# IoT Based Smart Prediction System for Crop Suitability

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***Abstract* - The majority of Indian population resides in villages and depends on the agriculture as their main source of income. Indian agriculture sector shares about 16% in the country's GDP. Day by day the urbanization and industrialization are occupying the lands of agriculture and thereby reducing the land available for the cultivation. In coming days, this may create food scarcity in the country. One of the most important problems faced by the farmers will be lack of identification of cultivation with an appropriate crop depending on the season and type of lands. Type of crops to be grown depends on land, temperature, humidity of the environment, soil moisture etc. Farmers will loose or reduced yield if an appropriate decision is not taken on type of crop. The objective of this proposed work is to develop an Internet of Things (IoT) based smart system that is capable of predicting the types of crops that can be cultivated in a given environmental condition and land. The environmental parameters can be obtained by using different sensors, even the soil moisture can be controlled automatically by controlling the water pump. This will improve by keeping the farmers with productive yields and keeps them motivated.**

***Keywords*— Smart agriculture system, Internet of Things, Crop yield and Crop suitability prediction**

## I. INTRODUCTION

India is a land of agriculture. Even today about 80% of the population in villages of India depend on agriculture. These days most of the people in India prefer to work in government and other sectors rather in agriculture. People started to reside in urban areas moving from villages. This has effected in scarcity of labors available to work in agricultural land. Most of the agricultural land is converting into residential properties. Based on the survey conducted by World Health Organisation (WHO), by 2050 the world population will increase by 50%. These factors reveal that, if farmers do not produce crops proportionately in forthcoming days, there will be a high scarcity of food. Such food demand can be met only by increasing the yield of crop.

Due to lack of information, farmer may choose wrong crop which may not be suitable to grow on particular land and environmental condition. The farmers depend on traditional methods of predicating the weather behavior like temperature and humidity, to decide and may cause loss in the crop yield. Traditional cultivation requires continuous monitoring towards the yield. Minor ignorance may cause loss and the sustainability of crop will be expensive in the agriculture field, such as not maintaining moisture of the soil. The conventional land water system procedures require manual mediation [4]. Farmers are facing problems to find sustainability of crop and pH values. Sometimes land moisture will change the soil texture due to soil disintegration by water, wind and unpredictable rainfall. The advancement in the technology may lead to overcome the problem faced by farmer i.e. smart agriculture using Internet of Things (IoT). Smart Agriculture is automatic monitoring and controlling the land features without intervention of human. The main criterion for cultivating the crops are climate condition, suitable soil to crop or soil type and quality and quantity of water. These three criteria play an important role in agriculture for cropping and can be implemented by a smart agriculture system using IoT [1, 2].

Question may arise why these criteria are important. Climate conditions such as temperature, humidity, sunshine hours are the parameters change for different crops, where every crop has its own parameters. Some crop grows in cold climate and some are in mild hot condition depending upon type of crops. Determining the water quality is very important, for example, sea water or chemical decompose on land may inhibit the growth of plants. So to overcome all these problems smart agriculture system will significantly help during the cultivation stage. Farmers are also facing problem in irrigation that is supplying water to land and smart agriculture system can provide automated watering system [5]. Parameters such as temperature, humidity, water pH and soil moisture can be predicted automatically, without human intervention. The name 'Smart' is offering criteria to control in the setting of goals. Smart agriculture system plays a vital role in agriculture field. It also helps for higher cultivation of crop with help of the sustainability of crop. Determination of water pH value help to maintain the soil alkaline or acidity that leads increase of crop yield. The acidic content is more which inhibits the growth of plants. The smart agriculture system can be implemented with different sensors such as thermal, soil moisture, and pH. The thermal sensor is used to sense the temperature and humidity of the agriculture field [3]. Soil moisture sensor determines the soil moist, if soil is dry then the automatically water pump turns ON and sustainability of soil can be maintained by creating the database with predicted value stored which helps in improve the crop yield. Collected data will be used to predict the sustainability of the crop growth that are suitable with soil result and increasing crop yield to reduce the loss to farmers and less human interference for better fertilization [5, 6]. In today's agriculture field, farmers have adapted the traditional method. The traditional method is of predicting the parameter such as temperature, humidity, soil pH and sustainability of crop [7]. In the traditional prediction human invention should be accurate without negligence, minor ignorance may cause high loss in the field. A farmer has to be in the agriculture field to check soil moist or not, if soil gets dried then farmer has to manually switch ON the water pump motor and then check moisture content and farmer manually has to switch OFF the motor. One of the important factors is sustainability of the crop growth on soil [8-10]. If crop is not suitable for soil then the yield will be less i.e. it will be a huge loss to the farmers.

