Applications of IoT for Soil Quality

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Abstract. The farming industry has become more important than ever before in the next few decades. Farmers and agricultural companies are turning to the Internet of Things (IoT) to meet demand. Since we need to continuously take measures manually it requires large amount of time. So using this Smart Agriculture we can effectively take the measurements in less amount of time. In this Smart Agriculture sensors can provide continuous measurements with respect to climate changes. Using Internet of things we can produce different ways to cultivate soil. Smart Agriculture and Smart Farming applications will help the farmer with 24/7 visibility into soil, crop health, and energy consumption level. This paper presents how to analyze soil moisture levels, soil type and soil quality according to the water and climate change. By considering all this factors, farmers can decide which type of crop is suitable for the particular soil to get profit instead of using traditional lengthy methods, and how much fertilizers have to use according to nutrients level in soil.

Keywords: IoT · NodeMCU · Smart agriculture

1 Introduction

Our country produce crop production with the foremost food staples. The farming industry is going to become very important in upcoming years. According to the UN Food and Agriculture Organization the world has to produce 70% more food in 2050 than 2006 [14]. In India agriculture system the continuous assessment for soil quality, type, evapotranspiration, and moisture levels are not done. Farmers need to take help of the soil department to know about features of soil [17, 18]. IoT is one of the technology which can provide a solution for this problem, which aims to extend system with more features. This paper presents to monitor soil moistures and consider different sensors to collect the data. Sensors are to be connected to the device through WiFi module and data which is retrieved from the sensor can be stored in the server or cloud. Later on the sensor data, data analysis has to be performed. From this analysis farmer can decide which crop can be choose according to the soil and climate change.

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2 Literature Review

In our country many ongoing methods are done manually to check the soil status. Doing manually the time consumption would be more for the larger areas. So to overcome these applications of e-agriculture were developed which were based on the Knowledge base for the framework [1]. Farmers need to use every possible opportunity to optimize production efficiency, other challenges and monitoring yields. One reason to reduce crop yield and quality is stress in water. To get effective crop production farmer has to maintain sufficient water in the root zone. Irrigation has become an important risk management tool farmers. A perfect study of soil moisture management is a key for farmers to take irrigation management decisions. Best approach for optimal root zone soil water management includes irrigation water maintenance and soil moisture maintenance. Advancements in soil moisture maintenance technology makes it a cost effective risk management tool [11]. Plant growth is depending upon sunlight, heat, air, water, and nutrients. All of these factors expect light are supplied in some degree by the soil. Different soil quality testing has to be done for the selection of the crop for the outright of the soil. By doing this step initially the right crop can be selected without any delay and effect crop growth is noted [10, 19]. Factors that affect the potential evapotranspiration, if water is readily available from soil and plant surfaces, are: (i) Solar radiation, (ii) Temperature, (iii) Humidity, (iv) Wind. Thermal Sources that cause water to evaporate from the field surface are Solar radiation and Temperature. The amount of heat energy needed to cause water to pass from a liquid to a gaseous state is called the latent heat of vaporization. Motion of air and Humidity are the aerodynamic forces which influence on the evapotranspiration. Humidity affects the vapor pressure grade of the atmosphere and wind mixes, and alters the vapor pressure grade. The total available water capacity is the portion of water that can be absorbed by plant roots. The amount of water available, stored, or released between the original field capacity and the permanent wilting point water contents. The average amount of total available water in the root zone for various soil types is given in the table below [15, 20].

Different Soils and Water holding capacity

Soil Type	Total Available Water, %	Total Available Water, In./ft
Coarse sand	5	0.6
Fine sand	15	1.8
Loamy sand	17	2.0
Sandy loam	20	2.4
Sandy clay loam	16	1.9
Loam	32	3.8
Silt loam	35	4.2
Silty clay loam	20	2.4
Clay loam	18	2.2
Silty clay	22	2.6
Clay	20	2.4
Peat	50	6.0

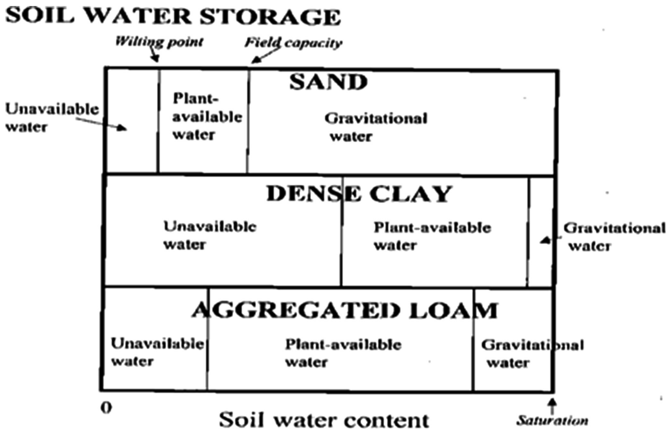


Fig. 1. Soil water storage

The above Fig. 1 shows an a visual representation of how various soil water storage parameters may be influenced by different texture and structure aspects.

