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(RESEARCH ARTICLE)

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Intelligent IoT based soil monitoring and irrigation system using fuzzy logic control and Nodemcuesp8266 Microcontroller

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Abstract

Internet of things (IoT), a well-known branch of computer science that has introduced intelligent farming to green agriculture. IoT depicts a self-configuring chain of components. The efficient implementation helps agriculture, a self-discipline as nicely as thriving for quality, increased yield and reduced human work. Development of irrigated agriculture has become one of the most reliable strategies of increasing world food supply in order to meet the ever-increasing demand for food by the increasingly complex and expanding global population of Homo sapiens. In areas of little rainfall, full-scale irrigation is practices, but some of these irrigation methods are not very efficient thus causing farmers to lose about 50% of water supplied. The study is aim at evaluating environmental parameters such as soil moisture, temperature and humidity while using the acquired data to develop an effective intelligent IoT based automated soil monitoring and irrigation system. These data are stored to the IoT Thing-Speak platform in order to analyze past conditions of plants and to predict their performance. Using the moisture sensor and the NodeMCUESP8266 microprocessor, this procedure will continue until the ideal moisture level is reached. Environmental conditions are monitored using temperature and humidity sensors. An intelligent IoT based automated soil monitoring and irrigation system get real-time data, increase the crop performance and reduce the water that is lost in the irrigation process, also reduce the time spent on the field.

Keywords: IoT; Thing-speak; NodeMCU; DHT 11; Soil Moisture sensor; Temperature and Humidity sensor

1. Introduction

As the world is trending into modern technologies and implementations, it is a necessary goal to trend up in agriculture also. In recent times, researches are working using internet of things (IoT) in the field of agriculture.

However, application of technology like artificial intelligence and IoT in agriculture could have the greatest impact especially in developing countries where there is infrastructure such as electricity and wired transmission lines. The availability of this infrastructure and the internet can be used to overcome deficiencies in agriculture(1).

IoT devices are expected to have a significant impact on farming while meeting the increasing consumption need of the global population which is expected to increase to 70% by 2050 (2).

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(3) Reported that smart agriculture often plays a very vital role in promoting cultivation. A further recommendation, that a solution be obtained by installing sensors in the agricultural land to track and assess soil productivity. Development of irrigation agriculture ha

s become one of the most reliable strategies of increasing world food supply in order to meet the ever-increasing global population of human beings (4)

Environmental parameters such as soil moisture content, temperature, humidity, ph., radiation and a host of other factors plays a vital role in development of plants (1). "Traditional methods of irrigation such as overhead sprinkler is not much efficient as it leads to water wastage and promote disease such as fungus formation due to excess soil moisture"(5). Therefore, for an increased soil quality, crop production and efficient soil irrigation, a means to maintaining these parameters are developed. Development of Intelligent IoT based soil monitoring and irrigation system not only solves this problem, also assists in gathering and storing data that farmers may evaluate and use to forecast agricultural output yield in the future. The design of a system to control irrigation pump using Fuzzy logic control and the NodeMCUESP8266.

2. Material and methods

2.1. Proposed System

The intelligent Internet of Things-based (IoT) soil monitoring and irrigation system can make farming operations easier by optimizing the rate of water consumption and conservation. This system helps to actualize the use of host components, software, and the fuzzy logic control system mainly for irrigation control.

2.2. System Architecture

The sensors connected in the NodeMCUesp8266 microcontroller as shown in Figure 1 known as the functional block diagram. This NodeMCUesp8266 controller was selected because is it an integrated Wi-Fi module with a wide range of sensors and its can also set up a network of its own, allowing other devices to connect directly to it. The controller processes the readings from the field sensors and implements intelligent irrigation using fuzzy logic control.

