learning | International Research Journal of Engineering and Technology (IRJET) | Nov 2018 | The DHT11, MQ2, Soil Moisture, Light Intensity sensors **send the readings in real time to the cloud server**. The data is displayed to the user in a webpage. **Machine Learning Algorithm( KNN Clustering ) is used to calculate the crop which is best to grow in the particular field** based on the values received at real time. A standardized dataset containing the minimum requirements for a particular crop is maintained and is used for the prediction of the crop. The data is also plotted and an e-mail is sent. |
| 4 | Smart Agriculture Using Pic Microcontroller and GSM Based Technology | International Research Journal of Engineering and Technology (IRJET) | April 2019 | Pic microcontroller based GSM technology consist of temperature sensor, humidity sensor, soil moisture sensor, light sensor, GSM module. All sensors are successfully interfaced with pic microcontroller. Each sensor is separately connected to the pic microcontroller. The pic microcontroller used interfaced with GSM. This **pic microcontroller transmits all the data collected by each sensor to the GSM and this data displayed on the LCD**. The GSM module sends a message on mobile phone. So**, on mobile phone we get a particular name of disease and medicine for that disease which we are going to detect the or identifying from our sensor data.** |

# LITERATURE SURVEY ( Contd. )

| S. NO. | TITLE OF PAPER | JOURNAL | YEAR | INFERENCE |
|---|---|---|---|---|
| 5 | Smart Irrigation System using Internet of Things | International Conference on Emerging Trends in Information Technology and Engineering (ic-ETITE) | May 2020 | A **smart irrigation system** is configured with Arduino UNO, DHT11 Temperature and Humidity Sensor, Water level Sensor, Soil Moisture Sensor attached to breadboard. The programming language runs instructions which extracts the data and reflects. If the data is not valid then the process ends. |
| 6 | IoT Enabled Smart Drip Irrigation System using Web / Android Applications | International Conference on Computing Communication and Networking Technologies (ICCCNT) | July 2020 | Sensors used are Soil Moisture, Temperature and Humidity. In the Arduino YUN microcontroller, the command from PC is sent to read the sensor values. Arduino interprets the instruction from the PC and activates/deactivates the sensors**. If watering of the plant is needed then the pump is activated and kept at the same state until the moisture level reaches a safe zone.** Finally, the last check is performed whether the user wants to terminate the process or not; if no termination is intended then the current set of sensor data and process status is saved in the PC side and the process is repeated for the continuous checking of any kind of issue. The data will be uploaded in the cloud through NodeMCU. |

# LITERATURE SURVEY ( Contd. )

| S. NO. | TITLE OF PAPER | JOURNAL | YEAR | INFERENCE |
|---|---|---|---|---|
| 7 | Proficient Smart Soil based IoT System for Crop Prediction | International Conference on Inventive Research in Computing Applications (ICIRCA) | September 2020 | Sensors used are pH sensor, Temperature and Humidity sensor along with Arduino UNO. These sensors are used to **measure the pH and macronutrients like the moisture level of the soil, temperature and humidity level in the environment.** Based on these factors **it predicts the crop** suitable for that soil. All the data collected from the sensors are **stored in the database for analysis of the yield.** |
| 8 | Smart Irrigation System using IoT | International Conference of Advance Computing & Communication Systems (ICACCS) | 2020 | Smart Irrigation system is developed by Arduino UNO with sensors like soil moisture sensor, water level sensor and the temperature sensor. On receiving the signal from those sensors, the **Microcontroller gives the appropriate output that turns on the relay according to the soil and the atmospheric conditions and operates the water pump.** With the help of GSM the information regarding the ON and OFF state of the pump can be sent to the user. To transfer the message to the user this GSM module uses the TDMA technique. |

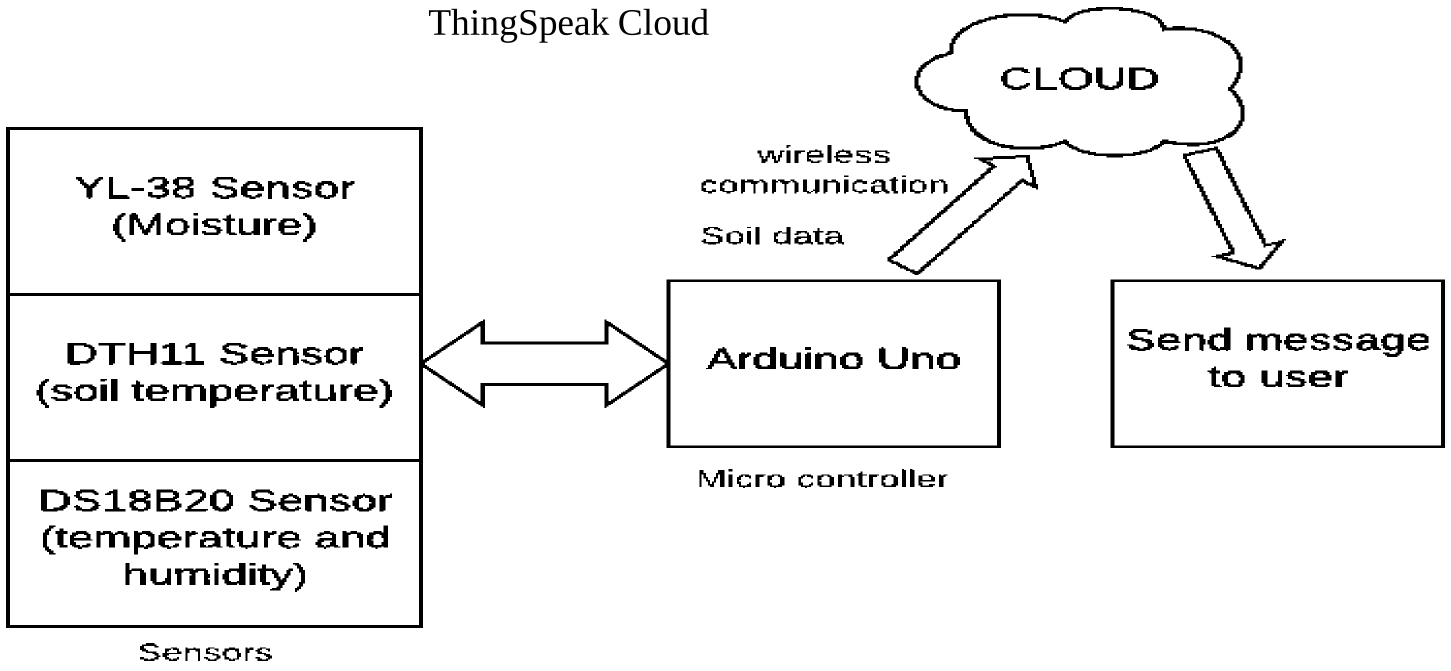
# LIMITATION OF EXISTING SYSTEM

- Proceedings of the International Conference on Electronics and Sustainable Communication Systems ( ICESC 2020 ) IEEE Xplore Part Number : CFP20V66-ART; ISBN : 978-1-7281-4108-4

- **IoT based Smart System for Enhanced Irrigation in Agriculture**

- **Authors** : Bhanu K.N. 1, Mahadevaswamy H.S.2 , Jasmine H.J.3 – Department of Computer Science, Amrita School of Arts & Sciences, Mysuru Amrita Vishwa Vidyapeetham, India.