We have to focus on the Transudations of carbon in soil which is occurred from different farming methodologies. The Transudation of carbon in soil and modern farming are the factors to create variations in climate and increasing the rate of biodiversity loss that is already spread though out the world [7]. The Transudations of the modern farming is relative cultivation practice and type of crop which is generated from three sources, which are fertilizer application, pesticides and irrigation [8]. Major reasons for low production levels are soil problems only. With little knowledge of soil problems, farmer will apply inefficient remedies. That will lead to get loss. To get profit farmer need to understand basic soil problems, those are 1. Soil lacking organic matter, 2. Soil too dry, 3. Soil too wet, 4. Soil acidic, 5. Soil alkaline, 6. Soil with excess salinity (Salt content) or Sodicity (sodium content) [9].

If we put soil moisture sensor into the soil, it displays percentage of water available in the soil on with the help of LCD [21]. Sensor data received from the sensor will be transmitted to the Raspberry Pi, them it will be uploaded to the cloud. If the soil is dry it gives 0% breading. If the water supplied to the soil then the readings will be increased [6]. Instead of using LCD directly we can upload the data in cloud. Then we can see the uploaded data in mobile app as well as in personal computer or laptops. Instead of collecting data only 4 times a day, continuously we can collect the data with some time gap. As mentioned in [6] instead of collecting only water levels if it find out type of soil it will be easy to rectify which crop is suitable for particular soil to get profit [22].

3 Different Sensors and Their Working

Several types of sensors are commercially available: Time Domain Reflectrometry sensor (TDR), this sensors gives the output in the form of the waves and this can be used to calculate the average of moisture content. Frequency Domain Reflectrometry (FDR), in this sensor the frequency-dependant electric and dielectric are kept in contact to each other. The properties of soil, natural products, snow, wood, etc. the moisture content can be checked with the help of this sensor [2]. Amplitude domain reflectrometry sensor

(ADR), can be used to measures the Soil water content [3]. Phase transition edge sensor (PT), this is used to check the temperature dependent resistance for the regulation of the phase transition [4]. To detect the deficiency of the nutrients Nitrogen (N), Phosphorus (P), and Potassium (K) in the soil NPK sensor is developed. The sensor is fabricated which has concentric arrangement of source and receiving fibers. It is based on the colorimetric principle where absorption of light by a solution results in variation in the output of the sensor. The advantage of this sensor is to reduce the undesired use of fertilizers to be added in the soil. Farmer can properly select the fertilizer quantity to be used for reducing the deficiency in the soil at a particular field [13]. With a portable sensor the measurements can be collected at different locations, we have to keep the sensor deeper in to the soil. Stationary sensors can be placed at several preordained and deeper locations. We have to place the stationary sensors in different locations where the soil can hold water characteristics. The primary functions of soil water holding capacity are soil texture and soil organic matter content. Both can be affected by the climate change and temperature, and can vary sententious within a single field. Different soil textures can hold the water with different capacity (Figs. 2, 3 and 4).

Fig. 2. TDR sensor

Fig. 3. FDR sensor

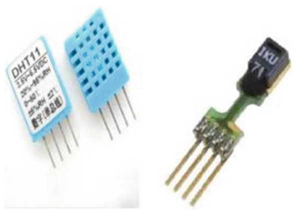
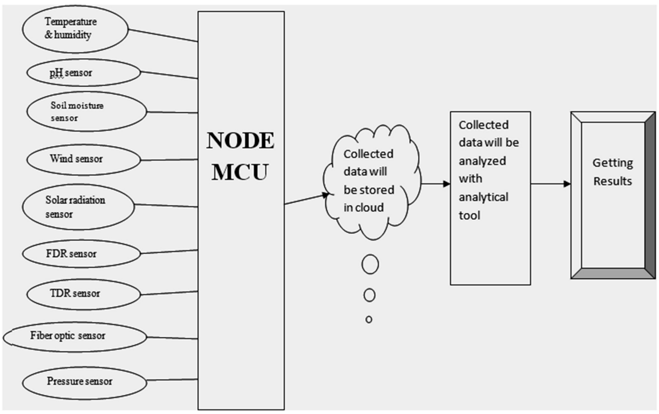


Fig. 4. Temperature and humidity sensor

3.1 Connection of Sensors to Node MCU



Node MCU is a firmware which is open-source on ESP8266. The numbers (16, 4, 5) are GPIO pin numbers and pins are named as Do, D1, D2, … D8. It is also considered as the part of the main source code. The Fig. 5 shows the picture of Node MCU which consists of pin. All the sensors are connected to the node MCU and the sensor data which is received at the node MCU can be either stored in the server or the cloud. Later sensor data can be collected and stored in cloud for the data analyzation. The sensor data analysis can be done using the analytical tool like R. Here while the sensors are connected to the node MCU and connection between the node MCU and cloud should be maintained. If at all any of the connection is lost data may not be obtained correctly and the predictions goes wrong. Hence to avoid this during the processes check the connections perfectly at initial stage. After the completion of the data analysis the notification is sent to the farmer or the registered members about the soil at which conditions it is in [16].