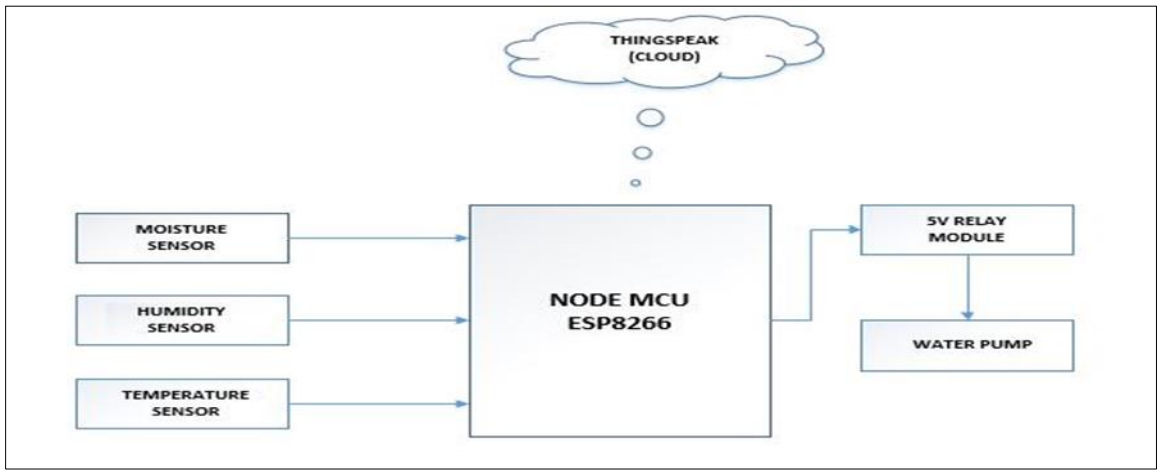

Figure 1 Functional block diagram of NodeMCUesp8266 microcontroller-based irrigation system