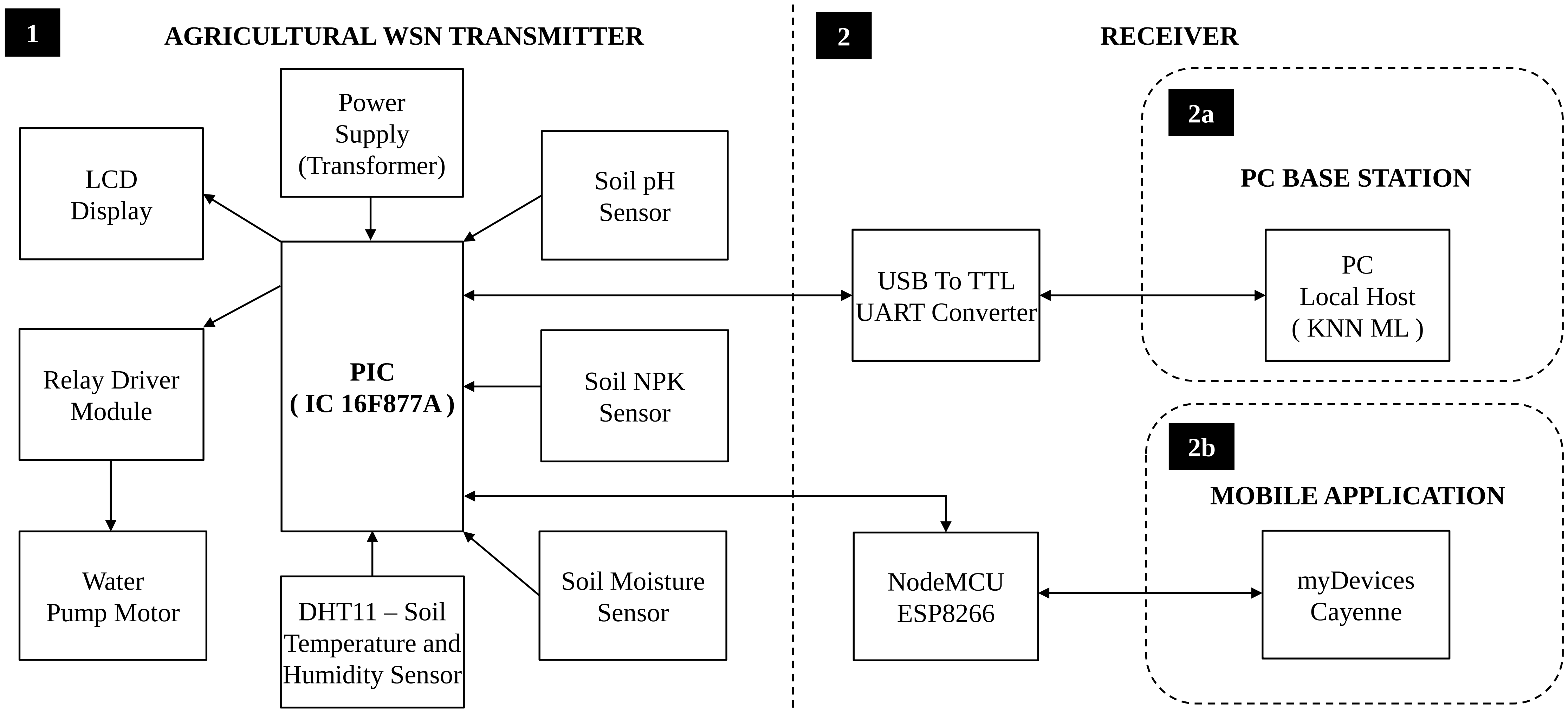
ThingSpeak Cloud



# LIMITATION OF EXISTING SYSTEM ( Contd. )

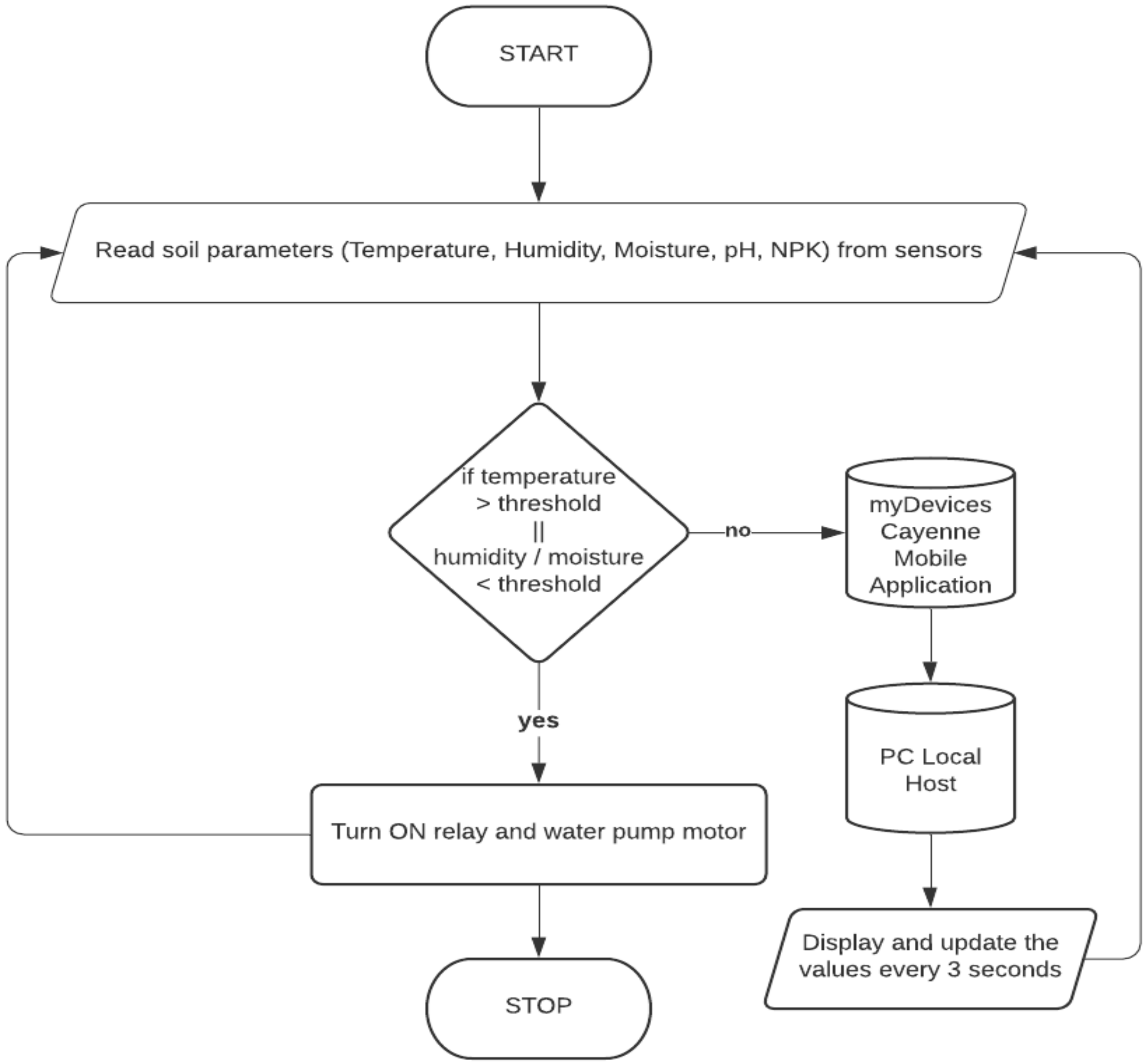
| EXISTING FUNCTIONALITIES | LIMITATIONS |
|---|---|
| ❑ Microcontroller – Arduino UNO ATmega328P | ❑ Microcontroller – Arduino is a common environment for different microcontrollers, below industry grade |
| ❑ Sensors – Soil Moisture, Soil Temperature and Humidity | ❑ Sensors – Soil pH and Soil NPK sensors are not available |
| ❑ Wi-Fi Module | ❑ Wi-Fi Module – Same |
| ❑ ThingSpeak IoT Cloud | ❑ ThingSpeak IoT Cloud – Not full-fledged and doesn’t support all machine learning techniques |
| ❑ Correlated Parameters – Soil Temperature and Soil Moisture | ❑ Correlated Parameters – Soil Humidity, Soil pH and Soil NPK aren’t considered |
| ❑ Classification Algorithm – SVM Classifier (87.5) > Naïve Bayes Classifier (76.4) > KNN Classifier(70.8) | ❑ Classification Algorithm – Accuracy decreased when parameters increased |

# PROPOSED SYSTEM ARCHITECTURE

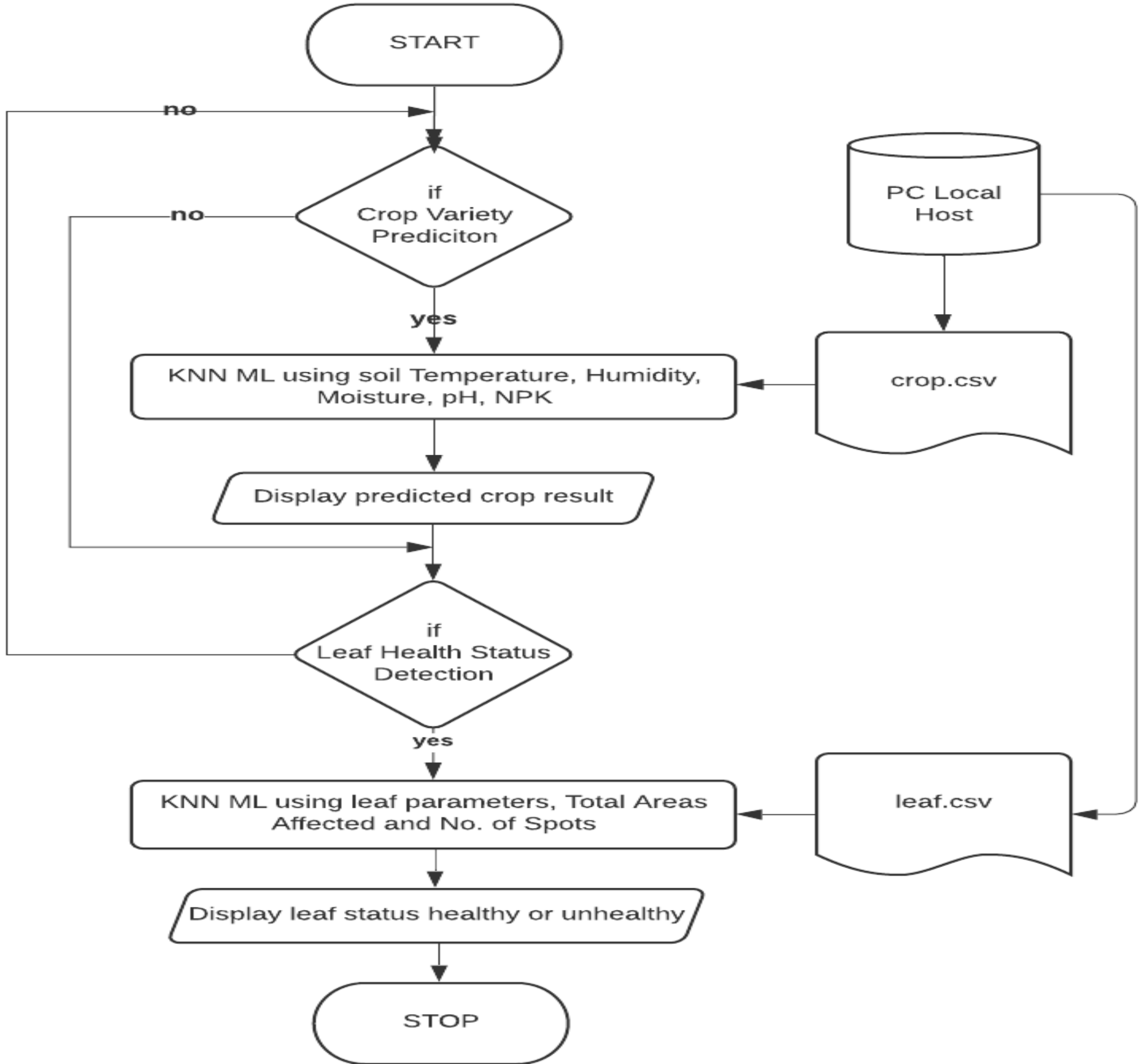


# PROPOSED SYSTEM METHODOLOGY – DATA FLOW DIAGRAM

**PIC Microcontroller**




**KNN ML for Crop Variety Prediction and Leaf Health Status Detection**



# PROPOSED SYSTEM METHODOLOGY – PROCESS STEPS

- **STEP 1: CONNECTIONS** – Sensors ( Soil Temperature and Humidity, Soil Moisture, Soil pH and Soil NPK ) are embedded to the PIC Microcontroller IC 16F877A for sensing / transmitting the agricultural field soil quality data.

  - **STEP 1.1:** This is converted and transmitted as serial data to the PC Localhost through USB to TTL UART Converter as well as to the myDevices Cayenne Mobile Application every 3 seconds ( real-time ) through Wi-Fi Module NodeMCU – ESP8266.

- **STEP 2: AUTOMATIC IRRIGATION** – When the Soil Temperature, Humidity and Moisture content go below their respective threshold value, the driver and relay are commanded to switch ON / OFF the water pump.

- **STEP 3: MACHINE LEARNING IN PC LOCALHOST** – **K-Nearest Neighbors ( KNN ) Classifier Algorithm**

  - **STEP 3.1: CROP PREDICTION**
    - A dataset named, crop.csv with real-time152 entries each of Soil NPK, Temperature, Humidity, pH and Moisture values, totally 760 values corresponding to the crop labels, rice, maize, dhal, is trained using KNN Classifier ML Algorithm with accuracy of 98%.
    - When the user requests crop prediction for the field, through USB-UART Converter, ESP8266 and PIC, the predicted crop for the current soil parameters is sent from the PC as result to the myDevices Cayenne Application.

# PROPOSED SYSTEM METHODOLOGY – PROCESS STEPS ( Contd. )

- **STEP 3.2: LEAF HEALTH STATUS DETECTION**
  - A train dataset  named, leaf.csv having 348 parameters each for, ‘total areas affected’, ‘no. of s.p. (number of spots of disease)’, totally 696 values derived through image processing of 348 healthy and unhealthy mango leaves images corresponding to the disease severity, ‘none’, ‘low’, ‘medium’, ‘high’ status labels, is used for training the model using KNN Classifier ML Algorithm with 97% accuracy.
  - A test dataset with images of both healthy and unhealthy leaves is used for testing the model results.
  - When the user requests leaf disease detection, through USB-UART Converter, PIC and ESP8266, the health status messages for the current soil parameters is sent from the PC as result to the myDevices Cayenne Application.

- **STEP 4: SOIL QUALITY MONITORING THROUGH DATA ANALYSIS** – All the soil parameters are represented as time-series line plots for easy data visualization and analysis . They are plotted as value / [live, month, hour, day, week, 1month, 3months, 6months, 1year] . The history of data can be downloaded for reference.

**Thus, the farmer / user can control and access the above system processes remotely through the myDevices Cayenne mobile application.**

# TECHNOLOGY STACK

| HARDWARE REQUIREMENTS | SOFTWARE REQUIREMENTS |
|---|---|
| 1. Microcontroller – Peripheral Interface controller ( PIC ) 16F877A 40-pin PDIP<br>2. Power Supply (Transformer)<br>3. Sensors<br>   i. DHT11 – Soil Temperature and Humidity Sensor<br>   ii. Soil Moisture Sensor<br>   iii. Soil pH Sensor<br>   iv. Soil NPK Sensor<br>4. Relay Driver Module<br>5. Water Pump Motor<br>6. LCD Display<br>7. USB To UART Converter<br>8. PC as Localhost<br>9. Wi-Fi Module – NodeMCU ESP8266<br>10. Mobile Phone for myDevices Cayenne Application<br>11. PCB Boards, Resistors, Capacitor Filters, Diodes, Rectifiers, Voltage Regulators, Connectors, Wires etc. | 1. PC Local Host Specifications<br>   i. OS – Windows 10 or Linux<br>   ii. CPU – Intel or AMD 7$^{th}$ Generation Processor and above<br>   iii. RAM – 16 GB recommended<br>   iv. SSD – Minimum 256 GB<br>2. PIC Microcontroller IC 16F877A Requirements<br>   i. Language – Embedded C<br>   **ii. IDE – MPLAB XC**<br>   iii. Loader Hardware – PICkit 2 Programmer<br>3. Wi-Fi ESP8266 MOD Requirement<br>   i. Language – Embedded C<br>   **ii. IDE – Arduino**<br>4. Machine Learning Environment<br>   i. Language – Python Version 3.7 and above<br>   **ii. IDE – Python IDLE** |

# MACHINE LEARNING – KNN ALGORITHM

“ Our KNN algorithm is a Multi-class Classification ”

**Working of KNN Algorithm:**

**Step 1** − We need dataset. First we should load the training as well as test data.
Our datasets here are **crop.csv** and **leaf.csv**.

