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# LOW COST IOT BASED SMART AGRICULTURE SYSTEM

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**Abstract**
In this project, we are going to build a Smart Farming System using IoT. The objective of this project is to offer assistance to farmers in getting Live Data (Temperature, Humidity, Soil Moisture, Soil Temperature) for efficient environment monitoring which will enable them to increase their overall yield and quality of isture sensor, Water Pump, and 12V led strip. When the IoT-based agriculture monitoring system starts, it checks the Soil moisture, temperature, humidity, and soil temperature. It then sends this data to the IoT cloud for live monitoring. If the soil moisture goes below a certain level, it automatically starts the water pump. We previously build Automatic Plant Irrigation System which sends alerts on mobile but doesn’t monitor other parameters. Apart from this, Rain alarm and soil moisture detector circuit can also be helpful in building Smart Agriculture Monitoring System.

**Keywords** : Internet of things, Soil nutrients, Colorimetric principle Sensor network, Fuzzy system.

## 1. INTRODUCTION

Agriculture is the unquestionably the largest livelihood provider in India. With rising population, there is a need for increased agricultural production. Over the past 15 years, farmers started using computers and software systems to organize their financial data and keep track of their transactions with third parties and also monitor their crops more effectively [1]. In the Internet era, where information plays a key role in people's lives, agriculture is rapidly becoming a very data intensive industry where farmers need to collect and evaluate a huge amount of information from a diverse number of devices (eg., sensors, faming machinery etc.) in order to become more efficient in production and communicating appropriate information [2].

## 2. RELATED WORK

The term "Internet of Things" refers to the connection of objects, equipment, vehicles, and other electronic devices to a network for the purpose of data exchange (IoT). The Internet of Things (IoT) is increasingly being utilised to connect objects and collect data. As a result, the Internet of Things' use in agriculture is crucial. The idea behind the project is to create a smart agriculture system that is connected to the internet of things. This system's microcontroller is a Raspberry Pi. The temperature and humidity in the surrounding region, as well as the moisture level of the soil, are monitored using the NPK and soil moisture sensor. The data will be available on both a smartphone and a computer. As a result, Internet of Things (IoT) and Raspberry Pi-based Smart Agriculture Systems have a significant impact on how farmers work. It will have a good impact on agricultural productivity as well.

**3. PROPOSED FRAMEWORK**

It should utilize minimum resources in terms of hardware and value. This overcomes the manual operations required to observe and maintain the agricultural farms in both automatic and manual modes. It should be able to measure the rise or decrease in level of water yet as moisture within the soil.