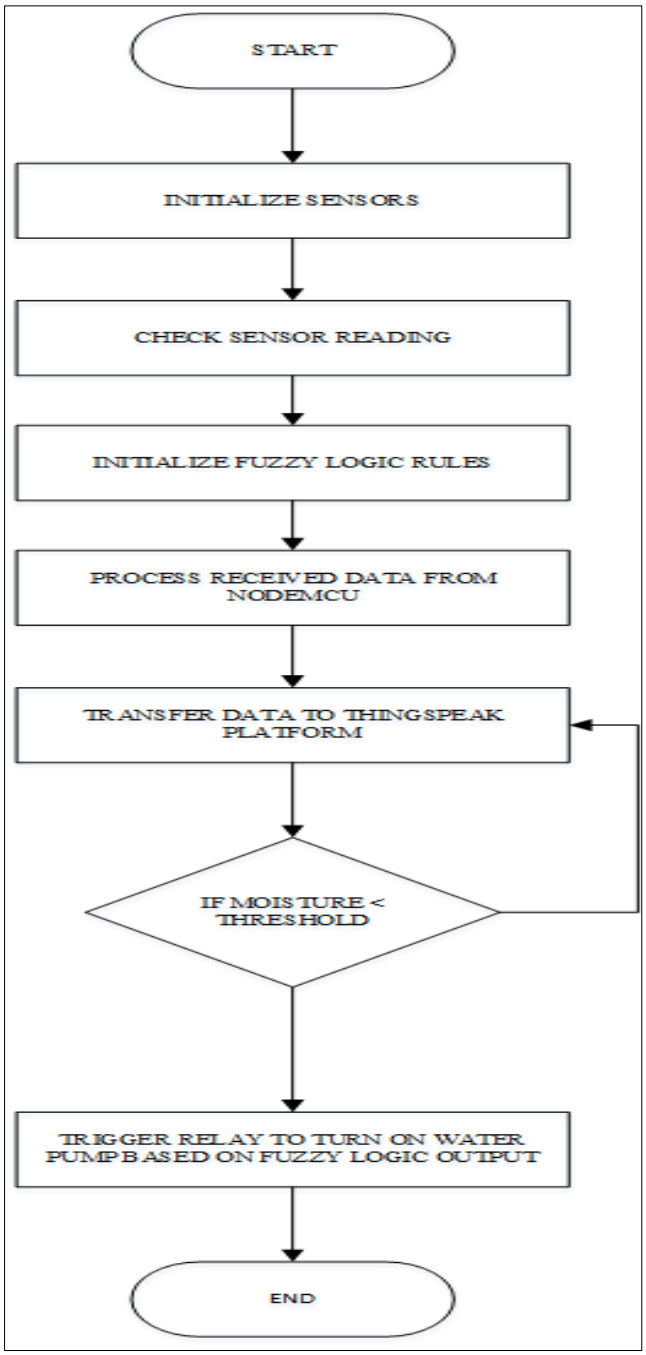

Figure 2 Flowchart for the system

2.3. Hardware Component Description

2.3.1. NodemcuEsp8266

According to (6) ESP8266 is a complete and self-contained Wi-Fi network solution that can carry software application, or through another application processor uninstall all Wi-Fi networking capabilities. When the device is mounted and as the only application of the application processor, direct access from an external move can start the flash memory as shown in Figure 3 below. Built-in cache memory will help improve system performance and reduce memory requirements. Another circumstance you may incorporate a Wi-Fi adaptor into any microcontroller-based design for wireless internet access, and the connection is simple, just by SPI / SDIO interface or central processor AHB bridge interface. Processing and storage capacity on ESP8266 powerful piece, it can be integrated via GPIO ports sensors and other applications specific equipment to achieve the lowest early in the development and operation of at least occupy system resources.

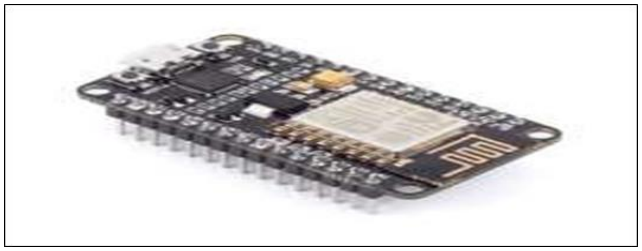

Figure 3 NodeMCUESP8266

2.3.2. Soil Moisture Sensor

This type of sensors measures the water content in soil based on the volume present in it at a time. Since the direct gravimetric measurement of free-soil moisture requires removing, drying, and weighting of a sample, soil moisture sensors measure the volumetric water content indirectly by using some other property of the soil, such as electrical resistance, dielectric constant, or interaction with neutrons, as a proxy for the moisture content. Depending on environmental parameters such soil type, temperature, or electric conductivity, the relationship between the measured value and soil moisture can change. The soil moisture has an impact on the reflected microwave radiation, employed for remote sensing in agriculture and hydrology (7)

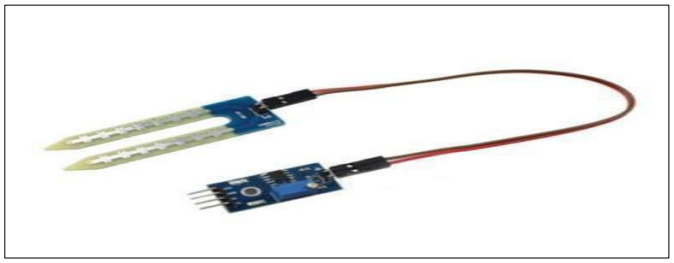

Figure 4 Soil Moisture Sensor

2.3.3. DHT 11

A DHT11 sensor measures temperature and humidity. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air. This sensor is cost effective, provides low power consumption and up-to 20-meter signal transmission is possible.