**Step 2** − Choose the value of K i.e. the nearest data points.
Here **K = 3.**

**Step 3** − For each point in the test data do the following −

**Step 3.1** − Calculate the distance between test data and each row of training data with the help of any of the method namely: Euclidean, Manhattan or Hamming distance.
The most commonly used method to calculate distance is **Euclidean.**
**Step 3.2** − Based on the distance value, **sort them in ascending order.**
**Step 3.3** − Next, it will choose the top K rows from the sorted array.
**Step 3.4** − Now, it will **assign a class** to the test point based on most frequent class of these rows.

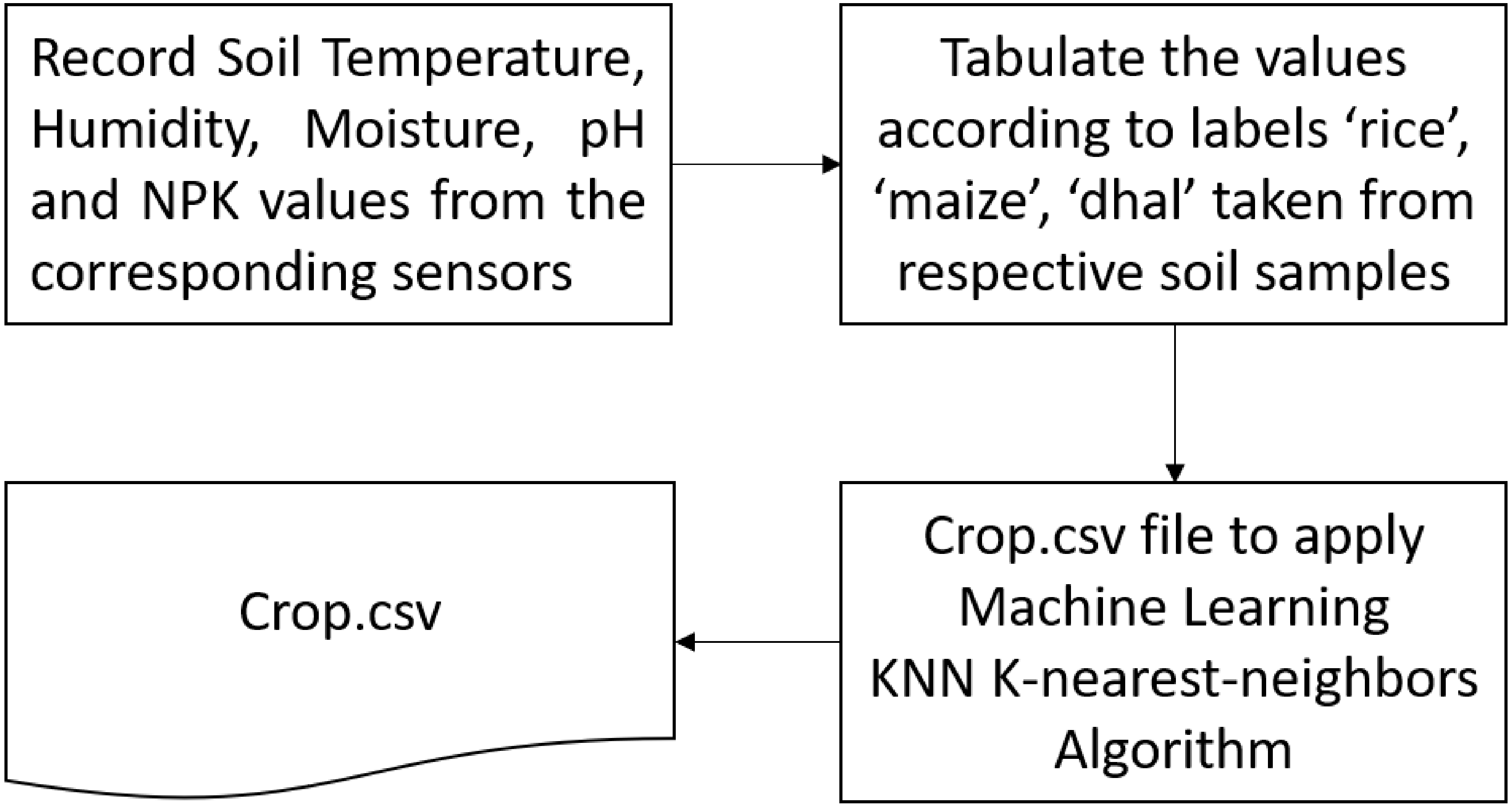
**Step 4** − End

**Datasets:**

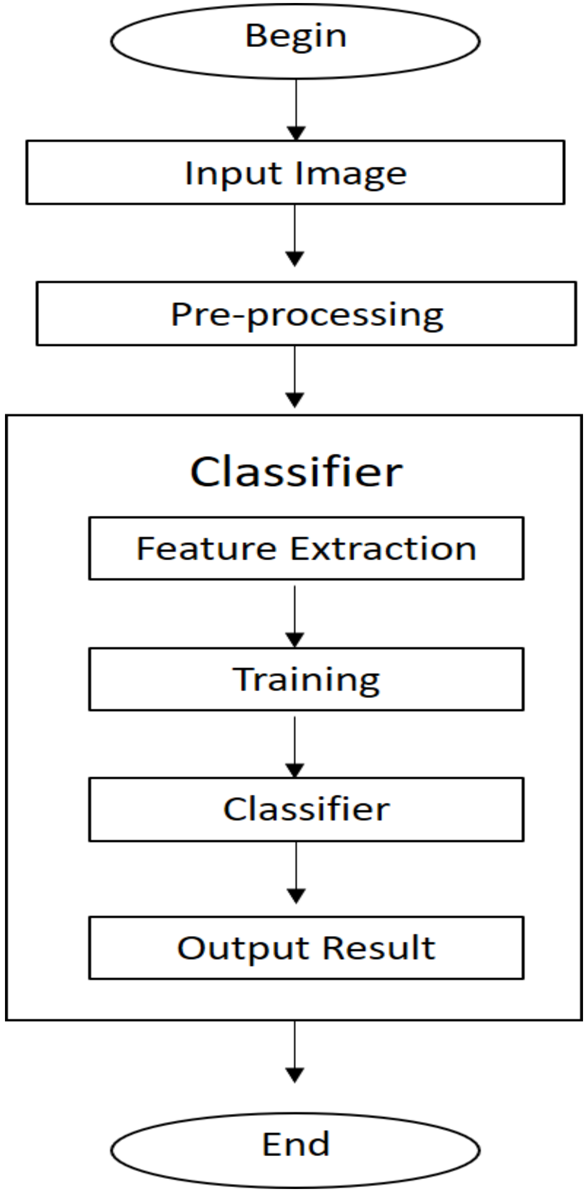
1. **Crop.csv –** We have recorded all soil temperature, humidity, moisture, pH and NPK values from the sensors for the rice, maize, dhal crop soil samples and tabulated them as crop.csv training file. Let us see how in the next slide.
2. **Leaf.csv –** Let us see how leaf.csv training file is generated in the following slide.

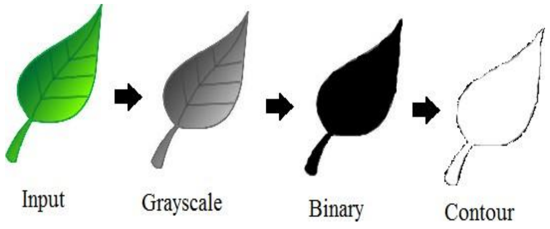
# MACHINE LEARNING – KNN METHODOLOGY

## crop.csv

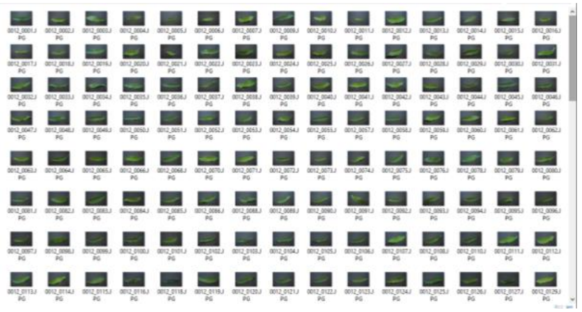


# MACHINE LEARNING – KNN METHODOLOGY
# leaf.csv

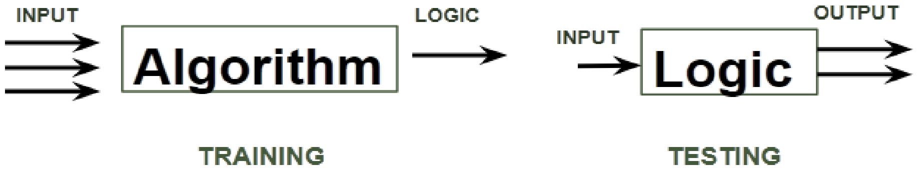




**348 mango leaves** are pre-processed and their two parameters, **'total areas affected'**, **'number of disease spots'** are recorded as **leaf.csv** file, with **696 values**, 348 entries each classified into **4 labels**, **'none'**, **'low'**, **'medium'** and **'high'**.



# MACHINE LEARNING – crop.csv DATASET

| NPK | Temperature | Humidity | pH | Soil Moisture | Label |
|---|---|---|---|---|---|
| 0 | 20.18 | 200 | 2 | 130 | Rice |
| 1 | 20.36 | 200.4 | 2.1 | 130.4 | Rice |
| 2 | 20.54 | 200.8 | 2.2 | 130.8 | Rice |
| 3 | 20.72 | 201.2 | 2.3 | 131.2 | Rice |
| 4 | 20.9 | 201.6 | 2.4 | 131.6 | Rice |
| 5 | 21.08 | 202 | 2.5 | 132 | Rice |
| 6 | 21.26 | 202.4 | 2.6 | 132.4 | Rice |
| 7 | 21.44 | 202.8 | 2.7 | 132.8 | Rice |
| 8 | 21.62 | 203.2 | 2.8 | 133.2 | Rice |
| 9 | 21.8 | 203.6 | 2.9 | 133.6 | Rice |
| 10 | 21.98 | 204 | 3 | 134 | Rice |
| 11 | 22.16 | 204.4 | 3.1 | 134.4 | Rice |
| 12 | 22.34 | 204.8 | 3.2 | 134.8 | Rice |
| 13 | 22.52 | 205.2 | 3.3 | 135.2 | Rice |
| 14 | 22.7 | 205.6 | 3.4 | 135.6 | Rice |
| 15 | 22.88 | 206 | 3.5 | 136 | Rice |
| 16 | 23.06 | 206.4 | 3.6 | 136.4 | Rice |
| 17 | 23.24 | 206.8 | 3.7 | 136.8 | Rice |
| 18 | 23.42 | 207.2 | 3.8 | 137.2 | Rice |
| 19 | 23.6 | 207.6 | 3.9 | 137.6 | Rice |
| 20 | 23.78 | 208 | 4 | 138 | Rice |
| 21 | 23.96 | 208.4 | 4.1 | 138.4 | Rice |
| 22 | 24.14 | 208.8 | 4.2 | 138.8 | Rice |
| 23 | 24.32 | 209.2 | 4.3 | 139.2 | Rice |
| 24 | 24.5 | 209.6 | 4.4 | 139.6 | Rice |
| 25 | 24.68 | 210 | 4.5 | 140 | Rice |