**4. EXPERIMENTAL RESULTS**

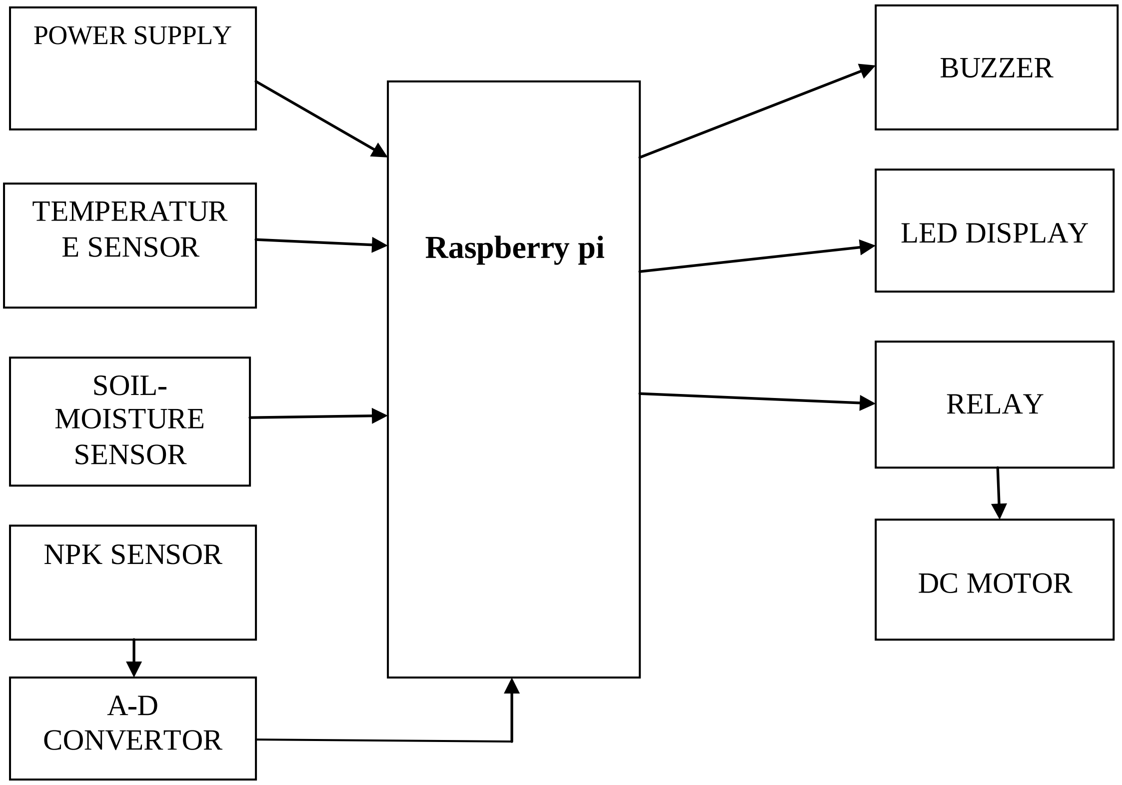


**Fig . 1** Block diagram of smart agriculture system.

This section discusses the results of designed NPK hardware sensor node and the simulationof the proposed system in Qualnet 4.0 simulator.

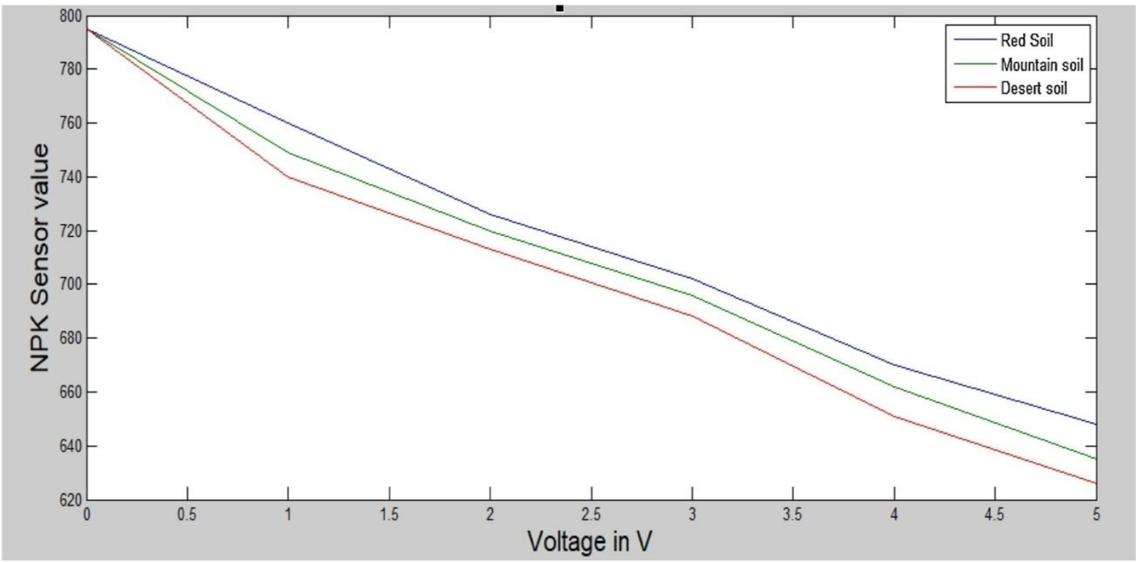


**Fig.2** Output of NPK sensor with voltage levels

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First, the NPK sensor is tested by varying the voltage of LEDs in the sensor. A sample soil solution in the ratio of 50 g of soil with 100 ml of water is taken for conducting the test. This test is carried out to prove that the sensor works according to Eqs. and mentioned in Section 3.1 By varying the voltage level from 0 V to 5 V to the NPK sensor, the output of the sensor also varies. It is shown in Fig.2 that the value of the sensor is declining proportionately as the voltage increases. This confirms that the designed NPK sensor performs its duty according to Beer-Lambert law.

Second, the NPK sensor is tested for nutrients level by varying the concentration of soil solution in order to prove the implemen- tation of colorimetric principle.

This test is conducted by providing an input of 5 V dc for three different variety of soil namely, red soil, mountain soil and desert soil. Fig.3 shows the NPK sensor value for the different type of soil with respect to the concentration of the soil solution.

It is observed that the sensor value varies for 3 different soil and is proportionately increasing with respect to the concentration of soil with an equal measure of water. The range of NPK sensor can be set based on the type of soil and their standard properties of the soil with the well defined concentration of the soil solution.