SPECIFICATION

- Supply Voltage: +5 V
- Temperature range :0-50 °C error of ± 2 °C
- Humidity :20-90% RH ± 5% RH error

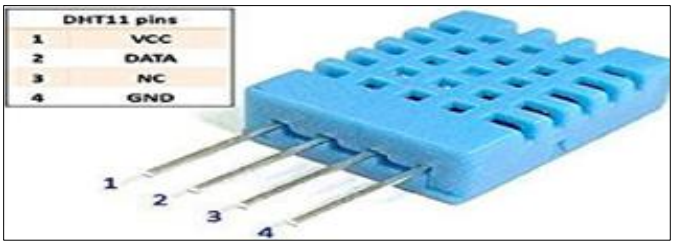

Figure 5 Humidity and Temperature sensor (DHT11)

2.4. 5v DC mini-Pump

Small DC Submersible water pumps push fluid to the surface as opposed to jet pumps having to pull fluids. Submersibles are more efficient than jet pumps usually operated between 3v to 12v. The water pump consumes electrical energy to perform mechanical work by moving the water as shown in Figure 6.

- Voltage: 2.5-10V 2.
- Maximum lift: 40-110cm / 15.75"-43.4" 3.
- Flow rate: 80-120L/H 4.
- Outside diameter: 7.5mm / 0.3"

Figure 6 5v Dc Pump

2.5. 5v Relay Module

The relay module is an electrically operated switch that allows you to turn on or off a circuit, using voltage and/or current much higher than a microcontroller could handle shown in Figure 7.

Figure 7 5V relay module

2.6. Fuzzy Inference system

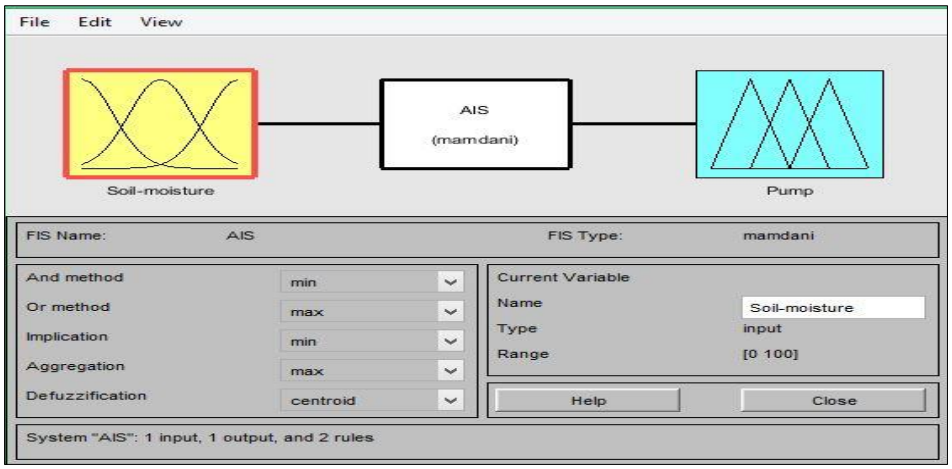

Figure 8 Fuzzy inference System GUI editor

3. Results and Discussion

The potential range of input and output values found by examining into a fuzzy system's peculiarities. A triangular membership function used to implement the Mamdani method. There are just two input membership function as shown in Figure 9a. These represent the soil moisture level labelled as low level and normal. The output membership function represents the pump control for the irrigation. The output membership function as shown in Figure 9b labelled as ON

pump and OFF pump. The same triangular shaped membership functions used for both input and output. The rule viewers as shown in Figure 10a and b, shows the simulated pump control status based on a soil moisture level.

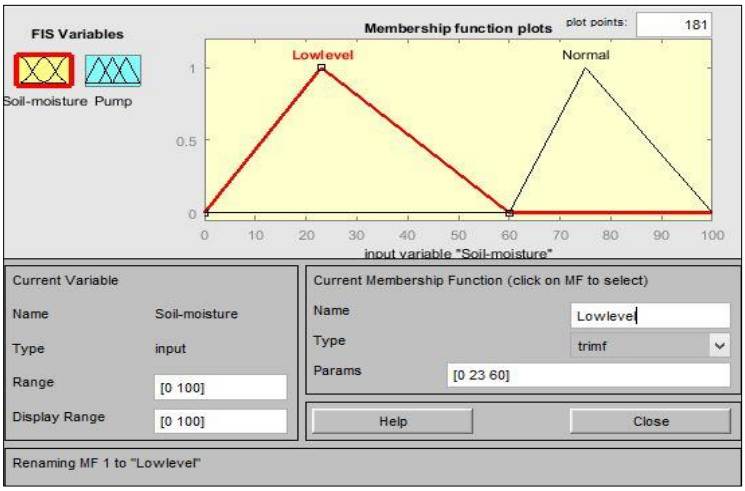

Figure 9a Fuzzy Input Membership Function (Pump control)