## II. BACKGROUND AND OBJECTIVES

Recent papers on smart agriculture, technologies based on IOT [11 - 13] have provided research on IoT based smart agriculture architecture and future challenges, however implementation is needed to understand the challenges better. Papers [14-16] have provided review of agriculture data, big data analysis and machine learning techniques, however collection and study of real data from the field is much needed. The proposed work provides a smart agriculture system with crop suitability prediction. Below are the main objectives of the work:

- Collection of the temperature of the environment where crop will be cultivated.
- Collection of moisture level of the soil by using soil moisture /soil wetness sensor.
- Collection of pH level of the water.
- Prediction: Use above parameters along with crop suitability table to predict the suitable crops in such conditions.
- Decrease human Intervention by maintaining the required moisture level

The implementation of new technologies and innovations in agriculture area is as an alternative to collect and process farm information manually. The expeditious development of Wireless Sensor Networks (WSNs) has triggered the design of low-cost and small sensor devices with the Internet of Things (IoT) empowered as a feasible tool for decision making and automating the domain of agriculture. The project is being implemented using IoT and a database that gives the crop suitability parameters such as thermal, soil moisture and water pH. The project is being implemented using IoT and a database that gives the crop suitability using the parameters such as temperature, humidity, soil moisture and water pH. Particular sensors can be used which gives correct values of these parameters. A controller unit, namely, Raspberry Pi has been used to interface all the sensors and collect the parameters. A database is built that gives the range of these parameters for a particular crop.

## III. PROPOSED SYSTEM

This section discusses the design of an automated system as per the objectives framed. Design of any project is one of the very important aspects. The correct design will result into correct implementation and in turn correct and expected result. In this section, modular design of the project has been discussed in detail.

Fig. 1 shows block diagram of smart agriculture system using IoT. The design consist of Raspberry Pi 3 model B+ chip and three sensors known as Temperature & humidity sensor, soil moisture sensor, and water pH sensor. The IoT is combination of embedded system and networking. Raspberry Pi is a Linux embedded system which collects the information from the different sensors, process the data and estimate the real valued data, which can be viewed by browsing in website. The data provided by the sensor share the data within network. The sensors are located in different place, where they collect the data from surrounding environments. The temperature sensor senses the data from the surrounding area of agriculture around 10 meters. The pH sensor senses the data from surrounding area to detect the soil alkaline or acidic which will help for the sustainability of crop. Temperature sensor and soil pH sensor data are provided by the Raspberry Pi chip through the Internet. Data will be processed and provide the predicted data. Soil moisture sensor senses the soil damp. If the soil is not moist enough for a particular crop, automatically water pump motor is switched ON to the soil until the soil reaches a particular moist condition for the crops, else motor is off. Raspberry Pi chip processes information accurately without human interprets which crop yield increase. The main reason for the system is to increase more crop yield, while selecting the suitability of crop.

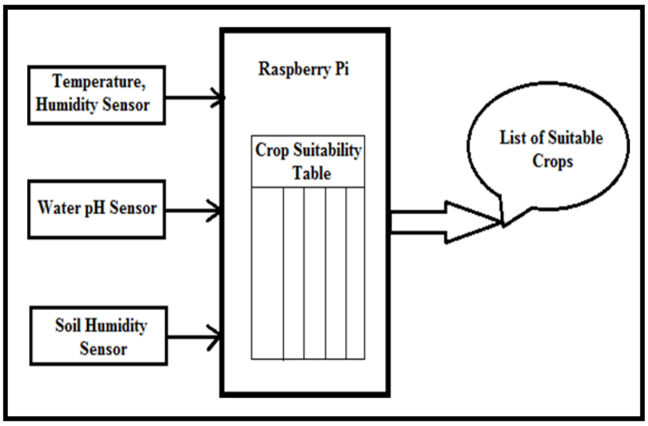



Fig. 1. Smart agriculture System with crop suitability

Sustainability of crop growth is the main goal of this system, by predicting values accurate to estimated real value. The predicted values will be stored in the database that compare with sensed processed data. If the both values are matched then crop growth is sustainable for soil and produce higher crop yield. Data are displayed on screen which can be browsed through the mobile or laptops or any browser site. Webpage is programmed in PHP and HTML. Initially user name and password is displayed for login page. Current parameter is generated and stored in sustainability link. The sustainability compares stored data with current parameter. Integration of sensors with Raspberry Pi will be discussed with relevant interfacing diagrams in following section.