It is advised that the designed sensor can be covered with an opaque material to ensure good response without the interference of the external light source. The developed hardware NPK sensor value for a soil sample remains constant in all instance for a period of 24 h. This is because the soil nutrients level does not vary with respect to time. But it will vary as the crops gain nutrients from the soil during their growth.

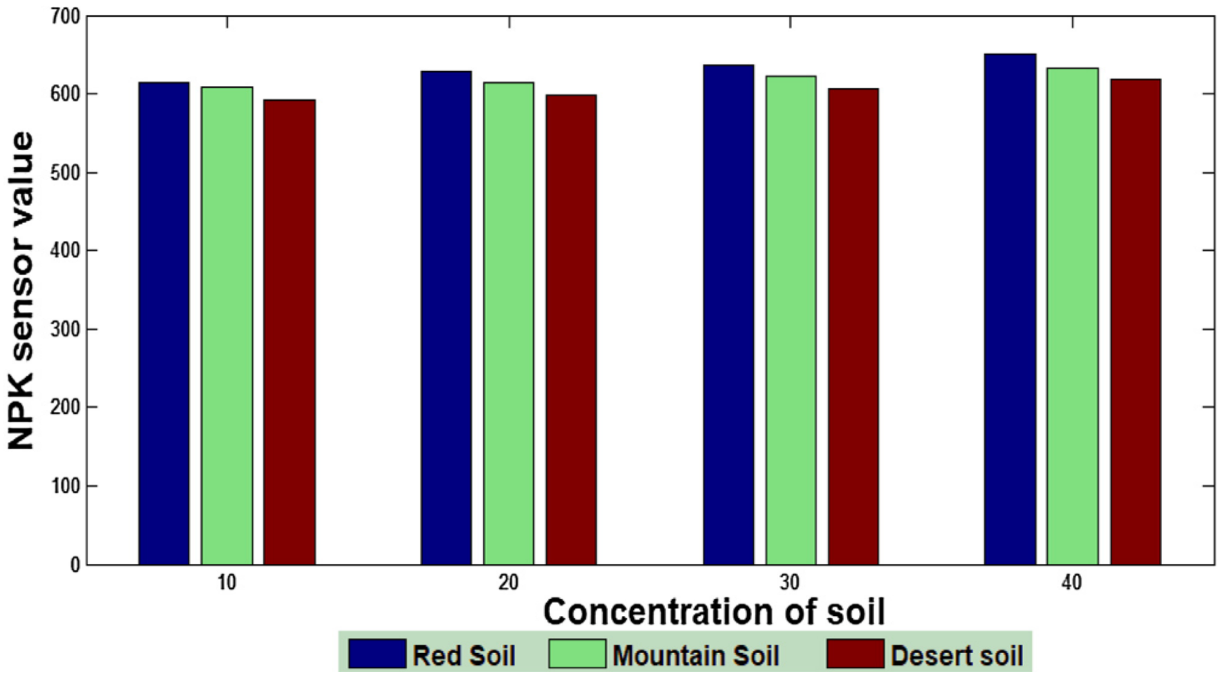


**Fig. .**NPK sensor response based on density of soil solution.

So the soil nutrients testing could be set to regular interval of time (weekly once or monthly once) in the software based on the type of soil and the crop planted in the field. It is recommended that the automated sensing can be set as the discrete measurement such that the sensor unit remains idle other than measurement. Since the components used in sensor design cost low, the cost of the developed system is less when compared to the manual soil testing in laboratory. Fig.4. shows the graphical view of simulated rules of the fuzzy system. The last row in the graph shows the

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inference from the sensor value. Fig.4. (a) shows Rule 1 with NPK sensor data as soil nutrients level being very low indicates the soil is deficient in nitro- gen, phosphorus and potassium. the low range of sensor value indicates that nitrogen is at an adequate and deficiency exists in phosphorus and potassium

In rule 3, the medium range of sensor value indicates the ade- quate level of nitrogen and phosphorus with potassium deficiency as shown in Fig.4. (c). The high sensor value in rule 4 indicates the high level of nitrogen and phosphorus with an adequate quantity of potassium as shown in Fig.4. (d). Rule 5 shown in Fig.4. (e) repre- sents the excess quantity of nitrogen, phosphorous and potassium in case of the very high value measured from NPK sensor.

The variation and decision on the level of nutrients present in the soil are realized and implemented in the fuzzy inference system embedded within the microcontroller. The simulated result of the designed fuzzy system is shown in Fig.4. (a–c). It is observed that for all fuzzified values of the NPK sensor value, there exist a fuzzified value of nitrogen, phosphorus and potassium as shown in Fig.4. (a–e).