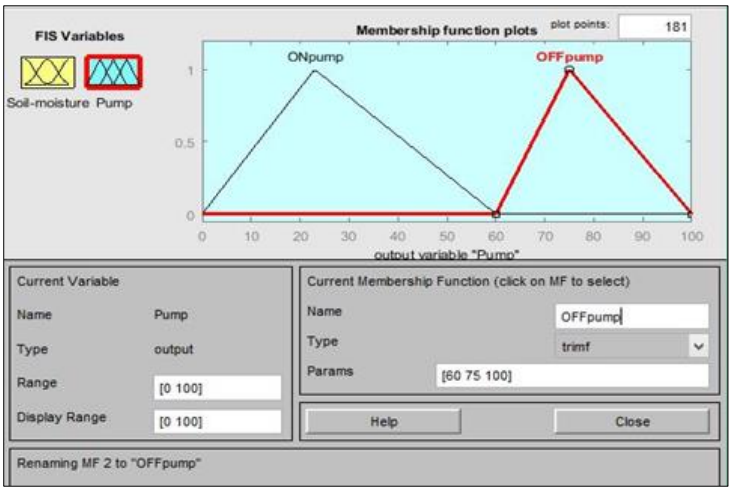

Figure 9b Fuzzy Output Membership (Soil moisture Level)

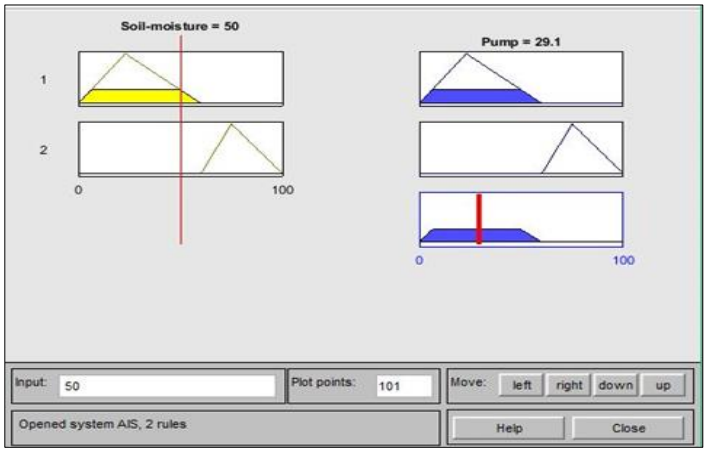

Figure 10a MATLAB Rule viewer for Output 1

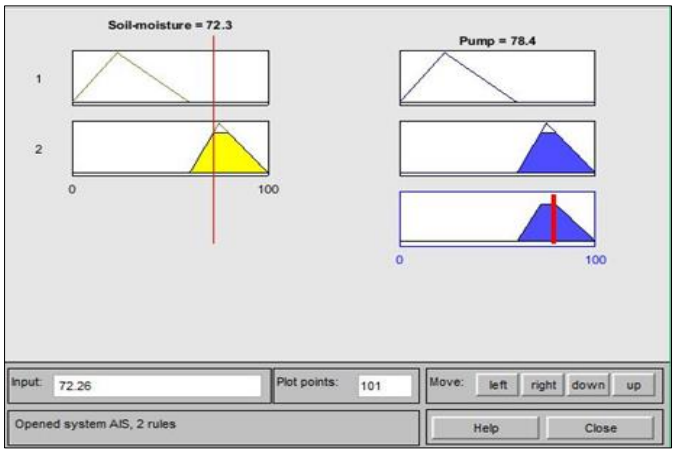

Figure 10b MATLAB Rule Viewer Output 2

The results of the data gotten from the DHT11 sensor and the soil moisture level captured in Figure 11a and b. These data acquired on the first Day of testing the model's performance, this test lasted for about 2hours. Further performance test carried on the model that also lasted for two hours, this showed good working condition of the system as shown in Figure 12a, b, and c.