| NPK | Temperature | Humidity | pH | Soil Moisture | Label |
|---|---|---|---|---|---|
| 0 | 50 | 220 | 7 | 100 | Maize |
| 1 | 51 | 220.6 | 7.05 | 100.4 | Maize |
| 2 | 52 | 221.2 | 7.1 | 100.8 | Maize |
| 3 | 53 | 221.8 | 7.15 | 101.2 | Maize |
| 4 | 54 | 222.4 | 7.2 | 101.6 | Maize |
| 5 | 55 | 223 | 7.25 | 102 | Maize |
| 6 | 56 | 223.6 | 7.3 | 102.4 | Maize |
| 7 | 57 | 224.2 | 7.35 | 102.8 | Maize |
| 8 | 58 | 224.8 | 7.4 | 103.2 | Maize |
| 9 | 59 | 225.4 | 7.45 | 103.6 | Maize |
| 10 | 60 | 226 | 7.5 | 104 | Maize |
| 11 | 61 | 226.6 | 7.55 | 104.4 | Maize |
| 12 | 62 | 227.2 | 7.6 | 104.8 | Maize |
| 13 | 63 | 227.8 | 7.65 | 105.2 | Maize |
| 14 | 64 | 228.4 | 7.7 | 105.6 | Maize |
| 15 | 65 | 229 | 7.75 | 106 | Maize |
| 16 | 66 | 229.6 | 7.8 | 106.4 | Maize |
| 17 | 67 | 230.2 | 7.85 | 106.8 | Maize |
| 18 | 68 | 230.8 | 7.9 | 107.2 | Maize |
| 19 | 69 | 231.4 | 7.95 | 107.6 | Maize |
| 20 | 70 | 232 | 8 | 108 | Maize |
| 21 | 71 | 232.6 | 8.05 | 108.4 | Maize |
| 22 | 72 | 233.2 | 8.1 | 108.8 | Maize |
| 23 | 73 | 233.8 | 8.15 | 109.2 | Maize |
| 24 | 74 | 234.4 | 8.2 | 109.6 | Maize |
| 25 | 75 | 235 | 8.25 | 110 | Maize |

| NPK | Temperature | Humidity | pH | Soil Moisture | Label |
|---|---|---|---|---|---|
| 0 | 100 | 255 | 10.1 | 125 | Dhal |
| 1 | 110 | 258 | 10.2 | 129 | Dhal |
| 2 | 120 | 261 | 10.3 | 133 | Dhal |
| 3 | 130 | 264 | 10.4 | 137 | Dhal |
| 4 | 140 | 267 | 10.5 | 141 | Dhal |
| 5 | 150 | 270 | 10.6 | 145 | Dhal |
| 6 | 160 | 273 | 10.7 | 149 | Dhal |
| 7 | 170 | 276 | 10.8 | 153 | Dhal |
| 8 | 180 | 279 | 10.9 | 157 | Dhal |
| 9 | 190 | 282 | 11 | 161 | Dhal |
| 10 | 200 | 285 | 11.1 | 165 | Dhal |
| 11 | 210 | 288 | 11.2 | 169 | Dhal |
| 12 | 220 | 291 | 11.3 | 173 | Dhal |
| 13 | 230 | 294 | 11.4 | 177 | Dhal |
| 14 | 240 | 297 | 11.5 | 181 | Dhal |
| 15 | 250 | 300 | 11.6 | 185 | Dhal |
| 16 | 260 | 303 | 11.7 | 189 | Dhal |
| 17 | 270 | 306 | 11.8 | 193 | Dhal |
| 18 | 280 | 309 | 11.9 | 197 | Dhal |
| 19 | 290 | 312 | 12 | 201 | Dhal |
| 20 | 300 | 315 | 12.1 | 205 | Dhal |
| 21 | 310 | 318 | 12.2 | 209 | Dhal |
| 22 | 320 | 321 | 12.3 | 213 | Dhal |
| 23 | 330 | 324 | 12.4 | 217 | Dhal |
| 24 | 340 | 327 | 12.5 | 221 | Dhal |
| 25 | 350 | 330 | 12.6 | 225 | Dhal |

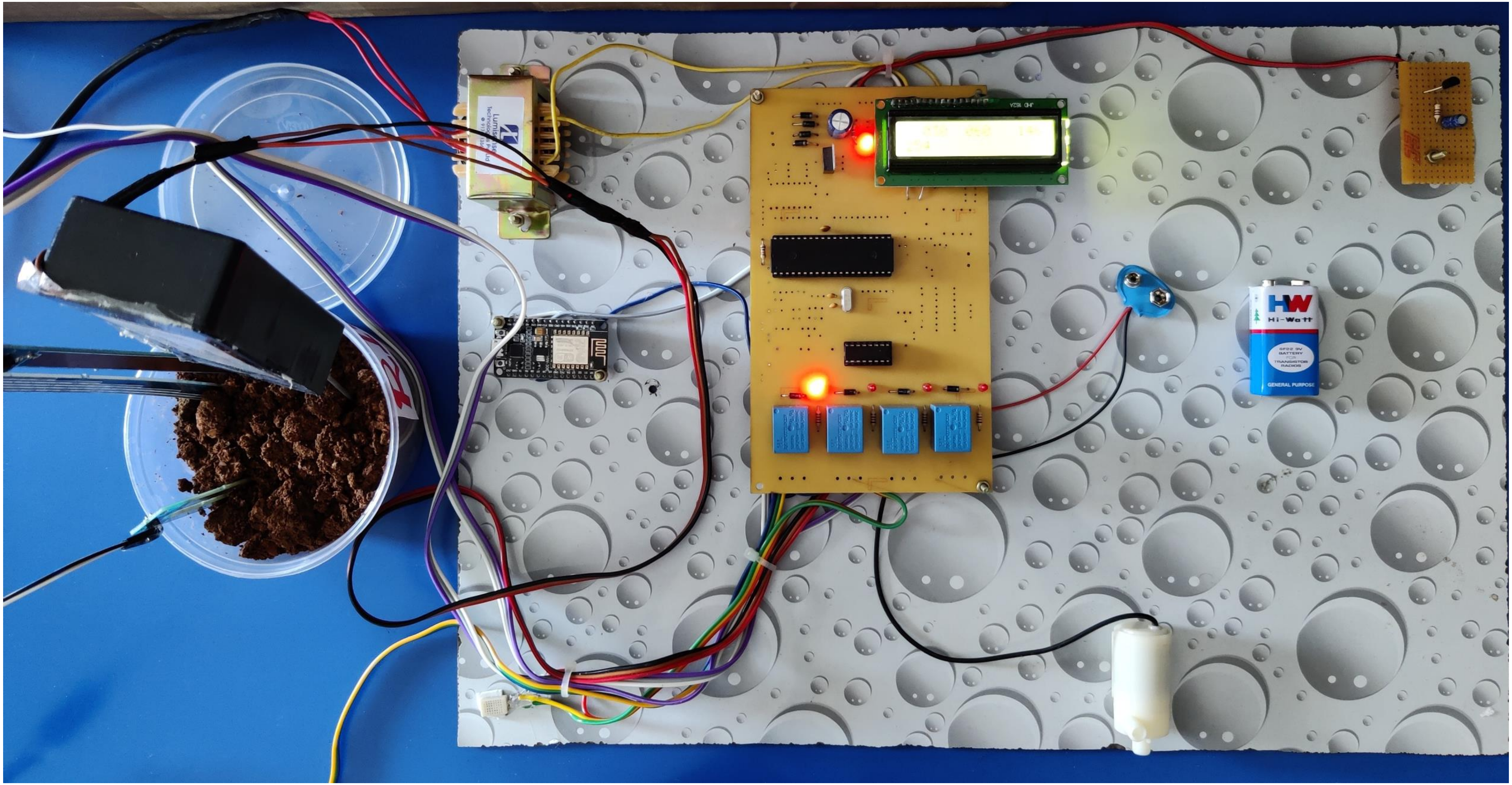
# MACHINE LEARNING – leaf.csv DATASET

| Total Areas Affected | No .Of S.P. | Status |
|---|---|---|
| 0 | 0 | N |
| 0 | 0 | N |
| 0 | 0 | N |
| 0 | 0 | N |
| 0 | 0 | N |
| 0 | 0 | N |
| 0 | 0 | N |
| 0 | 0 | N |
| 0 | 0 | N |
| 0 | 0 | N |
| 0 | 0 | N |
| 103 | 1 | S |
| 189 | 5 | S |
| 76 | 5 | S |
| 23 | 5 | S |
| 163.5 | 2 | S |
| 228 | 2 | S |
| 411.5 | 5 | S |
| 186.5 | 1 | S |
| 128 | 4 | S |
| 1 | 1 | S |
| 185.5 | 1 | S |
| 177.5 | 1 | S |
| 109.5 | 1 | S |
| 195 | 2 | S |

| Total Areas Affected | No .Of S.P. | Status |
|---|---|---|
| 351.5 | 1 | M |
| 266.5 | 2 | M |
| 259.5 | 1 | M |
| 289.5 | 5 | M |
| 320.5 | 2 | M |
| 387.5 | 1 | M |
| 428 | 1 | M |
| 318.5 | 1 | M |
| 258.5 | 2 | M |
| 316 | 3 | M |
| 408 | 4 | M |
| 442.5 | 4 | M |
| 389.5 | 2 | M |
| 416 | 3 | M |
| 437.5 | 3 | M |
| 294.5 | 1 | M |
| 259 | 1 | M |
| 699.5 | 1 | M |
| 295 | 1 | M |
| 490.5 | 1 | M |
| 258 | 2 | M |
| 327.5 | 1 | M |
| 308.5 | 1 | M |
| 334 | 3 | M |
| 378 | 1 | M |

| Total Areas Affected | No .Of S.P. | Status |
|---|---|---|
| 285.5 | 4 | M |
| 440 | 5 | M |
| 294.5 | 5 | M |
| 580.5 | 3 | M |
| 363 | 2 | M |
| 719.5 | 1 | M |
| 260.5 | 4 | M |
| 664.5 | 2 | M |
| 698 | 3 | M |
| 864 | 4 | M |
| 864 | 5 | H |
| 1448 | 5 | H |
| 952.5 | 2 | H |
| 2927 | 4 | H |
| 2159.5 | 5 | H |
| 2983.5 | 3 | H |
| 1034 | 1 | H |
| 1142.5 | 2 | H |
| 1167.5 | 5 | H |
| 2230 | 2 | H |
| 766 | 1 | H |
| 763.5 | 4 | H |
| 1448 | 5 | H |
| 952.5 | 2 | H |
| 285.5 | 4 | M |

# IMPLEMENTATION



# RESULTS AND DISCUSSION – APP INTERFACE

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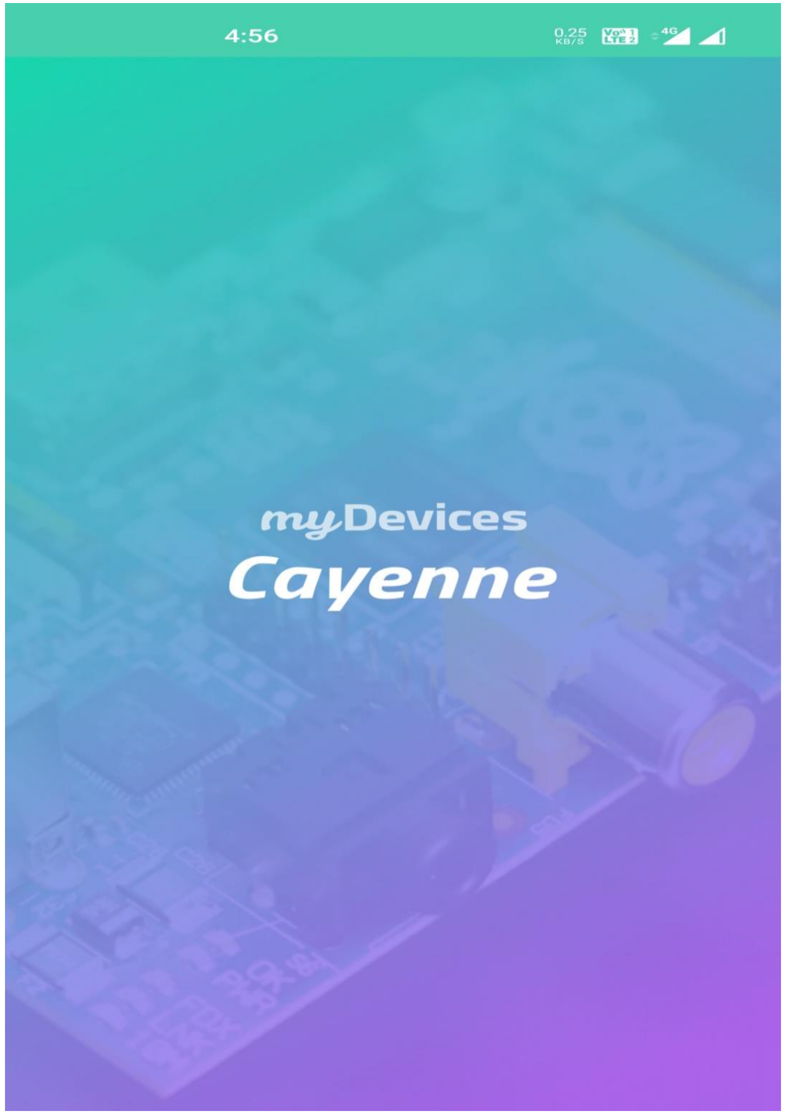