Fig.4. (a) shows the presence of nitrogen in the soil solution for various NPK sensor value sensed from the sample of the soil solution. It is observed that at the very low range of NPK sensor value results in the low range of nitrogen which implies that urea should be necessarily added to the soil. Low and medium range of NPK sensor value result in adequate (medium) level of nitrogen in the soil. The high and very high range of sensor value results in the high value of nitrogen indicating the excess quantity

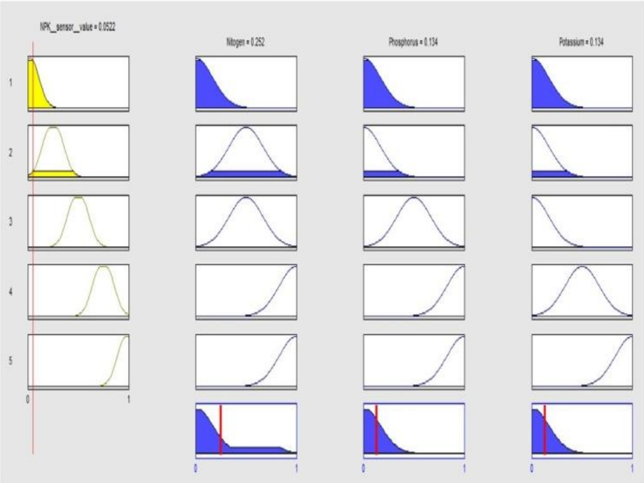
of nitrogen present in the soil that implies to avoid added urea to the soil.

Fig.4. (b) shows the existence of phosphorous in the soil with respect to different NPK sensor value sensed from the sample of the soil solution. The observation is that at very low and low range of NPK sensor value results in the low range of phosphorus. Medium range of NPK sensor results in the adequate level of nitrogen and phosphorus in the soil. The high and very high range of sensor value results in the high value of phosphorus indicating the excess quan- tity of phosphorous present in the soil and hence usage of fertilizers like Di-ammonium phosphate is avoided

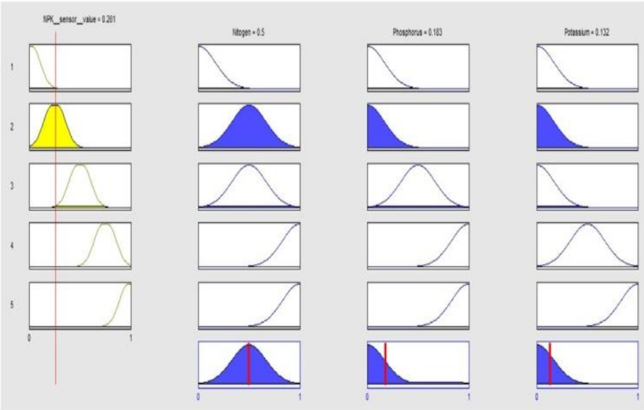
The variation of the presence of potassium level in the soil with the NPK sensor value is shown in Fig.4.(c). It is examined that at very low and low range of NPK sensor value results in the low range of potassium. Medium range of NPK sensor results in the adequate level of nitrogen and phosphorus in the soil with deficient in potassium. High range of sensor value results in an adequate level of potassium present in the soil and very high range of sensor value results in the high value of potassium indicating the excess quantity of potassium present in the soil. Finally, the aggregation of the three output variable will lead to the decision of selecting the appropriate fertilizer for the auto- matically tested soil. It was analyzed that a fertilizer with the composition of N,P and K is added to the soil at very low and low range of NPK sensor value since the soil is found to be deficient in all the three major nutrients. Similarly, the medium range of sensor value implies to add the fertilizer with the composition maximum of potassium and minimum of phosphorus and nitrogen. No fer- tilizer is suggested to be added for a very high range of sensed value

Hence, the inference system response shown in Fig.4.(a–c) at the edge level of the proposed IoT device leads to the delivery of SMS through internet agents to the farmers about the appropriate use of fertilizer based on the nutrients level present in the soil.