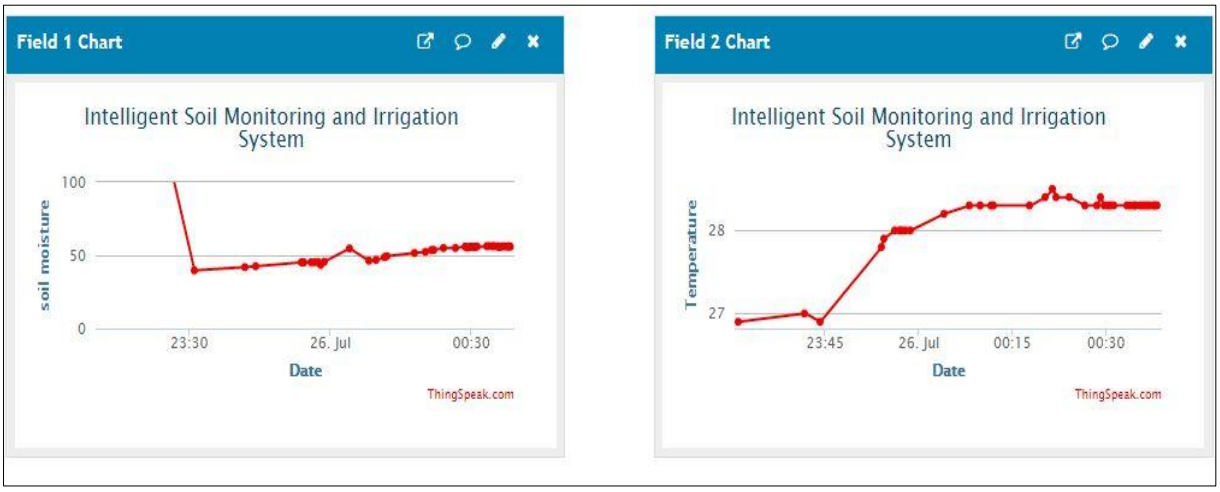

Figure 11a Soil moisture and Temperature results Day 1

Figure 11b Humidity and pump Status Day 1

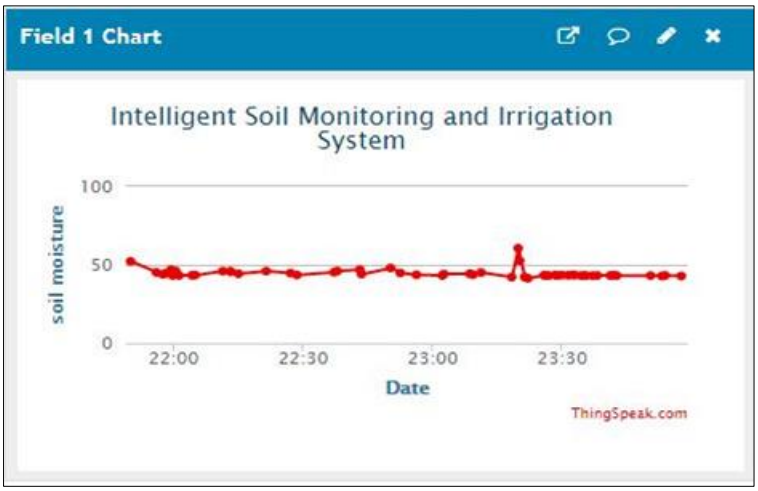

Figure 12a Soil moisture Reading Day 2

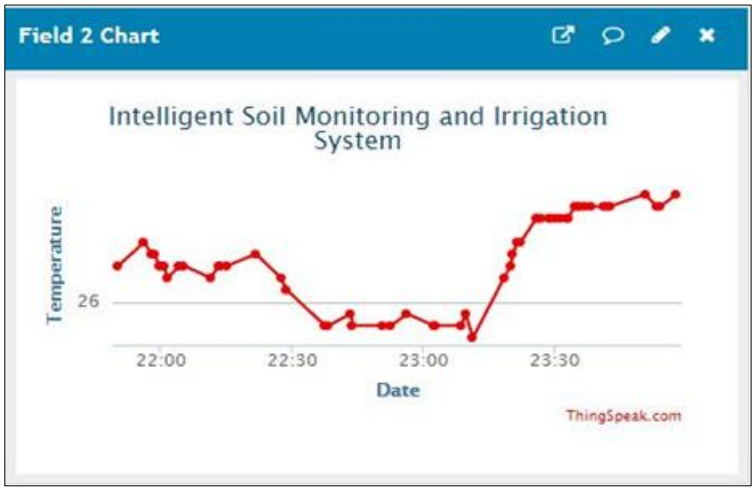

Figure 12b Temperature Reading Day 2

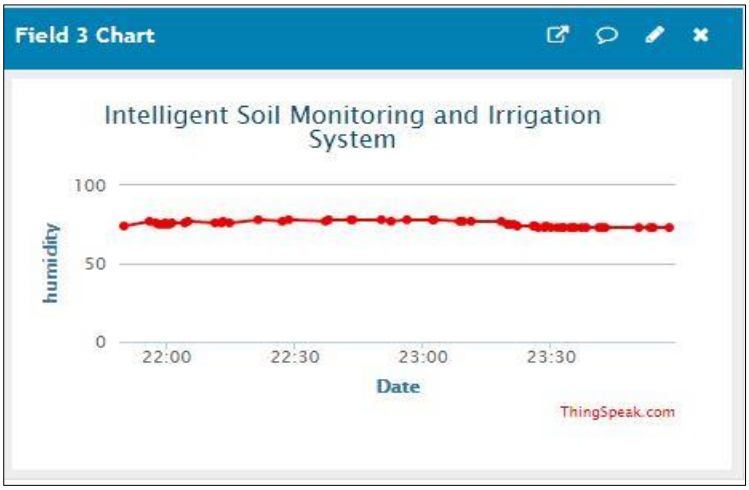

Figure 12c Humidity Reading Day 2

4. Conclusion

In order to reduce the need for human intervention in farming, agricultural monitoring is necessary, therefore, educating farmers on the ways technological application can help monitor and control processes. The actualization of this system will lead to smart water management system on the farm there by optimizing already existing irrigation processes. The data acquired are stored on the IoT platform for future analyzes and performance prediction of the farm land. Use of soil moisture sensor helps to reduce the water wastage and thus prevent from excessive irrigation of land. However, for future advancements of this system, different kinds of sensors such as pH sensors, Carbon dioxide Sensors and light Sensors could be installed thereby providing enough reference data for analysis. In order to create a more reliable system, the fuzzy system can also use many input variables.

Compliance with ethical standards

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Author Contributions**:** Conceptualization, A.J.C; methodology, A.J.C and A.F.O; investigation, preparation, A.J.C and A.A.O; data curation, A.B and A.J.C; writing -original draft preparation, A.J.C., I.C.T and A.J.E; writing-review and editing, A.B., A.J.C., A.F.O., A.A.O., A.J.E., and I.C.T, visualization, A.J.C., A.B., and I.C.T, supervision, A.J.C. and A.B., project administration, A.J.C.; funding acquisition, A.J.C. All authors have read and agreed to the published version of the manuscript.

Disclosure of conflict of interest

The Authors confirm that the content of this manuscript has no conflict of interest

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