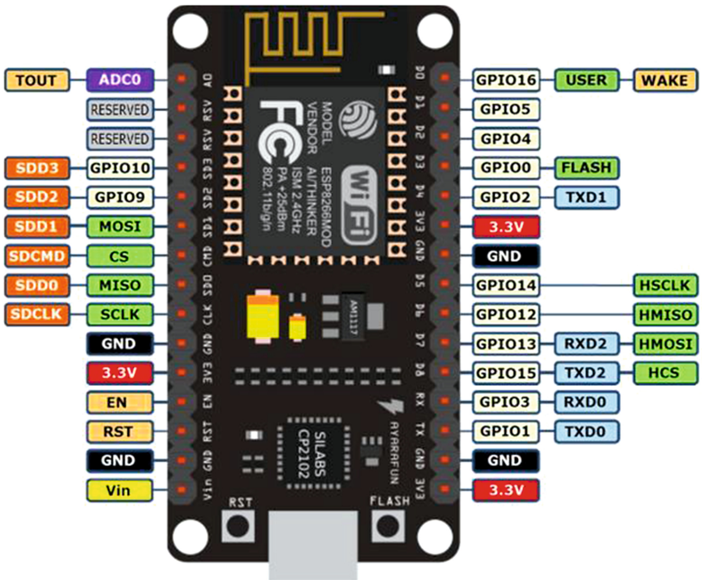


Fig. 5. NodeMCU pinout

Systematic Overview Design

The diagram shows the overall design of the system Data input controller is collecting the soil data through sensors using wifi module and NodeMCU. The collected data can be analyzed on cloud platform and that data is presented in the form of charts and in csv file as values are stored in the cloud. The mobile application also has been implemented to make easy access of data which is connected to the cloud platform. The user can be able to see the result of analyzed data (Fig. 6).

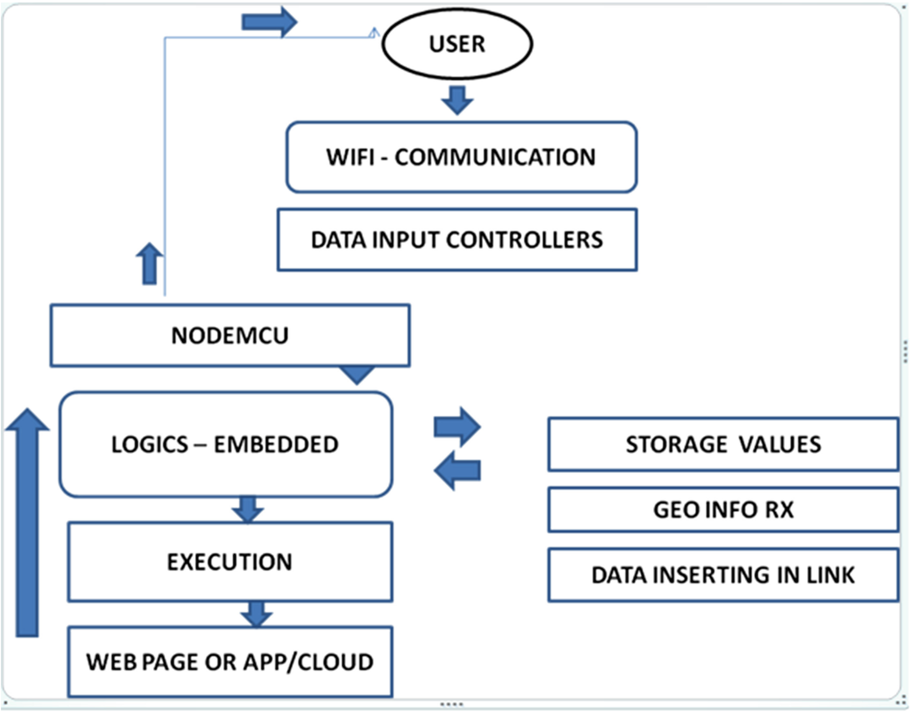


Fig. 6. Systematic overview design

Trained Data: Dataset which we upload gets displayed in the form of table (Fig. 7).