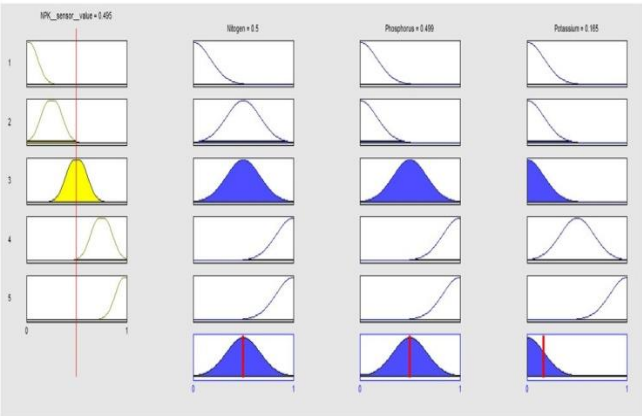
**Fig. 4.**Rules of Fuzzy inference system for soil nutrients testing (a) NPK sensor →



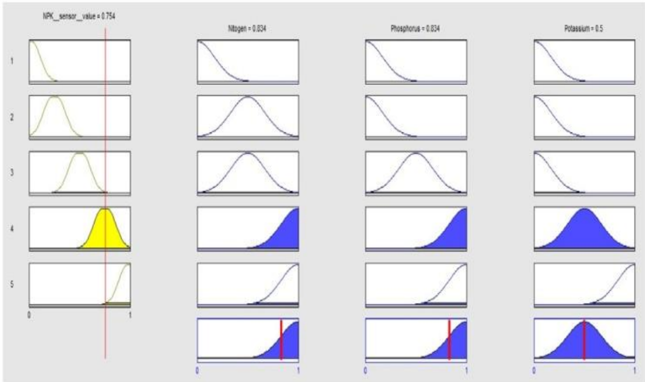
(a) NPK_sensor →Very Low ⇒ N- Low, P- Low and K – Low



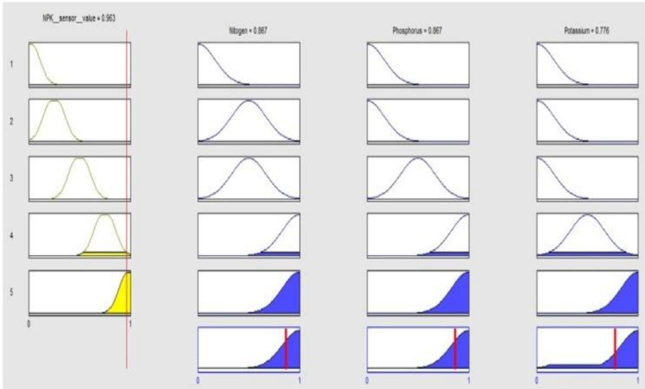
(b) NPK_sensor → Low ⇒ N-Medium, P – Low and K- Low



(c ) NPK_sensor →Medium ⇒ N- Medium, P- Medium and K- Low



(d) NPK_sensor →High ⇒ N- High,P-High ,K-Medium



(e) NPK_sensor →Very high ⇒N-High,P-High and K- High

Very Low ⇒ N → Low, P → Low and K → Low. (b) NPK sensor → Low ⇒ N → Medium, P → Low and K → Low. (c) NPK sensor → Medium ⇒ N → Medium, P → Medium and K → Low. (d) NPK sensor → High ⇒ N → High, P → High, K → Medium. (e) NPK sensor → Very high ⇒ N → High, P → High and K → High.

| Test case ID | Action | Expected output | Actual output | Result |
|---|---|---|---|---|
| 1 | When the soil moisture is high | Motor is turned off | Same as expected | Pass |
| 2 | When the soil moisture is low | Motor is turned on | Same as expected | Pass |

This table shows action and response of the soil moisture level detection. Soil moisture level can be controlled using water pump. This table contains 2 events, based upon these events the motor can be controlled to maintain optimal moisture level in the soil. If the soil moisture level is low, then automatically motor will be turned on and when the moisture level reaches the threshold value, the motor will be turned off automatically. An alert message will be sent to the farmer using GSM. If the soil moisture level is high, then the motor will remain turned off.

| | Action | Expected output | Actual output | Result |
|---|---|---|---|---|
| 1 | When the motion is detected | Buzzer and LED is turned on | Same as expected | Pass |
| 2 | When there is no motion | Buzzer and LED is turned off | Same as expected | Pass |

## 5. CONCLUSION AND FUTURE WORK

Fortitude of soil nutrients determination regularly in the agricultural field is difficult due to manual testing in laboratories. It causes the negligence to the farmers about the nutrient level in the soil and improper use of fertilizer at the inappropriate time. The proposed system provides the farmer regarding the deficiency of major soil nutrients namely nitrogen, phosphorous and potassium through SMS using the designed NPK sensor with its fuzzy rule-based system. Experimental simulations are carried out to understand the functionality and inform the intended purpose of the developed IoT system. From the experiment, the proposed system is a low cost, accurate and intelligent IoT system that intimates the farmer about the fertilizer to be used at right time automatically through SMS and can be used as a helping tool for the farmers in agriculture purpose.

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