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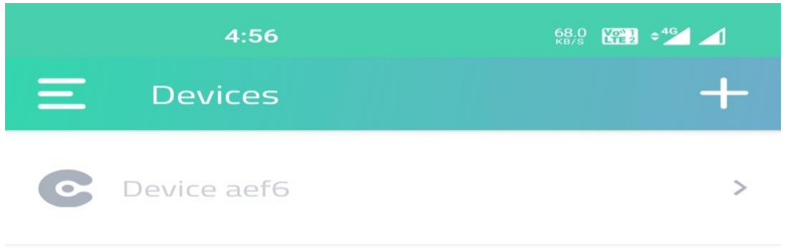
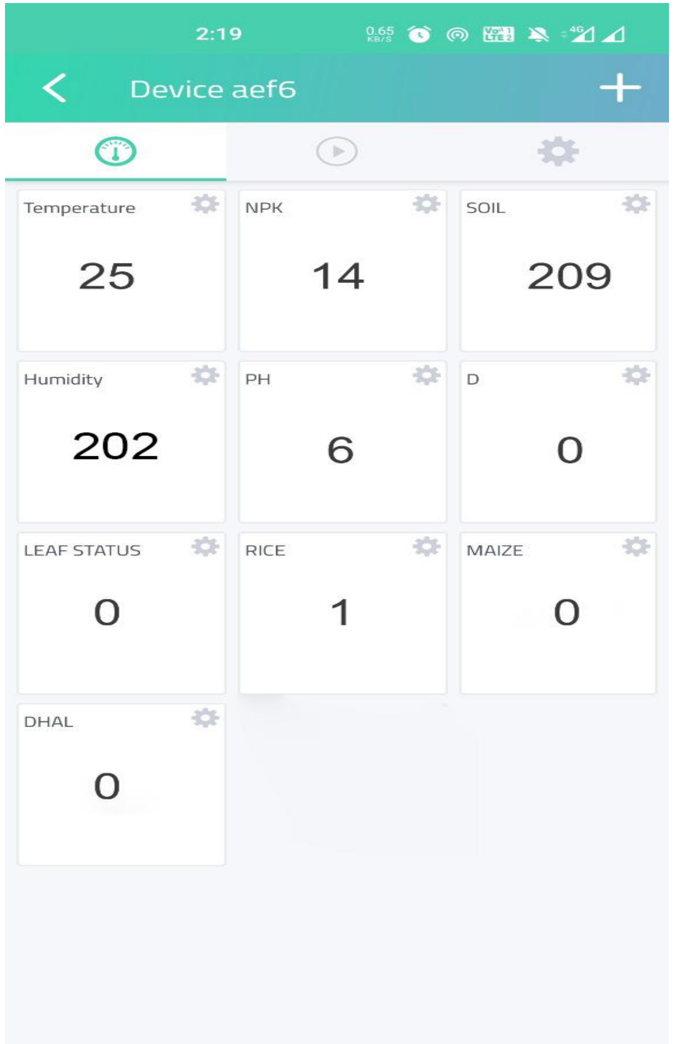


# RESULTS AND DISCUSSION – APP CROP PREDICTION

SOIL SAMPLE 1

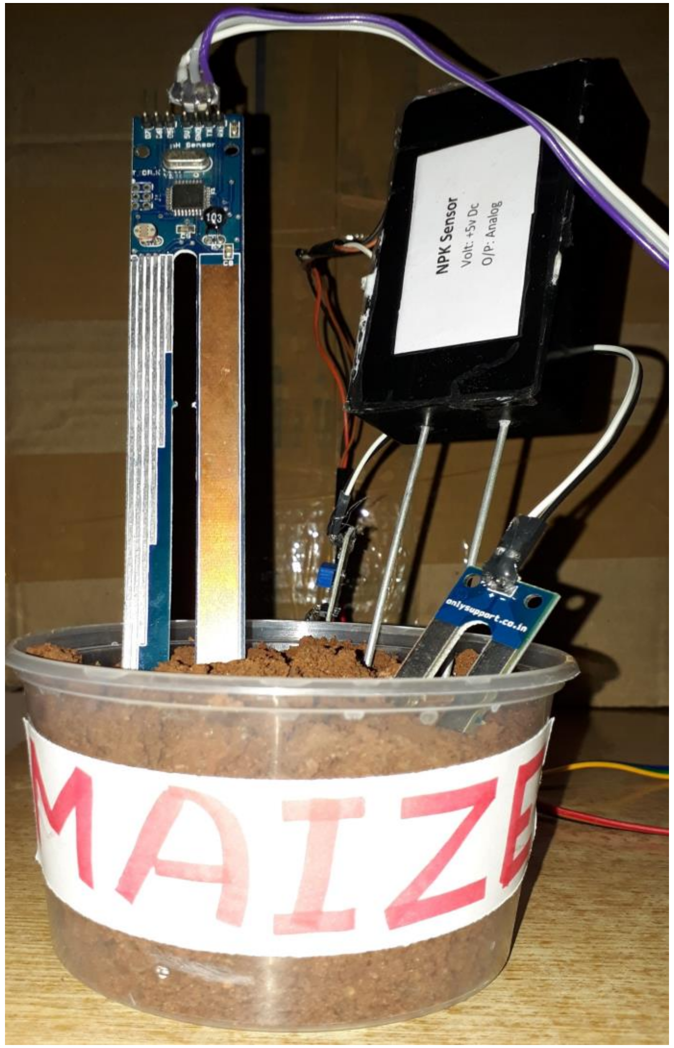

**‘1’** in **Rice** shows that Rice is the best crop to be cultivated for the current soil condition and other crops are thus marked ‘0’

APP RESULT 1



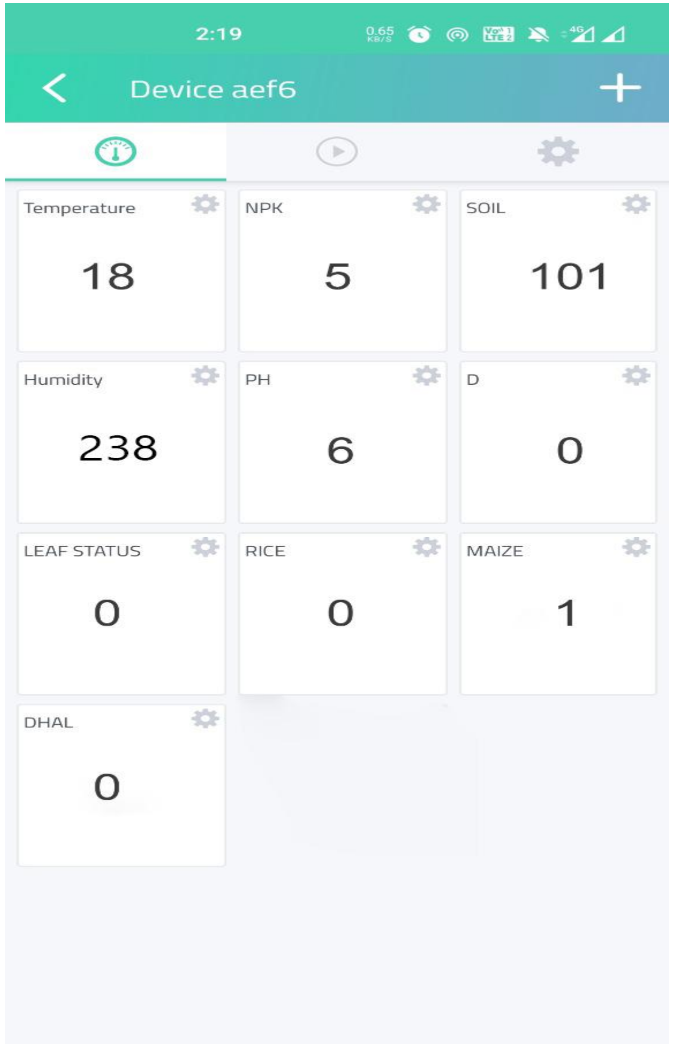
# RESULTS AND DISCUSSION – APP CROP PREDICTION (Contd. )

SOIL SAMPLE 2



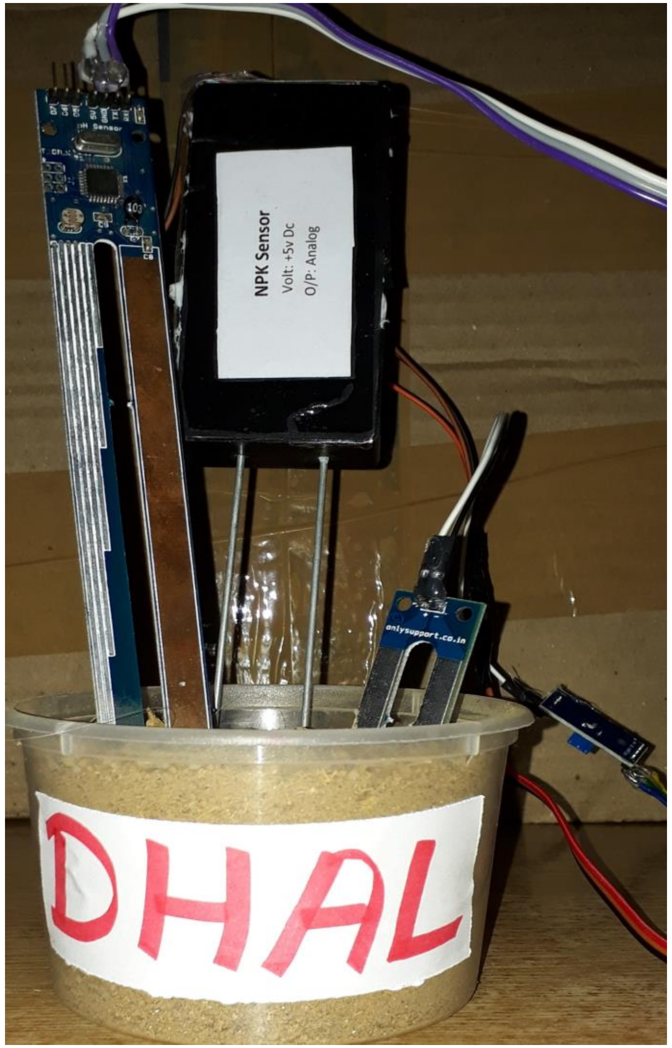

**‘1’** in **Maize** shows that Maize is the best crop to be cultivated for the current soil condition and other crops are thus marked ‘0’