### *A.* TEMPERATURE SENSOR INTERFACE

Fig. 2 shows the interface of temperature sensor, DHT11, with Raspberry Pi-3. The temperature sensor senses the temperature and humidity of the surrounding area. The four pins of DHT11 are VCC, DATA, NC, and GND. The VCC is connected to power supply +5V of Raspberry Pi chip. Data provides the sensed data, that is connected to general purpose input/output pin number 12 in Raspberry Pi. NC is not connected to Raspberry Pi and last pin is GND know as ground connected to pin number 14 in Raspberry Pi. The circuit diagram shows the interfaces between the raspberry pi and temperature sensor.

The Pin NC is basically analog output. This pin can be used to get the level of moisture in the soil. Some of the DHT11 have only three pins which do not include analog output pin. So this pin can be neglected if the output is sufficient from digital output.

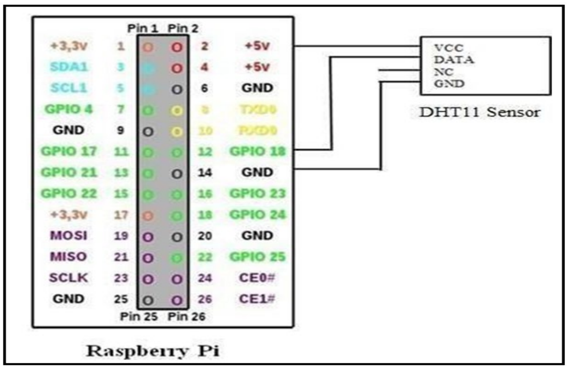



Fig. 2. Interfacing Temperature and Humidity Sensor to Raspberry Pi

### B. SOIL MOISTURE SENSOR INTERFACE

The circuit diagram shown in Fig. 3 is soil moisture sensor. It is interfaced to Raspberry Pi and soil moistures sensor is connected to amplifier which converts low input to high input. The amplifier has four pins VCC, GND, A0, and D0. The VCC is connected to power supply pin number four of Raspberry Pi. GND is ground connected to pin number 6, A0 is the analog signal connected to CH1 of MCP3008 chip and D0 is digital signal connected to general purpose input/output of Raspberry Pi chip. The MCP3008 converts analog to digital signal, it has 16 pin where pin number 16 and 15 combing to +3.3 Volt of Raspberry Pi, pin 14 and 9 connected to GND of Raspberry Pi, MCP3008 pin 13 CLK connected to SCLK of Raspberry Pi, Dout connected to MISO, Din pin connected to MOSI, and pin 10 connected to CED of Raspberry Pi.

### C. pH SENSOR INTERFACE

Fig. 4 shows the circuit diagram of the pH sensor module interfaced to Raspberry Pi using MCP3008. The interfacing MCP3008 has been already discussed in previous sections. The VCC is connected to Power supply of pin 4, GND is ground connected to pin 14 of Raspberry Pi and Pin OUT is connected to PIN1 CH0 of MCP3008. The MCP3008 converts analog to digital signals. It has 16 pins where pin number 16 and 15 are connected to +3.3V of Raspberry Pi, pin 14 and 9 are connected to GND of Raspberry Pi, MCP3008 pin 13 CLK is connected to SCLK of Raspberry Pi, Dout is connected to MISO, Din pin is connected to MOSI, and pin 10 is connected to CED of Raspberry Pi.

Implementation of the project details are as follows. There are basically two parts in the implementation: hardware and software; but these two have been implemented hand in hand. The total implementation details have been discussed using flow diagrams. Before discussion of every module implementation, it is necessary to glance on database used.