SNO	SOILNAME	SOIL MOISTURE	TEMP	HUMIDITY	PH	CROPTYPE
1	RED	50	20	50	4	WHEAT
2	BLACK	75	24	70	6	COTTON
3	RED	60	30	60	7	RICE
4	BLACK	45	21	45	5	OIL
5	LATERITE	70	25	40	5	COCONUT

Fig. 7. Trained data

Sensor Data: The values which are retrieved from the sensors are transferred to Arduino from there to the database and eventually on to the webapp. These results are now been displayed in the form of following table (Fig. 8).

SOILMOISTURE	PH	TEMPERATURE	HUMIDITY
56	6	22	70
58	4	23	65
60	5	24	68
55	7	25	54
45	8	25	49
65	9	24	60
70	5	26	55
65	4	23	65

Fig. 8. Sensor data

Crop Prediction: Finally, if we use analytical tool we can do analysis on the values that were obtained from the sensors previously and the recommendation of the crop is displayed which is further stored under the results (Fig. 9).

SNO	SOILNAME	SOIL MOISTURE	TEMP	HUMIDITY	PH	CROPTYPE
1	RED	50	20	50	4	WHEAT
2	BLACK	75	24	70	6	COTTON
3	RED	60	30	60	7	RICE
4	BLACK	45	21	45	5	OIL
5	LATERITE	70	25	40	5	COCONUT

Fig. 9. Choose the crop type with the help of sensor data analyzation

Graphs

See Fig. 10.

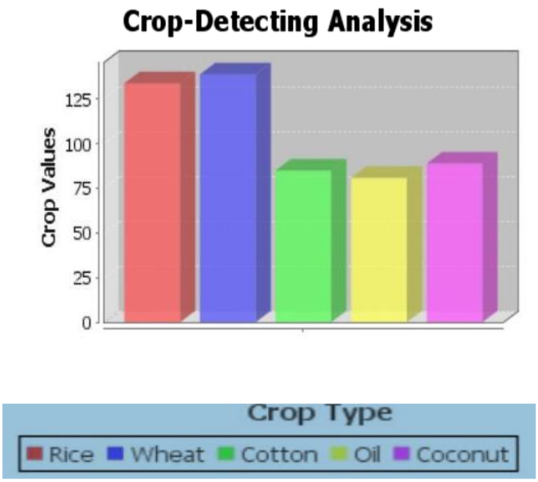


Fig. 10. Bar graph

Data Analysis: We can do analysis in the form of graph also like shown in the following Fig. 11.

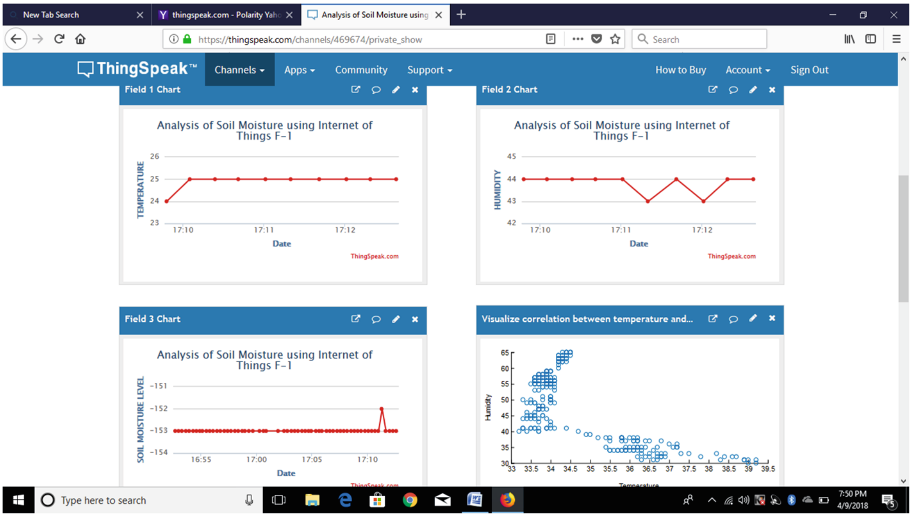


Fig. 11. Data analysis graph

4 Conclusion

Smart agriculture can be made with more accurate and efficient with IoT enabled technologies. This survey tells about what all the problems farmer is facing with soil according to the climate change, aspects that affect the evapotranspiration, plant growth factors, soil problems, how to connect different sensors to the controller, how to collect sensor data, how to store data in cloud, how to analyze data and what all the benefits farmer going to get. With the help of soil moisture levels, soil type, soil quality, and water quality according to the climate change farmers can decide which type of crop is suitable for the particular soil to get profit instead of using traditional lengthy methods and he will come to know how much fertilizers he has to use for the particular field to reduce the deficiency in soil according to the Nitrogen, Phosphorus, and Potassium levels.

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