APP RESULT 2

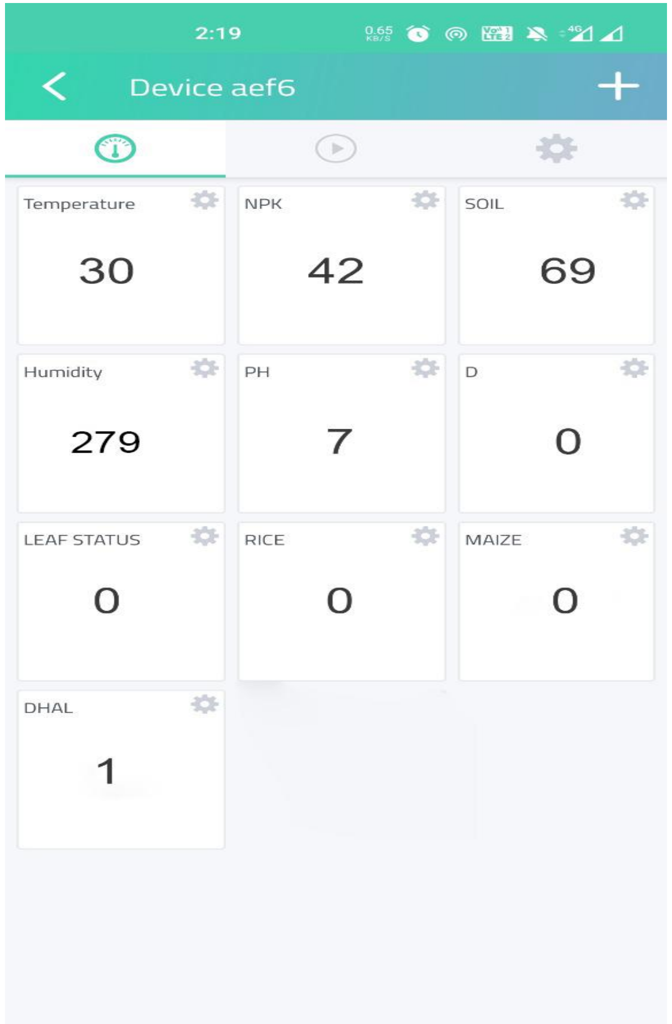


# RESULTS AND DISCUSSION – APP CROP PREDICTION (Contd. )

SOIL SAMPLE 3




APP RESULT 3



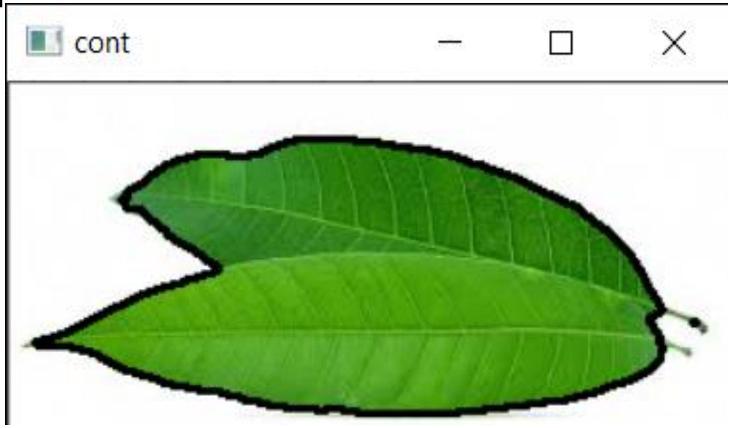

**‘1’** in **Dhal** shows that Dhal is the best crop to be cultivated for the current soil condition and other crops are thus marked ‘0’