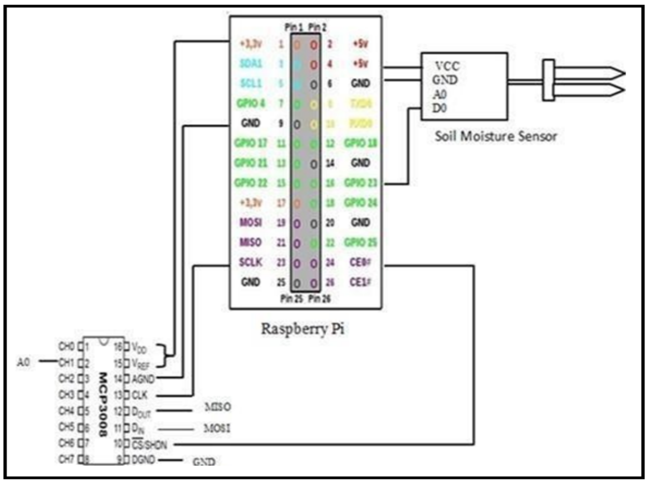



Fig. 3. Interfacing Soil Moisture Sensor to Raspberry Pi

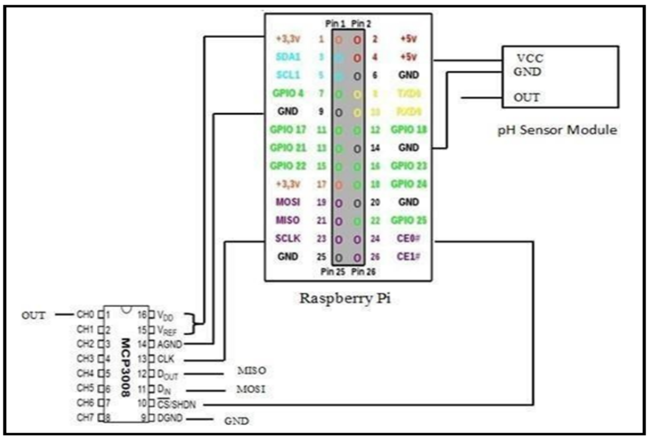



Fig. 4. Interfacing pH Sensor to Raspberry Pi

### D. MYSQL – DATA BASE SYSTEM

Crop details and its required environmental parameters are stored in a database. The database size depends on the number of crops and their details. The environmental parameters to be stored are temperature, humidity, pH value and soil moisture. MYSQL is one of the open-source environments that is used to design database system. This information can be maintained by agricultural department or any government sector. The agricultural experts can decide the favorable environmental parameters for a particular type of crop. Table I shows the database of some of the crops.

TABLE I. CROPS SMALL DATABASE EXAMPLE

| Sr. No. | Name of the Crop | Humidity | Moisture | pH Value | Tempre (in deg Cel.) |
|---|---|---|---|---|---|
| 1 | Rice | 85 | 14 | 5.5 | 20-27 |
| 2 | Cotton | 95 | 5 | 6 | 21-37 |
| 3 | Coriander | 70 | 15 | 6.2 | 10-30 |
| 4 | Melon | 50 | 83 | 6 | 30-45 |

## MAIN FLOW DIAGRAM

Fig. 5 shows the flow diagram of the smart agriculture system. Sensors are placed in different locations on the agricultural field. Three important modules in the implementation are temperature module, soil moisture module and pH module. The data collected by these modules are collected in the database.

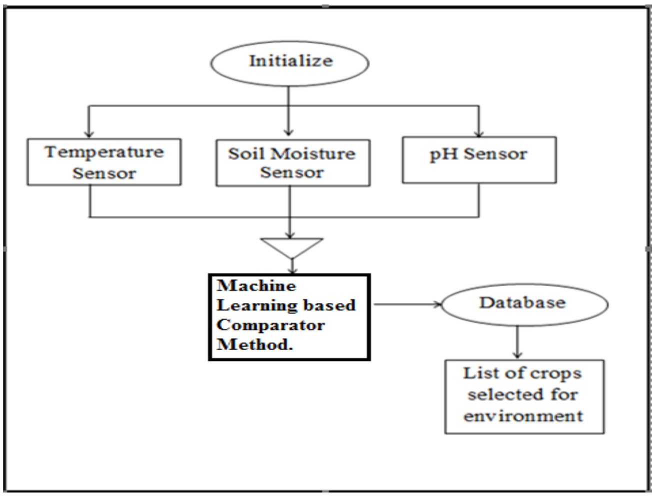



Fig. 5. Complete Flow of smart agriculture system

The temperature sensor module senses the temperature along with the humidity of the environment. Soil moisture sensor senses the water content in the soil and send the details to database. pH sensor senses the pH value of the water and same are updated on to database. The sensed data is sent to the central server where it will compare against all the crop parameters and lists all the crops suitable to grow as per the present sensed values. The sensed data is merged, processed and compared with available data in the database. The machine learning based comparison method is used to compare with predefined data set [9]. If any one of sensed data is not match then it displays zero crops are selected.

## IV. RESULTS AND DISCUSSION

It is very important to test the prototype/ algorithm/ methodology after the implementation. The proper tests can only ensure the correct working of the developed system. This section discusses the tests conducted and the results obtained against each of those tests. Prototype miniature of the proposed system is explained herewith. The tests are carried out using the manually increasing/decreasing the temperature, soil moisture and the pH values. Fig. 6 shows the implementation of the complete system. As it is miniature model, soil moisture is tested using the small portion of the soil as shown in the Fig. 6. The small submersible pump is used to irrigate the soil.

Referring to the Fig. 6, it has all three modules connected to the central controlling unit, Raspberry Pi. The complete project has been built using the concept of IoT. The software part at the back end has been developed using the Python and the front end has been developed using the html and PHP. A apache server is used in central server computer system for getting the service of the crop suitability.

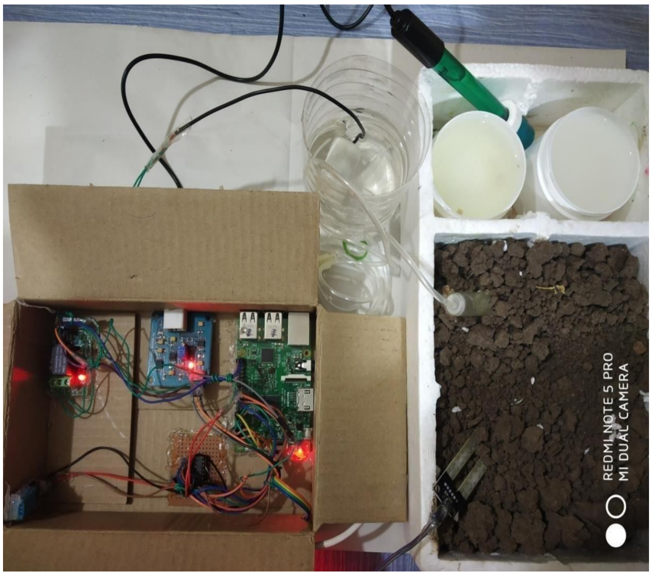



Fig. 6. Smart Agriculture System

The testing starts with front-end design of the central database server. Login page of the smart agriculture system has two fields for entering the user-name and password. To test the system, the server is located locally and can be accessed using the IP address 192.168.43.110. After submitting the correct credentials, user is given access to web page, to get the present environmental parameters.

Webpage has two links namely, “present parameter” and “check suitability”. The present parameter link displays the environmental parameters of the crop field. The second link checks the suitable crops for the present environmental condition.

ph value = 7.32299804688
Temp= 31.0C Humidity = 51%
Water Content (in %) = 0.9765625
Moisture absent

Fig. 7. Environmental parameters showing absence of moisture in soil

Upon clicking on the “present parameter” link, Raspberry Pi activates all the sensors connected to it and sends the value to the database server system and same will be displayed on to the user screen. User can access the server either using computer or smart phone through Internet connection. Webpage as shown in Fig.7. shows the values of present parameters i.e. temperature, humidity, pH and moisture content levels. The moisture absent, indicates that the required moisture level is not present in the soil of the field. This automatically triggers the water pump to ON mode till the soil reaches required moisture level.