# RESULTS AND DISCUSSION – APP
# LEAF HEALTH STATUS DETECTION

**1**

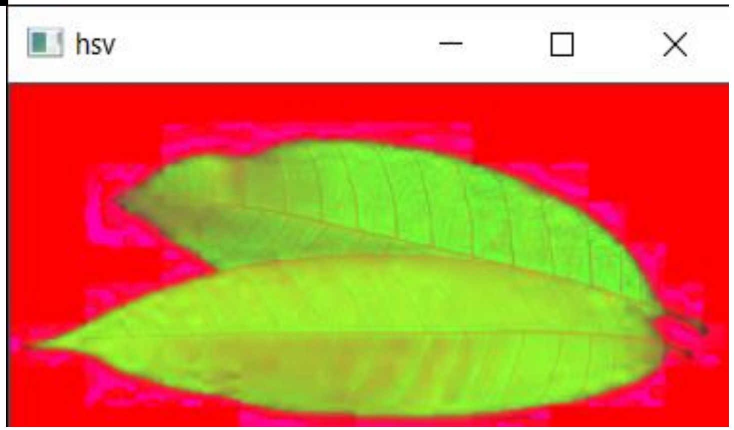

HEALTHY LEAF
TEST IMAGE
PRE-PROCESSING

**2**



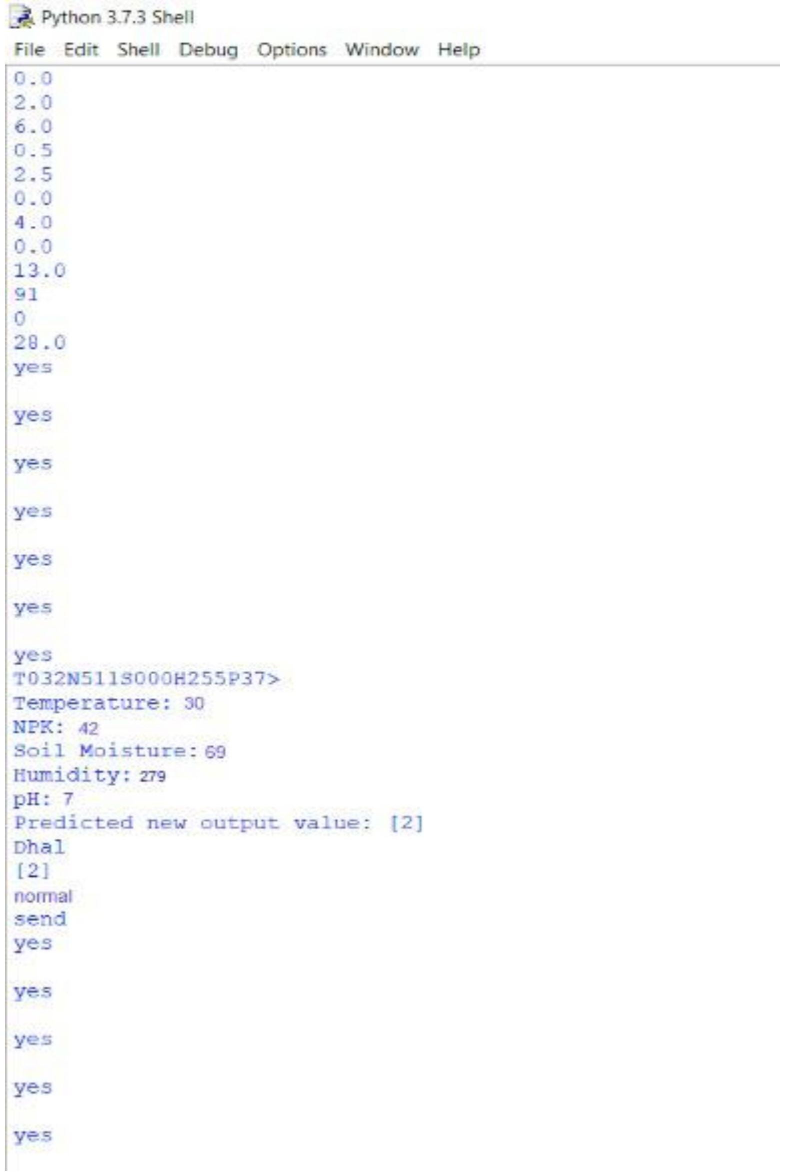

**3**


**4**



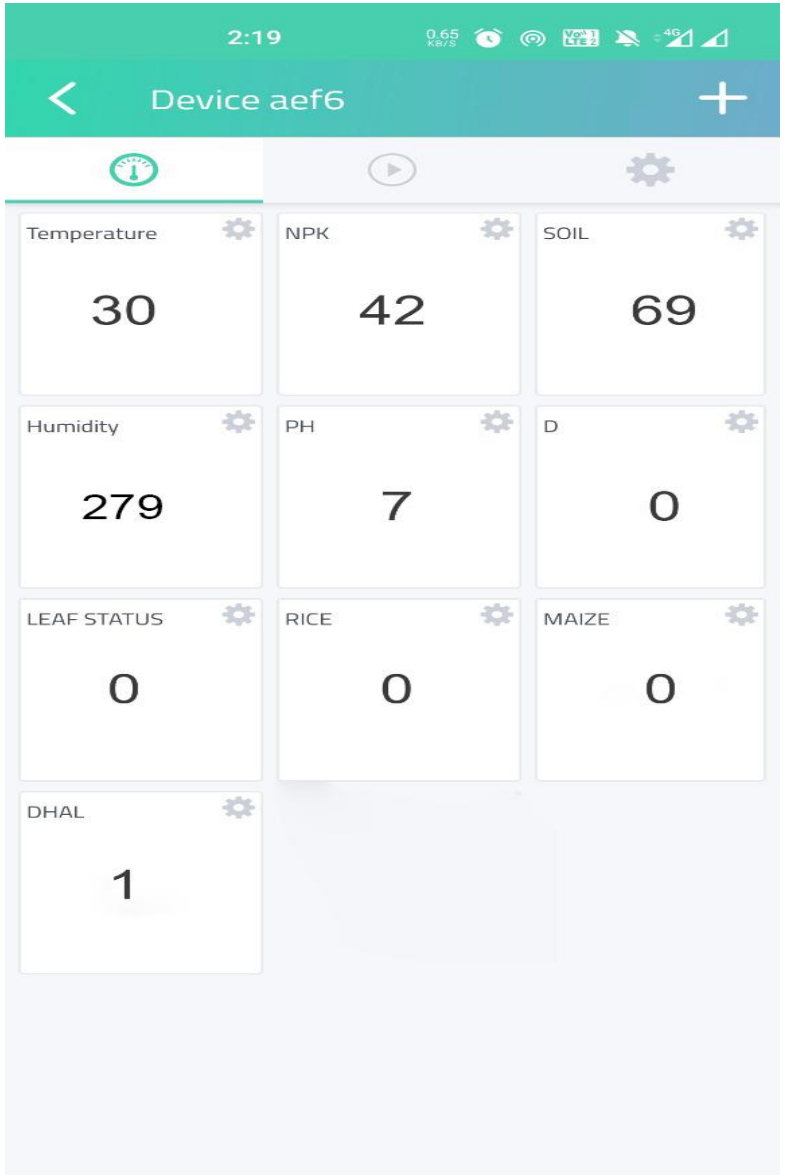

**5**

# RESULTS AND DISCUSSION – APP
# LEAF HEALTH STATUS DETECTION ( Contd. )




IDLE SHELL
AND
APP RESULT 1

**‘0’** in **Leaf** shows that the plant leaf is not affected by any disease, i.e., it is **‘healthy’**.

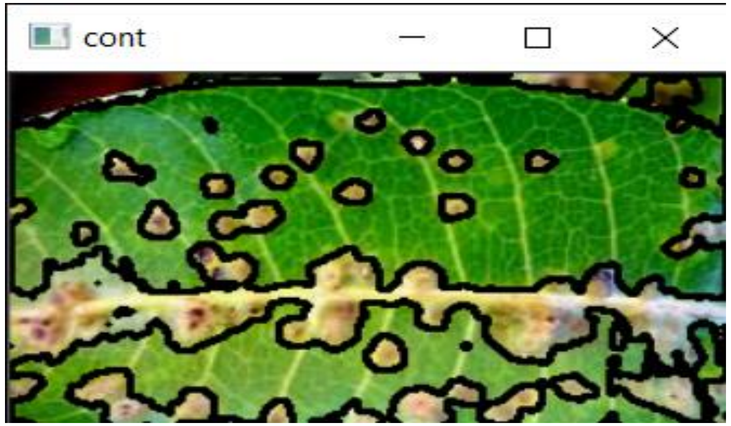


# RESULTS AND DISCUSSION – APP
# LEAF HEALTH STATUS DETECTION ( Contd. )

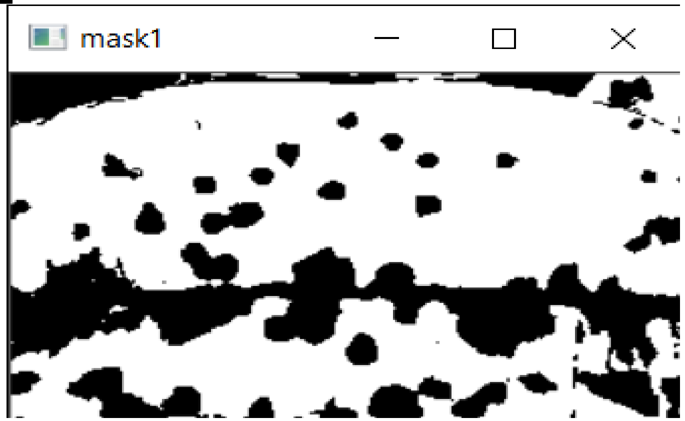
**1**


UNHEALTHY LEAF
TEST IMAGE
PRE-PROCESSING

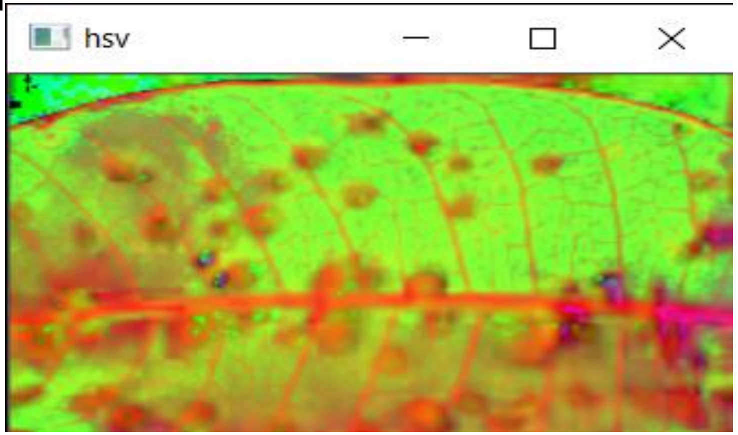
**2**



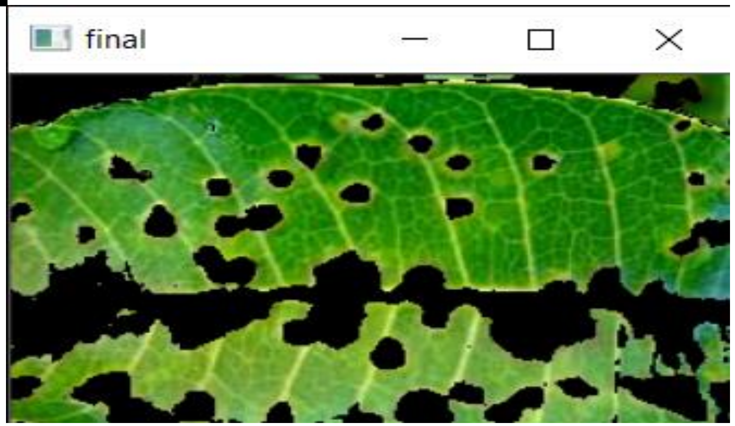

**3**



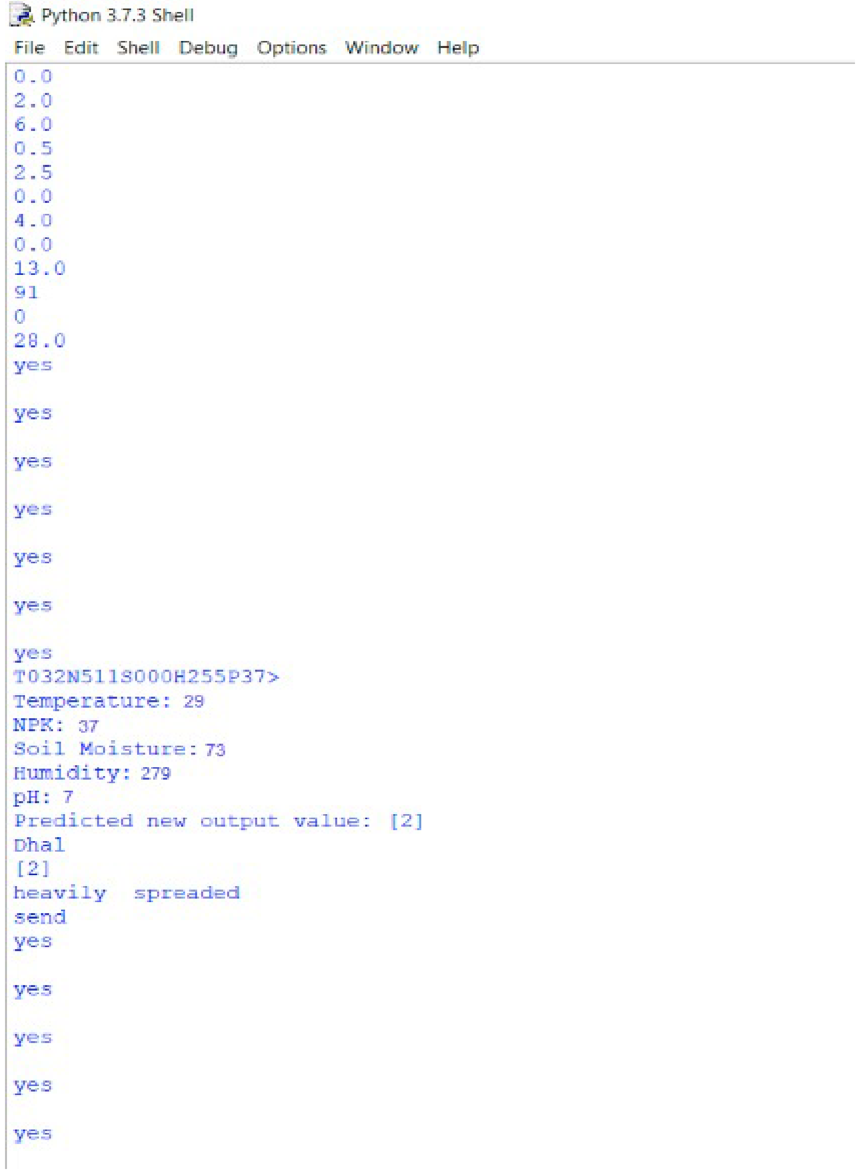

**4**




**5**

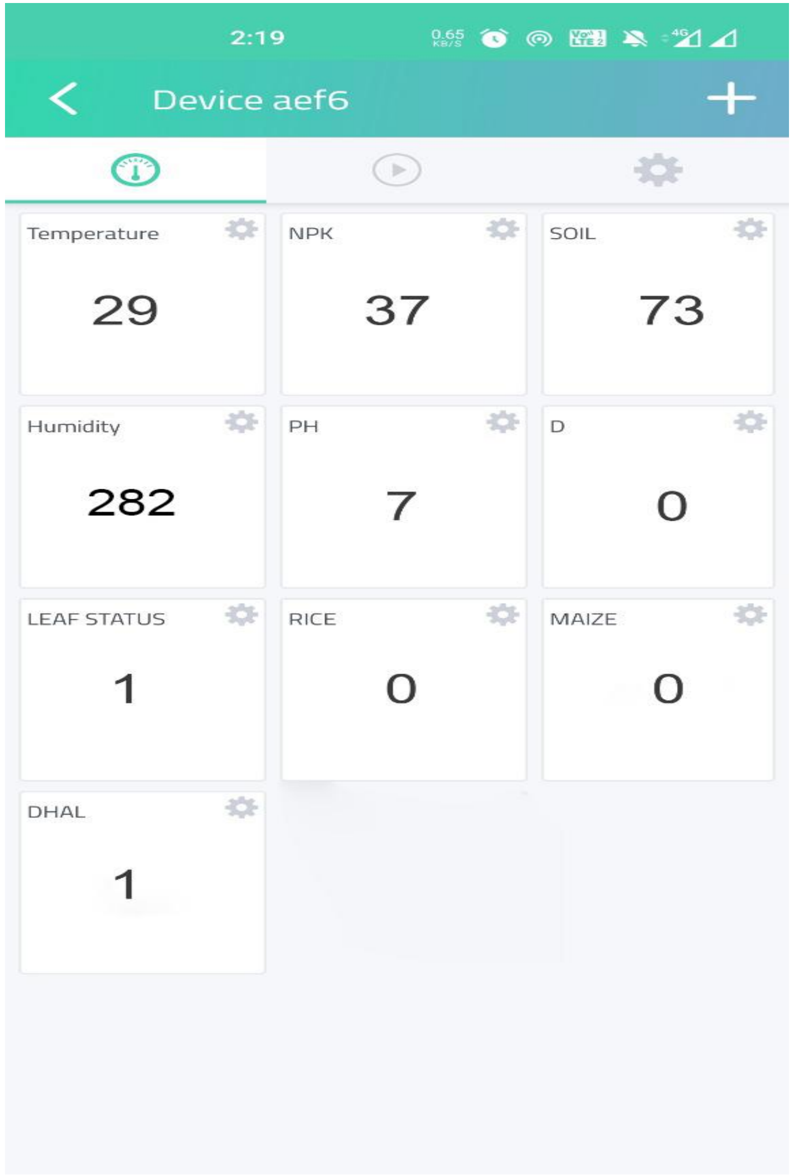


# RESULTS AND DISCUSSION – APP
# LEAF HEALTH STATUS DETECTION ( Contd. )

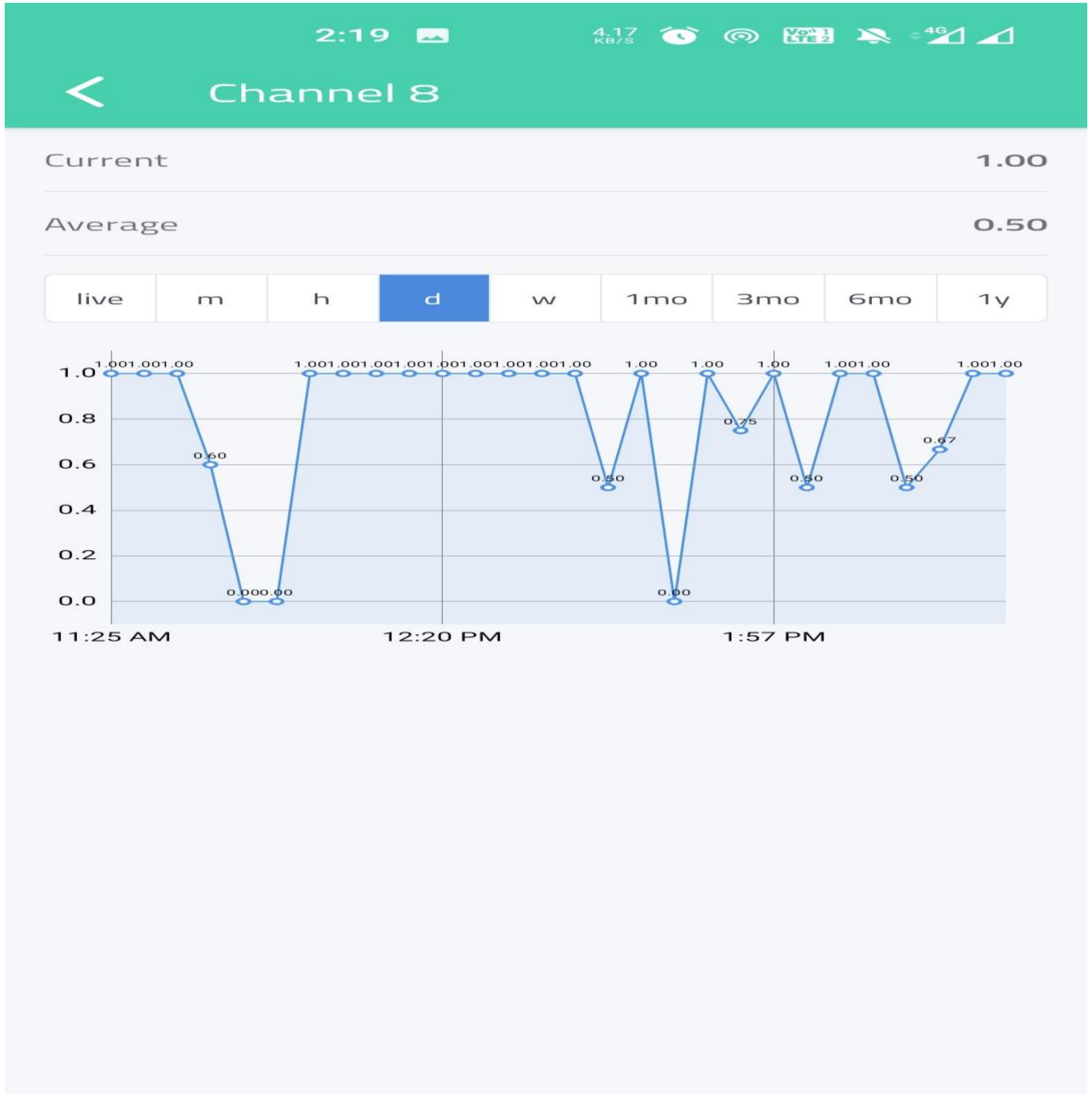


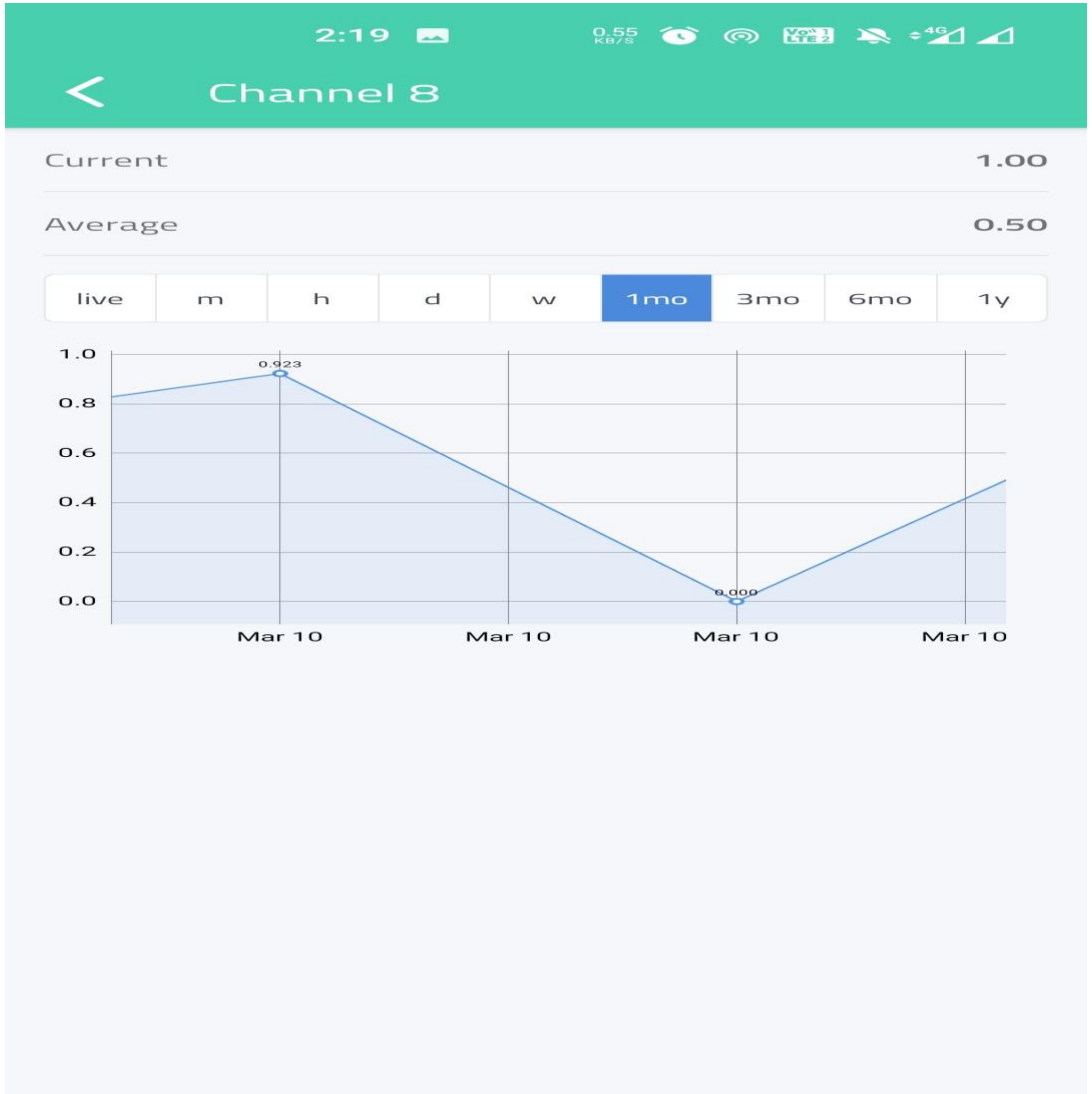

IDLE SHELL
AND
APP RESULT 2

**‘1’** in **Leaf** shows that the plant leaf is affected by a disease, i.e., it is **‘unhealthy’**.

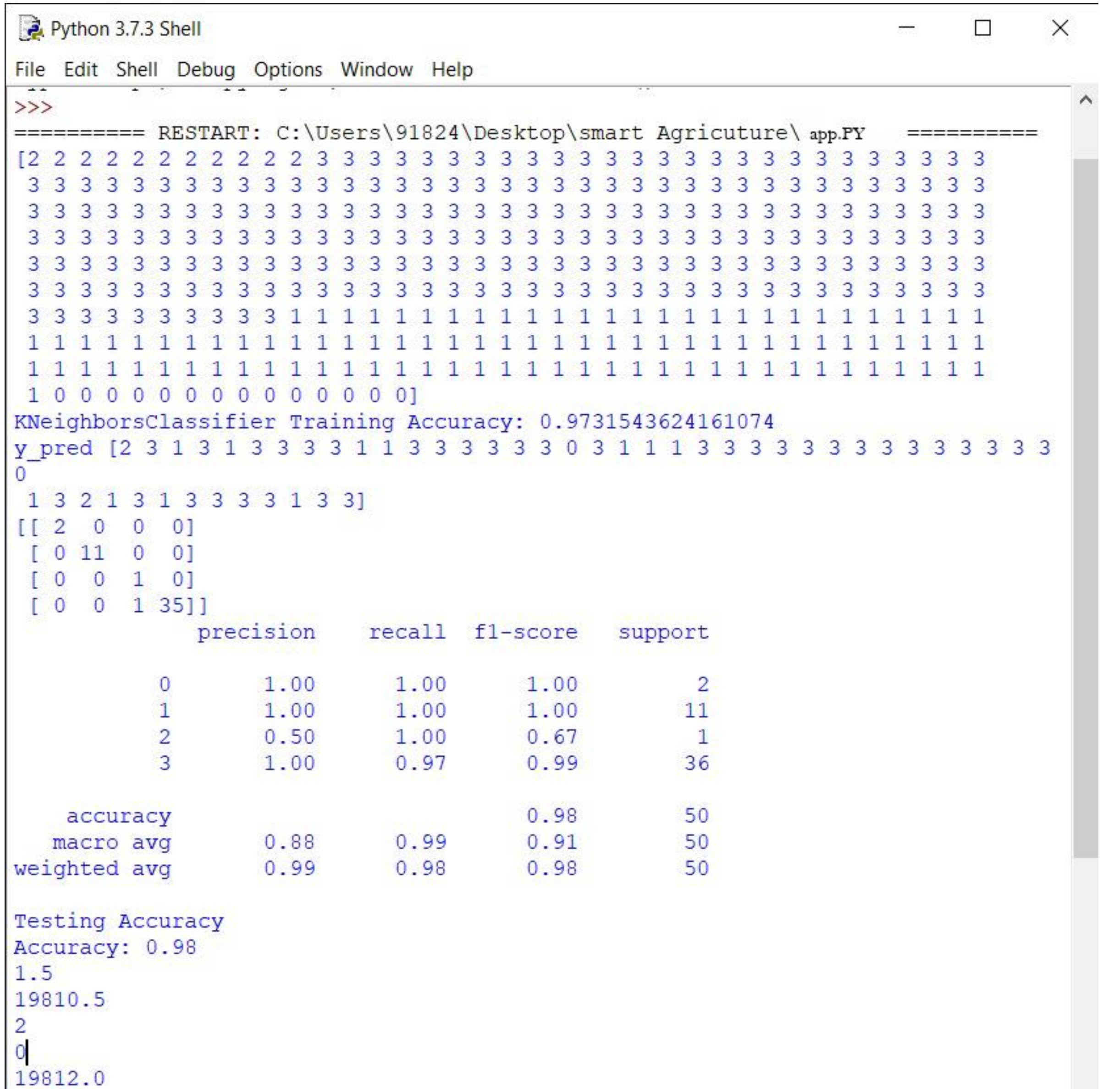


# RESULTS AND DISCUSSION – DATA VISUALIZATIONS



# RESULTS AND DISCUSSION – MODEL ACCURACY



```
Python 3.7.3 Shell
File  Edit  Shell  Debug  Options  Window  Help
>>>
========== RESTART: C:\Users\91824\Desktop\smart Agricuture\ app.PY   ==========
[2 2 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
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 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0]
KNeighborsClassifier Training Accuracy: 0.9731543624161074
y_pred [2 3 1 3 1 3 3 3 3 1 1 3 3 3 3 3 3 0 3 1 1 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3
0
 1 3 2 1 3 1 3 3 3 3 1 3 3]
[[ 2  0  0  0]
 [ 0 11  0  0]
 [ 0  0  1  0]
 [ 0  0  1 35]]
              precision    recall  f1-score   support

           0       1.00      1.00      1.00         2
           1       1.00      1.00      1.00        11
           2       0.50      1.00      0.67         1
           3       1.00      0.97      0.99        36

    accuracy                           0.98        50
   macro avg       0.88      0.99      0.91        50
weighted avg       0.99      0.98      0.98        50

Testing Accuracy
Accuracy: 0.98
1.5
19810.5
2
0
19812.0
```

# DEVELOPMENTS

| EXISTING FUNCTIONALITIES | DEVELOPED FUNCTIONALITIES |
|---|---|
| ❑ Microcontroller – Arduino UNO ATmega328P | ❑ Microcontroller – PIC 16F877A |
| ❑ Sensors – Soil Moisture, Soil Temperature and Humidity | ❑ Sensors – Soil Moisture, Soil Temperature and Humidity, Soil pH and Soil NPK sensors are used |