Once the motor or water pump is ON, switches OFF automatically, only after reaching the required soil moisture level. This particular feature helps the farmers to the great extent. Because of the electric power shortage, farmers will get the electricity only for about 4 to 6 hours per day. Even such power supply will be round the clock of 24 hours. In present situation, limitation of the electricity supply in a day, farmers are disadvantageous. They should wait even during night to switch the water pump manually. But by adopting this system, farmers need not have to worry about watering the land. The water pump will switch automatically based on the moisture requirement. If there is no electricity at that time, the water pump will switch ON whenever electric supply is present.

The presence of soil moisture is in percentage; 100% moisture indicates presence of water on the top of land and 0% indicates no water content at the required level inside the soil. To test water content variation and its sensitivity, more water has been added and the readings taken. Fig. 8 shows the screen-shot taken after adding more water to soil than the previous test. Here, one can observe the increase in moisture level.

ph value = 76.94702148438
Temp= 31.0C Humidity = 51%
Water Content (in %) = 0.9765625

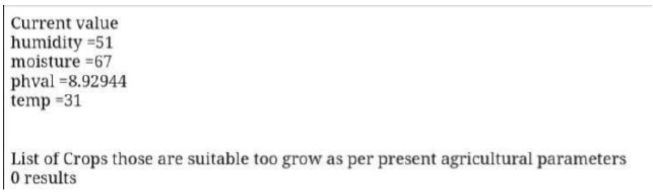
Fig. 8. Screen-shot taken after adding more water

Fig. 8 shows the pH value of acidic water. As discussed earlier, the pH value is very important to decide the proper growth and the yield of the crop. In the test carried out, the pH value has been varied by adding lemon juice and alcohol into the water.

Referring to the Fig. 9, the pH value is around 3.77 which indicate the acidic water. The acidity of the water can be changed by adding the substances like washing powder, and baking powder. The screen-shot taken after adding the enough base chemicals.

ph value = 3.77115885417
Temp= 31.0C Humidity = 51%
Water Content (in %) = 67.87109375

Fig. 9. Screen-shot showing the acidic pH values


Current value
humidity =51
moisture =67
phval =8.92944
temp =31

List of Crops those are suitable too grow as per present agricultural parameters
0 results

Fig. 10. Screen-shot showing basic water

Referring to the Fig. 10, the pH value of water is basic (pH less than7). As discussed in pH sensor, the pure/distilled water is neutral with respect to alkalinity.

The pH value of distilled water is 7.0. Adding the chemical substances like baking soda and washing soda will increase this value. Whereas adding chemical substances like lime juice will decrease this value. In all the screen-shots of Fig.10, one can observe the values of temperature and humidity also. These parameters have been recorded by changing the temperature level and water content of the area surrounding the sensor.

The second link of webpage can be used to check the suitability of the obtained environmental conditions for different crops. After clicking on the link "check suitability", the controller will take the present environmental parameters and starts the comparison process. This is done against every row, nothing but crop, of the database system.

Fig. 11 shows the message of 0 results. This indicates that there are no crops those can be grown on this environmental condition. Reason for this is the pH value of water, which is 3.7. The pH of 3.7 indicates high acidic water. In such water no plant can grow and even plants roots will destroy in higher acidic water.


7:38 PM
192.168.43.110/check.php
Current value
humidity =51
moisture =67
phval =3.72843
temp =31

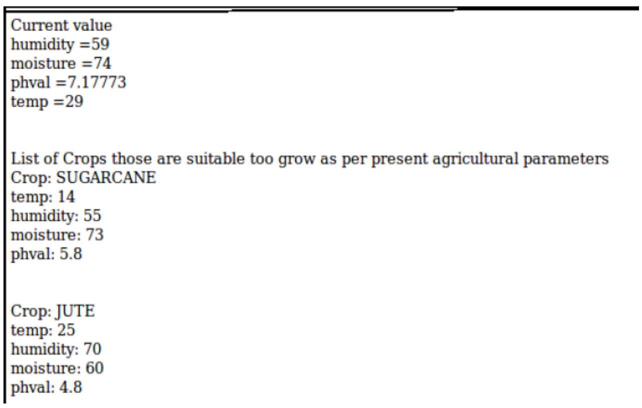
List of Crops those are suitable too grow as per present agricultural parameters
0 results
back

Fig. 11. No matching crops because of acidic water

If the pH value of the water is high then also no crops can be grown. The high pH value makes the soil granular and will be hard to cultivate.

Referring to the screen-shot of Fig. 12, the pH is value 8.9 which indicates basic water. Due high pH value plants cannot grow easily in such soil. A pH test of a soil indicates whether the land can produce good yield of the crop or not. For most of the plants favorable pH value will be in between 5.5 to 7.0. But still some of the plants will grow in little more acidic or alkaline soil or water. Even the pH value of soil directly depends on the pH value of the water used for irrigating the land.

Fig. 12 show the screen-shot of matching the crops for given environmental parameters. There are many crops listed for the given parameters, where humidity is equals to 59, moisture is 74%, pH value is 7.1 and temperature is 29 degree Celsius. The values given in the Fig. are best suitable for the many plants. Growth of plants will be good in such conditions and it increases the yield of the crops grown. If the crop is not listed in this list, growing such crop will result either reduced yield or total loss.


Current value
humidity =59
moisture =74
phval =7.17773
temp =29

List of Crops those are suitable too grow as per present agricultural parameters
Crop: SUGARCANE
temp: 14
humidity: 55
moisture: 73
phval: 5.8

Crop: JUTE
temp: 25
humidity: 70
moisture: 60
phval: 4.8

Fig. 12. Matching of present parameters with many crops

Fig. 13 shows partial list of database stored on the central server. It consists of crops with fields of parameters humidity, temperature, pH value and water content. These dataset are collected from various sensors. This database can be increased to add all the crops with their environmental parameters.

| sln | name | humidity | moisture | phval | temp |
|---|---|---|---|---|---|
| 0 | Present_Value | 59 | 74 | 7.17773 | 29 |
| 19 | WHEAT | 60 | 14 | 6 | 21 |
| 20 | RICE | 85 | 14 | 5.5 | 25 |
| 21 | CORN | 95 | 25 | 5.8 | 10 |
| 22 | SUGARCANE | 55 | 73 | 5.8 | 14 |
| 23 | COTTON | 95 | 5 | 6 | 24 |
| 24 | JUTE | 70 | 60 | 4.8 | 25 |
| 25 | coconut | 80 | 30 | 5.5 | 27 |
| 26 | JOWAR | 25 | 62 | 7.18343 | 32 |
| 27 | RAGI | 90 | 40 | 7.3 | 27 |
| 28 | COFFEE | 50 | 12 | 5 | 25 |
| 29 | CASHEWS | 70 | 60 | 6.3 | 10 |
| 30 | TABACCO | 60 | 16 | 5.5 | 20 |
| 31 | MUNG BEANS | 80 | 12 | 6.2 | 27 |
| 32 | SUNFLOWER | 70 | 15 | 6 | 70 |

Fig. 13. Database list

## V. CONCLUSION

This research work has good scope in agriculture area particularly in India[10]. There will be a high demand for the crop production as the percentage of agricultural land decreasing every year. The decrease in the land is the direct reason of urbanization and the industrialization. If agriculture is not cultivated systematically, the food production will decrease and the country will no longer provides good life for the citizen.

The proposed method can be used to increase in good yield for the selected crop. This automated smart system will suggest the crop as per the present environmental conditions. If adopted properly, this system will increase the yield of the crop, making farmers to have profit. The automatic control of moisture level of the soil is added advantage of the proposed system. This system requires less human intervention. If human intervention is decreases, in turn decreases the maintenance and labor cost. Raspberry Pi works accurately and controls all the sensors. Sensors are used to measure surrounding parameters that are made out of electronic equipments which provide accurate results than the manual prediction. The prediction of crop totally depends on the sensor values. If database is constructed accurately after consulting agricultural experts, this system benefits the farmers and in turn the country's economic growth.

## VI. FUTURE SCOPE

The proposed system has been implemented considering only one sensor per parameters. When adopted this system in practical use, a single sensor cannot produce correct results. This can be solved by using many sensors as per the available area. The number of sensors and the distance between sensors need to be calculated for accurate results. Future work will focus on data analytics of big data collected from multiple sensors. Future work will also be extended on collection of data from multiple sensors with Software Defined Network (SDN) approach, where SDN provides flexibility in handling big data and mitigates many challenges such as machine learning, Artificial Intelligence (AI) use, network bandwidth, computational power and most importantly security of data [10].

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