| ❑ Correlated Parameters – Soil Temperature and Soil Moisture | ❑ Correlated Parameters – Soil Moisture, Soil Temperature, Soil Humidity, Soil pH and Soil NPK |
| ❑ Classification Algorithm – SVM Classifier (87.5) > Naïve Bayes Classifier (76.4) > KNN Classifier(70.8) | ❑ Classification Algorithm – KNN Classifier |
| ❑ ThingSpeak IoT Cloud and web results | ❑ PC LocalHost and Mobile Cayenne Application |

# ADVANTAGES AND DISADVANTAGES

| ADVANTAGES | DISADVANTAGES |
|---|---|
| ❑ PIC microcontroller system is low-cost, reliable and malfunctioning percentage is less. The performance is fast because of using RISC architecture. Power consumption is also very less when compared to other micro controllers.<br>❑ We have embedded almost all necessary sensors at affordable prices.<br>❑ The system works in real-time with updates every 3 seconds.<br>❑ The mobile application myDevices Cayenne is the easiest drop and place IoT solution with in-built and customization features.<br>❑ The upgradation of the system from smart irrigation to smart crop prediction and leaf health status detection through machine learning algorithm KNN Supervised Classifier is successful and works accurately along with the hardware.<br>❑ KNN ML accuracy for crop prediction is 98% and that of leaf health status detection is 97%. | ❑ Low-cost sensors reduce accurate measurements slightly. Hence, with continuous usage, the system loses efficiency and may start deviating.<br>❑ For crop prediction, only 3 crop labels are successfully trained in KNN ML.<br>❑ There is no leaf disease identification in leaf health status detection. |

# APPLICATIONS

- Smart Agriculture using IoT with Machine Learning and Mobile Application is the most smart, advantageous and productive tool functioning as the ‘remote eyes and hands for our farmer’.
- It helps farmers to generate data with the help of sensors and analyze that information to take intelligent and quick decisions in the field to reduce losses and increase yield.
- Agricultural lands
- Greenhouses
- Gardens
- Terrace farming
- Hydroponics and others.

# FUTURE SCOPE

- If any other sensor component becomes necessary and useful, it can be added.
- Mobile application myDevices Cayenne supports multiple devices. Hence, we can add multiple nodes and monitor them, in case the farmer has more than one field.
- We can train the KNN ML model using other crop labels and include leaf disease identification apart from health status detection.
- Various other processes in farming can be automated, UAVs or drones shall be used to enable remote sensing and facilitate 100% automation using Farm AI.

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